Flood Management Evaluation Memorandum

Date:	Thursday, June 08, 2023
To:	Region 13 Flood Planning Group c/o Nueces River Authority
From:	Bryan Martin, PE HDR, Inc/ Firm No. 754 4401 W Gate Blvd Ste 400 Austin, TX 78745
Subject:	FME ID: 131000006 Project Sponsor: Camp Wood Project Name: Downtown Camp Wood Drainage Improvements

Methodologies and Procedures

1. Background

HDR Engineering, Inc. (HDR) advanced a Flood Mitigation Evaluation (FME) for the City of Camp Wood, Texas. This analysis was done to provide data for the 2023 Nueces Regional Flood Plan (the Plan) concerning potential FMEs and Flood Mitigation Projects (FMPs) to be recommended in the 2023 Plan. An existing conditions hydrologic and hydraulic (H&H) model of the area was created to better understand local drainage patterns and major risk areas. However, proposed solutions as well as a benefit-cost analysis still need to be completed to identify potential projects for consideration in future flood plan amendments or updates.

The project area is located in downtown Camp Wood, with major areas of flooding including Pecos St, Nueces St, E South St, and Ranch Rd 337. Flooding is caused by a large quantity of local drainage flowing into an inadequate storm drain network. Proposed Camp Wood Drainage Improvements should consider reducing the amount of stormwater going into the existing storm drains, improving the stormwater conveyance, and/or other flood risk reduction strategies to reduce the total amount of flood risk.

This memorandum documents the assumptions, methodologies and processes used to advance the FME in accordance with the Texas Water Development Board (TWDB) Exhibit C Technical Guidelines for Regional Flood Planning FMP requirements.

2. Data Collection

All data were obtained as digital files in Geographic Information System (GIS) and Excel format. HDR gathered and compiled the following readily available geospatial data:

- National Oceanic and Atmospheric Administration (NOAA) - Atlas 14 Precipitation Frequency Data for Camp Wood, Texas (Table 1)

- Texas Natural Resources Information System (TNRIS) - United States Geological Survey (USGS) 1 meter resolution 2018 LiDAR-based digital elevation models (DEMs)
- United States Department of Agriculture Natural Resources Conservation Service - Soil Survey Geographic Database (SSURGO) data for Real County
- TWDB – 2021 Texas Buildings with SVI and Estimated Population (TWDB, Center for Disease Control, Oak Ridge National Laboratory)
- Texas Department of Transportation (TxDOT) – 2016 TxDOT Roadways

Table 1. NOAA Precipitation Frequency Estimates (in inches) for Camp Wood Texas

Duration	Average Recurrence Interval (years):			
	2	10	25	100
5-min:	0.528	0.814	0.994	1.28
15-min:	1.06	1.62	1.98	2.53
60-min:	1.94	2.99	3.66	4.69
2-hr:	2.38	3.78	4.75	6.42
3-hr:	2.63	4.26	5.46	7.64
6-hr:	3.08	5.11	6.67	9.65
12-hr:	3.54	5.96	7.83	11.4
24-hr:	4.03	6.83	8.98	13.1

3. Drainage Analysis

Distributed Hydrology

Infoworks ICM v2023.2 modeling software was used to prepare the rain-on-mesh approach for the 2-, 10-, 25-, and 100-year frequency storms. Hydrologic calculations were performed using Infoworks ICM software which applies designated rainfall, spatial distributions of hydrologic soil group, and corresponding constant infiltration rates within the 2D hydraulic domain.

INFILTRATION RATE

The infiltration rate was determined using SSURGO data for Camp Wood, Texas. Table 2 and Table 3 summarize the type of soils found in the project area and the infiltration rates. Constant infiltration rates were applied spatially based on hydrologic soil group data.

Table 2. SSURGO Soils in Camp Wood Texas

Soil Description	Hydraulic Soil Group	Condition
Campwood-Knippa complex, 0 to 3 percent slopes	C	Well drained
Dev-Riverwash complex, 0 to 3 percent slopes, frequently flooded	A	Well drained
Eckrant-Rock outcrop complex, 15 to 60 percent slopes	D	Well drained
Kerrville-Real complex, 1 to 8 percent slopes	C	Well drained
Kerrville-Real association, 8 to 30 percent slopes	C	Well drained
Mailtrail-Mereta complex, 0 to 5 percent slopes	D	Well drained
Nuvalde clay loam, 1 to 3 percent slopes, rarely flooded	B	Well drained
Oakalla-Dev complex, 0 to 2 percent slopes, flooded	B	Well drained
Orif soils, 0 to 3 percent slopes, frequently flooded	A	Well drained
Pratley clay, 0 to 3 percent slopes	C	Well drained
Real-Oplin complex, 1 to 20 percent slopes	D	Well drained
Rio Frio-Vanderpool complex, 0 to 2 percent slopes, rarely flooded	B	Well drained
Riverwash and Dev soils, 0 to 3 percent slopes, frequently flooded	A	Excessively drained

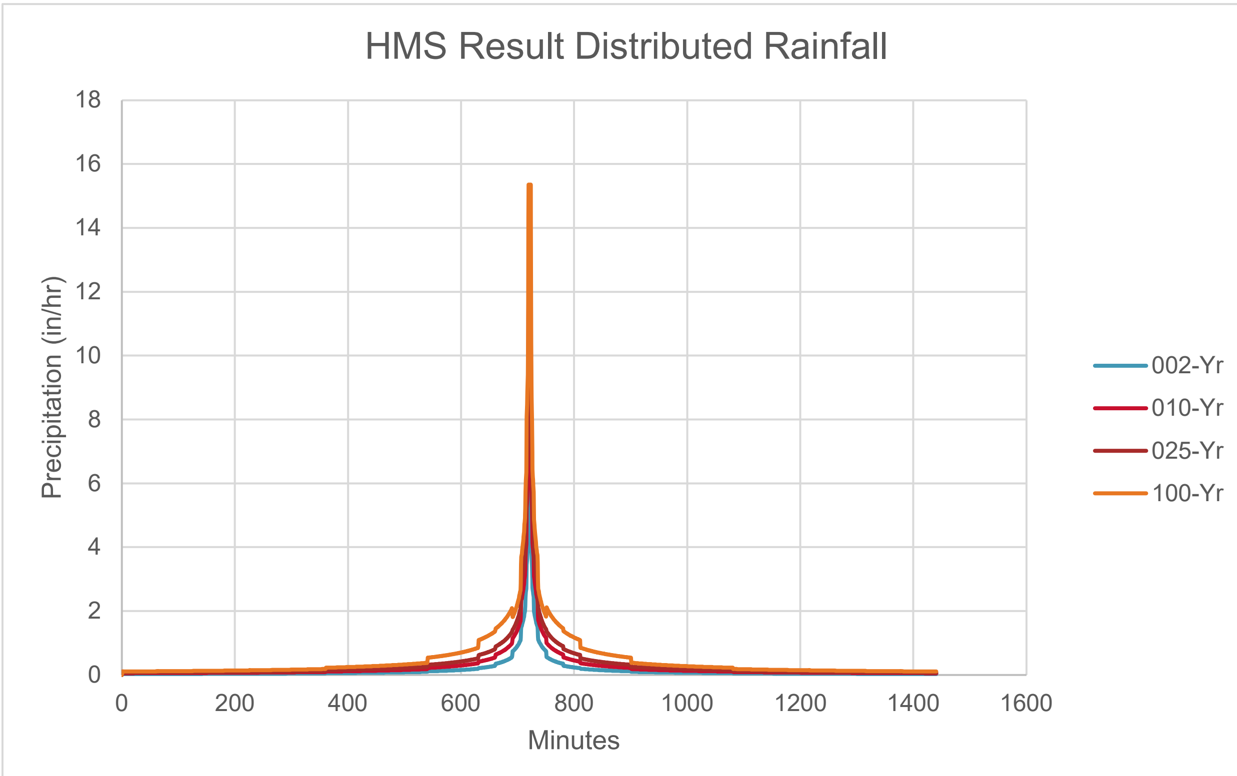
Table 3. Infiltration Model

Hydrologic Soil Group	Constant Infiltration Rate (in/hr)
A	0.35
B	0.23
C	0.1
D	0.02

RAINFALL

The rainfall data used in the ICM model were developed by inputting the Precipitation Frequency Estimates from NOAA (Table 1) into HEC-HMS v4.10 and running them with a generic basin. HEC-HMS calculates rainfall hyetographs that can then be imported into ICM. Figure 1 displays the distributed rainfall per storm frequency for Camp Wood, Texas;

Figure 1. HMS Result Distributed Rainfall for Camp Wood



ROUGHNESS

The ICM model roughness component was created by combining the structure and pavement data with assigned Manning’s N roughness values. The Manning’s N values are based on engineering assessment of satellite imagery, TWDB building and TxDOT roadway data, the United States Army Corps of Engineers HEC-RAS Hydraulic Reference Manual, and the “Open Channel Hydraulics” (Chow, 1959) Manning’s N for Channels table. Manning’s N values are typically given in ranges to reflect the empirical nature of Manning’s equation as well as the natural variability in land surface. An artificially high roughness value of 1.00 was used for building structures to allow flow to enter buildings with low velocity to represent flow conditions through buildings. The following Table 4 summarizes the N values used:

Table 4. Manning's N Roughness Values

Description	Manning N Value
Developed, Open Space	0.05
Buildings	1.00
Impervious Area - Pavement (combined concrete and asphalt)	0.011 – 0.02

Baseline Hydraulic Conditions

Components used in the ICM model were adjusted to run baseline conditions and facilitate the benefit-cost analysis (BCA) process – as described below.

TERRAIN ADJUSTMENTS

To determine the damages for this problem area, structures need to be evaluated based on flood depths. It was assumed that structures would only flood once the water surface elevation is above the structure's finished floor elevation (which was assumed to be the lowest adjacent ground elevation plus an average slab height of 0.5 feet). Structures were adjusted in ICM by assigning a finished floor elevation to each structure.

POROUS POLYGON ELEMENT

Elements provide a break in the 2D mesh elements at the boundary definition. A nominal porosity is defined for each element. These modified elements do not allow rainfall to fall onto the to fall onto the structure element so that all calculated flooding within the structure elements is caused by external runoff. The exclusion of rainfall directly on structures is assumed to have a negligible effect on the distributed hydrology.

Existing Hydraulic Condition

<<document the results of the existing condition model, where are structures at risk of flooding, how many? Where are streets flooded? Provide inundation maps for the various storm events run>>

Existing models demonstrate significant areas of flooding throughout the City of Camp Wood. Figure 2 below demonstrates the maximum stormwater inundation in a 100-year event in downtown Camp Wood. Area of flooding include:

- E 4th Street: Significant volumes of water move from west to east along the street and inundate approximately 9 structures in the 100-year storm, including Nueces County Elementary School.
- E South Street: Significant volumes of water move from west to east along the street and inundate approximately 20 structures in the 100-year storm.
- E 6th Street: Water moves northeast to southwest along east sixth and crossing through Camp Wood City Park. Approximately 6 structures are inundated in this area during the 100-year storm.

- Nueces St and 1st/2nd Street: The two blocks on either side of Nueces St bookended by 2nd Street to the north and 1st Street to the south experience significant flooding during the 100-year storm, with approximately 17 structures inundated.
- Pecos Street: Pecos street becomes a significant stormwater flow path during the 100-year event, inundating approximately 20 structures and depths greater than 2 feet along the roadway.

Figure 2. Major Flood Areas in Camp Wood Texas

Proposed Hydraulic Conditions

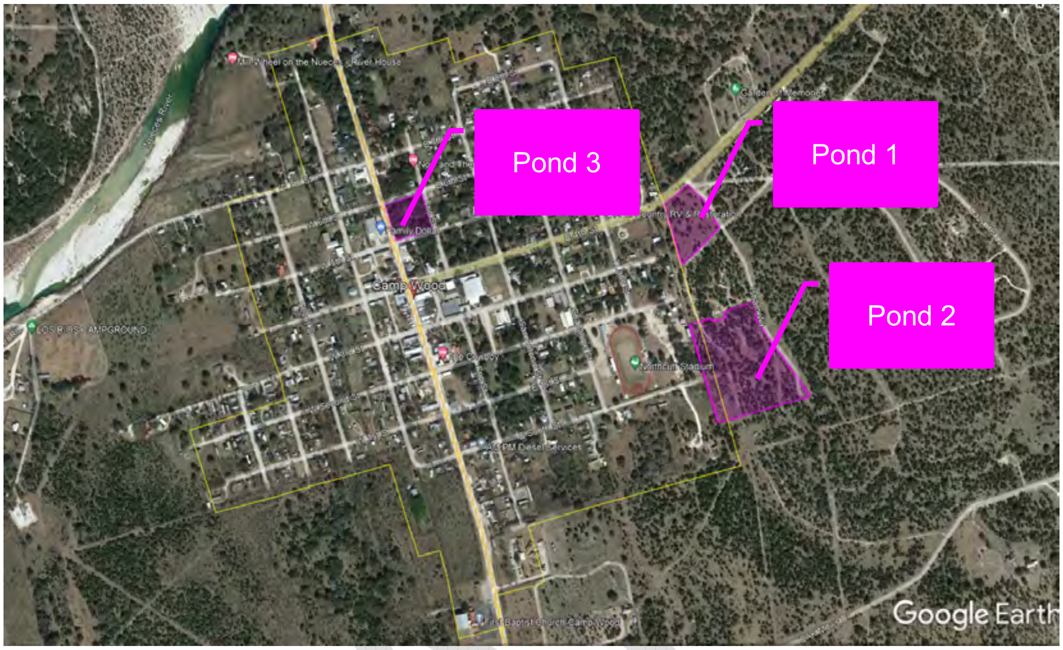
Proposed project conditions were analyzed in the same manner as baseline conditions by using the ICM software with the same components and run for the same storms, 2-, 10-, 25-, and 100-year. Only potential regional detention solutions were evaluated. A full alternative analysis and further coordination with the city is required to determine a recommended flood risk reduction project.

Regional Detention Alternative

Three independent regional detention pond locations were identified upstream of high flood risk areas within the city, displayed in Figure 3 below. The regional detention ponds were sized and evaluated to determine their potential to reduce the identified flood risk.

Other regional pond locations may be viable or preferred to the ones identified. Further coordination and study of this alternative is required.

Figure 3. Camp Wood Proposed Detention Pond Locations

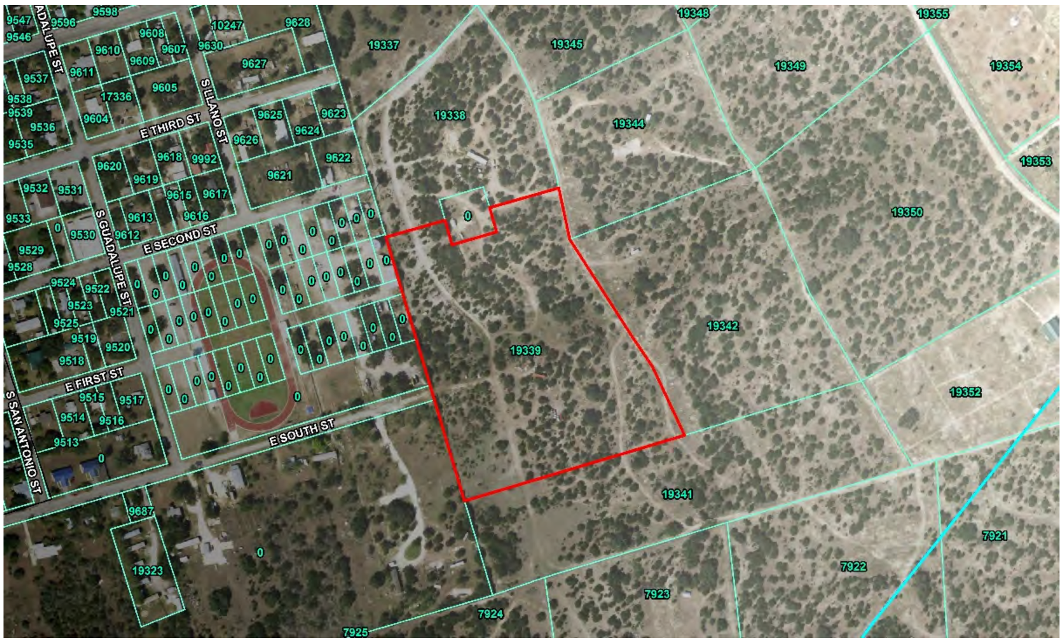


The first pond lies west of the City, south of the intersection between Ranch Road 337 and Isham Way (Figure 4). This project would require acquisition of the 5.11 acre parcel 19337 by the City and would be completely contained within the parcel. The pond itself would be approximately 10 feet deep with roughly 40 acre-feet of storage capacity.

Figure 4. Proposed Detention Pond 1

The second pond would be located southwest of the City, upstream of E South St (Figure 5). This project would require acquisition of the 13.30 acre parcel 19339 by the City and would be completely contained within the parcel. The pond itself would be approximately 6 feet deep with roughly 60 acre-feet of storage capacity.

Figure 5. Proposed Detention Pond 2



The third pond would be located downtown within Camp Wood City Park (Figure 6). This project would require use of the 2.22 acre parcel believed to be owned by the by the City and would be completely contained within the parcel. The pond itself would be approximately 7 feet deep with roughly 15 acre-feet of storage capacity.

Figure 6. Proposed Detention Pond 3

4. Results, Benefits, and Impacts

Results

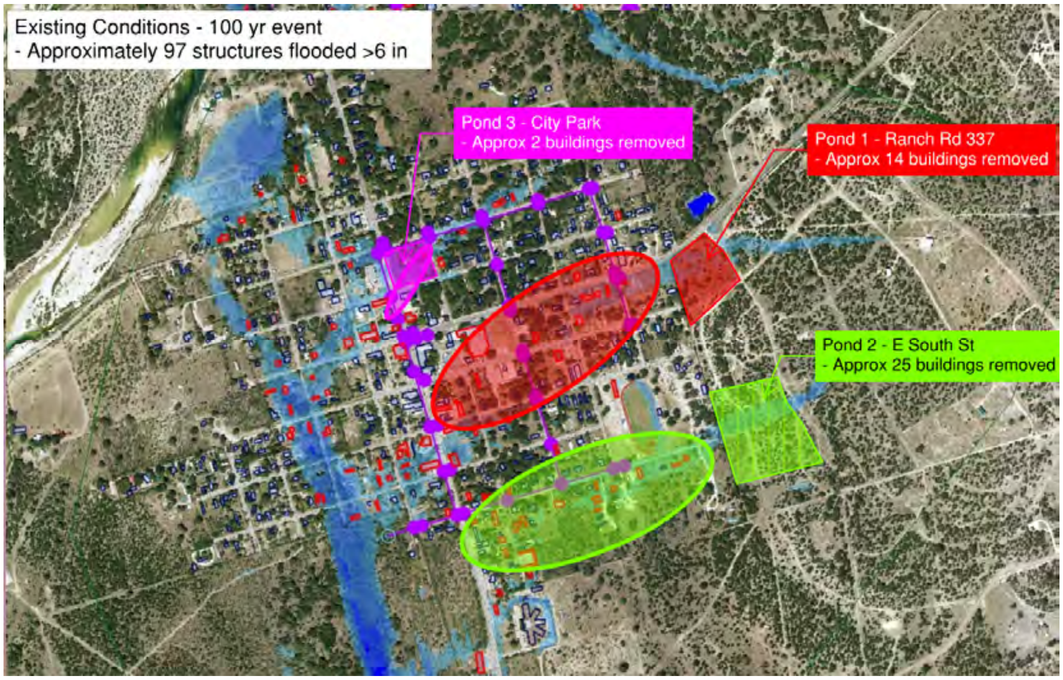
While preliminary modeling of these three pond scenarios has been completed in ICM, further validation and analysis of the results is required to provide confidence in any proposed solution. The following information has not yet been approved nor sponsored by the City of Camp Wood and cannot be included into the Region 13 State Flood Plan as a possible Flood Mitigation Project (FMP) at this time.

Preliminary, draft model results are summarized in Table 5 and Figure 7 below.

Table 5. Total Impacted Structures for Baseline and Proposed Conditions

Storm Frequency Event (Years)	Baseline Conditions (structures)	Proposed Pond 1 Removed (structures)	Proposed Pond 2 Removed (structures)	Proposed Pond 3 Removed (structures)
2	21	15	18	17
10	48	34	36	45
25	62	48	44	60
100	97	83	72	95

Figure 7. Proposed Detention Pond Inundation Impacts



Further advancement of these proposed pond locations as possible FMPs for the Region 13 flood plan is recommended.

Flood Mitigation Project Technical Memorandum

Date: Thursday, June 08, 2023

To: Region 13 Flood Planning Group
c/o
Nueces River Authority

From: Bryan Martin, PE
HDR, Inc/
Firm No. 754
4401 W Gate Blvd Ste 400
Austin, TX 78745

Subject: FMP ID: 133000005
Project Sponsor: City of Jourdanton
Project Name: Jourdanton Drainage and Regional Detention Improvements, from SH-16 to Marion Road

Methodologies and Procedures

1. Background

HDR Engineering, Inc. (HDR) advanced a flood mitigation project for the City of Jourdanton, TX (the City). This analysis was done to provide data for the 2023 Nueces Regional Flood Plan (the Plan) concerning potential Flood Mitigation Projects (FMPs) to be recommended in the 2023 Plan.

The City of Jourdanton has flooding issues in residential areas even during relatively small rainfall events. The majority of the city drains at the surface through streets and roadside ditches with a few existing culverts, inlets, and storm sewer systems located along State Highways 16 and 97. The project area addressed by these improvements is a relatively flat, low-lying residential area that extends from State Highway 16 to Marion Road and includes two minor tributaries to Goose Creek. The City plans to improve drainage conveyance from this problematic area to reduce the depth and duration of flooding events that impact city residents. The proposed project consists of an earthen drainage channel and some drainage culverts located along roadsides and undeveloped city right-of-way. The proposed channel alignment runs along Cedar, McDowell, and Commerce Streets north of State Highway 97. Three dry retention ponds are also proposed to reduce peak flow rates. These drainage improvements add conveyance and reduce minor flooding; however this project will not solve major flooding issues.

This memorandum documents the assumptions, methodologies and processes used to advance the FMP in accordance with the Texas Water Development Board (TWDB) Exhibit C Technical Guidelines for Regional Flood Planning FMP requirements.

2. Drainage Analysis

Existing and proposed hydrology models were developed for this project by 6S Engineering to support the analysis of these proposed improvements. Hydraflow software was used to evaluate hydrology and HEC-RAS modeling software was used to analyze existing and proposed project scenarios. A summary of the hydrologic and hydraulic assumptions and results from these models are included in the Engineering Feasibility Report for the City of Jourdanton provided by 6S Engineering included in the digital submittal of the Plan.

Two options were presented in the report to add conveyance and address residential flooding concerns. Both alternatives present the same channel improvements, and Option 1 includes the addition of three dry retention ponds which provide additional benefit of reducing peak flows downstream by approximately 22-46% and reducing sediment transport. Option 1 is the preferred alternative recommended to the city and maximizes floodplain improvements within the project area. A summary of the improvements proposed in each alternative is included in the report by 6S Engineering.

3. Results, Benefits, and Impacts

Results

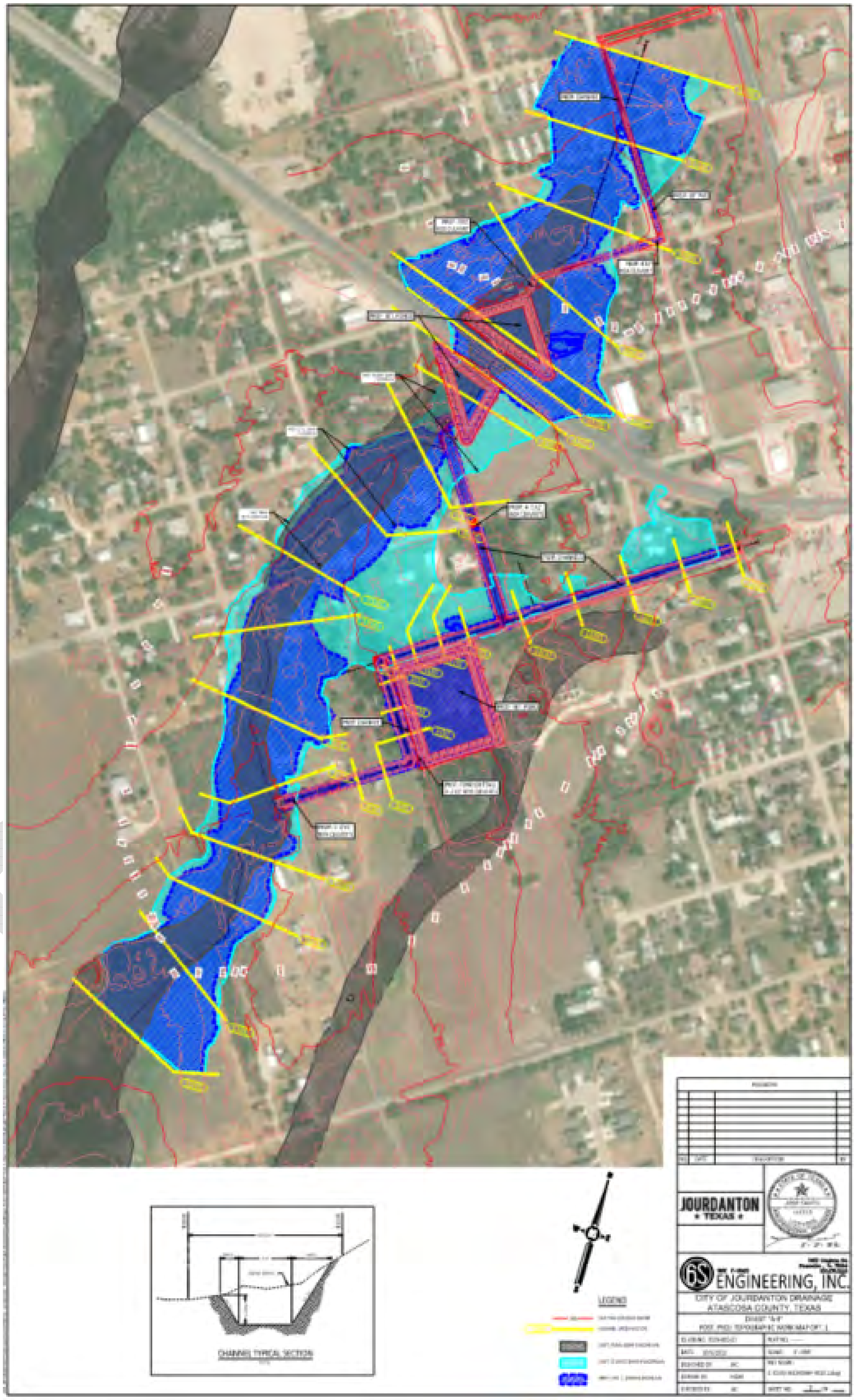
Baseline and proposed conditions were analyzed, and proposed conditions showed a significant reduction in the floodplain due to the additional volume of storage provided by the proposed retention ponds and conveyance channel. Comparing the water surface elevations for both pre- and post-development conditions showed no increase in water surface elevation. Table 1 shows the reduction in impacted structures due to the proposed project.

Table 1. Total Impacted Structures for Baseline and Proposed Conditions

Storm Frequency Event (Years)	Baseline Conditions (structures)	Proposed Conditions (structures)	Difference (structures)
2	2	0	-2
10	6	2	-4
100	9	8	-1

Figure 1shows the 100-year inundation boundary created by both the baseline and proposed conditions model results provided in the report by 6S Engineering

Figure 1. Baseline and Proposed Conditions Model Inundation Boundaries



Benefit Measurement

Per the TWDB, each FMP included in a the Plan is required to have a benefit cost analysis (BCA) performed. Some flood mitigation studies document a computed benefit cost ratio (BCR) and those can be incorporated into the Plan. For situations where a BCR is not available for a project, TWDB has developed the BCA Input Tool to facilitate the calculation of costs and benefits. The tool estimates flood impacts before and after implementation of the FMP for up to three recurrence interval flood events. The BCA considered the following project impacts: Residential Structures, Street Flooding, and Low Water Crossings.

In addition to the TWDB tool assumptions, the following section describes other assumptions which were applied during the BCA.

COST

The previous approved amount for Jourdanton Drainage Improvements was $1,504,770. HDR added additional construction costs for the three proposed detention ponds, land acquisition costs, right of way management fees, and additional design and construction engineering costs. The 2023 estimated total project cost amounts to $2,500,335 and was input into the TWDB BCA Toolkit. The total cost includes all the required applicable TWDB FMP costs including basic engineering fees, special services such as surveying, environmental, geotech, etc., other costs such as fiscal services, and contingency. An itemization of the construction costs can be found in the Engineering Feasibility Report (EFR) provided by 6S Engineering.

Per the TWDB FMP cost requirements, all costs in the Plan should be reported using 2020 prices. A Construction Cost Index (CCI) factor of 0.87 was applied to convert the costs from 2023 to 2020 dollars, resulting in a total project cost of $2,182,260. Figure 2 shows the estimated 2023 costs for this project.

Figure 2: 2023 Jourdanton Project Cost Estimate

2023 Nueces Regional Flood Plan (NRFP): Project Cost Estimate	
Cost Verification Controls must be in place to assure that construction costs are reasonable and consistent with market costs at the time and place of construction.	
Applicant/Subrecipient:	City of Jourdanton
Site/Activity Title:	Jourdanton Drainage Improvements
Consultant:	HDR Engineering, Inc. TBPE Registration No. F-754
Date:	44981
Eligible Activity:	Flood control and drainage improvements
Materials/Facilities/Services	**2023 Cost**
Previously funded amount	$ 1,504,770.00
New construction	$ 722,565.00
ROW	$ 200,000.00
Right of Way Management fees	$ 18,000.00
Additional Design	$ 30,000.00
Construction Engineering	$ 25,000.00
TOTAL PROJECT COST	**$ 2,500,335.00**
TOTAL NRFP FUNDING REQUESTED	**$ 995,565.00**

CONSTRUCTION YEAR

Construction is assumed to start in the near future, dependent on funding. Construction year in the BCA was set to begin in 2025 and end in 2026 for the project.

RESIDENTIAL STRUCTURES

Residential structures are evaluated by the size and amount its flooded for the baseline and proposed project conditions. Based on the BCA Input Tool, size categories for residential structures are designated as “Small Home” (1000 square feet), “Average Home” (2,500 square feet) and “Large Home” (5,000 square feet). For the analysis the following refinements to the BCA size assumptions were made:

- Small: x <2,500 square feet
- Average: 2,500 square feet < x <5,000 square feet
- Large: x >5,000 square feet

Inundation depths for structures were rounded to the nearest inch.

FLOODED STREETS

Streets are considered impassable if the flood depth is above 6 inches. The daily traffic count was estimated based on the TxDOT daily traffic count or the nearest adjacent road, as provided by the TxDOT TPP District Traffic Web Viewer[1].The additional time that the longest detour takes for an individual is calculated assuming a speed limit of 35 miles per hour (mph). The Normal Emergency Medical Services (EMS) response time for both baseline and proposed conditions is assumed to be 14.5 minutes, based on the rural mean value from Table 2 of the NIH JAMA Surgery study[2].The EMS response time during a storm event is assumed to double for baseline conditions. For proposed conditions, the EMS response time is scaled to match the difference between detour routes (baseline- and post-project). The number of households and commercial structures impacted by EMS delay due to flooded streets is assumed to be the total number of residential and commercial structures inundated during the given storm event.

Benefit Result

The BCA Input Tool is intended to be used in conjunction with the Federal Emergency Management Agency (FEMA) BCA Toolkit 6.0, which calculates annual benefits from the information compiled in the TWDB BCA Input Tool. The annual benefits data are then inputted back into the TWDB BCA Input Tool to compute the resulting BCR for the project. Figure 3 summarizes each of the impacts per storm and the final BCR for the project.

[1] https://txdot.maps.arcgis.com/apps/webappviewer/index.html?id=06fea0307dda42c1976194bf5a98b3a1

[2] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5831456/

Figure 3. BCA Tool Results – Jourdanton Drainage Improvements FMP

Input Into BCA Toolkit

Project Useful Life	**30**

Event Damages	Baseline	Project
2 - year storm	**$145,787**	**$0**
10 - year storm	**$380,598**	**$104,136**
100 - year storm	**$622,808**	**$495,699**

Total Benefits from BCA Toolkit	$1,474,976
Other Benefits (Not Recreation)	$20,044
Recreation Benefits	-
Total Costs[1]	$2,044,134
Net Benefits	-$549,114
Net Benefits with Recreation	-$549,114
Final BCR	**0.7**
Final BCR with Recreation	**0.7**

1: BCA Costs in Figure 3 are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Impact Analysis

An FMP is required to have no negative impacts in the neighboring area, either upstream or downstream of the project. No negative impact means that a project will not increase flood risk of surrounding properties. The increase in flood risk must be measured by the 100-year frequency storm water surface elevation and peak discharge using the best available data. No rise in water surface elevation or discharge is permissible, and the study area must be sufficiently large to demonstrate that proposed project conditions are equal to or less than the existing (baseline) conditions.

For the purposes of regional flood planning efforts, a determination of no negative impacts can be established if stormwater runoff does not increase inundation of infrastructure such as residential and commercial structures or exceed the design capacity of stormwater systems. According to the TWDB Exhibit C Technical Guidelines, all of the following requirements should be met to establish no negative impact, as applicable:

1. Stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement.

2. Stormwater does not increase inundation of storm drainage networks, channels, and roadways beyond design capacity.

3. Maximum increase of 1D Water Surface Elevation must round to 0.0 feet (<0.05 feet) measured along the hydraulic cross-section.

4. Maximum increase of 2D Water Surface Elevations must round to 0.3 feet (<0.35 feet) as measured at each computation cell.

5. Maximum increase in hydrologic peak discharge must be <0.5 percent measured at computation nodes (sub-basins, junctions, reaches, reservoirs, etc.). This discharge restriction does not apply to a 2D overland analysis.

Because the Jourdanton Drainage Improvements analysis was performed using 2D modeling software, only requirements #1, #2, and #4 are applicable. In Table 1, the baseline conditions affected structures were compared to the proposed conditions affected structures. The comparison shows that the number of commercial and residential structures affected by the 100-year storm was reduced by 17 structures in proposed conditions and no flooding at existing structures was increased, satisfying requirement #1. The maximum increase of the 2D water surface elevation when comparing baseline and proposed conditions is less than the 0.35 feet, satisfying both requirements #2 and #4. An evaluation of the baseline- versus post- project conditions does not indicate increases in 100-year water surface elevations for neighboring properties and therefore satisfies the impact analysis requirements.

Flood Mitigation Project Technical Memorandum

Date:	Thursday, June 08, 2023
To:	Region 13 Flood Planning Group c/o Nueces River Authority
From:	Bryan Martin, PE HDR, Inc/ Firm No. 754 4401 W Gate Blvd Ste 400 Austin, TX 78745
Subject:	FMP ID: 133000006 Project Sponsor: City of Poteet Project Name: Rutledge Hollow Creek Tributary Regional Detention Pond Improvements

Methodologies and Procedures

1. Background

HDR Engineering, Inc. (HDR) advanced a flood mitigation project for the City of Poteet, TX (the City). This analysis was done to provide data for the 2023 Nueces Regional Flood Plan (the Plan) concerning potential Flood Mitigation Projects (FMPs) to be recommended in the 2023 Plan.

The problem area is located in downtown Poteet, where a tributary of Rutledge Hollow Creek floods, stretching to adjacent roadways and structures from School Drive to Avenue J. Flooding is caused by a large quantity of localized drainage flowing to an undersized storm drain network along 3rd Street between Avenue F and H. The Poteet Drainage Improvements (the Project) would reduce the amount of stormwater going to the existing storm drain and reduce the total amount of structures flooded.

This memorandum documents the assumptions, methodologies and processes used to advance the FMP in accordance with the Texas Water Development Board (TWDB) Exhibit C Technical Guidelines for Regional Flood Planning FMP requirements.

2. Data Collection

All data were obtained as digital files in Geographic Information System (GIS) and Excel format. HDR gathered and compiled the following readily available geospatial data:

- National Oceanic and Atmospheric Administration (NOAA) - Atlas 14 Precipitation Frequency Data for the City of Poteet (Table 1)
- Texas Natural Resources Information System (TNRIS) - United States Geological Survey (USGS) 1 meter resolution 2018 LiDAR-based digital elevation models (DEMs)

- United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) - Soil Survey Geographic Database (SSURGO) data for Atascosa County
- TWDB – 2021 Texas Buildings with SVI and Estimated Population (TWDB, Center for Disease Control, Oak Ridge National Laboratory)
- Texas Department of Transportation (TxDOT) – 2016 TxDOT Roadways

Table 1. NOAA Precipitation Frequency Estimates (in inches) for Poteet

Duration	Average Recurrence Interval (years):			
	2	10	25	100
5-min:	0.53	0.76	0.90	1.13
15-min:	1.06	1.5	1.78	2.25
60-min:	1.94	2.78	3.31	4.15
2-hr:	2.37	3.54	4.32	5.59
3-hr:	2.61	4.02	4.97	6.58
6-hr:	3.02	4.8	6.04	8.19
12-hr:	3.41	5.47	6.94	9.53
24-hr:	3.83	6.17	7.85	10.9

3. Drainage Analysis

Distributed Hydrology

The methodology for the determination of storm water runoff is common between both Baseline- (also known as Existing) and Proposed- Conditions modeling. Infoworks ICM v2023.2 modeling software was used to prepare the rain-on-mesh approach for the 2-, 10-, 25-, and 100-year frequency storms. Hydrologic calculations were performed using Infoworks ICM software which applies designated rainfall, spatial distributions of hydrologic soil group, and corresponding constant infiltration rates within the 2D hydraulic domain.

Infiltration Rate Table 3 summarize the type of soils found in the project area and the infiltration rates. Constant infiltration rates were applied spatially based on hydrologic soil group data.

Table 2. SSURGO Soils in Poteet

Soil Description	Hydraulic Soil Group	Condition
Sayers soils, frequently flooded	A	Somewhat excessively drained
Duval loamy fine sand, 0 to 5 percent slopes	B	Well drained
Sinton soils, frequently flooded	B	Well drained
Amphion sandy clay loam, 0 to 1 percent slopes	C	Well drained
Amphion sandy clay loam, 1 to 3 percent slopes	C	Well drained
Christine soils, occasionally flooded	C	Somewhat poorly drained
Floresville fine sandy loam, 1 to 3 percent slopes	C	Well drained
Floresville fine sandy loam, 1 to 5 percent slopes, eroded	C	Well drained
Hanis sandy clay loam, 1 to 3 percent slopes	C	Well drained
Hanis sandy clay loam, 3 to 5 percent slopes	C	Well drained
Miguel fine sandy loam, 1 to 3 percent slopes	C	Well drained
Nusil-Rhymes association, 0 to 5 percent slopes	C	Well drained
Poteet soils, occasionally flooded	C	Moderately well drained
Poth loamy fine sand, 0 to 3 percent slopes	C	Well drained
Webb fine sandy loam, 1 to 3 percent slopes	C	Well drained
Webb fine sandy loam, 3 to 5 percent slopes	C	Well drained
Wilco loamy fine sand, 0 to 3 percent slopes	C	Well drained
Wilco loamy fine sand, 3 to 5 percent slopes	C	Well drained
Dilley fine sandy loam, 1 to 5 percent slopes	D	Well drained

Elmendorf-Denhawken complex, 1 to 4 percent slopes	D	Well drained
Tiocano clay, cool, 0 to 1 percent slopes, occasionally ponded	D	Somewhat poorly drained
Tordia clay, 1 to 4 percent slopes	D	Well drained
Water	D	

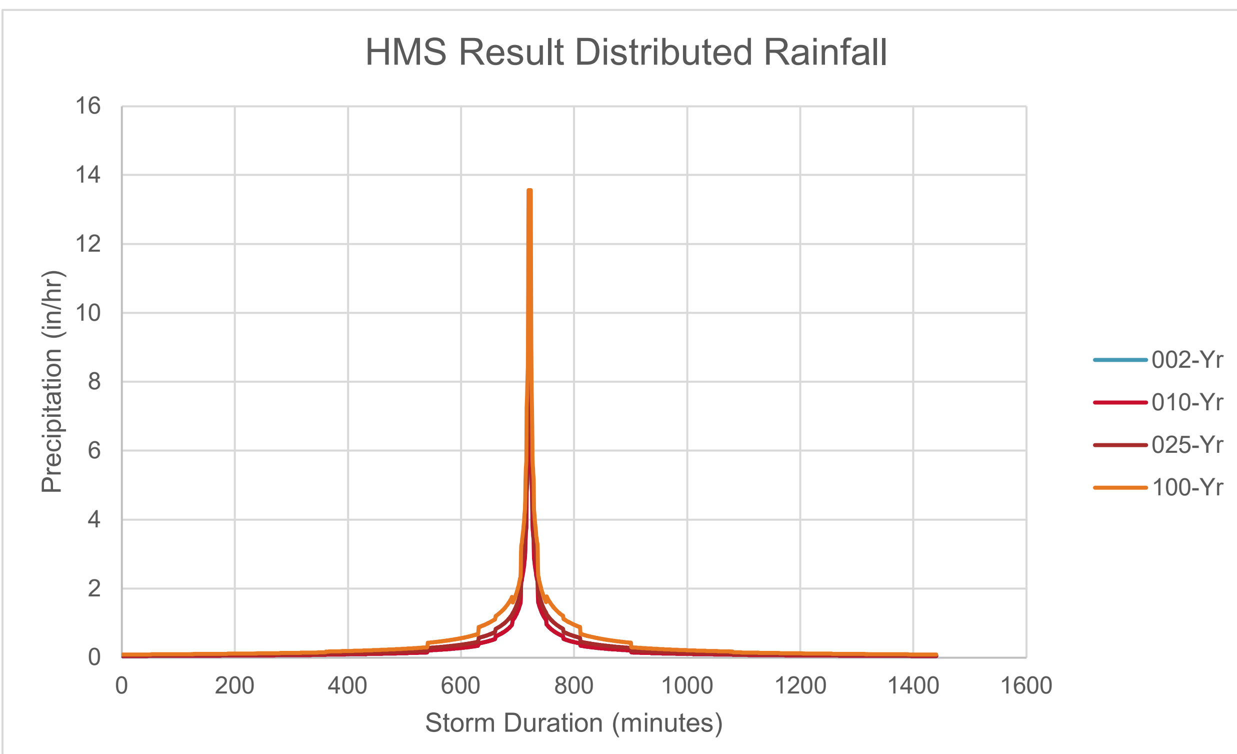
Table 3. Infiltration Model

Hydrologic Soil Group	Constant Infiltration Rate (in/hr)
A	0.35
B	0.23
C	0.1
D	0.02

RAINFALL

The rainfall data used in the ICM model were developed by inputting the Precipitation Frequency Estimates from NOAA (Table 1) into HEC-HMS v4.10 and running them with a generic basin. HEC-HMS calculates rainfall hyetographs that can then be imported into ICM. Figure 1 displays the distributed rainfall per storm frequency for Poteet, Texas:

Figure 1. HMS Result Distributed Rainfall for Poteet



ROUGHNESS

The ICM model roughness component was created by combining the structure and pavement data with assigned Manning's N roughness values. The Manning's N values are based on engineering assessment of satellite imagery, TWDB building and TxDOT roadway data, the United States Army Corps of Engineers HEC-RAS Hydraulic Reference Manual, and the "Open Channel Hydraulics" (Chow, 1959) Manning's N for Channels table. Manning's N values are typically given in ranges to reflect the empirical nature of Manning's equation as well as the natural variability in land surface. An artificially high roughness value of 1.00 was used for structures to allow flow to enter structures with low velocity to represent flow conditions through structures. Table 4 summarizes the N values used:

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Description	Manning's N Value
Structure	1.00
Impervious Area - Pavement (combined concrete and asphalt)	0.011 – 0.02
Developed, Open Space	0.050

Baseline Hydraulic Conditions

Components used in the ICM model were adjusted to run baseline conditions and facilitate the benefit-cost analysis (BCA) process as described below.

TERRAIN ADJUSTMENTS

To determine the damages for this problem area, structures need to be evaluated based on flood depths. It was assumed that structures would only flood once the water surface elevation is above the structure's finished floor elevation (which was assumed to be the lowest adjacent ground elevation plus an average slab height of 0.5 feet). Structures were adjusted in ICM by assigning a finished floor elevation to each structure.

POROUS POLYGON ELEMENT

Elements provide a break in the 2D mesh elements at the boundary definition. A nominal porosity is defined for each element. These modified elements do not allow rainfall to fall onto the structure element so that all calculated flooding within the structure elements is caused by external runoff. The exclusion of rainfall directly on structures is assumed to have a negligible effect on the distributed hydrology.

Proposed Hydraulic Conditions

Proposed project conditions were analyzed in the same manner as baseline conditions by using the ICM software with the identical components and running the same storm events (2-, 10-, 25-, and 100-year). In proposed conditions a detention pond with an outfall system was used to mitigate the flooding issues. The placement of the detention pond is located at property owned by the City at the corner of Avenue B and Kelly St. The proposed pond has approximately 15 acre-feet of storage. The outlet pipe is 24-inch diameter and it connects the pond to the Rutledge Hollow Creek tributary by passing under Avenue C.

4. Results, Benefits, and Impacts

Results

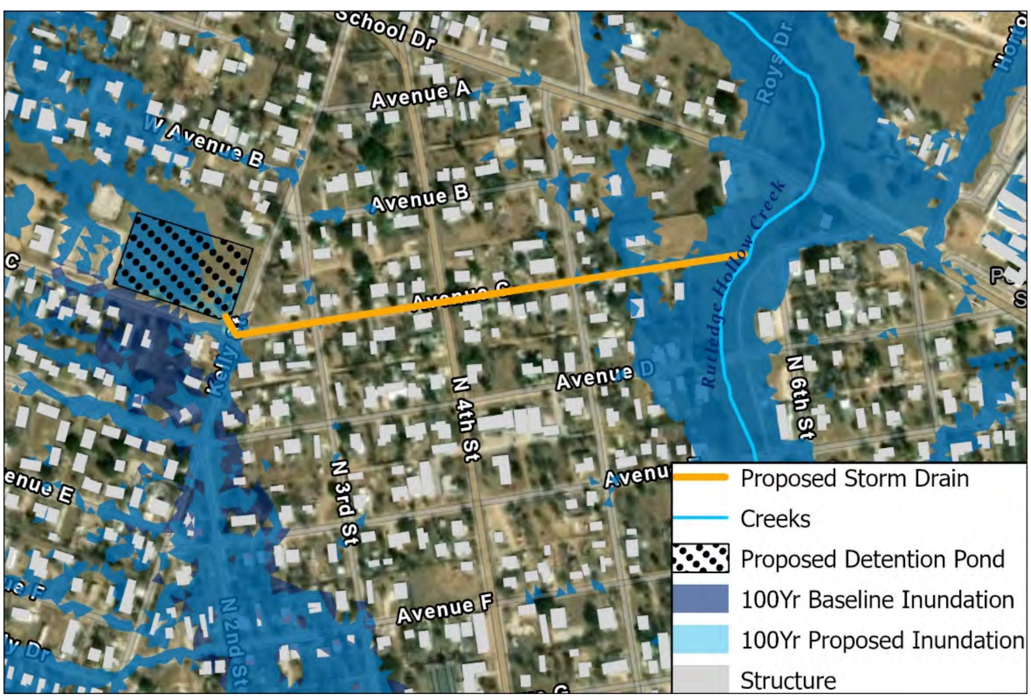
Table 5 summarizes the number of inundated commercial and residential structures for each analyzed storm event:

Table 5. Total Impacted Structures for Baseline and Proposed Conditions

Storm Frequency Event (Years)	Baseline Conditions (structures)	Proposed Conditions (structures)	Difference (structures)
2	207	197	-10
10	305	298	-7
100	438	421	-17

The following figure displays the inundation boundary created by both the baseline and proposed conditions model results.

Figure 2. Baseline and Proposed Conditions Model Inundation Boundaries



Benefit Measurement

Per the TWDB, each FMP included in a regional flood plan is required to have a benefit cost analysis (BCA) performed. Some flood mitigation studies document a computed benefit cost ratio (BCR) and those can be incorporated into the regional flood plan. For situations where a BCR is not available for a project, TWDB has developed the BCA Input Tool to facilitate the calculation of costs and benefits. The tool estimates flood impacts before and after implementation of the FMP for up to three recurrence interval flood events. The BCA considered the following project impacts: Residential Structures, Commercial Structures, Street Flooding, and Recreational Benefits.

In addition to the TWDB tool assumptions, the following assumptions were made to run the tool:

COST

HDR used 2023 costs to estimate the total cost for the Poteet Drainage Improvements to be $1,126,361. The 2023 estimated total project cost was input into the TWDB BCA Toolkit. The total cost includes all the required applicable TWDB FMP costs including basic engineering fees, special services such as surveying, environmental, geotech, etc., other costs such as land/easement acquisition and administration, fiscal services, and contingency. The following are the assumptions made for each cost:

- Design and Permitting - 15% of the estimated construction costs
- Environmental; archaeological & historical resources – $10,000
- Legal assistance; fiscal services & costs (bond counsel); outreach - 3% of estimated construction costs
- Interest during construction (assumed at 1 year) – 3.5%
- Contingency(s) - 35% of the estimated construction costs per the American Association of Cost Engineering (AACE) Class 4 Estimates for Feasibility Studies

Note that for this project the land acquisition cost is assumed to be $0 because the proposed detention pond area is owned by the City and would not require additional costs to obtain. Per the TWDB FMP cost requirements, all costs in the Plan should be reported using 2020 prices. A Construction Cost Index (CCI) factor of 0.87 was applied to convert the costs from 2023 to 2020 dollars, resulting in a total project cost of $1,132,000.

CONSTRUCTION YEAR

Construction is assumed to start in the near future, dependent on funding. Construction year in the BCA was set to begin in 2025 and end in 2026 for the project.

RESIDENTIAL STRUCTURES

Residential structures are evaluated by the size and amount its flooded for the baseline and proposed project conditions. The size categories in the BCA are classified as “Small Home,” “Average Home,” and “Large Home.” The TWDB guidelines give the following as typical sizes for each: “Small” = 1000 square feet., “Average” = 2,500 square feet, and

"Large" = 5,000 square feet. For the residential structure analysis the following size assumptions were made:

- Small: x <2500 square feet
- Average: 2500 square feet< x <5000 square feet
- Large: x >5000 square feet

The TWDB tool limits the total amount of residential structures that can be assessed per project to 100 structures. For this project, more than 100 structures were impacted. Instead of looking at each individual structure's damages for baseline and proposed conditions, the total amount of impacted structures within the same size category and inundation depth were totaled per condition analyzed. Inundation depths were rounded to the nearest inch.

COMMERCIAL STRUCTURES

Commercial structure damages are determined by business type and size (square footage). With limited data on the type of commercial structures, all commercial structures were assumed to be Retail-Clothing. This type has the closest damages per square feet to the average of all commercial types damages per square feet as determined by the BCA assumptions. Inundation depths were rounded to the nearest inch.

FLOODED STREETS

Streets are considered impassable if the flood depth is above 6 inches. The daily traffic count was estimated based on the TxDOT daily traffic count or the nearest adjacent road, as provided by the TxDOT TPP District Traffic Web Viewer[1]. The additional time that the longest detour takes for an individual is calculated assuming a speed limit of 35 miles per hour (mph). The Normal Emergency Medical Services (EMS) response time for both baseline and proposed conditions is assumed to be 14.5 minutes, based on the rural mean value from Table 2 of the NIH JAMA Surgery study[2]. The EMS response time during a storm event is assumed to double for baseline conditions. For proposed conditions, the EMS response time is scaled to match the difference between detour routes (baseline- and post-project). The number of residential and commercial structures impacted by EMS delay due to flooded streets is assumed to be the total number of residential structures and commercial structures inundated during the given storm event.

[1](https://txdot.maps.arcgis.com/apps/webappviewer/index.html?id=06fea0307dda42c1976194bf5a98b3a1)

[2](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5831456/)

Benefit Result

The BCA Input Tool is intended to be used in conjunction with the Federal Emergency Management Agency (FEMA) BCA Toolkit 6.0, which calculates annual benefits from the information compiled in the TWDB BCA Input Tool. The annual benefits data are then inputted back into the TWDB BCA Input Tool to compute the resulting BCR for the project. The following Figure 3 summarizes each of the impacts per storm and the final BCR for the project.

Figure 3. BCA Tool Results – Poteet Drainage Improvements FMP

Input Into BCA Toolkit

Project Useful Life	**30**	
Event Damages	**Baseline**	**Project**
2 - year storm	**$10,670,771**	**$10,081,734**
10 - year storm	**$17,109,982**	**$16,492,620**
100 - year storm	**$26,318,058**	**$25,088,479**

Total Benefits from BCA Toolkit	$4,198,438
Other Benefits (Not Recreation)	$0
Recreation Benefits	-
Total Costs[1]	$1,095,254
Net Benefits	$3,103,184
Net Benefits with Recreation	$3,103,184
Final BCR	**3.8**
Final BCR with Recreation	**3.8**

1: BCA Costs in Figure 3 are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Impact Analysis

An FMP is required to have no negative impacts in the neighboring area, either upstream or downstream of the project. No negative impact means that a project will not increase flood risk of surrounding properties. The increase in flood risk must be measured by the 100-year frequency storm water surface elevation and peak discharge using the best available data. No rise in water surface elevation or discharge is permissible, and the study area must be sufficiently large to demonstrate that proposed project conditions are equal to or less than the existing (baseline) conditions.

For the purposes of regional flood planning efforts, a determination of no negative impacts can be established if stormwater runoff does not increase inundation of infrastructure such as residential and commercial structures or exceed the design capacity of stormwater systems. According to the TWDB Exhibit C Technical Guidelines, all of the following requirements should be met to establish no negative impact, as applicable:

1. Stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement.

2. Stormwater does not increase inundation of storm drainage networks, channels, and roadways beyond design capacity.

3. Maximum increase of 1D Water Surface Elevation must round to 0.0 feet (<0.05 feet) measured along the hydraulic cross-section.

4. Maximum increase of 2D Water Surface Elevations must round to 0.3 feet (<0.35 feet) measured at each computation cell.

5. Maximum increase in hydrologic peak discharge must be <0.5 percent measured at computation nodes (sub-basins, junctions, reaches, reservoirs, etc.). This discharge restriction does not apply to a 2D overland analysis.

Because the Poteet Drainage Improvements analysis was performed using a 2D modeling software, only requirements #1, #2, and #4 are applicable. In Table 5, the baseline conditions affected structures were compared to the proposed conditions affected structures. The comparison shows that the number of commercial and residential structures affected by the 100-year storm was reduced by 17 structures in proposed conditions and no flooding at existing structures was increased, satisfying requirement #1. The maximum increase of the 2D water surface elevation when comparing baseline and proposed conditions is less than the 0.35 feet, satisfying both requirements #2 and #4. An evaluation of the baseline- versus post- project conditions does not indicate increases in 100-year water surface elevations for neighboring properties and therefore satisfies the impact analysis requirements.

Flood Mitigation Project Technical Memorandum

Date: Thursday, June 08, 2023

To: Region 13 Flood Planning Group
c/o
Nueces River Authority

From: Bryan Martin, PE
HDR, Inc/
Firm No. 754
4401 W Gate Blvd Ste 400
Austin, TX 78745

Subject: FMP ID's: 133000007, 133000008
Project Sponsor: City of Benavides
Project Names:

- City of Benavides Las Animas Conveyance Infrastructure
- City of Benavides Main City Network Storm Drain Improvements

Methodologies and Procedures

1. Background

HDR Engineering, Inc. (HDR) advanced two flood mitigation projects for the City of Benavides, TX (the City). This analysis was done to provide data for the 2023 Nueces Regional Flood Plan (the Plan) concerning potential Flood Mitigation Projects (FMPs) to be recommended in the 2023 Plan.

The two projects for Benavides were identified in the 2022 Duval County Master Plan done by CDM Smith. The two projects are as follows:

- *Las Animas Conveyance Infrastructure Improvements*: Clear out creek channel (4,000 linear feet) and upsize culverts to six 5 foot by 3 foot boxes.
- *Benavides Main City Network Storm Drain Improvements*: Clean filled-in trench drain and outfall channel, upsize existing pipes (7,900 linear feet), 12 new inlets.

This memorandum documents the assumptions, methodologies and processes used to advance the FMP in accordance with the Texas Water Development Board (TWDB) Exhibit C Technical Guidelines for Regional Flood Planning FMP requirements.

2. Drainage Analysis

Existing and proposed hydrology models were developed for this project by CDM Smith. A summary of the hydrology and hydraulic assumptions and information provided by these models are included in the Duval County Master Plan included in the digital submittal of the Plan.

3. Benefit Measurement

Per the TWDB, each FMP included in the Plan is required to have a benefit cost analysis (BCA) performed. Some flood mitigation studies document a computed benefit cost ratio (BCR) and those can be incorporated into the Plan. For situations where a BCR is not available for a project, TWDB has developed the BCA Input Tool to facilitate the calculation of costs and benefits. The tool estimates flood impacts before and after implementation of the FMP for up to three recurrence interval flood events. The BCA considered the following project impacts: Residential Buildings, Commercial Buildings, Street Flooding, and Low Water Crossings.

In addition to the TWDB tool assumptions, the following section describes other assumptions which were applied during the BCA.

Cost

CDM Smith used 2023 costs to estimate the total cost for the improvements are as follows:

- *Las Animas Conveyance Infrastructure Improvements*: $5,800,000
- *Benavides Main City Network Storm Drain Improvements*: $9,585,000

The 2023 estimated total project cost was input into the TWDB BCA Toolkit. The total cost includes all the required applicable TWDB FMP costs including basic engineering fees, special services such as surveying, environmental, geotech, etc., other costs such as land/easement acquisition and administration, fiscal services, and contingency. The following are the assumptions made for each cost:

- Contractor's mobilization and de-mobilization costs were estimated at 5% of the subtotaled direct costs.
- Contractor's overhead and profit (OH&P) and required bonds were estimated at 25% and 3%, respectively.
- Total project contingency was estimated at 50%, in line with planning-level estimates with 0 to 5% design maturity.

Per the TWDB FMP cost requirements, all costs in the Plan should be reported using 2020 prices. A Construction Cost Index (CCI) factor of 0.87 was applied to convert the costs from 2023 to 2020 dollars, resulting in a total project cost of:

- *Las Animas Conveyance Infrastructure Improvements*: $5,213,975.29
- *Benavides Main City Network Storm Drain Improvements*: $8,616,543.65

Construction Year

Construction is assumed to start in the near future, dependent on funding. Construction year in the BCA was set to begin in 2025 and end in 2026 for the project.

Residential Structures

Residential structures are evaluated by the size and amount flooded for the baseline and proposed project conditions. Based on the BCA Input Tool, size categories for residential structures are designated as “Small Home” (1000 square feet), “Average Home” (2,500 square feet and “Large Home” (5,000 square feet For the analysis the following refinements to the BCA size assumptions were made:

- Small: x <2,500 square feet
- Average: 2,500 square feet < x <5,000 square feet
- Large: x >5,000 square feet

Inundation depths for structures were rounded to the nearest inch.

Commercial Structures

Commercial building damages are determined by business type and size (square footage). With limited data on the type of commercial buildings, all commercial buildings were assumed to be Retail-Clothing. This type has the closest damages per square foot. to the average of all commercial types damages per square foot, as determined by the BCA assumptions. Inundation depths were rounded to the nearest inch.

Structures labeled as vacant or agriculture were not included in the BCA damages.

Flooded Streets

Streets are considered impassable if the flood depth is above 6 inches. The daily traffic count was estimated based on the TxDOT daily traffic count or the nearest adjacent road, as provided by the TxDOT TPP District Traffic Web Viewer[1]. The additional time that the longest detour takes for an individual is calculated assuming a speed limit of 35 miles per hour (mph). The Normal Emergency Medical Services (EMS) response time for both baseline and proposed conditions is assumed to be 14.5 minutes, based on the rural mean value from Table 2 of the NIH JAMA Surgery study[2]. The EMS response time during a storm event is assumed to double for baseline conditions. For proposed conditions, the EMS response time is scaled to match the difference between detour routes (baseline- and post-project). Number of households and commercial buildings impacted by EMS delay due to flooded streets is assumed to be the total number of residential buildings and commercial buildings inundated during the given storm event.

Low water crossings

Low Water Crossings (LWC) are considered impassable if the flood depth is above 6 inches. LWC benefits and Flooded Streets benefits were considered in the BCA. LWC benefits are based on reduced rescues/injuries/fatalities associated with people attempting to cross, whereas Flooded Streets benefits are based on reduced detours.

If there are multiple LWCs in a project that are all in close proximity to one another, the combined LWC benefits were evaluated as one LWC. All costs and benefits were aggregated to compute one BCA for the multiple LWCs for flood planning purposes.

[1] https://txdot.maps.arcgis.com/apps/webappviewer/index.html?id=06fea0307dda42c1976194bf5a98b3a1

[2] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5831456/

Benefit Result

The BCA Input Tool is intended to be used in conjunction with the Federal Emergency Management Agency (FEMA) BCA Toolkit 6.0, which calculates annual benefits from the information compiled in the TWDB BCA Input Tool. The annual benefits data are then inputted back into the TWDB BCA Input Tool to compute the resulting BCR for the project. Figure 1 and Figure 2 summarize each of the impacts per storm and the final BCR for the projects.

Figure 1. BCA Tool Results – Las Animas Conveyance Infrastructure Improvements

Input Into BCA Toolkit

Project Useful Life	**0**

Event Damages	Baseline	Project
2 - year storm	**$107,722**	**$0**
10 - year storm	**$96,950**	**$0**
100 - year storm	**$165,461**	**$0**

Total Benefits from BCA Toolkit	$742,768
Other Benefits (Not Recreation)	$0
Recreation Benefits	-
Total Costs[1]	$4,900,236
Net Benefits	-$4,157,468
Net Benefits with Recreation	-$4,157,468
Final BCR	**0.2**
Final BCR with Recreation	**0.2**

1: BCA Costs in Figure 1 are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Figure 2. BCA Tool Results – Benavides Main City Network Storm Drain Improvements

Input Into BCA Toolkit

Project Useful Life	**0**

Event Damages	Baseline	Project
2 - year storm	**$930,486**	**$183,442**
10 - year storm	**$1,782,048**	**$605,389**
100 - year storm	**$3,558,316**	**$1,548,248**

Total Benefits from BCA Toolkit	$6,718,056
Other Benefits (Not Recreation)	$0
Recreation Benefits	-
Total Costs[1]	$8,098,063
Net Benefits	-$1,380,007
Net Benefits with Recreation	-$1,380,007
Final BCR	**0.8**
Final BCR with Recreation	**0.8**

1: BCA Costs in Figure 2 are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Impact Analysis

An FMP is required to have no negative impacts in the neighboring area, either upstream or downstream of the project. No negative impact means that a project will not increase flood risk of surrounding properties. The increase in flood risk must be measured by the 100-year frequency storm water surface elevation and peak discharge using the best available data. No rise in water surface elevation or discharge is permissible, and the study area must be sufficiently large to demonstrate that proposed project conditions are equal to or less than the existing (baseline) conditions.

For the purposes of regional flood planning efforts, a determination of no negative impacts can be established if stormwater runoff does not increase inundation of infrastructure such as residential and commercial structures or exceed the design capacity of stormwater systems. According to the TWDB Exhibit C Technical Guidelines, all of the following requirements should be met to establish no negative impact, as applicable:

1. Stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement.

2. Stormwater does not increase inundation of storm drainage networks, channels, and roadways beyond design capacity.

3. Maximum increase of 1D Water Surface Elevation must round to 0.0 feet (<0.05 feet) measured along the hydraulic cross-section.

4. Maximum increase of 2D Water Surface Elevations must round to 0.3 feet (<0.35 feet) as measured at each computation cell.

5. Maximum increase in hydrologic peak discharge must be <0.5 percent measured at computation nodes (sub-basins, junctions, reaches, reservoirs, etc.). This discharge restriction does not apply to a 2D overland analysis.

Projects for the City of Benavides within the Duval County Master Plan were checked for downstream impacts under the 100-year storm event by CDM Smith. No downstream impacts were found. Please see the Duval County Master Plan for documentation of the modeling analysis and results.

POZNECKI CAMARILLO
CIVIL ENGINEERING // LAND SURVEYING // ENVIRONMENTAL // PUBLIC INVOLVEMENT

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www.pozcam.com

TECHNICAL MEMO

TO: Judge Rochelle Camacho, Frio County Judge

FROM: Fernando Camarillo P.E., Poznecki-Camarillo, LLC.

SUBJECT: Flood Study of Tehuacana Creek at CR 1520

DATE: May 12, 2023

STATE OF TEXAS
FERNANDO CAMARILLO
86882
LICENSED
PROFESSIONAL ENGINEER

Introduction and Objective

This technical memorandum reviews the flooding issues of Tehuacana Creek at County Road 1520 in Frio County, TX. The objective of this memo is to present existing and proposed watershed hydrologic data, analyze the potential for inundation of CR 1520 under different storm events, and establish existing and proposed water surface elevations for the 1% annual chance flood event peak discharges using limited 1D modeling. This memorandum also identifies the design frequency and a drainage structure size with capacity to relieve flooding across FM 1520 and the area and simultaneously comply with the "no negative impact" guidelines.

Data Collection

There is no existing floodplain study incorporating the Tehuacana Creek watershed. Data used to perform the hydrologic and hydraulic analysis was collected from sources including:

- Soil Maps from the Natural Resources Conservation Service (USGS)
- Topographical Map derived from USGS GIS data supplemented by survey field data
- Texas Natural Resources Information System (TNRIS) Hydrology Maps
- National Oceanic and Atmosphere Atlas 14 Database for Intensity and Frequency Data Parameters
- HEC-HMS (Watershed Hydrology Analysis for the Different Design Frequencies)
- HEC-RAS (Structure Performance and Water Surface Elevation Analysis for the Different Design Frequencies, Existing vs Proposed)

Knowns and Observations

Existing Conditions

- Applicable TXDOT roadway functional classification is "Off-System Projects: Culverts".
- TxDOT Hydraulic Manual, Recommended Design Standards: Table 4-2: FHWA policy "same or slightly better" than existing.
- Project is located within the Tehuacana Creek Watershed, and discharges specifically into Choke Canyon Reservoir. Overall existing drainage pattern flows are primarily from northwest to southeast.

- The Tehuacana Creek at County Road 1520 crossing is not within any FEMA studied floodplain.
- Existing surrounding areas are comprised of rural land with very minor development. Flood plain area is very flat.
- Existing cross drainage structure includes a 36” Corrugated Metal Pipe (CMP) culvert.
- HEC-RAS model of the existing conditions shows the CMP crossing has significantly low conveyance capacity. The roadway within the vicinity of the existing drainage structure is easily overtopped at the 1-YR flood event. Based on the roadway functional classification, the 1-YR flood event will be used as the recommended storm design frequency.

Proposed Conditions

- Proposed improvements include raising the roadway profile to replace the existing structure with a taller drainage structure consisting of multiple reinforced concrete culverts (RCP). The proposed roadway section will be a 10-ft lane with 2-ft shoulders in each direction, safety end treatments at the upstream and downstream ends of the structure, slope and roadway protection against undermining and erosion. The existing open ditches will be maintained, no roadway curbs or sidewalks are proposed.
- A public temporary detour to route traffic from the project site during construction is not available. It is recommended that a by-pass detour adjacent to the existing roadway be constructed to manage traffic during construction. A temporary construction easement(s) outside of county ROW may be necessary.

Hydrologic Analysis

Existing Conditions

A hydrologic analysis was performed by Poznecki-Camarillo (PCI) to determine the peak discharges for the Tehuacana Creek watershed for different storm design frequencies. The drainage area of approximately 47,093 acres (73.6 square miles) was delineated using a combination of 10-ft USGS contour maps, aerials, and topographical survey information collected within the ROW in the vicinity of the existing structure. A location map illustrating the overall drainage study area for Tehuacana Creek is shown in *Figure 1*.

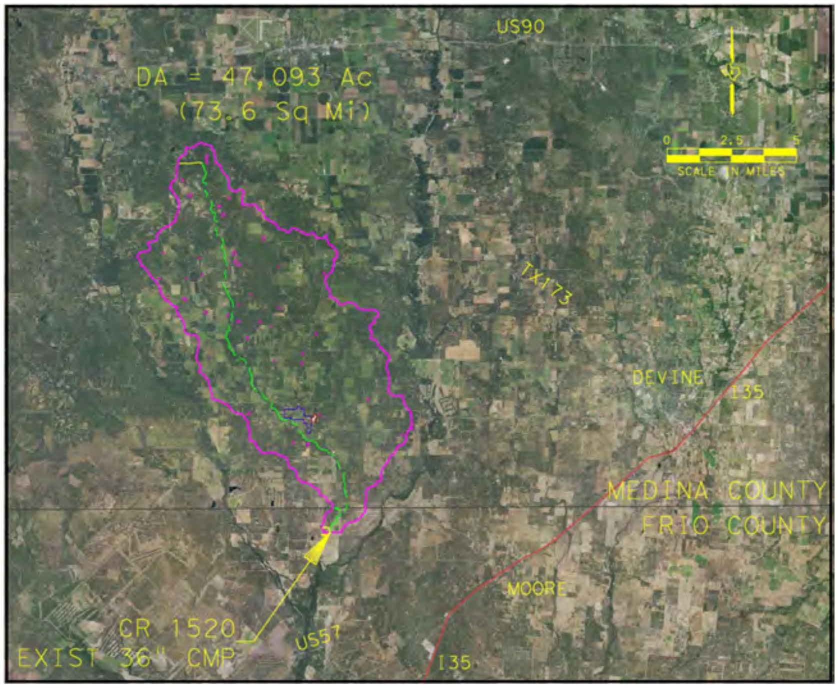


Figure 1 – Tehuacana Creek Drainage Area Map, Crossing at CR 1520

The peak runoff flow rates were computed using the SCS method for several storm events, the predominant Soil Type C, with a weighted CN of 62 with adjustments. The rainfall data was obtained from the Atlas-14 Point Precipitation Frequency Estimates, *Table 1*, and used to create the existing hydrologic model in HEC-HMS.

Peak runoff values using the Omega Regression Equation were determined only for general Comparison purposes against the HEC-HMS results. Since the area does not have nearby rain gauges for model calibration, the storm discharges generated by the Omega Regression Equation were disregarded as they were significantly higher.

The results of HEC-HMS and Omega Regression Equation hydrologic analysis are listed in *Table 2*.

Duration	Recurrence Intervals (years)						
	1	2	5	10	25	50	100
	Depth (inches)						
5-min:	0.449	0.529	0.658	0.766	0.918	1.04	1.16
10-min:	0.714	0.843	1.05	1.23	1.47	1.67	1.86
15-min:	0.904	1.06	1.32	1.53	1.83	2.07	2.3
30-min:	1.28	1.5	1.85	2.14	2.54	2.87	3.18
60-min:	1.65	1.95	2.42	2.82	3.38	3.82	4.26
2-hr:	1.94	2.36	3.03	3.6	4.42	5.08	5.78
3-hr:	2.08	2.6	3.39	4.09	5.11	5.93	6.82
6-hr:	2.34	3	3.99	4.89	6.21	7.29	8.49
12-hr:	2.62	3.39	4.52	5.55	7.1	8.38	9.83
24-hr:	2.95	3.81	5.07	6.24	7.99	9.45	11.1

Table 1 – NOAA-14 Precipitation Depths

Storm Event	SCS Method	Regression Equation
1-yr	658	*1376
2-yr	1,310	2,884
5-yr	2,511	7,012
10-yr	3,810	10,637
25-yr	5,966	16,576
50-yr	7,916	22,013
100-yr	10,157	28,560
* denotes linear interpolation		

Table 2 – HEC-HMS vs Omega Regression Equation Existing Peak Discharges for Different Storm Events

Proposed Conditions

It is not anticipated that the contributing watershed will undergo significant development within the next 30 years. Therefore, the calculated existing conditions runoff peak discharges were used for the proposed condition hydraulic analysis.

Hydraulic Analysis

Existing Conditions

A hydraulic model was constructed to analyze the performance for the existing drainage structure (36” CMP) crossing CR 1520 using the HEC-RAS program. The model was used to establish water surface elevations and conveyance capacities for the existing condition for several storm events. Following are HEC-RAS figures and tables illustrating the WSE results for the different storm frequency events.

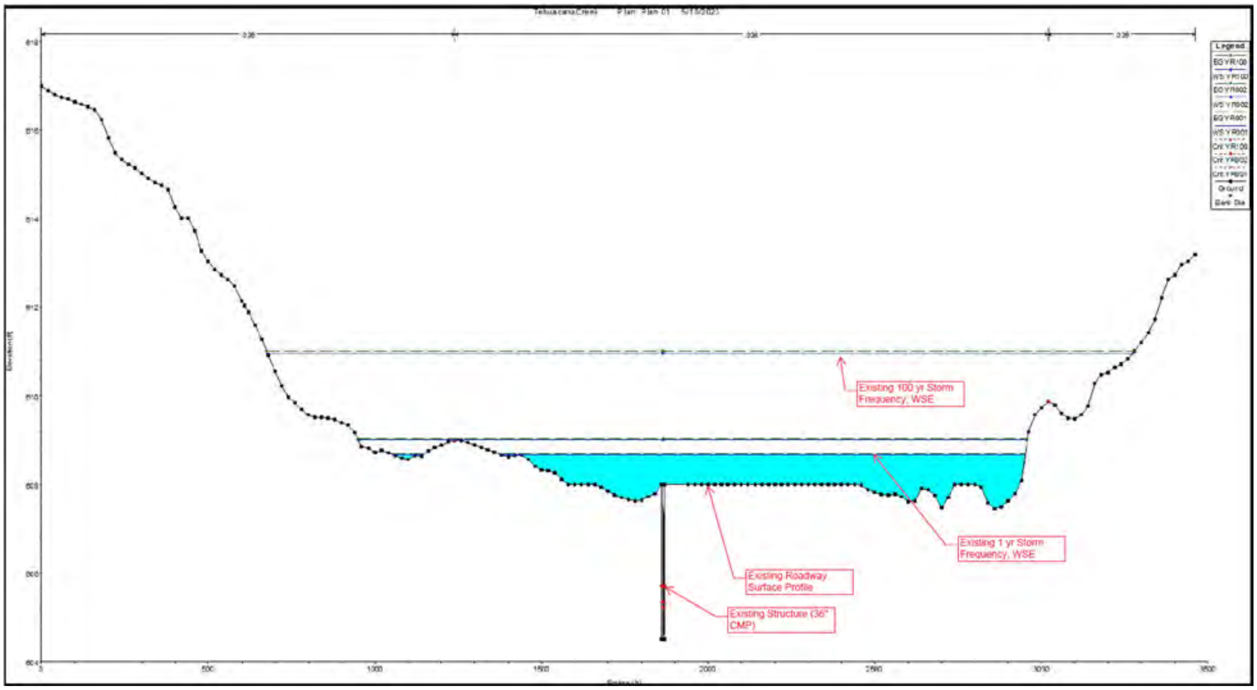


Figure 2 Section View Along CR 1520, Existing WSE

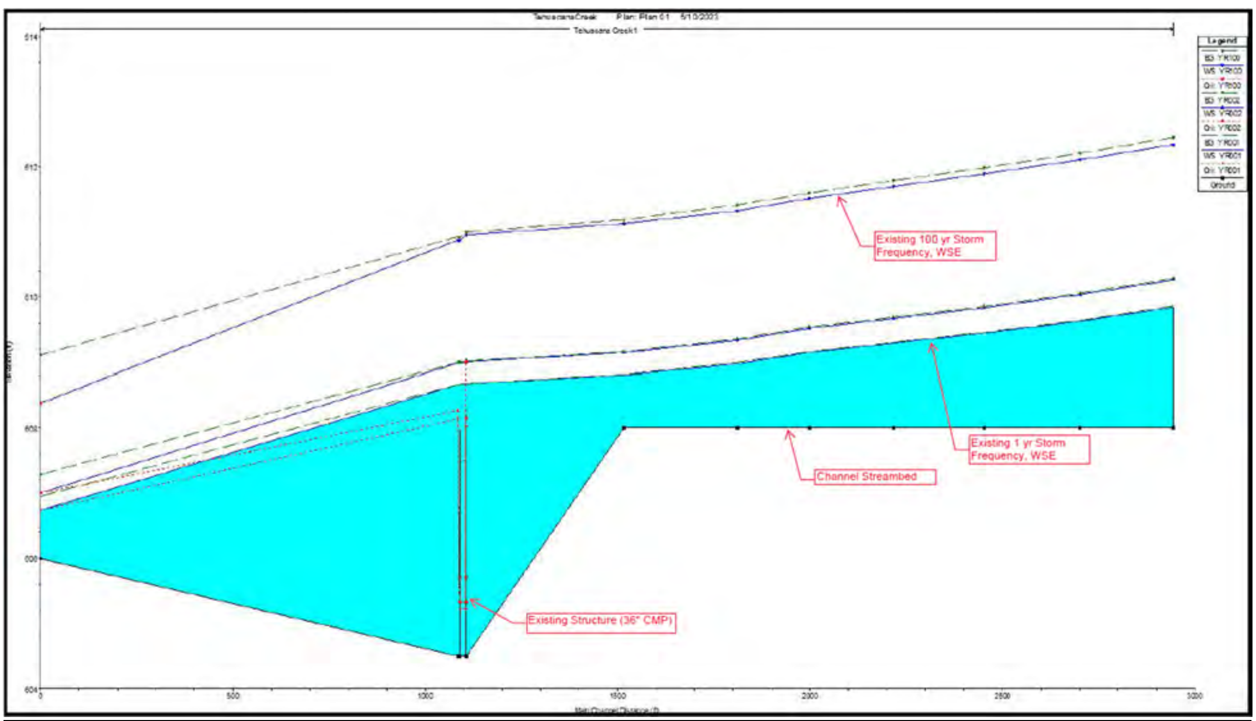


Figure 3 – Profile View Along Streambed, Existing WSE

River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)
8	YR001	658.3	608	609.85		609.86	0.001048	1.07	616.66	882.39
8	YR100	10157.8	608	612.34		612.45	0.00107	2.81	3765.86	1398.92
7	YR001	658.3	608	609.63		609.64	0.000776	0.94	702.86	955.98
7	YR100	10157.8	608	612.1		612.21	0.00093	2.6	4025.07	1493.15
6	YR001	658.3	608	609.45		609.46	0.000697	0.87	759.79	1071.61
6	YR100	10157.8	608	611.89		611.98	0.000831	2.44	4230.53	1528.9
5	YR001	658.3	608	609.3		609.31	0.000601	0.8	823.94	1174.82
5	YR100	10157.8	608	611.7		611.79	0.000824	2.42	4258.4	1620.99
4	YR001	658.3	608	609.15		609.17	0.000729	0.87	753.87	1086.37
4	YR100	10157.8	608	611.51		611.6	0.000893	2.41	4256.67	1621.94
3	YR001	658.3	608	608.98		609	0.001068	1.02	643.3	973.48
3	YR100	10157.8	608	611.32		611.42	0.001063	2.55	4032.92	1619.02
2	YR001	658.3	608	608.81		608.82	0.000396	0.62	1065.68	1634.57
2	YR100	10157.8	608	611.13		611.19	0.000535	1.95	5339.57	1982.77
1	YR001	658.3	604.5	608.67	608.02	608.68	0.000288	0.57	1161.19	1666.19
1	YR100	10157.8	604.5	610.95	609.01	610.99	0.000424	1.72	6315.98	2596.82
0.75		Culvert								
0.5	YR001	658.3	604.5	608.66	608.13	608.67	0.000508	0.69	953.39	1484.09
0.5	YR100	10157.8	604.5	610.87		610.92	0.000526	1.89	5921.34	2604.15
0	YR001	658.3	606	606.73	606.73	606.95	0.025666	3.72	177.05	419.9
0	YR100	10157.8	606	608.38	608.38	609.11	0.016588	6.88	1487.17	1056.52

Table 3 – HEC-RAS Existing Water Surface Elevation Analysis Results

From survey topographic information it was established that the roadway surface lowest elevation point is 608.00’. For the parameters of the area studied in this preliminary analysis, the results indicate that the existing WSE immediately upstream (608.67) and downstream (608.66) of the structure are almost equivalent. The existing structure is completely submerged for the 1 yr storm frequency and thus in inhibited from performing hydraulically. See *Appendix A* for Existing HEC-RAS Data Output.

Proposed Conditions

Following TxDOT's guidance on Design Flood Frequencies for the different roadway classifications, the objective of the proposed plan is to identify a drainage structure configuration that will convey a 1 yr and 2 yr storm frequency, "same or slightly better than existing", allowing traffic to drive along County Road 1520 for this storm event and generate a "no negative impact" for the 100 yr storm frequency analysis.

Using the same hydrology results as the existing condition (no proposed major development changes to the watershed during the next 30 years), several iterations of HEC-RAS analysis were performed to identify different drainage structure configurations that would comply with the objective. In addition to altering the size of the structure in the HEC-RAS model for proposed purposes, the roadway profile and channel streambed were modified to show improvements. The slope of the streambed within the county ROW was steepened and the roadway profile was raised to provide the cover needed for a taller structure.

The proposed drainage structure consists of multiple reinforced concrete culverts using 12-42"x30' pipes (RCP). The proposed roadway width is 24' and the roadway profile is proposed to be raised approximately 1' within the vicinity of the proposed structure. In the proposed condition, the WSE for the 1 yr storm frequency at the roadway is roughly 608.46, 0.54' below the proposed roadway crown, however the roadway will overtop at larger storm events. See *Appendix B* Plan and Profile of Proposed Improvements and the HEC-RAS diagrams and table below, for the proposed conditions output.

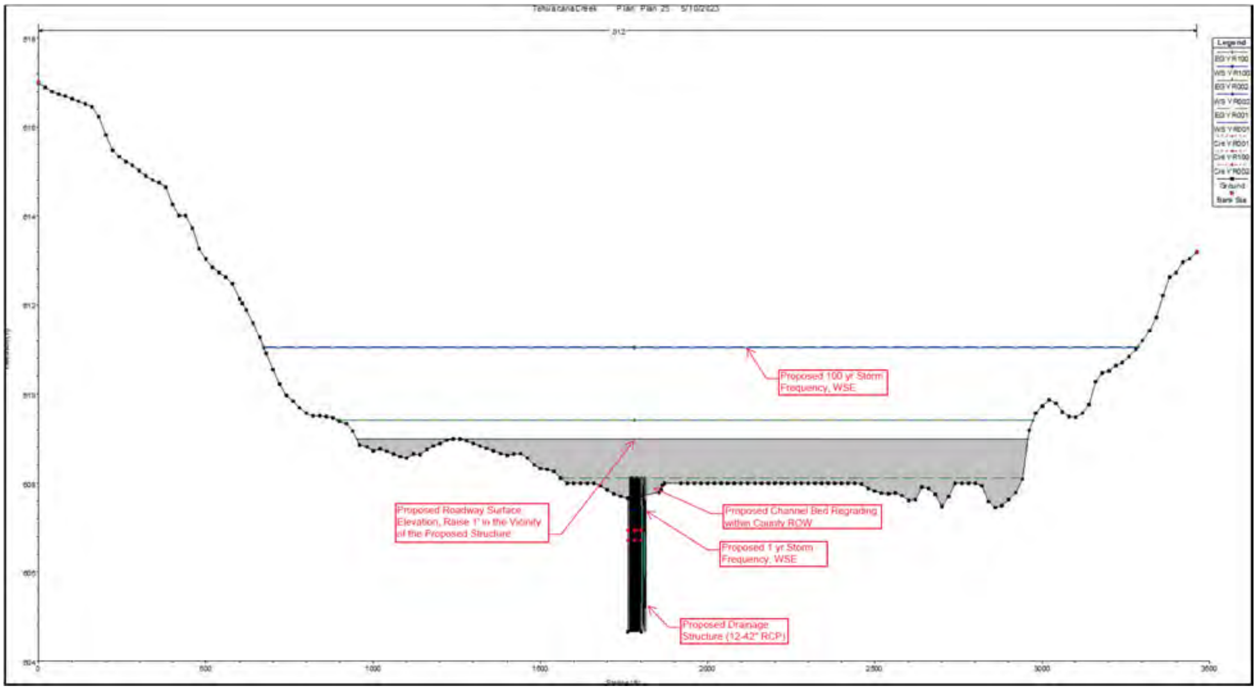


Figure 4 - Section View Along CR 1520, Proposed WSE

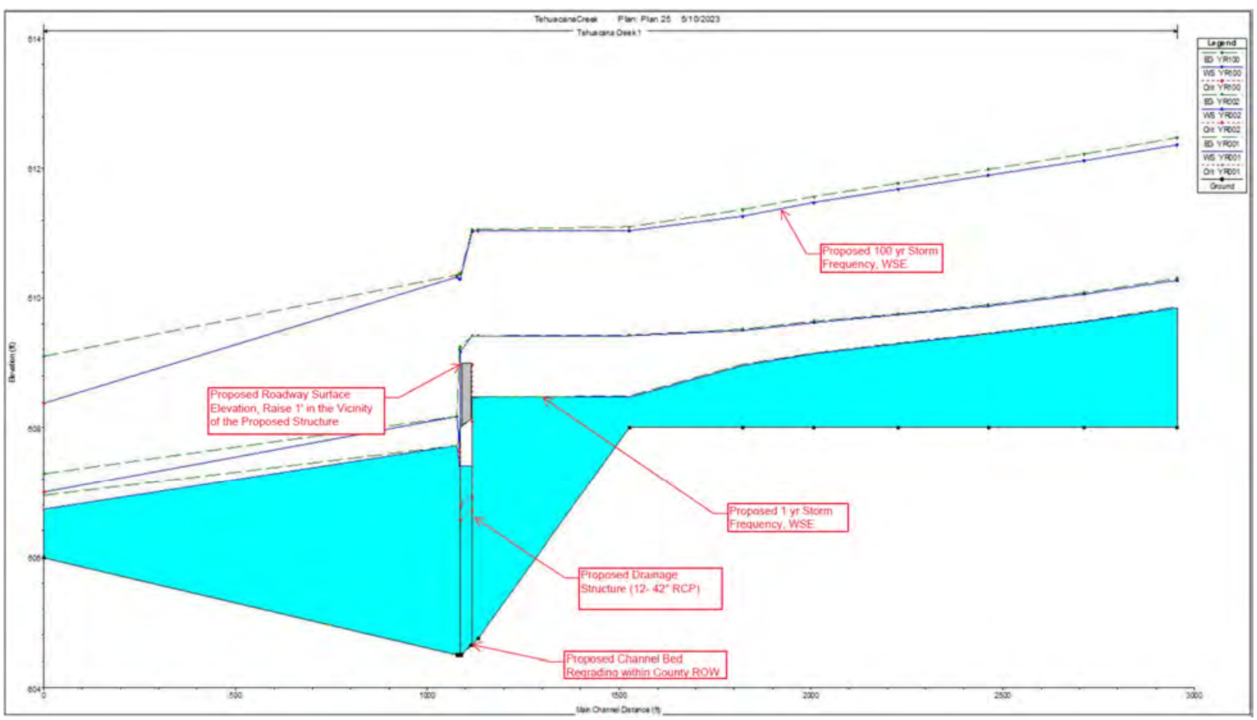


Figure 5 – Profile View Along Streambed, Proposed WSE

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)
Tehuacana Creek	1	8	YR001	658.3	608	609.85		609.86	0.001072	1.07	618.12	883.12
Tehuacana Creek	1	8	YR002	1310.6	608	610.28		610.3	0.000978	1.21	1084.77	1197.68
Tehuacana Creek	1	8	YR100	10157.8	608	612.36		612.47	0.001107	2.67	3802.86	1401.25
Tehuacana Creek	1	7	YR001	658.3	608	609.63		609.64	0.000781	0.94	701.22	954.96
Tehuacana Creek	1	7	YR002	1310.6	608	610.06		610.08	0.000821	1.12	1175.08	1282.88
Tehuacana Creek	1	7	YR100	10157.8	608	612.12		612.22	0.00098	2.51	4045.95	1494.25
Tehuacana Creek	1	6	YR001	658.3	608	609.44		609.46	0.000706	0.87	756.07	1068.83
Tehuacana Creek	1	6	YR002	1310.6	608	609.88		609.89	0.000655	1.02	1289.54	1365.73
Tehuacana Creek	1	6	YR100	10157.8	608	611.89		611.98	0.00087	2.4	4232.87	1528.99
Tehuacana Creek	1	5	YR001	658.3	608	609.29		609.3	0.000616	0.81	817.42	1173.03
Tehuacana Creek	1	5	YR002	1310.6	608	609.74		609.76	0.000503	0.95	1384.32	1337.98
Tehuacana Creek	1	5	YR100	10157.8	608	611.68		611.77	0.000938	2.4	4231.23	1616.74
Tehuacana Creek	1	4	YR001	658.3	608	609.14		609.16	0.000761	0.89	742.49	1080.69
Tehuacana Creek	1	4	YR002	1310.6	608	609.63		609.64	0.00058	0.99	1327.6	1342.21
Tehuacana Creek	1	4	YR100	10157.8	608	611.47		611.56	0.000969	2.42	4192.86	1619.96
Tehuacana Creek	1	3	YR001	658.3	608	608.96		608.98	0.001166	1.06	623.18	960.17
Tehuacana Creek	1	3	YR002	1310.6	608	609.5		609.52	0.000711	1.06	1235.31	1305.77
Tehuacana Creek	1	3	YR100	10157.8	608	611.26		611.36	0.001191	2.58	3937.57	1615.61
Tehuacana Creek	1	2	YR001	658.3	608	608.47		608.49	0.00246	1.16	565.82	1320.72
Tehuacana Creek	1	2	YR002	1310.6	608	609.42		609.42	0.000182	0.62	2098.57	1765.89
Tehuacana Creek	1	2	YR100	10157.8	608	611.04		611.1	0.000631	1.97	5161.68	1974.46
Tehuacana Creek	1	1.25	YR001	658.3	604.75	608.47		608.47	0.000011	0.37	1775.95	2030
Tehuacana Creek	1	1.25	YR002	1310.6	604.75	609.42		609.42	0.000004	0.34	3875.03	2300.87
Tehuacana Creek	1	1.25	YR100	10157.8	604.75	611.04		611.06	0.000025	1.3	7835.46	2587.65
Tehuacana Creek	1	1	YR001	658.3	604.65	608.46	606.63	608.47	0.000061	0.71	929.98	1473.73
Tehuacana Creek	1	1	YR002	1310.6	604.65	609.41	608.09	609.42	0.000011	0.49	2693.17	2077.77
Tehuacana Creek	1	1	YR100	10157.8	604.65	611.02	608.98	611.06	0.000045	1.54	6591.83	2609.17
Tehuacana Creek	1	0.75		Culvert								
Tehuacana Creek	1	0.5	YR001	658.3	604.5	607.41		607.87	0.000557	5.46	120.67	41.5
Tehuacana Creek	1	0.5	YR002	1310.6	604.5	607.63	607.63	609.21	0.001746	10.08	129.96	41.5
Tehuacana Creek	1	0.5	YR100	10157.8	604.5	610.29		610.37	0.000146	2.23	4549.84	2488.97
Tehuacana Creek	1	0.25	YR001	658.3	604.5	607.73		607.73	0.00021	0.55	1207.26	1387.38
Tehuacana Creek	1	0.25	YR002	1310.6	604.5	608.17		608.18	0.000244	0.7	1874.47	1659.08
Tehuacana Creek	1	0.25	YR100	10157.8	604.5	610.32		610.36	0.000358	1.46	6965.44	2732
Tehuacana Creek	1	0	YR001	658.3	606	606.74	606.74	606.95	0.025213	3.69	178.23	421.27
Tehuacana Creek	1	0	YR002	1310.6	606	607	607	607.29	0.023196	4.26	307.48	550.72
Tehuacana Creek	1	0	YR100	10157.8	606	608.38	608.38	609.1	0.017318	6.83	1488.26	1056.59

Table 4 – HEC-RAS Proposed Water Surface Elevation Analysis Results

Comparisons of the 100 YR storm frequency event WSE for existing and proposed conditions indicate minimal impact by the proposed conditions. The results show that there are no adverse impacts to adjacent properties upstream and downstream of the proposed crossing before or after the improvements in the vicinity of the project. Note that there are no structures within the 100 yr HEC-RAS defined floodplain

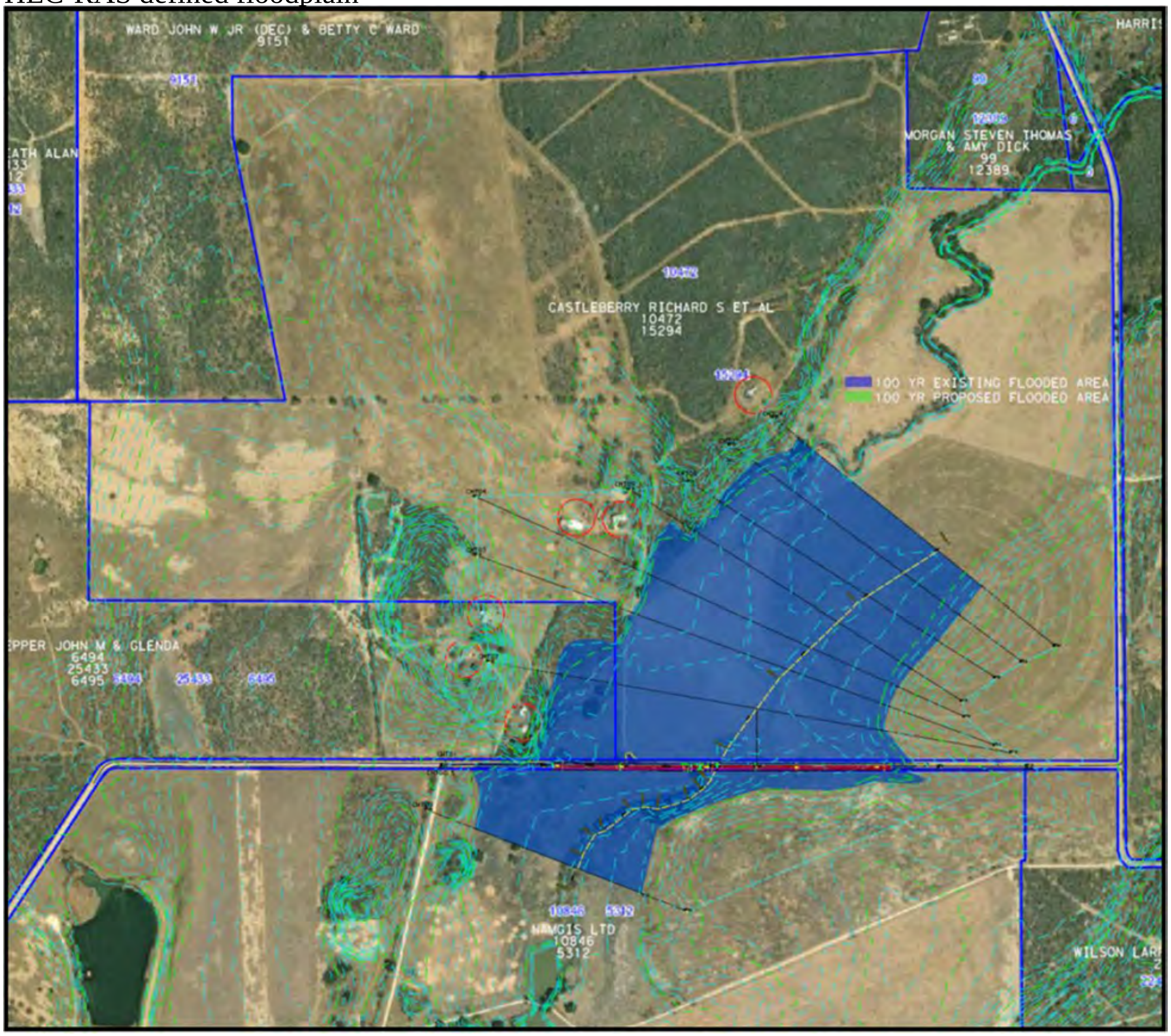


Figure 6 – 100 yr Storm Frequency Floodplain Boundaries Superimpose Almost Exact (No Building Structures in HEC-RAS Defined Floodplain Area)

For the majority of the stream length under study, the channel velocities remained almost equal between existing and proposed conditions. At the proposed outlet, the 1yr storm frequency velocity was higher than existing condition velocity but is well within values non-conducive to erosion or scour. As a preventative maintenance however, it will be recommended that stone riprap protection be constructed on the downstream end to maintain a clean channel and smooth natural streambed surface. See *Appendix C* for proposed HEC RAS Data.

Conclusion and Recommendations

The existing 36" CMP drainage culvert lacks the hydraulic capacity to convey a 1 yr storm frequency peak discharge across CR 1520 and thus the roadway is non-operational even during this low frequency storm event. As such, per TxDOT guidance, a 1 yr storm design frequency was selected as the basis for defining "flooding relief" and "roadway overtopping". Referencing the objective of this memorandum, a 1D model was created that presented existing and proposed hydrologic data, including WSE, identifies a structure that will alleviate flooding conditions and, based on a comparison of existing vs proposed WSE for the channel (with the proposed structure in place), complies with the "no negative impact" guidelines. The existing and proposed 1D HEC-RAS models created were used to study the hydraulic performance of several different drainage structure configurations at this location. The results indicate that installing a larger crossing culvert in combination with improvements that increase the structure's slope and raise the roadway profile, will work collectively in order that the design storm will pass under pressure through the revised opening size without roadway overtopping. Through several iterations, it was determined that a solution consisting of using a structure of 12 - 42" x 30' RCPs and raising the roadway profile by approximately 1' in the vicinity of the structure eliminates roadway overtopping for the 1 yr storm frequency and still passable for the 2 yr storm event with **"No Adverse Impacts"** to adjacent properties upstream or downstream for the 100 yr storm frequency discharge peaks.

PCI's recommendation is that the County move forward with improving the hydraulic conditions at the CR 1520 water crossing of Tehuacana Creek. Estimated costs for the recommended improvements is included in this report.

Construction Cost Estimate

CR 1520 AT TEHUACANA CREEK

12-42" Multiple Box Culvert
Opinion of Probable Construction Cost
Replace Existing Culverts

Prepared By: **Poznecki Camarillo, Inc.**
Date: **5/11/2023**

THIS OPINION OF PROBABLE COST REPRESENTS OUR JUDGMENT AS PROFESSIONALS FAMILIAR WITH THE CONSTRUCTION INDUSTRY WE CAN NOT AND DO NOT GUARANTEE THAT BIDS WILL NOT VARY FROM THIS ESTIMATE. THIS ESTIMATE IS BASED ON YEAR 2023 DOLLARS.

Item No		Description	Unit	Quantity	Unit Cost	Cost
TXDOT SPECIFICATION ITEMS - REMOVALS						
100	6002	PREPARING RIGHT of WAY	STA	5	$ 2,000	$ 10,000
					SUBTOTAL	$ 10,000
TXDOT SPECIFICATION ITEMS - TCP						
502	6001	BARRICADES, SIGNS, AND TRAFFIC HANDLING	MO	2	$ 7,000	$ 14,000
					SUBTOTAL	$ 14,000
TXDOT SPECIFICATION ITEMS - ROADWAY						
110	6001	EXCAVATION (ROADWAY)	CY	950	$ 22	$ 20,900
132	6001	EMBANKMENT (ROADWAY)	CY	4100	$ 13	$ 53,300
247	6041	FL BS (CMP IN PLC)(TYA GR1-2)(FNAL POS)	CY	191	$ 100	$ 19,100
316	6001	ASPH (MULTI OPTION)	GAL	456	$ 10	$ 4,560
316	6002	AGGR (MULTI OPTION)	CY	8.28	$ 275	$ 2,277
552	6009	GATE (SPECIAL)	EA	2	$ 1,500	$ 3,000
					SUBTOTAL	$ 103,137
TXDOT SPECIFICATION ITEMS - DRAINAGE						
432	6008	RIPRAP (CONC)(CL B)(RR8&RR9)	SY	55	$ 700	$ 38,500
464	6009	RC PIPE (CL III)(42 IN)	LF	360	$ 225	$ 81,000
467	6461	SET (TY II) (42 IN) (RCP) (3: 1) (P)	EA	24	$ 8,000	$ 192,000
496	6042	REMOV STR (SMALL)	EA	1	$ 1,000	$ 1,000
					SUBTOTAL	$ 312,500
TXDOT SPECIFICATION ITEMS - TRAFFIC						
644	6001	IN SM RD SN SUP&AM TY10BWG(1)SA(P)	EA	2	$ 1,000.00	$ 2,000
658	6014	INSTL DEL ASSM (D-SW)SZ (BRF)CTB (BI)	EA	6.0	$ 30.00	$ 180
658	6062	INSTL DEL ASSM (D-SW)SZ 1(BRF)GF2(BI)	EA	12	$ 30	$ 360
666	6170	REFL PAV MRK TY II (W) 4" (SLD)	LF	790	$ 4	$ 2,765
666	6207	REFL PAV MRK TY II (Y) 4" (SLD)	LF	790	$ 3.50	$ 2,765
					SUBTOTAL	$ 8,070
TXDOT SPECIFICATION ITEMS - SW3P						
160	6001	FURNISHING AND PLACING TOPSOIL (4")	SY	5330	$ 1.00	$ 5,330
164	6001	BROADCAST SEED (PERM) (RURAL) (SANDY)	SY	5330	$ 0.25	$ 1,333
168	6001	VEGETATIVE WATERING	MG	83.1	$ 50.00	$ 4,157
506	6001	ROCK FILTER DAMS (INSTALL) (TY 1)	LF	80	$ 48	$ 3,840
506	6011	ROCK FILTER DAMS (REMOVE)	LF	80	$ 8	$ 640
506	6038	TEMP SEDMT CONT FENCE (INSTALL)	LF	420	$ 2.50	$ 1,050
506	6039	TEMP SEDMT CONT FENCE (REMOVE)	LF	420	$ 0.60	$ 252
					SUBTOTAL	$ 16,602
					TOTAL	$ 464,309
500	6001	MOBILIZATION	EA	1	10%	$ 46,431
		CONTINGENCY	EA	1	20%	$ 92,862
					Total Construction Cost	**$ 603,602**
		Design Fee	**20%**			**$ 120,720**
		Environmental Contingency	**20%**			**$ 120,720**
		Environmental archeological & historical resources				**$ 8,000**
		Permit Requirements				**$ 10,000**
		Material Testing	**2%**			**$ 12,072**
					GRAND TOTAL	**$ 875,114**

Appendix A
Existing Conditions Hydraulic Analysis

Plan: Plan 04 Tehuacana Creek 1 RS: 0.75 Culv Group: Culvert #1 Profile: YR001			
Q Culv Group (cfs)	5.25	Culv Full Len (ft)	16
# Barrels	1	Culv Vel US (ft/s)	0.74
Q Barrel (cfs)	5.25	Culv Vel DS (ft/s)	0.74
E.G. US. (ft)	608.68	Culv Inv El Up (ft)	604.5
W.S. US. (ft)	608.67	Culv Inv El Dn (ft)	604.5
E.G. DS (ft)	608.67	Culv Frctn Ls (ft)	0
W.S. DS (ft)	608.66	Culv Exit Loss (ft)	0
Delta EG (ft)	0.01	Culv Entr Loss (ft)	0
Delta WS (ft)	0.01	Q Weir (cfs)	652.42
E.G. IC (ft)	605.48	Weir Sta Lft (ft)	1050.99
E.G. OC (ft)	608.68	Weir Sta Rgt (ft)	2950.72
Culvert Control	Outlet	Weir Submerg	0.99
Culv WS Inlet (ft)	607.5	Weir Max Depth (ft)	1.23
Culv WS Outlet (ft)	607.5	Weir Avg Depth (ft)	0.68
Culv Nml Depth (ft)		Weir Flow Area (sq ft)	1135.04
Culv Crt Depth (ft)	0.72	Min El Weir Flow (ft)	607.98

Plan: Plan 1 Tehuacana Creek 1 RS: 0.75 Culv Group: Culvert #1 Profile: YR002			
Q Culv Group (cfs)	7.06	Culv Full Len (ft)	16
# Barrels	1	Culv Vel US (ft/s)	1
Q Barrel (cfs)	7.06	Culv Vel DS (ft/s)	1
E.G. US. (ft)	609.02	Culv Inv El Up (ft)	604.5
W.S. US. (ft)	609.01	Culv Inv El Dn (ft)	604.5
E.G. DS (ft)	609	Culv Frctn Ls (ft)	0.01
W.S. DS (ft)	608.99	Culv Exit Loss (ft)	0
Delta EG (ft)	0.02	Culv Entr Loss (ft)	0.01
Delta WS (ft)	0.02	Q Weir (cfs)	1358.27
E.G. IC (ft)	605.64	Weir Sta Lft (ft)	949.93
E.G. OC (ft)	609.02	Weir Sta Rgt (ft)	2956.91
Culvert Control	Outlet	Weir Submerg	0.98
Culv WS Inlet (ft)	607.5	Weir Max Depth (ft)	1.57
Culv WS Outlet (ft)	607.5	Weir Avg Depth (ft)	0.88
Culv Nml Depth (ft)		Weir Flow Area (sq ft)	1763.09
Culv Crt Depth (ft)	0.84	Min El Weir Flow (ft)	607.98

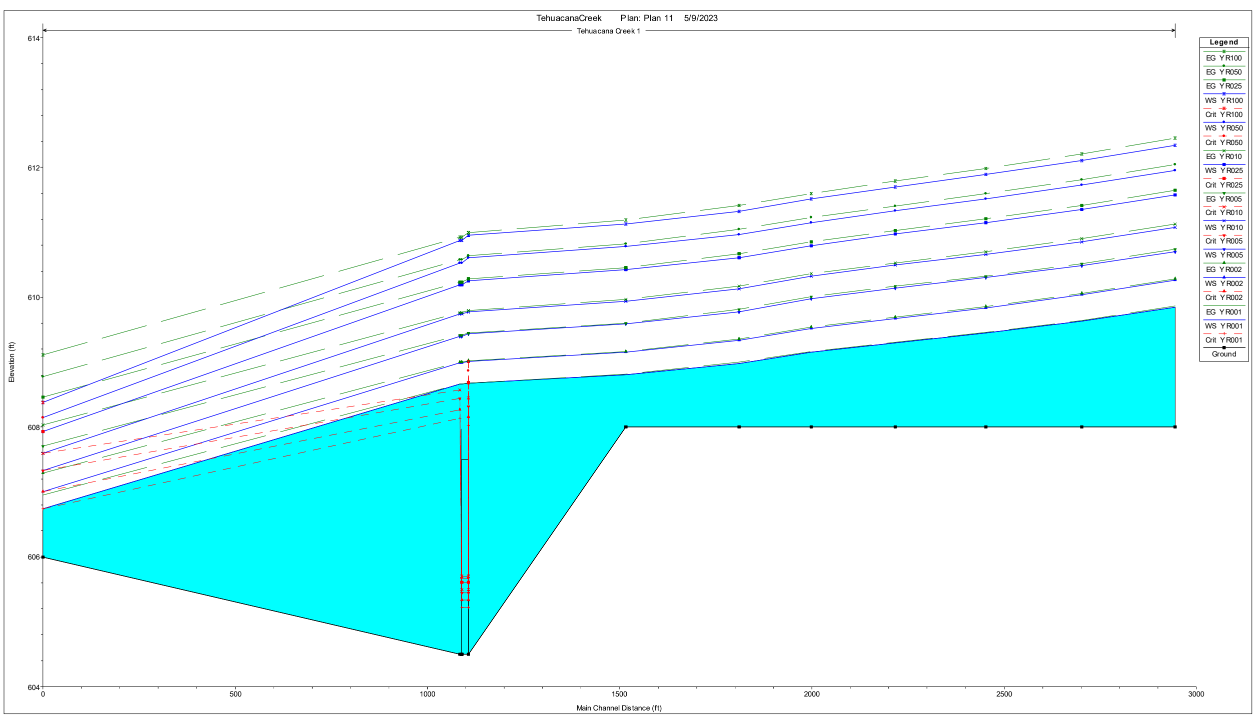
Plan: Plan 1 Tehuacana Creek 1 RS: 0.75 Culv Group: Culvert #1 Profile: YR005			
Q Culv Group (cfs)	8.91	Culv Full Len (ft)	16
# Barrels	1	Culv Vel US (ft/s)	1.26
Q Barrel (cfs)	8.91	Culv Vel DS (ft/s)	1.26
E.G. US. (ft)	609.45	Culv Inv El Up (ft)	604.5
W.S. US. (ft)	609.43	Culv Inv El Dn (ft)	604.5
E.G. DS (ft)	609.42	Culv Frctn Ls (ft)	0.01
W.S. DS (ft)	609.4	Culv Exit Loss (ft)	0.01
Delta EG (ft)	0.03	Culv Entr Loss (ft)	0.01
Delta WS (ft)	0.03	Q Weir (cfs)	2612.15
E.G. IC (ft)	605.8	Weir Sta Lft (ft)	884.67
E.G. OC (ft)	609.45	Weir Sta Rgt (ft)	2973.65
Culvert Control	Outlet	Weir Submerg	0.97
Culv WS Inlet (ft)	607.5	Weir Max Depth (ft)	2
Culv WS Outlet (ft)	607.5	Weir Avg Depth (ft)	1.26
Culv Nml Depth (ft)		Weir Flow Area (sq ft)	2640.04
Culv Crt Depth (ft)	0.94	Min El Weir Flow (ft)	607.98

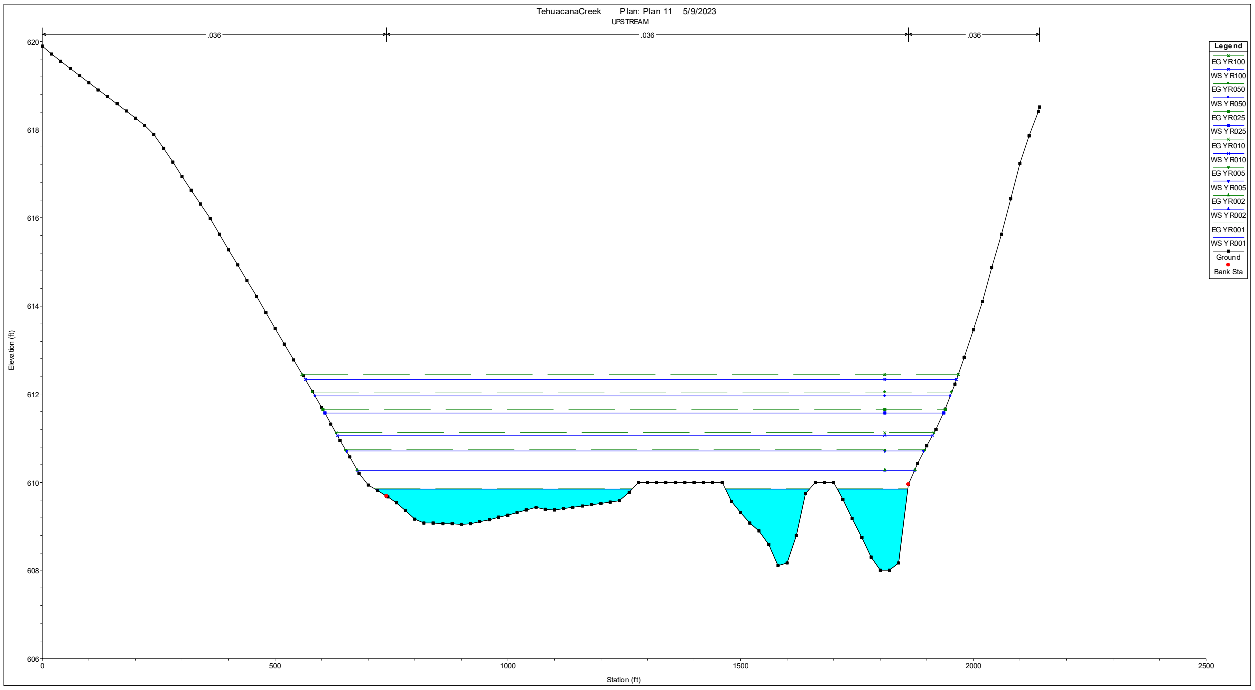
Plan: Plan 1 Tehuacana Creek 1 RS: 0.75 Culv Group: Culvert #1 Profile: YR010			
Q Culv Group (cfs)	9.94	Culv Full Len (ft)	16
# Barrels	1	Culv Vel US (ft/s)	1.41
Q Barrel (cfs)	9.94	Culv Vel DS (ft/s)	1.41
E.G. US. (ft)	609.8	Culv Inv El Up (ft)	604.5
W.S. US. (ft)	609.78	Culv Inv El Dn (ft)	604.5
E.G. DS (ft)	609.76	Culv Frctn Ls (ft)	0.01
W.S. DS (ft)	609.74	Culv Exit Loss (ft)	0.01
Delta EG (ft)	0.03	Culv Entr Loss (ft)	0.02
Delta WS (ft)	0.04	Q Weir (cfs)	3694.88
E.G. IC (ft)	605.88	Weir Sta Lft (ft)	765.96
E.G. OC (ft)	609.8	Weir Sta Rgt (ft)	3141.17
Culvert Control	Outlet	Weir Submerg	0.97
Culv WS Inlet (ft)	607.5	Weir Max Depth (ft)	2.35
Culv WS Outlet (ft)	607.5	Weir Avg Depth (ft)	1.46
Culv Nml Depth (ft)		Weir Flow Area (sq ft)	3421.58
Culv Crt Depth (ft)	1	Min El Weir Flow (ft)	607.98

Plan: Plan 1 Tehuacana Creek 1 RS: 0.75 Culv Group: Culvert #1 Profile: YR025			
Q Culv Group (cfs)	12.21	Culv Full Len (ft)	16
# Barrels	1	Culv Vel US (ft/s)	1.73
Q Barrel (cfs)	12.21	Culv Vel DS (ft/s)	1.73
E.G. US. (ft)	610.28	Culv Inv El Up (ft)	604.5
W.S. US. (ft)	610.26	Culv Inv El Dn (ft)	604.5
E.G. DS (ft)	610.23	Culv Frctn Ls (ft)	0.02
W.S. DS (ft)	610.2	Culv Exit Loss (ft)	0.01
Delta EG (ft)	0.05	Culv Entr Loss (ft)	0.02
Delta WS (ft)	0.06	Q Weir (cfs)	6295.17
E.G. IC (ft)	606.04	Weir Sta Lft (ft)	716.28
E.G. OC (ft)	610.28	Weir Sta Rgt (ft)	3159.77
Culvert Control	Outlet	Weir Submerg	0.96
Culv WS Inlet (ft)	607.5	Weir Max Depth (ft)	2.84
Culv WS Outlet (ft)	607.5	Weir Avg Depth (ft)	1.88
Culv Nml Depth (ft)		Weir Flow Area (sq ft)	4604.88
Culv Crt Depth (ft)	1.11	Min El Weir Flow (ft)	607.98

Plan: Plan 1 Tehuacana Creek 1 RS: 0.75 Culv Group: Culvert #1 Profile: YR050			
Q Culv Group (cfs)	13.61	Culv Full Len (ft)	16
# Barrels	1	Culv Vel US (ft/s)	1.92
Q Barrel (cfs)	13.61	Culv Vel DS (ft/s)	1.92
E.G. US. (ft)	610.64	Culv Inv El Up (ft)	604.5
W.S. US. (ft)	610.61	Culv Inv El Dn (ft)	604.5
E.G. DS (ft)	610.57	Culv Frctn Ls (ft)	0.02
W.S. DS (ft)	610.53	Culv Exit Loss (ft)	0.02
Delta EG (ft)	0.07	Culv Entr Loss (ft)	0.03
Delta WS (ft)	0.07	Q Weir (cfs)	8040.7
E.G. IC (ft)	606.14	Weir Sta Lft (ft)	695.01
E.G. OC (ft)	610.64	Weir Sta Rgt (ft)	3219.62
Culvert Control	Outlet	Weir Submerg	0.96
Culv WS Inlet (ft)	607.5	Weir Max Depth (ft)	3.19
Culv WS Outlet (ft)	607.5	Weir Avg Depth (ft)	2.17
Culv Nml Depth (ft)		Weir Flow Area (sq ft)	5475.19
Culv Crt Depth (ft)	1.17	Min El Weir Flow (ft)	607.98

Plan: Plan 04 Tehuacana Creek 1 RS: 0.75 Culv Group: Culvert #1 Profile: YR100			
Q Culv Group (cfs)	14.28	Culv Full Len (ft)	16
# Barrels	1	Culv Vel US (ft/s)	2.02
Q Barrel (cfs)	14.28	Culv Vel DS (ft/s)	2.02
E.G. US. (ft)	610.99	Culv Inv El Up (ft)	604.5
W.S. US. (ft)	610.95	Culv Inv El Dn (ft)	604.5
E.G. DS (ft)	610.92	Culv Frctn Ls (ft)	0.03
W.S. DS (ft)	610.87	Culv Exit Loss (ft)	0.01
Delta EG (ft)	0.07	Culv Entr Loss (ft)	0.03
Delta WS (ft)	0.08	Q Weir (cfs)	9904.83
E.G. IC (ft)	606.19	Weir Sta Lft (ft)	675.08
E.G. OC (ft)	610.99	Weir Sta Rgt (ft)	3279.55
Culvert Control	Outlet	Weir Submerg	0.96
Culv WS Inlet (ft)	607.5	Weir Max Depth (ft)	3.55
Culv WS Outlet (ft)	607.5	Weir Avg Depth (ft)	2.45
Culv Nml Depth (ft)		Weir Flow Area (sq ft)	6391.45
Culv Crt Depth (ft)	1.2	Min El Weir Flow (ft)	607.98




TehuacanaCreek Plan: Plan 11 5/9/2023
UPSTREAM
.036
.036
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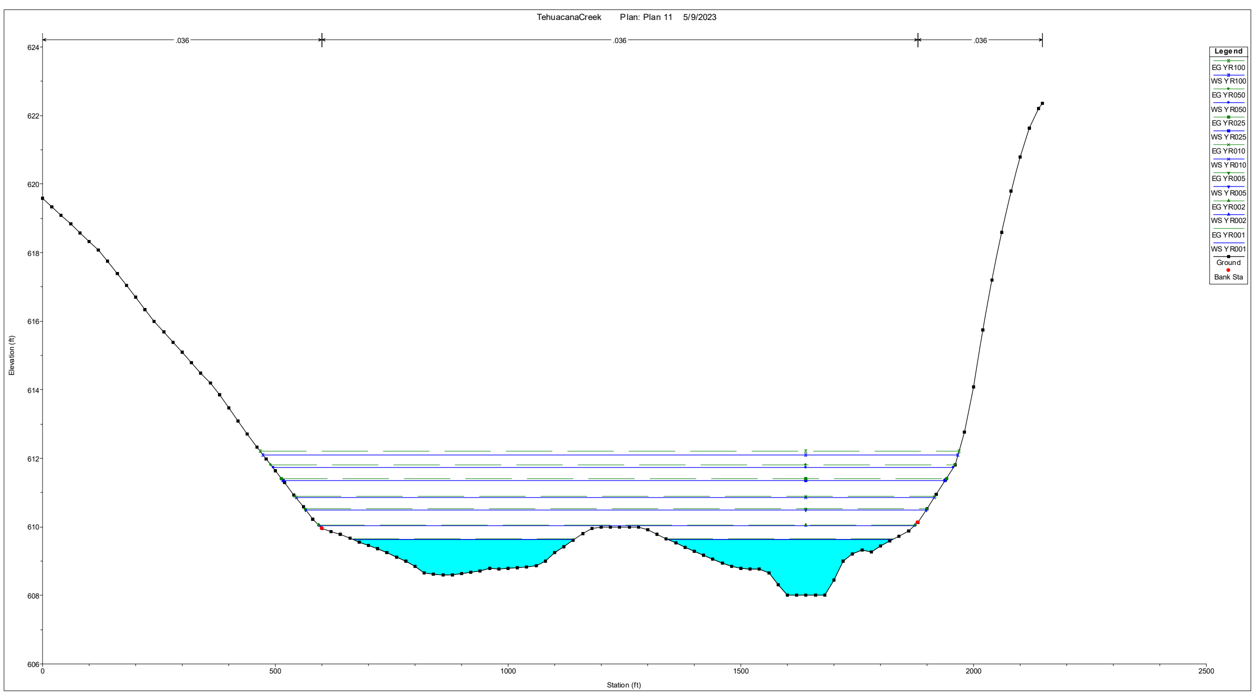
Legend
EG YR100
WS YR100
EG YR050
WS YR050
EG YR025
WS YR025
EG YR010
WS YR010
EG YR005
WS YR005
EG YR002
WS YR002
EG YR001
WS YR001
Ground
Bank Sta
Elevation (ft)
Station (ft)


TehuacanaCreek Plan: Plan 11 5/9/2023
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Legend
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EG YR025
WS YR025
EG YR010
WS YR010
EG YR005
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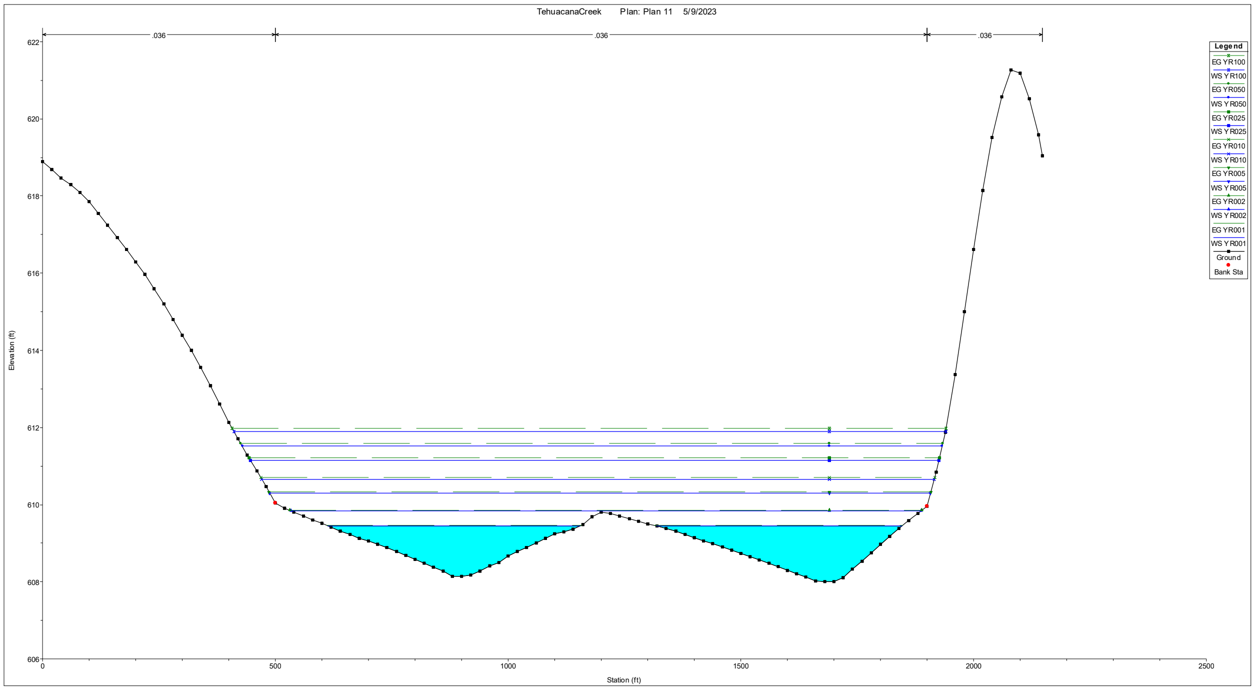
EG YR002
WS YR002
EG YR001
WS YR001
Ground
Bank Sta
Elevation (ft)
Station (ft)


TehuacanaCreek Plan: Plan 11 5/9/2023
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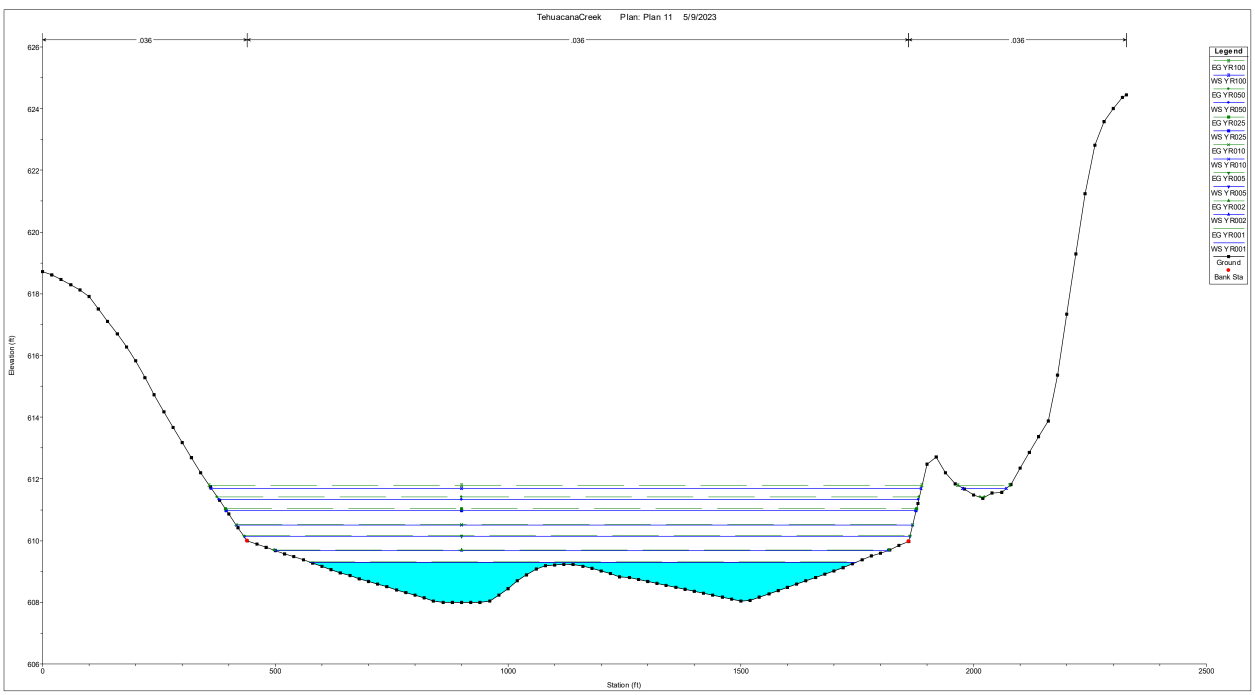
WS YR100
EG YR050
WS YR050
EG YR025
WS YR025
EG YR010
WS YR010
EG YR005
WS YR005
EG YR002
WS YR002
EG YR001
WS YR001
Ground
Bank Sta
Elevation (ft)
Station (ft)


TehuacanaCreek Plan: Plan 11 5/9/2023
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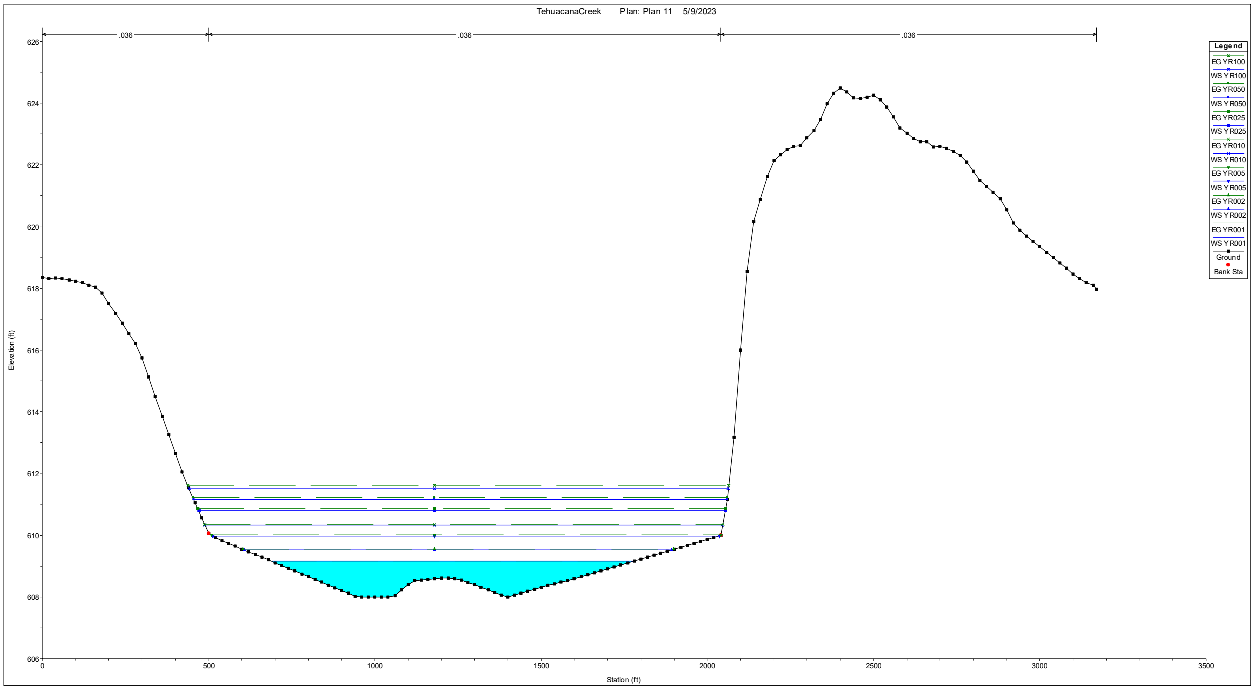
EG YR025
WS YR025
EG YR010
WS YR010
EG YR005
WS YR005
EG YR002
WS YR002
EG YR001
WS YR001
Ground
Bank Sta
Elevation (ft)
Station (ft)



TehuacanaCreek Plan: Plan 11 5/9/2023
Legend
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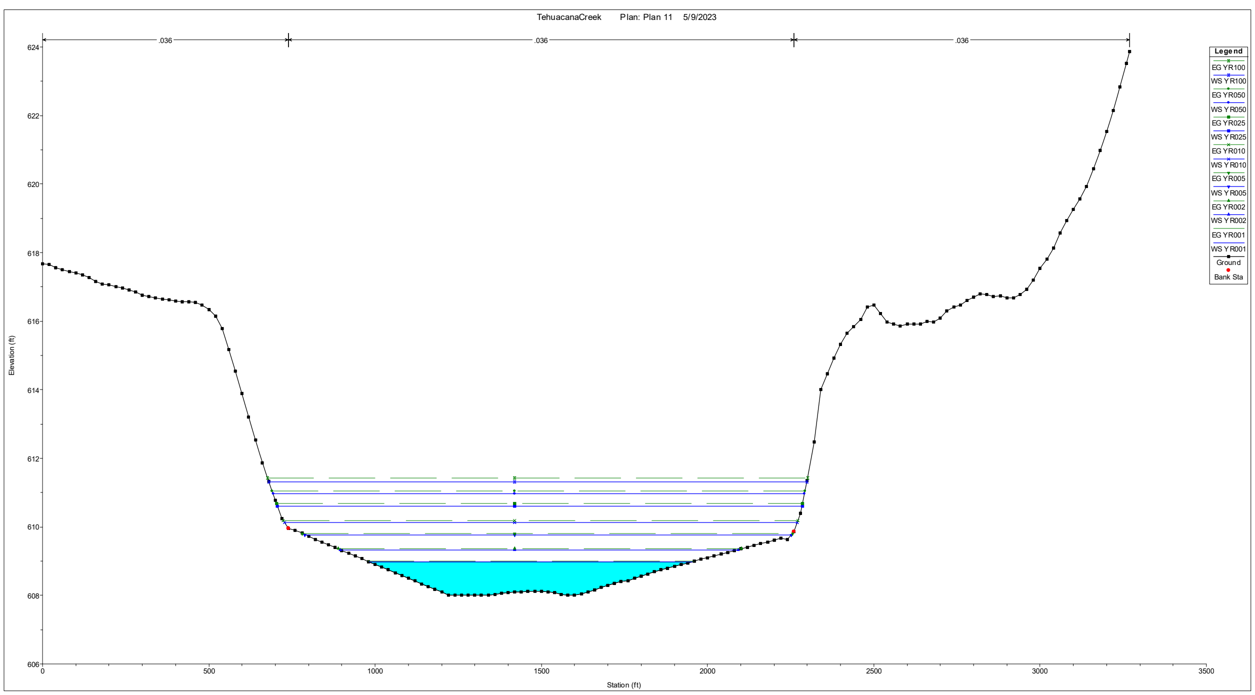
EG YR050
WS YR050
EG YR025
WS YR025
EG YR010
WS YR010
EG YR005
WS YR005
EG YR002
WS YR002
EG YR001
WS YR001
Ground
Bank Sta
Elevation (ft)
Station (ft)



TehuacanaCreek Plan: Plan 11 5/9/2023
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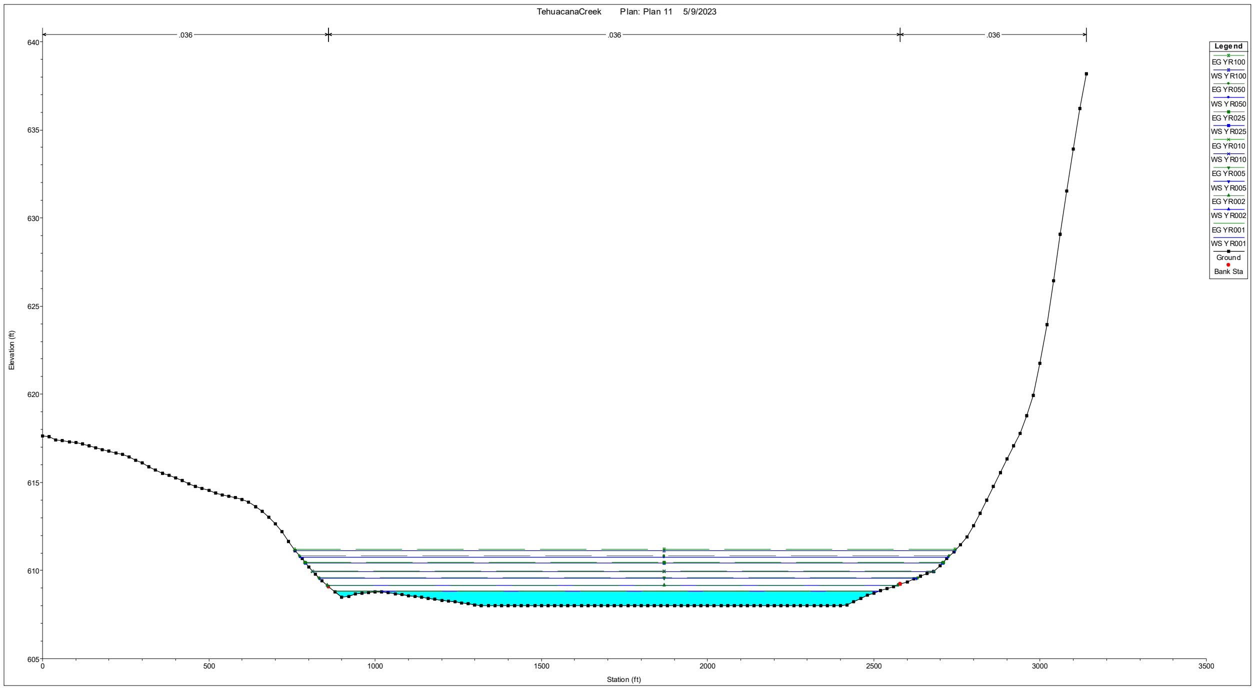
WS YR025
EG YR010
WS YR010
EG YR005
WS YR005
EG YR002
WS YR002
EG YR001
WS YR001
Ground
Bank Sta
Elevation (ft)
Station (ft)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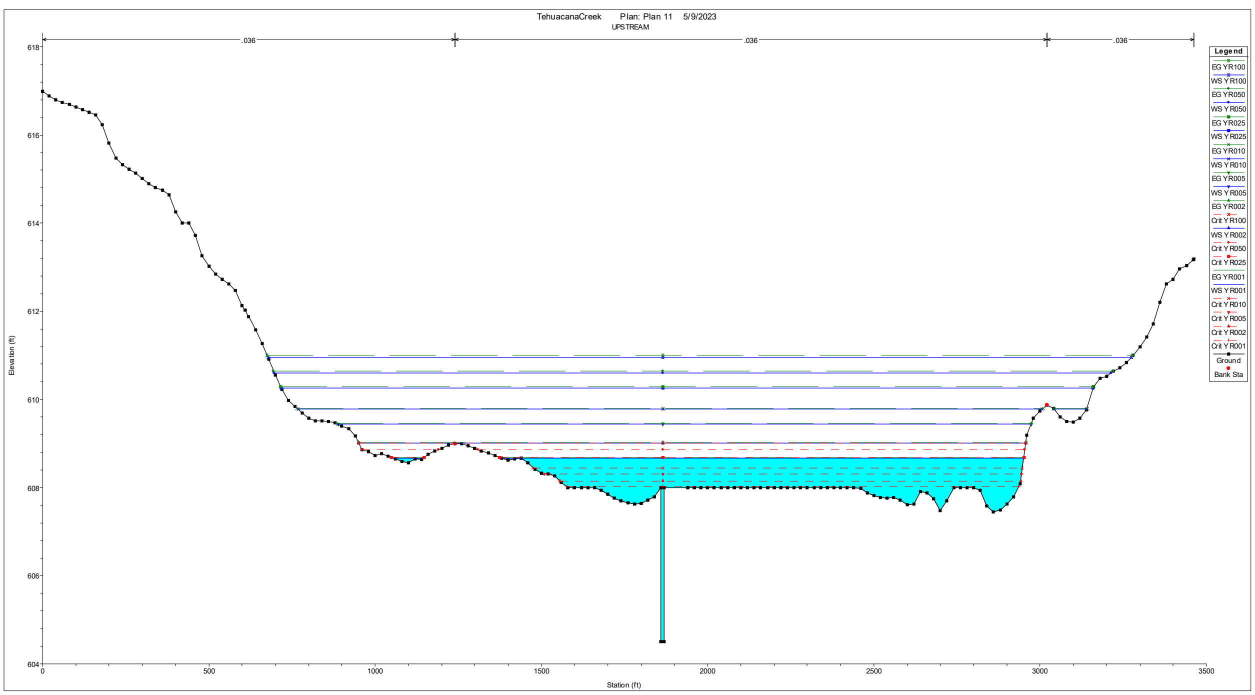
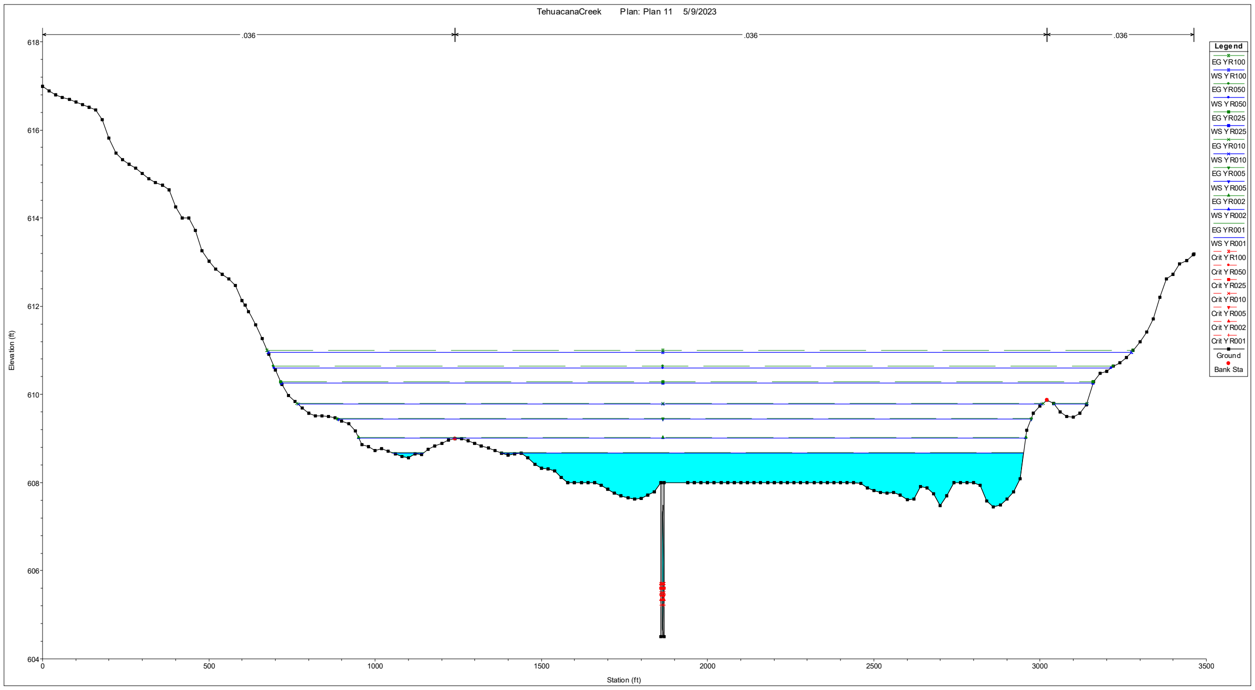
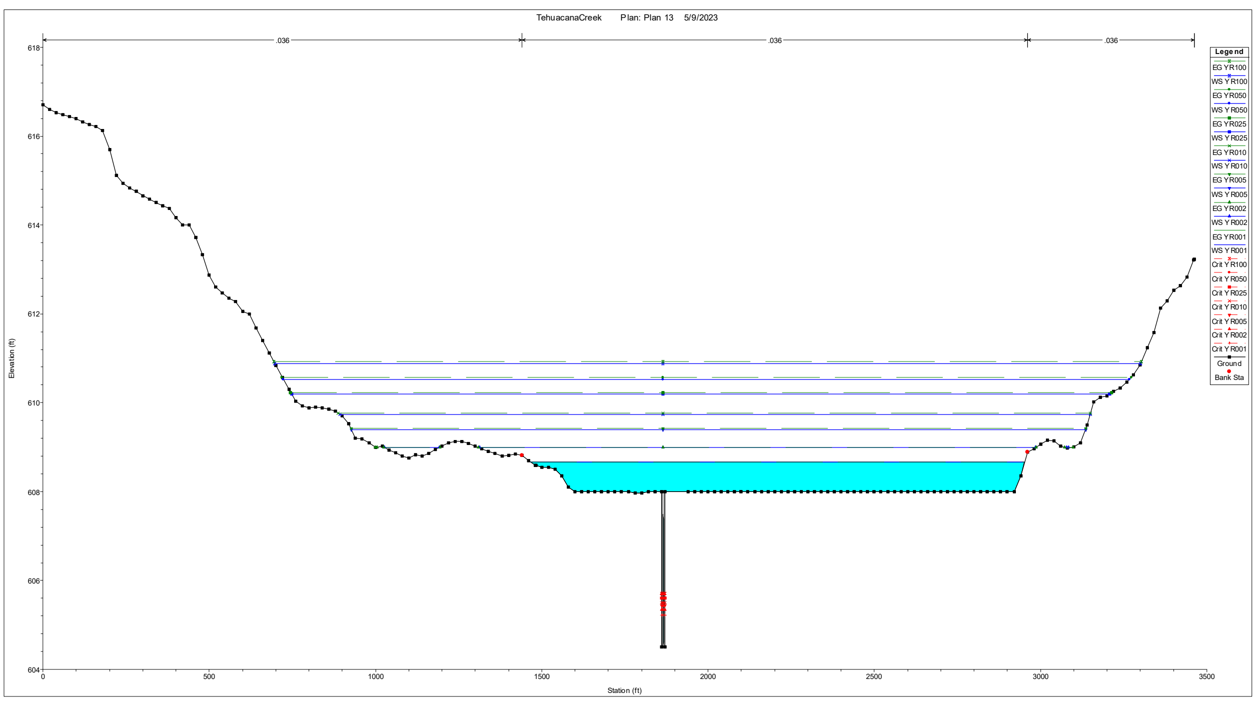
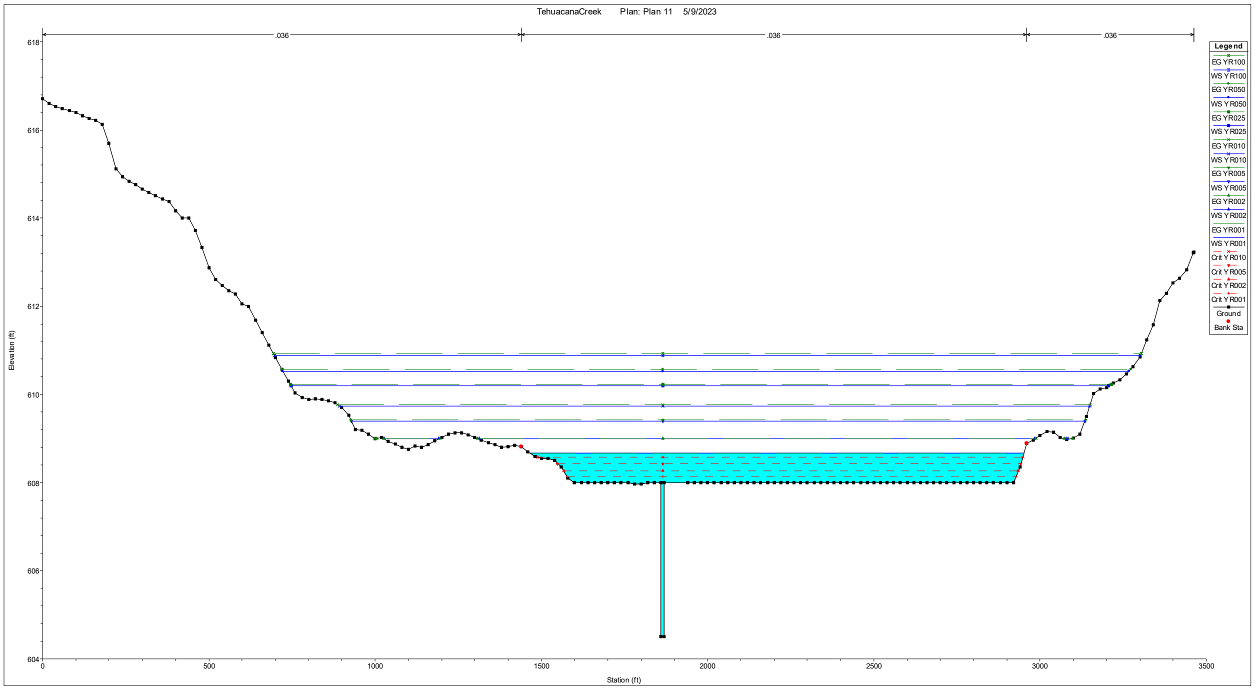
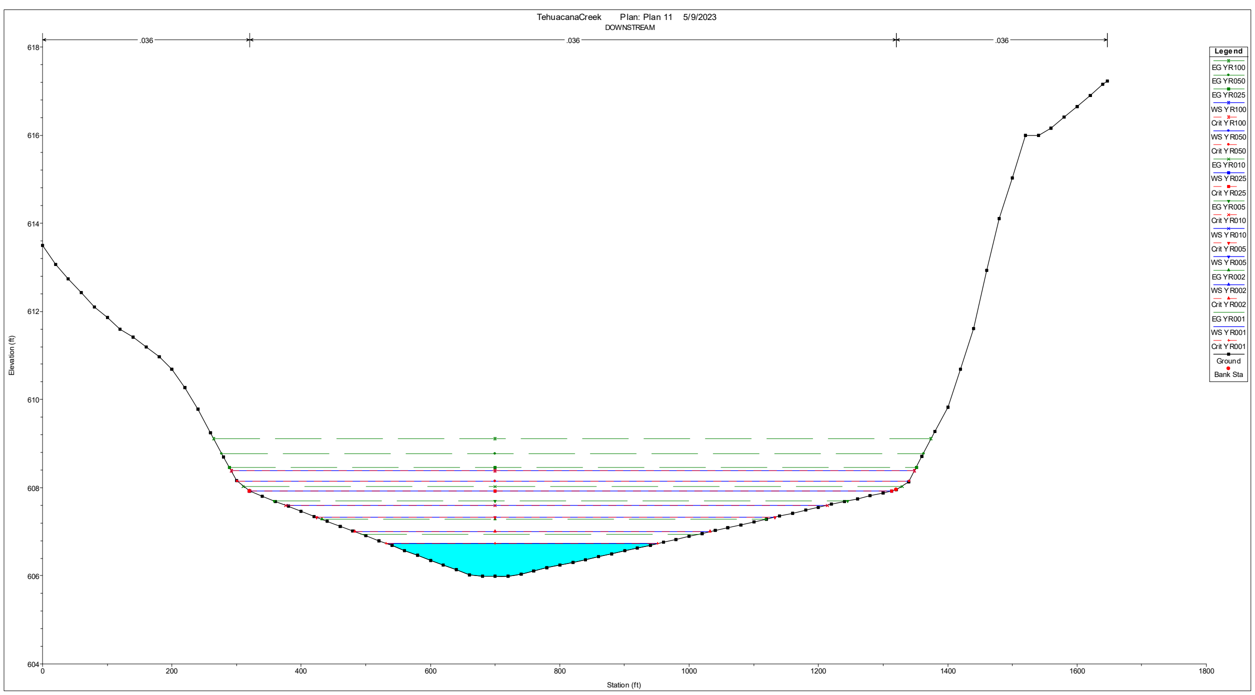
Legend
Elevation (ft)
Station (ft)


TehuacanaCreek Plan: Plan 11 5/9/2023
UPSTREAM
Legend
Elevation (ft)
Station (ft)


TehuacanaCreek Plan: Plan 11 5/9/2023
Elevation (ft)
Station (ft)
Legend
EG Y R100
WS Y R100
EG Y R050
WS Y R050
EG Y R025
WS Y R025
EG Y R010
WS Y R010
EG Y R005
WS Y R005
EG Y R002
WS Y R002
EG Y R001
WS Y R001
Crit Y R100
Crit Y R050
Crit Y R025
Crit Y R010
Crit Y R005
Crit Y R002
Crit Y R001
Ground
Bank Sta

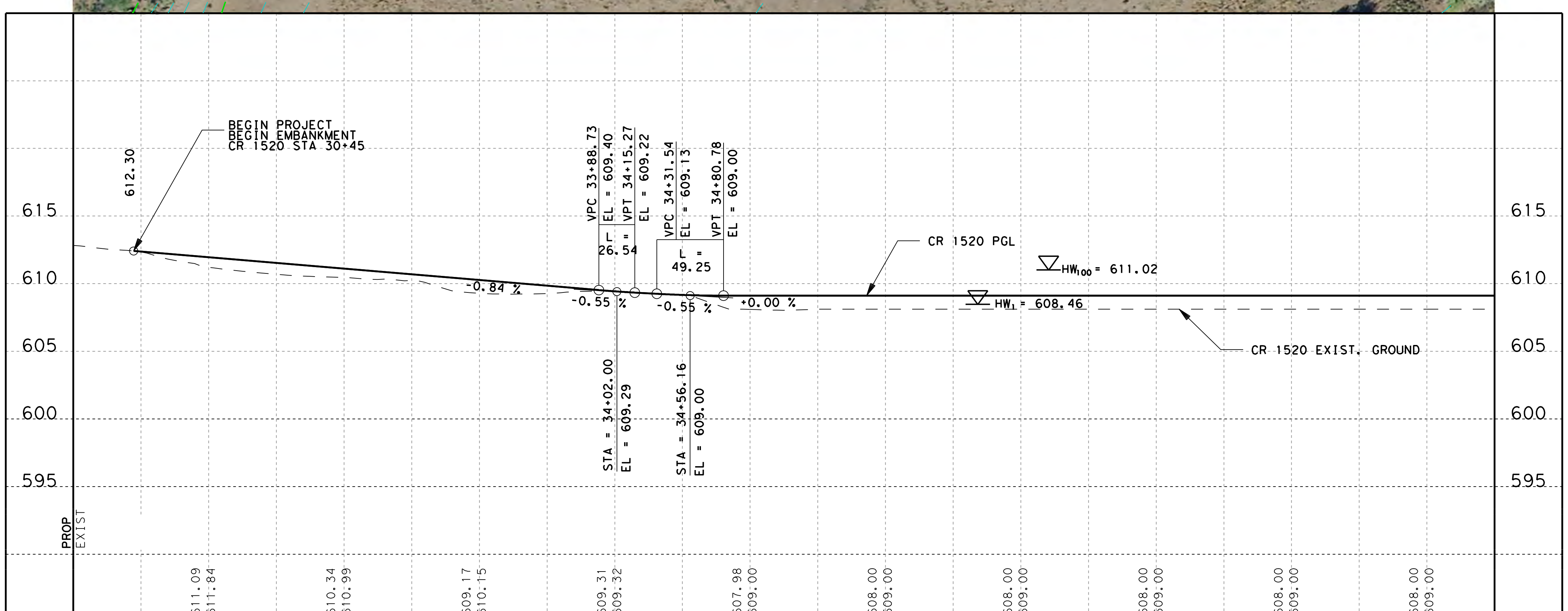

TehuacanaCreek Plan: Plan 13 5/9/2023
Elevation (ft)
Station (ft)
Legend
EG Y R100
WS Y R100
EG Y R050
WS Y R050
EG Y R025
WS Y R025
EG Y R010
WS Y R010
EG Y R005
WS Y R005
EG Y R002
WS Y R002
EG Y R001
WS Y R001
Crit Y R100
Crit Y R050
Crit Y R025
Crit Y R010
Crit Y R005
Crit Y R002
Crit Y R001
Ground
Bank Sta


TehuacanaCreek Plan: Plan 11 5/9/2023
.036
.036
.036
Legend
EG Y R100
WS Y R100
EG Y R050
WS Y R050
EG Y R025
WS Y R025
EG Y R010
WS Y R010
EG Y R005
WS Y R005
EG Y R002
WS Y R002
EG Y R001
WS Y R001
Crit Y R010
Crit Y R005
Crit Y R002
Crit Y R001
Ground
Bank Sta
Elevation (ft)
Station (ft)


TehuacanaCreek Plan: Plan 11 5/9/2023
DOWNSTREAM
.036
.036
.036
Legend
EG Y R100
EG Y R050
EG Y R025
WS Y R100
Crit Y R100
WS Y R050
Crit Y R050
EG Y R010
WS Y R025
Crit Y R025
EG Y R005
Crit Y R010
WS Y R010
Crit Y R005
WS Y R005
EG Y R002
WS Y R002
Crit Y R002
EG Y R001
WS Y R001
Crit Y R001
Ground
Bank Sta
Elevation (ft)
Station (ft)

Appendix B
Plan and Profile of Proposed Improvements

Plotted on: 5/11/2023 2:43:32 PM



N

0 50 100

SCALE: 1"=100' HORIZ
1"=10' VERT

LEGEND

- EXISTING ROW
- PROPOSED TRAFFIC LANE
- EXISTING TRAFFIC LANE
- CONCRETE RIPRAP
- PROPOSED PAVEMENT
- PROPOSED BRIDGE
- METAL BEAM GUARD FENCE

90% SUBMITTAL

INTERIM REVIEW ONLY

DOCUMENT IS FOR INTERIM REVIEW AND NOT INTENDED FOR CONSTRUCTION, BIDDING, OR PERMIT PURPOSES.

Engineer: JOSE DIAZ

P.E. Serial No.: 99365

Date: 5/11/2023

DATE	BY	REV	REVISION

POZNECKI CAMARILLO

(210) 349-3273
(210) 349-4395 (FAX)

5835 CALLAGHAN RD. SUITE 200
SAN ANTONIO, TEXAS, 78228

TBPE REG. NO. F-483
TBPLS REG NO 100423-00
https://www.pozcam.com/

THE STATE OF TEXAS · COUNTY OF FRIO

CR 1520 @ TEHUACANA CREEK

PLAN AND PROFILE

SHEET 1 OF 3

DSN	$DSGN$	FED. RD. DIV. NO.	PROJECT NO.		SHEET NO.
		DIV			
CHK	$CHKD$	STATE	DIST.	COUNTY	
		TEXAS	DISTRICT	COUNTY	
DRN	$DRWN$	CONT.	SECT.	JOB	HIGHWAY NO.
CHK	$CHKD$	CONT	SEC	JOB	HIGHWAY

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Plotted on: 5/12/2023 9:47:03 AM

PROP
EXIST

N

0 50 100

SCALE: 1"=100' HORIZ
1"=10' VERT

LEGEND

EXISTING ROW
PROPOSED TRAFFIC LANE
EXISTING TRAFFIC LANE
CONCRETE RIPRAP
PROPOSED PAVEMENT
PROPOSED BRIDGE
METAL BEAM GUARD FENCE

90% SUBMITTAL

INTERIM REVIEW ONLY
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Engineer: JOSE DIAZ
P.E. Serial No.: 99365
Date: 5/12/2023

DATE	BY	REV	REVISION

POZNECKI CAMARILLO
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(210) 349-4395 (FAX)
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TBPE REG. NO. F-483
TBPLS REG NO 100423-00
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THE STATE OF TEXAS · COUNTY OF FRIO

CR 1520 @ TEHUACANA CREEK

PLAN AND PROFILE

SHEET 2 OF 3

DSN	$DSGN$	FED. RD. DIV. NO.	PROJECT NO.		SHEET NO.
		DIV			
CHK	$CHKD$	STATE	DIST.	COUNTY	
		TEXAS	DISTRICT	COUNTY	
DRN	$DRWN$	CONT.	SECT.	JOB	HIGHWAY NO.
CHK	$CHKD$	CONT	SEC	JOB	HIGHWAY

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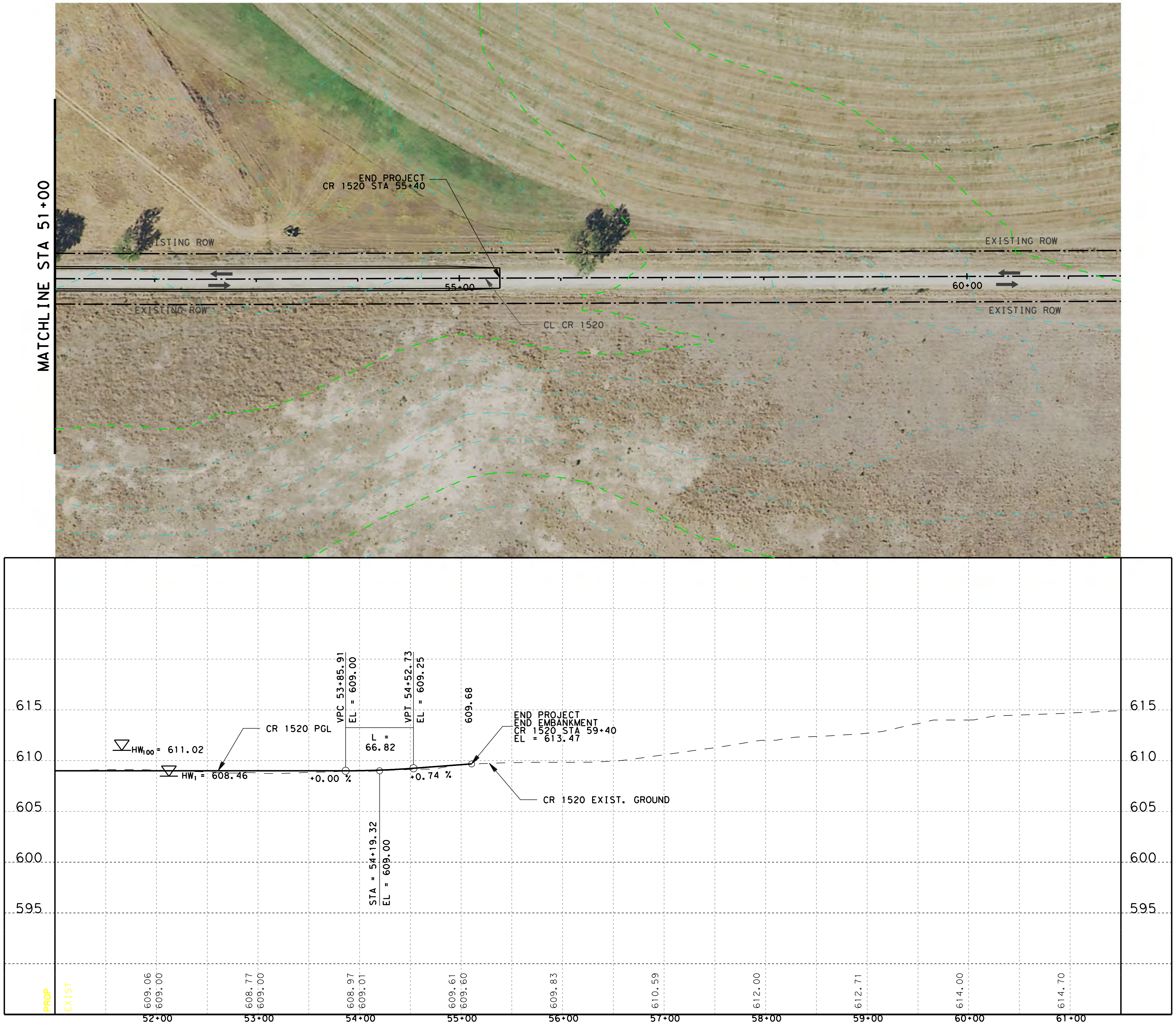

0 50 100

SCALE: 1"=100' HORIZ
1"=10' VERT

LEGEND

- EXISTING ROW
- PROPOSED TRAFFIC LANE
- EXISTING TRAFFIC LANE
- CONCRETE RIPRAP
- PROPOSED PAVEMENT
- PROPOSED BRIDGE
- METAL BEAM GUARD FENCE

90% SUBMITTAL

INTERIM REVIEW ONLY

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Engineer: JOSE DIAZ

P.E. Serial No.: 99365

Date: 5/11/2023

DATE	BY	REV	REVISION

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THE STATE OF TEXAS COUNTY OF FRIO

CR 1520 @ TEHUACANA CREEK

PLAN AND PROFILE

SHEET 3 OF 3

DSN	$DSGN$	FED.RD. DIV.NO.	PROJECT NO.		SHEET NO.
		DIV			$PP01$
CHK	$CHKD$	STATE	DIST.		COUNTY
		TEXAS	DISTRICT		COUNTY
DRN	$DRWN$	CONT.	SECT.	JOB	HIGHWAY NO.
CHK	$CHKD$	CONT	SEC	JOB	HIGHWAY

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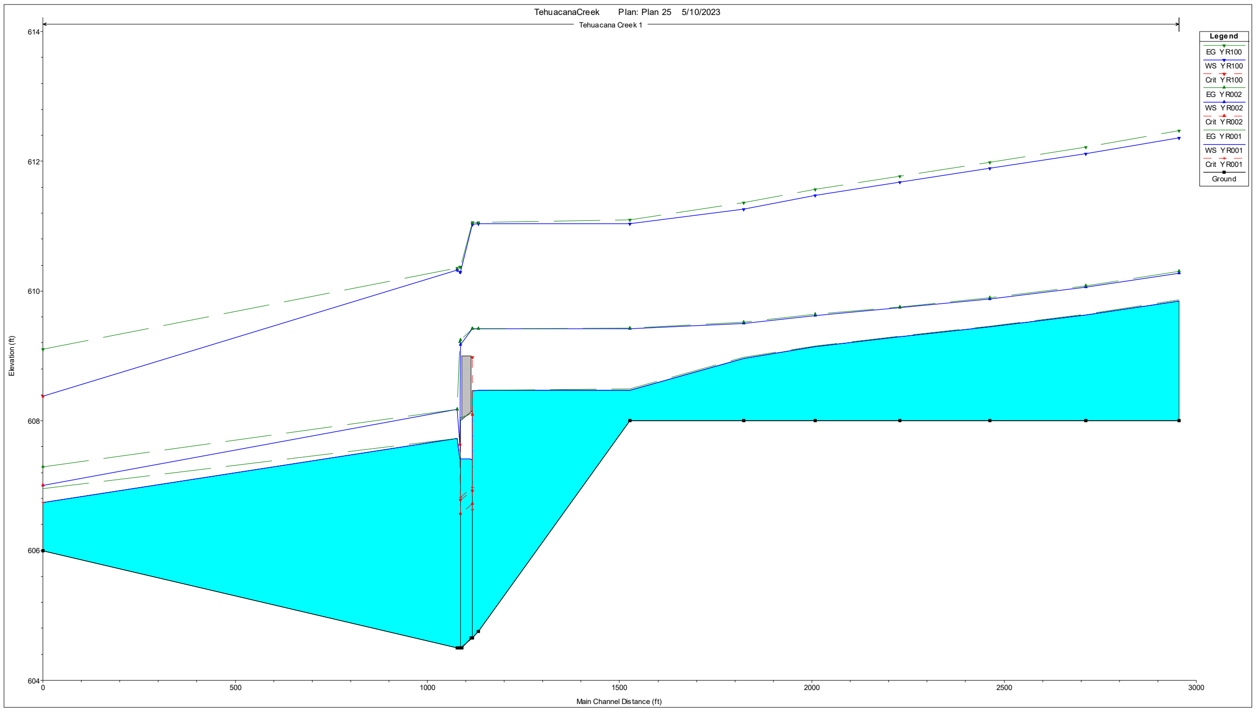
Appendix C
Proposed Condition Hydraulic Analysis

Plan: Plan 23 Tehuacana Creek 1 RS: 0.75 Culv Group: Culvert #1 Profile: YR001			
Q Culv Group (cfs)	658.3	Culv Full Len (ft)	
# Barrels	12	Culv Vel US (ft/s)	6.75
Q Barrel (cfs)	54.86	Culv Vel DS (ft/s)	6.42
E.G. US. (ft)	608.47	Culv Inv El Up (ft)	604.65
W.S. US. (ft)	608.46	Culv Inv El Dn (ft)	604.5
E.G. DS (ft)	607.87	Culv Frctn Ls (ft)	0.07
W.S. DS (ft)	607.41	Culv Exit Loss (ft)	0.18
Delta EG (ft)	0.6	Culv Entr Loss (ft)	0.35
Delta WS (ft)	1.05	Q Weir (cfs)	
E.G. IC (ft)	608.3	Weir Sta Lft (ft)	
E.G. OC (ft)	608.47	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	607.41	Weir Max Depth (ft)	
Culv WS Outlet (ft)	607.41	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	2.06	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	2.32	Min El Weir Flow (ft)	609.01

Plan: Plan 23 Tehuacana Creek 1 RS: 0.75 Culv Group: Culvert #1 Profile: YR002			
Q Culv Group (cfs)	529.23	Culv Full Len (ft)	30
# Barrels	12	Culv Vel US (ft/s)	4.58
Q Barrel (cfs)	44.1	Culv Vel DS (ft/s)	4.58
E.G. US. (ft)	609.42	Culv Inv El Up (ft)	604.65
W.S. US. (ft)	609.41	Culv Inv El Dn (ft)	604.5
E.G. DS (ft)	609.21	Culv Frctn Ls (ft)	0.04
W.S. DS (ft)	607.63	Culv Exit Loss (ft)	0
Delta EG (ft)	0.2	Culv Entr Loss (ft)	0.16
Delta WS (ft)	1.78	Q Weir (cfs)	781.37
E.G. IC (ft)	609.29	Weir Sta Lft (ft)	891.18
E.G. OC (ft)	609.42	Weir Sta Rgt (ft)	2972.39
Culvert Control	Outlet	Weir Submerg	0
Culv WS Inlet (ft)	608.15	Weir Max Depth (ft)	0.42
Culv WS Outlet (ft)	608.89	Weir Avg Depth (ft)	0.41
Culv Nml Depth (ft)		Weir Flow Area (sq ft)	860.85
Culv Crt Depth (ft)	2.07	Min El Weir Flow (ft)	609.01

Plan: Plan 23 Tehuacana Creek 1 RS: 0.75 Culv Group: Culvert #1 Profile: YR100			
Q Culv Group (cfs)	635.37	Culv Full Len (ft)	30
# Barrels	12	Culv Vel US (ft/s)	5.5
Q Barrel (cfs)	52.95	Culv Vel DS (ft/s)	5.5
E.G. US. (ft)	611.06	Culv Inv El Up (ft)	604.65
W.S. US. (ft)	611.02	Culv Inv El Dn (ft)	604.5
E.G. DS (ft)	610.37	Culv Frctn Ls (ft)	0.06
W.S. DS (ft)	610.29	Culv Exit Loss (ft)	0.39
Delta EG (ft)	0.69	Culv Entr Loss (ft)	0.24
Delta WS (ft)	0.73	Q Weir (cfs)	9522.43
E.G. IC (ft)	610.96	Weir Sta Lft (ft)	670.89
E.G. OC (ft)	611.06	Weir Sta Rgt (ft)	3287.7
Culvert Control	Outlet	Weir Submerg	0.6
Culv WS Inlet (ft)	608.15	Weir Max Depth (ft)	2.07
Culv WS Outlet (ft)	608	Weir Avg Depth (ft)	1.86
Culv Nml Depth (ft)		Weir Flow Area (sq ft)	4860.74
Culv Crt Depth (ft)	2.28	Min El Weir Flow (ft)	609.01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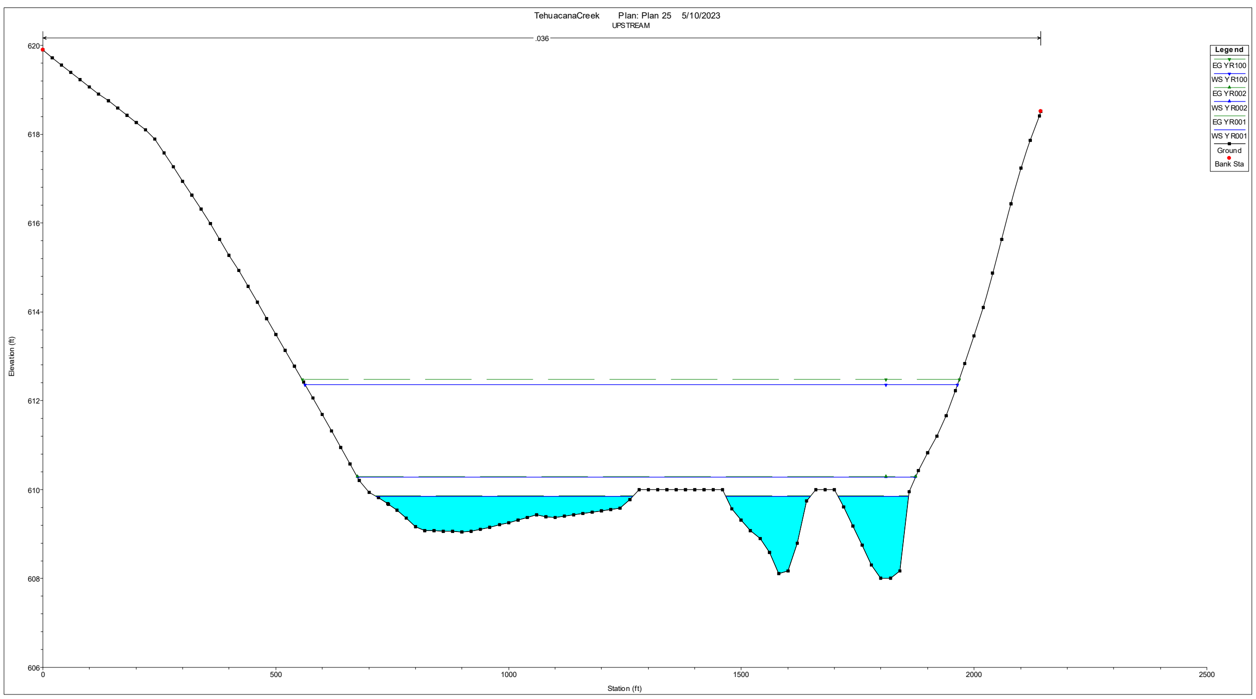
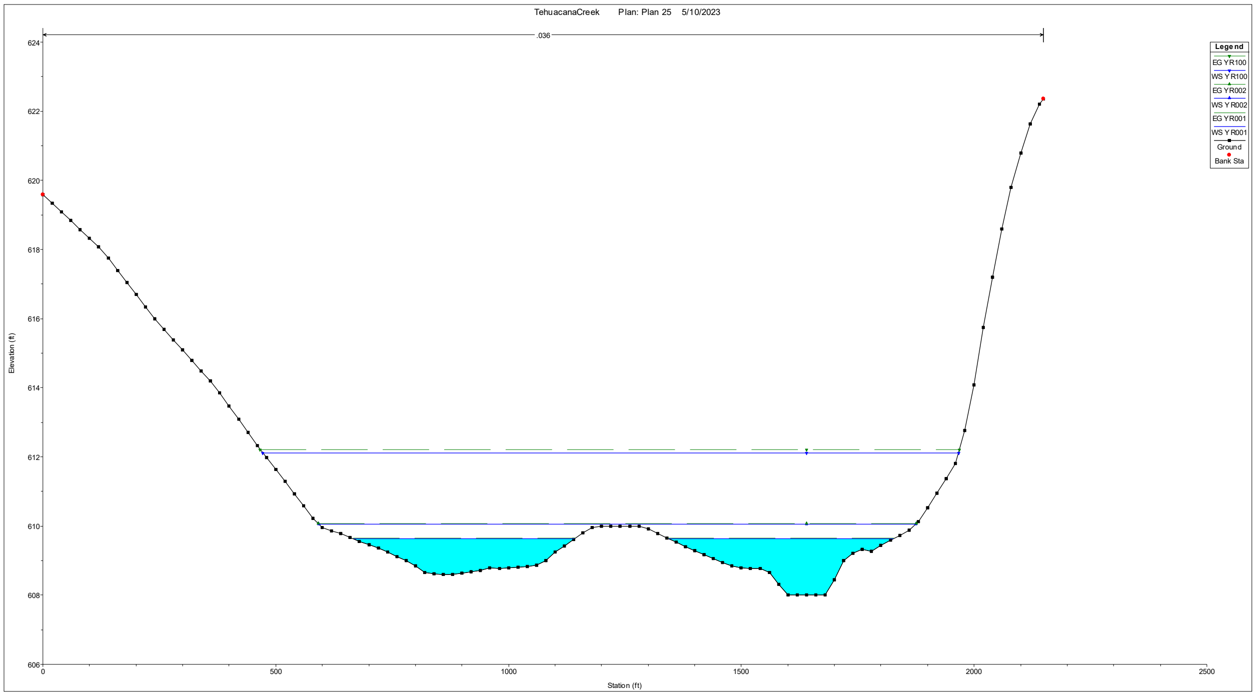
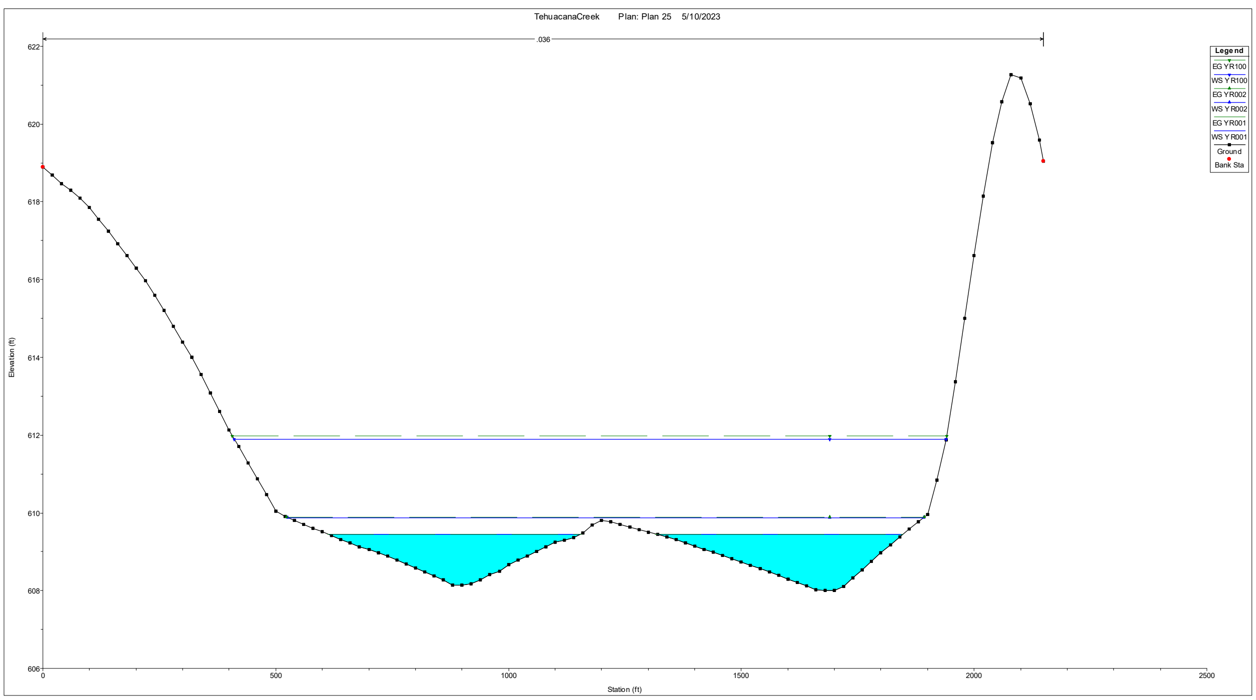
Tehuacana Creek 1
Legend
EG YR100
WS YR100
Crit YR100
EG YR002
WS YR002
Crit YR002
EG YR001
WS YR001
Crit YR001
Ground
Elevation (ft)
Main Channel Distance (ft)

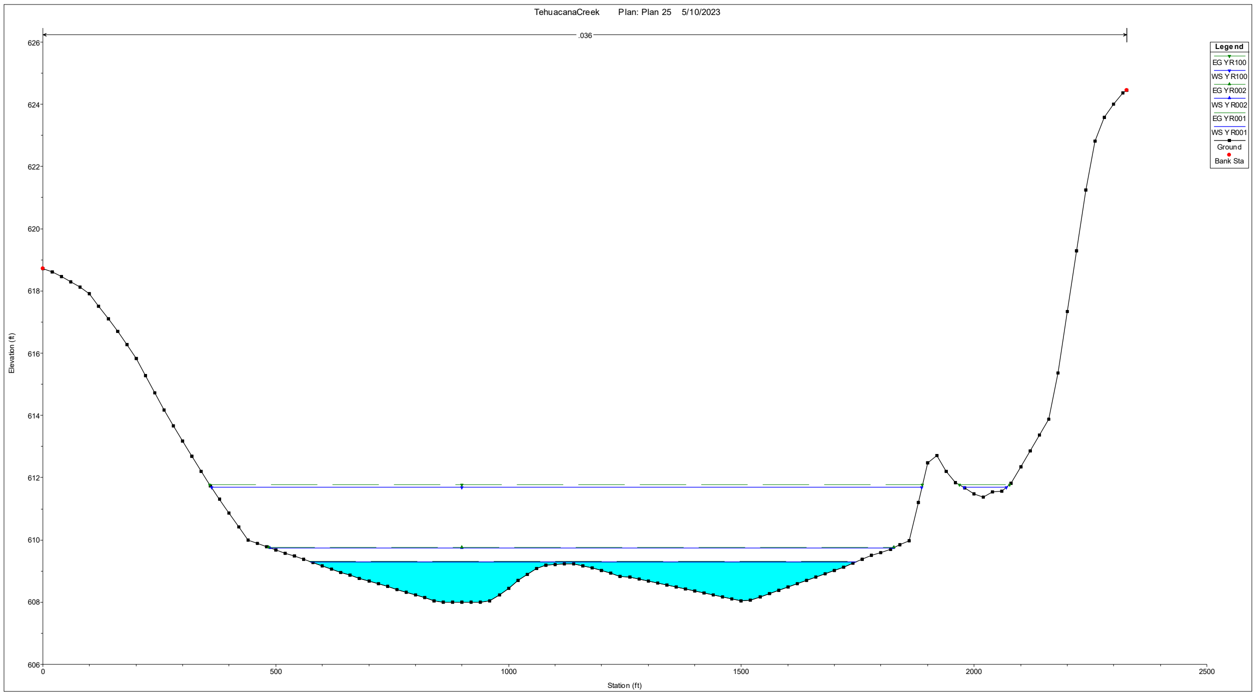

TehuacanaCreek Plan: Plan 25 5/10/2023
UPSTREAM
.036
Legend
EG YR100
WS YR100
EG YR002
WS YR002
EG YR001
WS YR001
Ground
Bank Sta
Elevation (ft)
Station (ft)

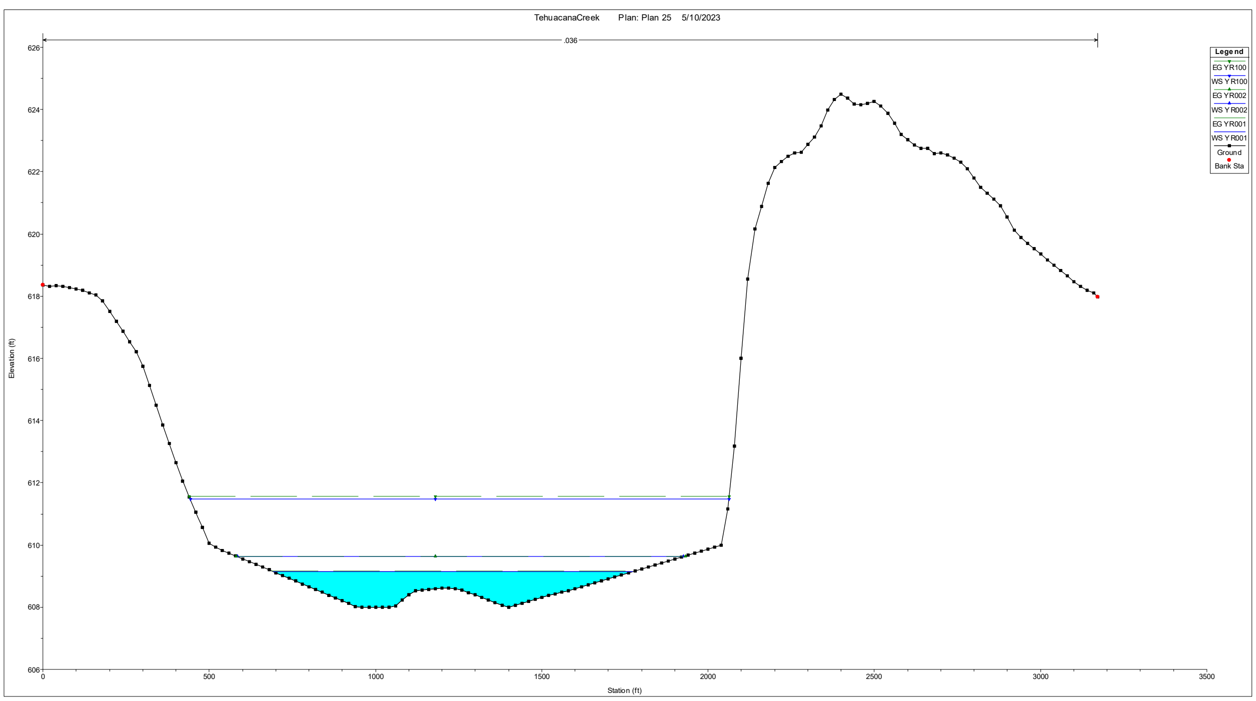


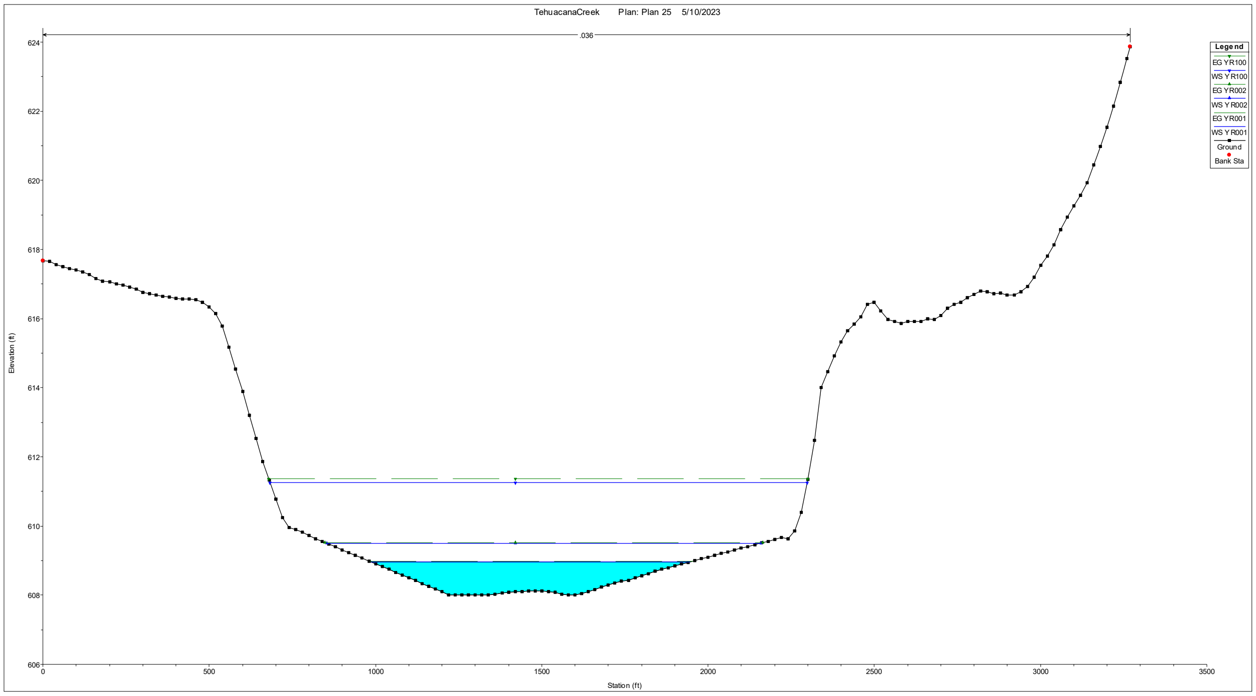
TehuacanaCreek Plan: Plan 25 5/10/2023
.036
Legend
EG YR100
WS YR100
EG YR002
WS YR002
EG YR001
WS YR001
Ground
Bank Sta
Elevation (ft)
Station (ft)

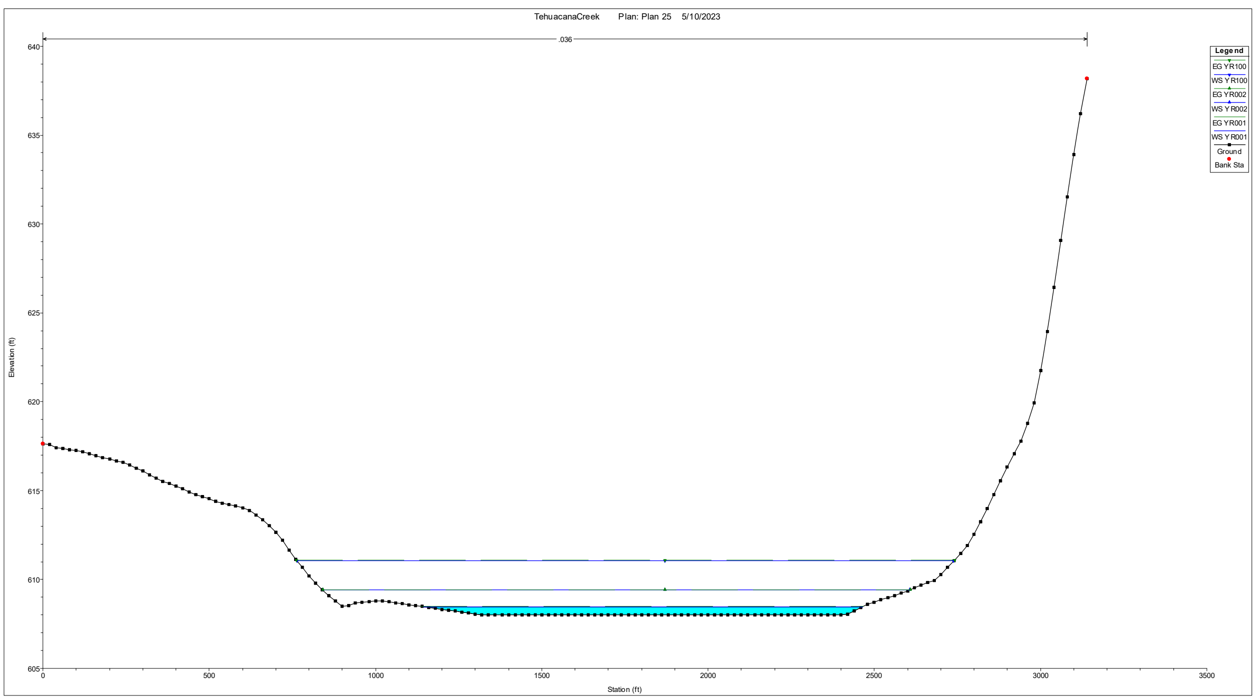


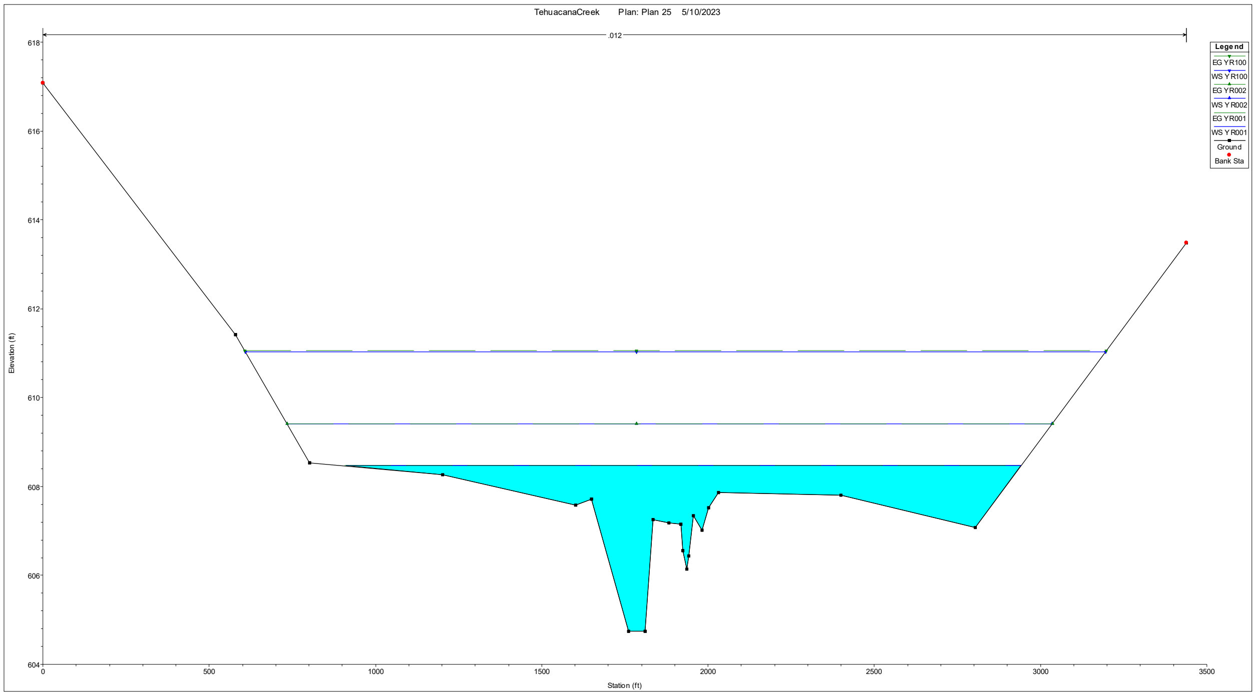
TehuacanaCreek Plan: Plan 25 5/10/2023
.036
Legend
EG YR100
WS YR100
EG YR002
WS YR002
EG YR001
WS YR001
Ground
Bank Sta
Elevation (ft)
Station (ft)


TehuacanaCreek Plan: Plan 25 5/10/2023
.036
Legend
EG YR100
WS YR100
EG YR002
WS YR002
EG YR001
WS YR001
Ground
Bank Sta
Elevation (ft)
Station (ft)

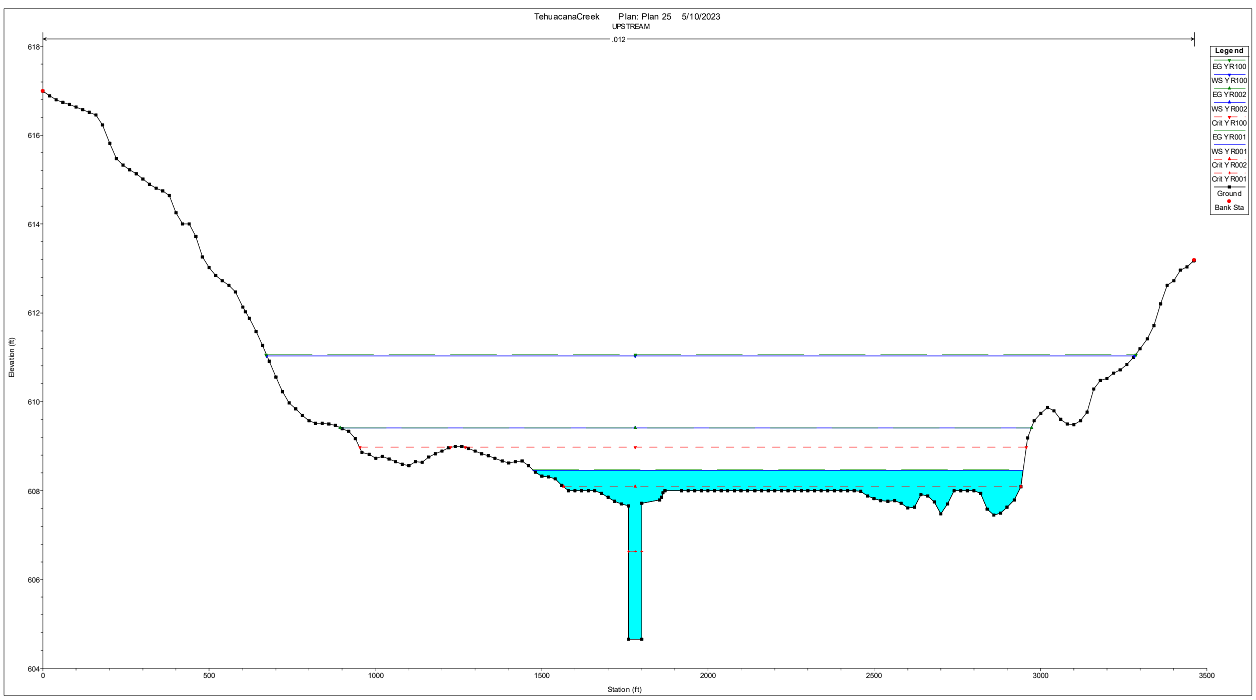

TehuacanaCreek Plan: Plan 25 5/10/2023
.036
Legend
EG YR100
WS YR100
EG YR002
WS YR002
EG YR001
WS YR001
Ground
Bank Sta
Elevation (ft)
Station (ft)


TehuacanaCreek Plan: Plan 25 5/10/2023
.036
Legend
EG YR100
WS YR100
EG YR002
WS YR002
EG YR001
WS YR001
Ground
Bank Sta
Elevation (ft)
Station (ft)

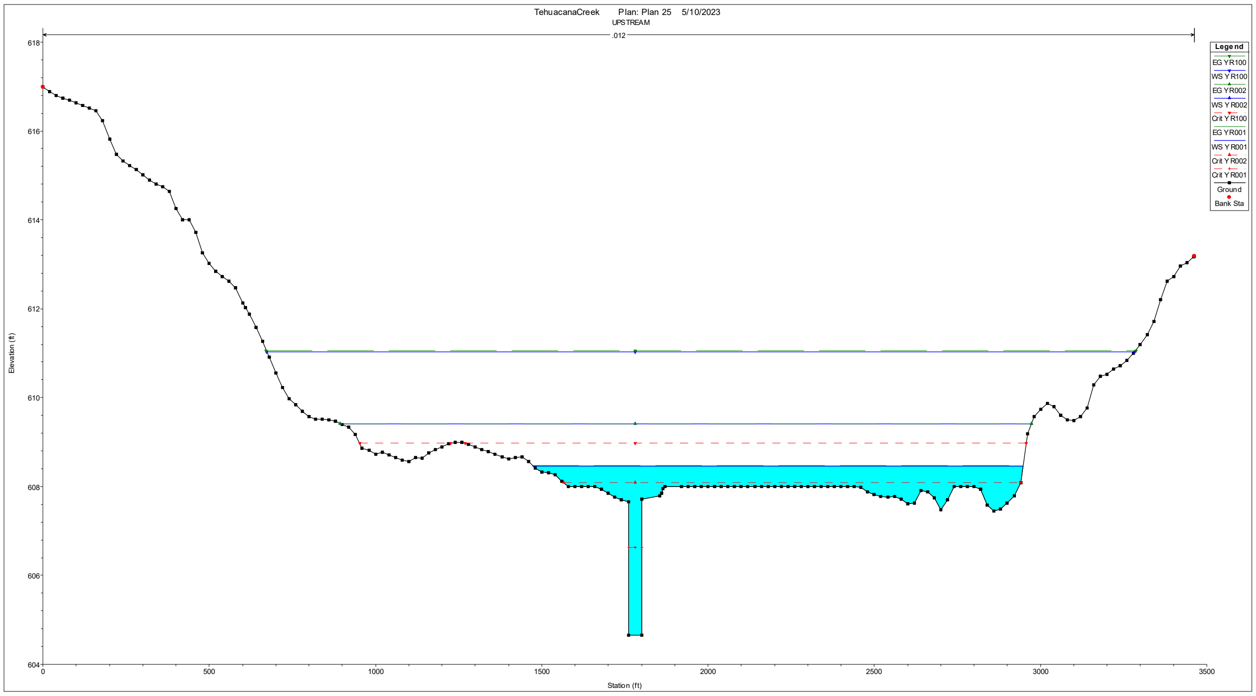

TehuacanaCreek Plan: Plan 25 5/10/2023
.036
Legend
EG YR100
WS YR100
EG YR002
WS YR002
EG YR001
WS YR001
Ground
Bank Sta
Elevation (ft)
Station (ft)



TehuacanaCreek Plan: Plan 25 5/10/2023
.012
Legend
EG YR100
WS YR100
EG YR002
WS YR002
EG YR001
WS YR001
Ground
Bank Sta
Elevation (ft)
Station (ft)



TehuacanaCreek Plan: Plan 25 5/10/2023
UPSTREAM
.012
Legend
EG YR100
WS YR100
EG YR002
WS YR002
Crit YR100
EG YR001
WS YR001
Crit YR002
Crit YR001
Ground
Bank Sta
Elevation (ft)
Station (ft)


TehuacanaCreek Plan: Plan 25 5/10/2023
UPSTREAM
.012
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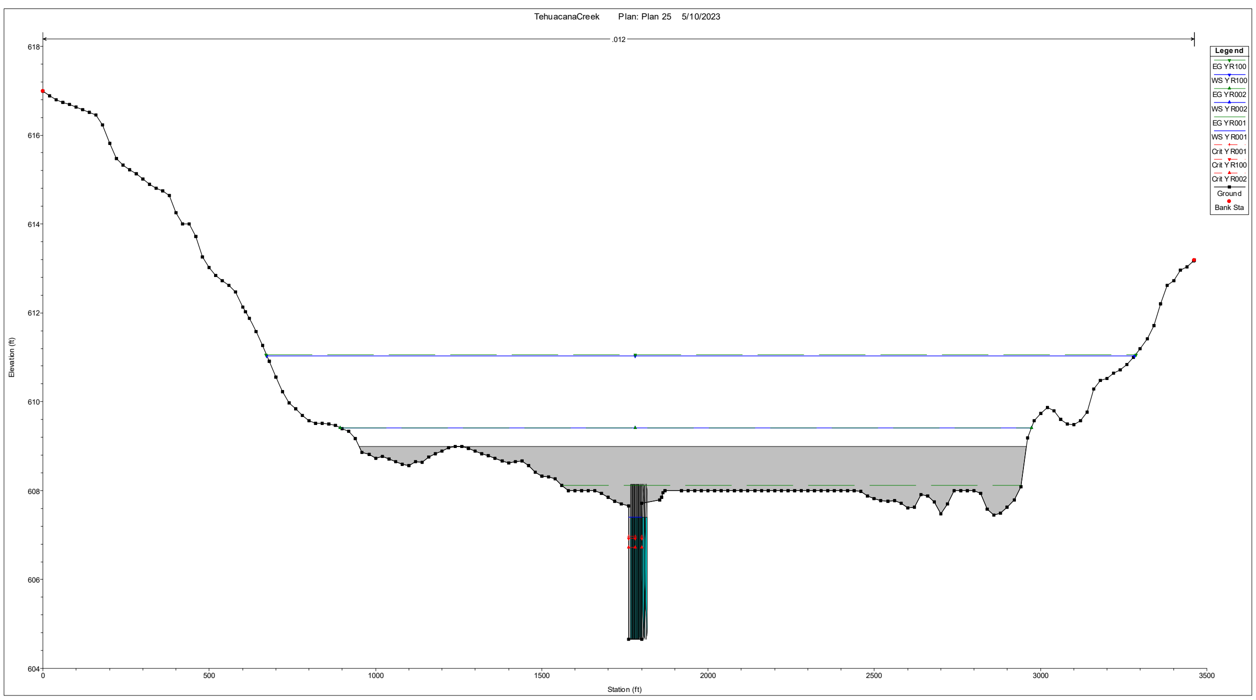
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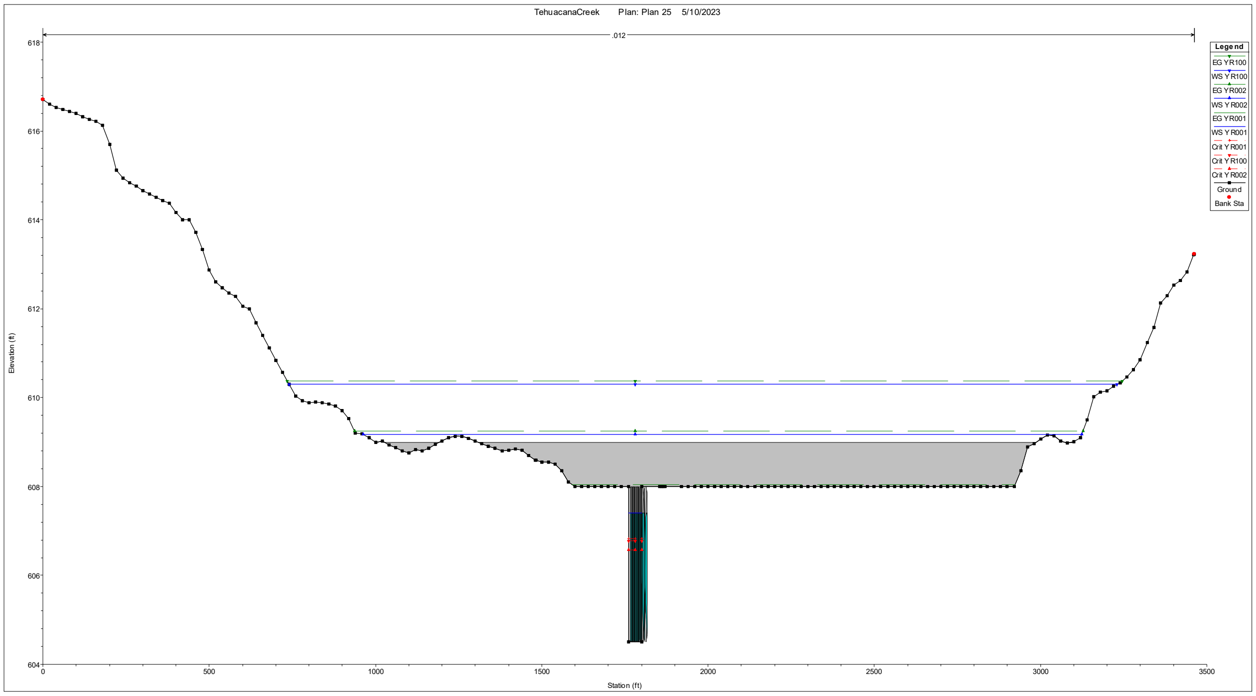
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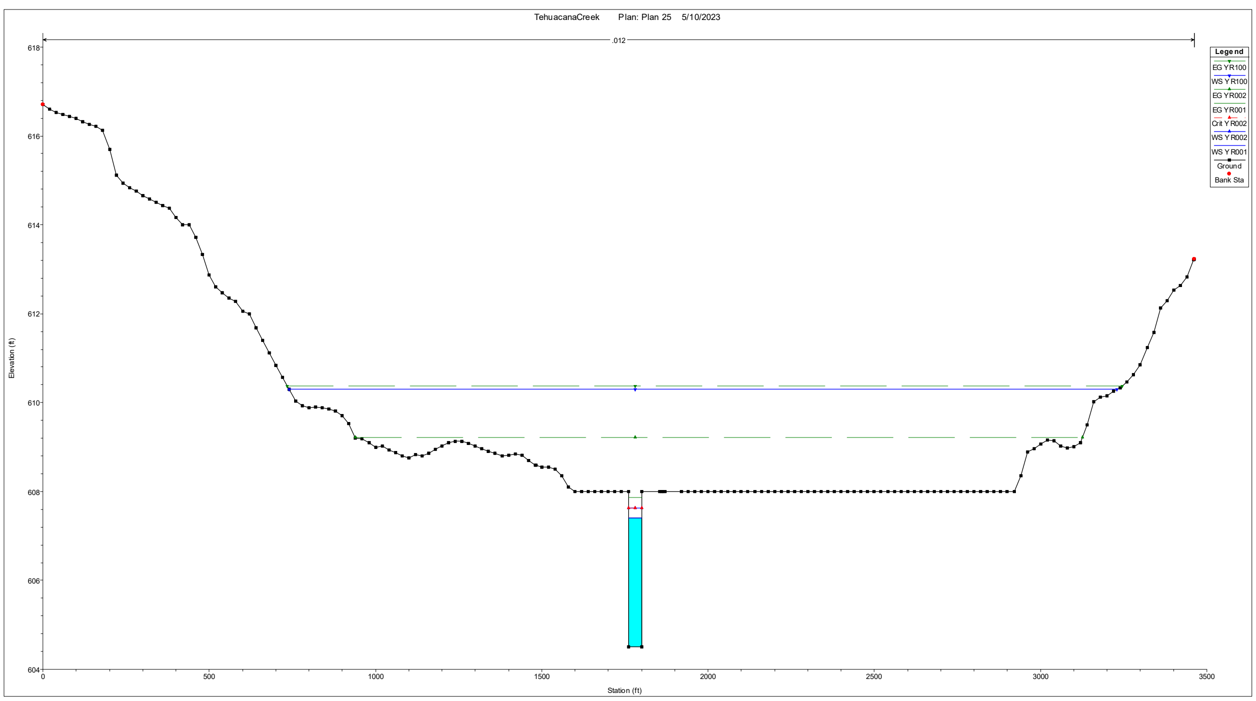
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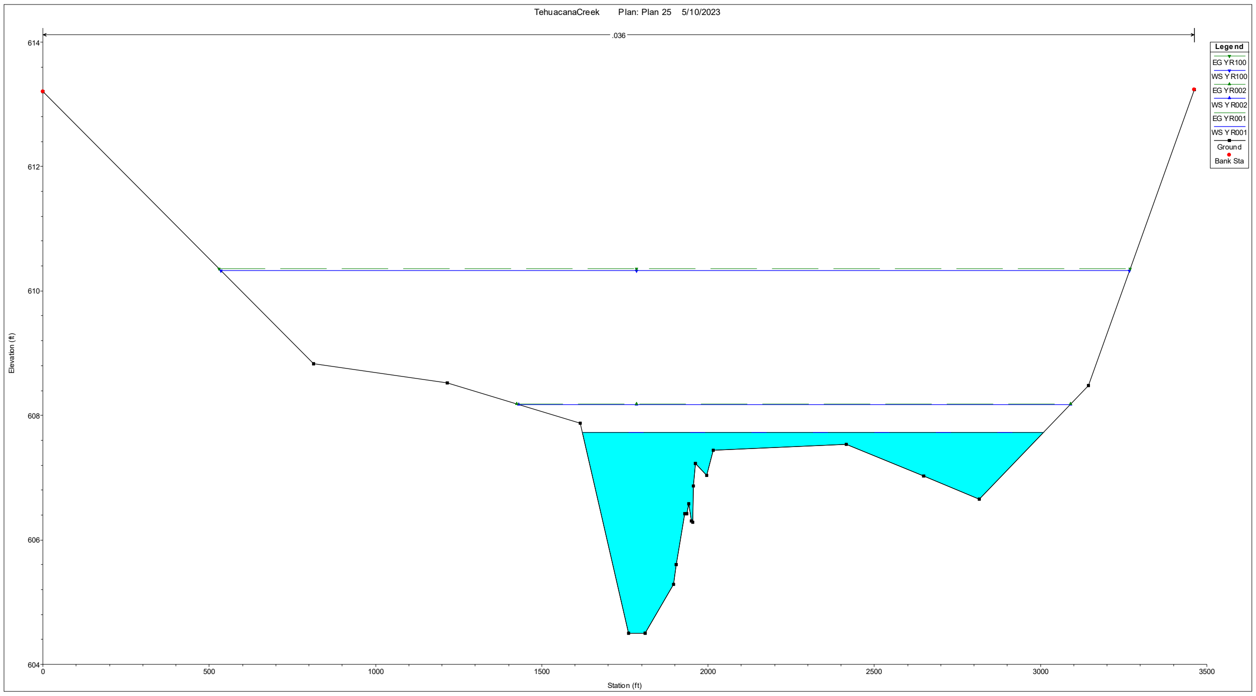
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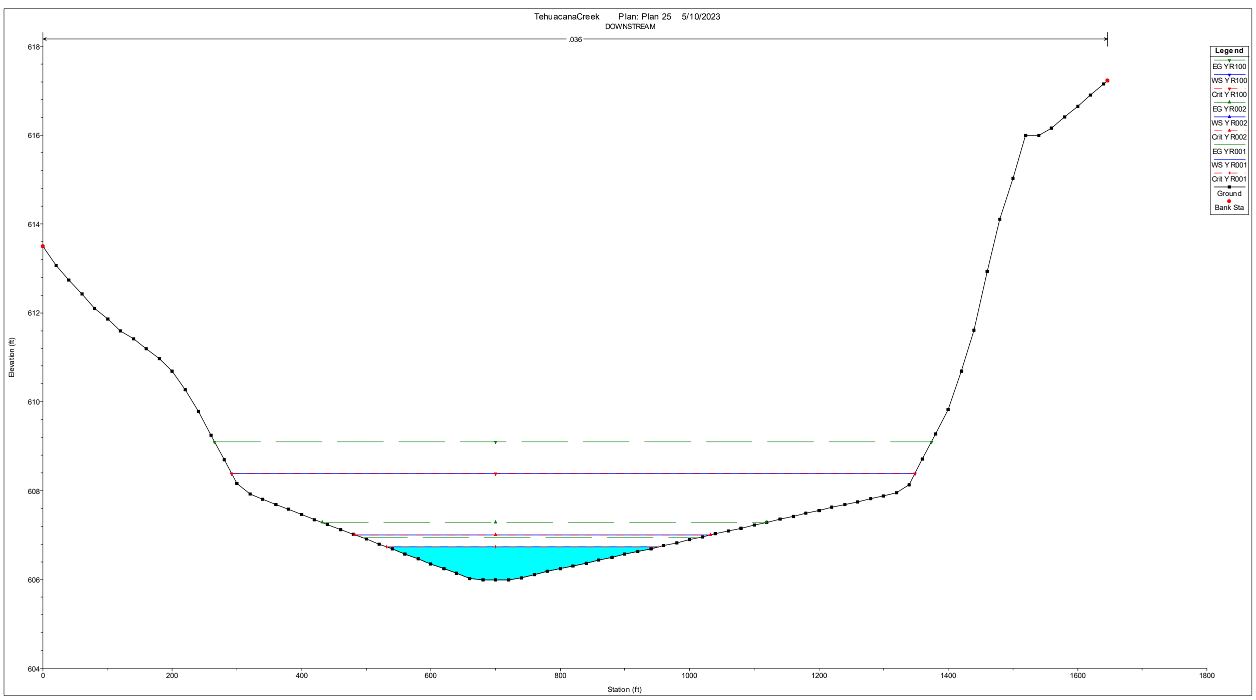
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Flood Mitigation Project Technical Memorandum

Date:	Thursday, June 08, 2023
To:	Region 13 Flood Planning Group c/o Nueces River Authority
From:	Bryan Martin, PE HDR, Inc/ Firm No. 754 4401 W Gate Blvd Ste 400 Austin, TX 78745
Subject:	FMP ID's: 133000010, 133000011, 133000012, 133000013 Project Sponsor: Pearsall City Project Names: • FH#1.1: Regional Detention Pond in Davila Street Tributary • FH#2.1: Storm sewer bypass improvements in Trinity St Tributary from Trinity St to Radio Rd • FH#2.2: Detention ponds in the Pearsall High School Grounds • FH#3.1: Channel lining and conveyance improvements along FM 1581

Methodologies and Procedures

Background

HDR Engineering, Inc. (HDR) advanced four flood mitigation projects for the City of Pearsall, TX (the City) from the 2022 City of Pearsall Drainage Masterplan. This analysis was done to provide data for the 2023 Nueces Regional Flood Plan (the Plan) concerning potential Flood Mitigation Projects (FMPs) to be recommended in the 2023 Plan.

For additional description of known flood problem areas, refer to the 2022 City of Pearsall Drainage Masterplan Report.

This memorandum documents the assumptions, methodologies and processes used to advance the FMPs in accordance with the Texas Water Development Board (TWDB) Exhibit C Technical Guidelines for Regional Flood Planning FMP requirements.

Data Collection

All data were obtained as digital files in Geographic Information System (GIS) and Excel format. HDR gathered and compiled the following readily-available geospatial data:

- National Oceanic and Atmospheric Administration (NOAA) - Atlas 14 Precipitation Frequency Data for the City of Pearsall (Table 1)

- Texas Natural Resources Information System (TNRIS) - United States Geological Survey (USGS) 1 meter resolution 2018 LiDAR-based digital elevation models (DEMs)
- United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) - Soil Survey Geographic Database (SSURGO) data for Frio County
- TWDB – 2021 Texas Buildings with SVI and Estimated Population (TWDB, Center for Disease Control, Oak Ridge National Laboratory)
- Texas Department of Transportation (TxDOT) – 2016 TxDOT Roadways

Table 1. NOAA Precipitation Frequency Estimates (in inches) for Pearsall, Texas

Duration	Average Recurrence Interval (years):			
	2	10	25	100
5-min:	0.53	0.775	0.924	1.15
15-min:	1.06	1.55	1.84	2.28
60-min:	1.93	2.82	3.37	4.19
2-hr:	2.32	3.57	4.38	5.68
3-hr:	2.53	4.04	5.04	6.69
6-hr:	2.9	4.76	6.05	8.26
12-hr:	3.26	5.35	6.82	9.41
24-hr:	3.65	5.93	7.57	10.5

Drainage Analysis

Distributed Hydrology

The methodology for the determination of storm water runoff is common between both Baseline- (also known as Existing) and Proposed- Conditions modeling. Infoworks ICM v2023.2 modeling software was used to prepare the rain-on-mesh approach for the 2-, 10-, 25-, and 100-year frequency storms. Hydrologic calculations were performed using Infoworks ICM software which applies designated rainfall, spatial distributions of hydrologic soil group, and corresponding constant infiltration rates within the 2D hydraulic domain.

INFILTRATION RATE

The infiltration rate was determined using SSURGO soil data for Pearsall, Texas. Table 2 and Table 3 summarize the type of soils found in the project area and the infiltration rates. Constant infiltration rates were applied spatially based on hydrologic soil group data.

Table 2. SSURGO Soils in Pearsall

Soil Description	Hydraulic Soil Group	Condition
Dilley fine sandy loam, 1 to 5 percent slopes	D	Well drained
Tiocano clay, cool, 0 to 1 percent slopes, occasionally ponded	D	Somewhat poorly drained
Webb very fine sandy loam, 0 to 1 percent slopes	C	Well drained
Duval very fine sandy loam, 1 to 3 percent slopes	B	Well drained
Zavco sandy clay loam, 0 to 1 percent slopes	C	Well drained
Poth loamy fine sand, 0 to 3 percent slopes	C	Well drained
Water	D	
Duval loamy fine sand, 0 to 5 percent slopes	B	Well drained
Webb very fine sandy loam, 1 to 3 percent slopes	C	Well drained
Duval very fine sandy loam, 0 to 1 percent slopes	B	Well drained
Wilco loamy fine sand, 0 to 3 percent slopes	C	Well drained
Lacoste very fine sandy loam, 1 to 5 percent slopes	D	Well drained
Ruiz-Falfurrias-Bobillo complex, gently undulating	A	Well drained
Caid very fine sandy loam, 1 to 3 percent slopes	B	Well drained
Caid sandy clay loam, 0 to 1 percent slopes	B	Well drained
Brystal very fine sandy loam, 1 to 3 percent slopes	B	Well drained
Poteet very fine sandy loam, occasionally flooded	C	Moderately well drained
Miguel very fine sandy loam, 1 to 3 percent slopes	C	Well drained
Miguel very fine sandy loam, 0 to 1 percent slopes	C	Well drained
Zavco sandy clay loam, 1 to 3 percent slopes	C	Well drained
Amphion sandy clay loam, 0 to 1 percent slopes	C	Well drained

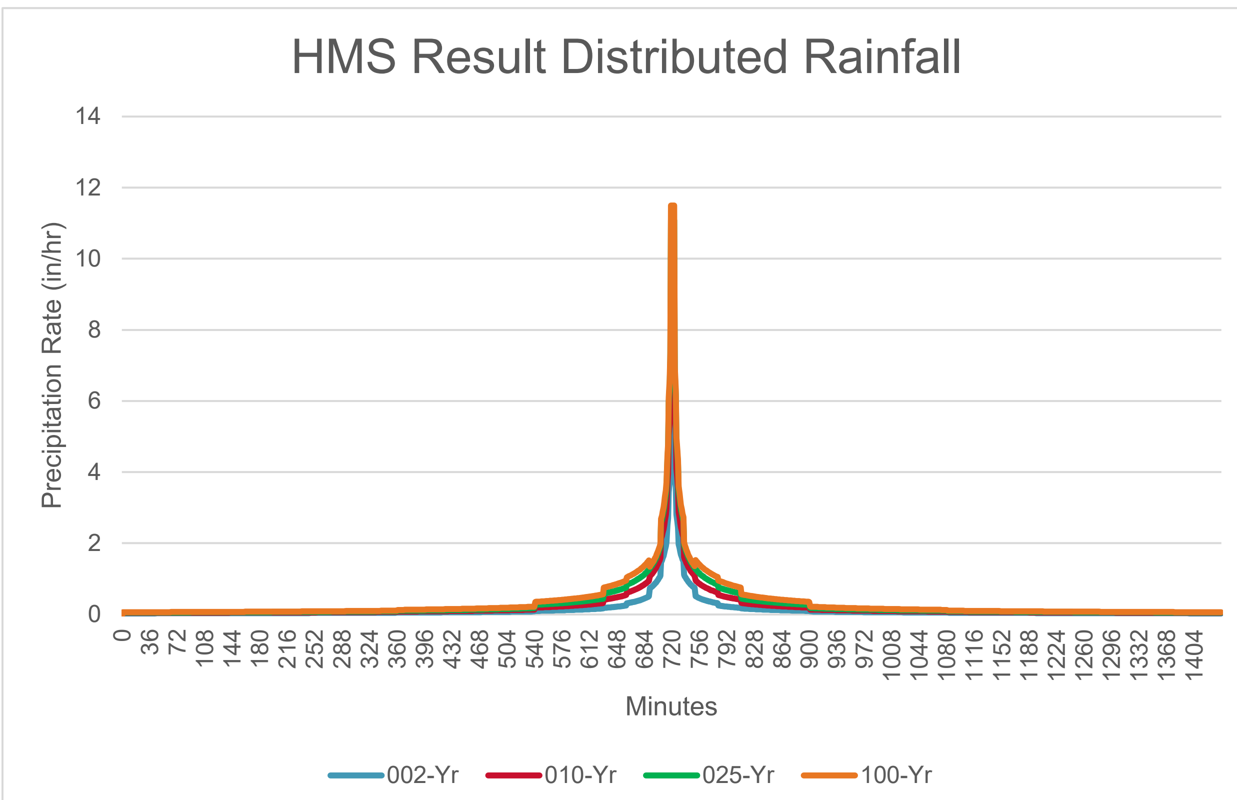
Table 3. Infiltration Model

Hydrologic Soil Group	Constant Infiltration Rate (in/hr)
A	0.35
B	0.23
C	0.1
D	0.02

RAINFALL

The rainfall data used in the ICM model was developed by inputting the Precipitation Frequency Estimates from NOAA (Table 1**)** into HEC-HMS v4.10 and run for a generic basin. HEC-HMS calculates rainfall hyetographs that can then be imported into ICM. Figure 1 displays the distributed rainfall per storm frequency for Pearsall:

Figure 1. HMS Result Distributed Rainfall for Pearsall



ROUGHNESS

The ICM model roughness component was created by combining the structure and pavement data with assigned Manning's N roughness values. The Manning's N values are based on engineering assessment of satellite imagery, TWDB building and TxDOT roadway data, the United States Army Corps of Engineers HEC-RAS Hydraulic Reference Manual, and the "Open Channel Hydraulics" (Chow, 1959) Manning's N for Channels table. Manning's N values are typically given in ranges to reflect the empirical nature of Manning's equation as well as the natural variability in land surface. An artificially high roughness value of 1.00 was used for structures to allow flow to enter structures with low velocity to represent flow conditions through structures. Table 4 summarizes the N values used:

Table 4. Manning's N Roughness Values

Description	Manning's N Value
Structure	1.00
Impervious Area – Pavement (combined concrete and asphalt)	0.011 – 0.020
Developed, Open Space	0.050

Baseline Hydraulic Conditions

Components used in the ICM model were adjusted to run baseline conditions and facilitate the benefit-cost analysis (BCA) process – described below.

TERRAIN ADJUSTMENTS

To determine the damages for this problem area, structures need to be evaluated based on flooding depths. It was assumed that structures would only flood once the water surface elevation is above the structure's finished floor elevation (which was assumed to be the lowest adjacent ground elevation plus an average slab height of 0.5 feet). Structures were adjusted in ICM by assigning a finished floor elevation to each structure.

POROUS POLYGON ELEMENT

Elements provide a break in the 2D mesh elements at the boundary definition. A nominal porosity is defined for each element. These modified elements do not allow rainfall to fall onto the structure element so that all calculated flooding within the structure elements is caused by external runoff. The exclusion of rainfall directly on structures is assumed to have a negligible effect on the distributed hydrology.

Proposed Hydraulic Conditions and Results

There are four projects proposed flood risk reduction benefit. Proposed project conditions were analyzed in kind with baseline conditions by using the ICM software with the identical components and running the same storm events (2-, 10-, 25-, and 100-year). Proposed projects are outlined in the following sections;

- FH#1.1: Regional detention pond in Davila Street Tributary.
- FH#2.1: Storm sewer bypass improvements in Trinity Street Tributary from Trinity Street to Radio Road.
- FH#2.2: Detention ponds in the Pearsall High School Grounds.
- FH#3.1: Channel lining and conveyance improvements along FM 1581.

FH#1.1: REGIONAL DETENTION POND IN DAVILA STREET TRIBUTARY.

The project proposes a regional detention pond to mitigate the flooding issues. The placement of the detention pond is located on a private property along N Garcia St between W Sanches St and Gonzales St. The pond has approximately 58 acre-feet of storage. The outlet pipe is 2 feet in diameter and outfalls to the drainage ditch to the culvert under W Comal St. The outlet pipe runs from the pond down N Garcia St to S Puente St and discharges to the drainage ditch.

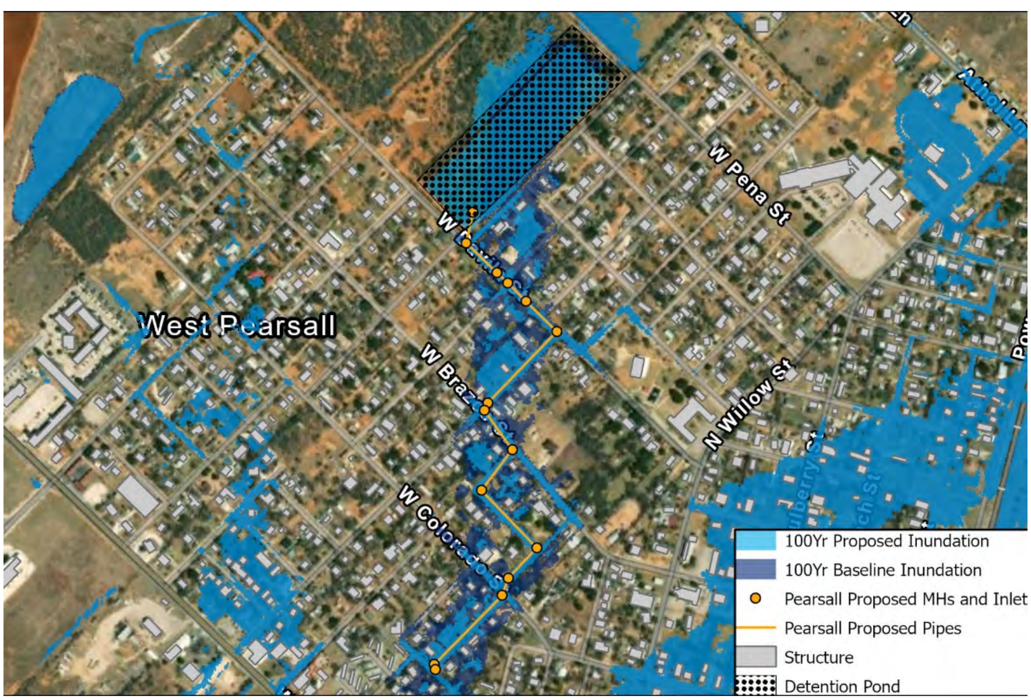
Table 5 summarizes the number of inundated commercial and residential structures for each analyzed storm event. This project is expected to provide reduction in structural flooding as outlined in Table 5.

Table 5. FH#1.1 Total Impacted Structures for Baseline and Proposed Conditions

Storm (Year)	Baseline	Proposed	Difference
2	22	15	-7
10	105	80	-25
25	163	145	-18
100	213	182	-31

Figure 2 displays the inundation boundary created by both the baseline and proposed condition model results.

Figure 2. FH#1.1 Regional detention pond in Davila Street Tributary



FH#2.1: STORM SEWER BYPASS IMPROVEMENTS IN TRINITY STREET TRIBUTARY FROM TRINITY STREET TO RADIO ROAD.

A relief storm sewer is proposed on parallel streets to the existing storm sewer. The storm sewer varies in size from twin 6x5 reinforced box culvert to twin 7x6 reinforced box culvert. The bypass storm sewer runs from an added small detention pond that acts as an inlet for the storm sewer at W Trinity and Power Plant Rd.

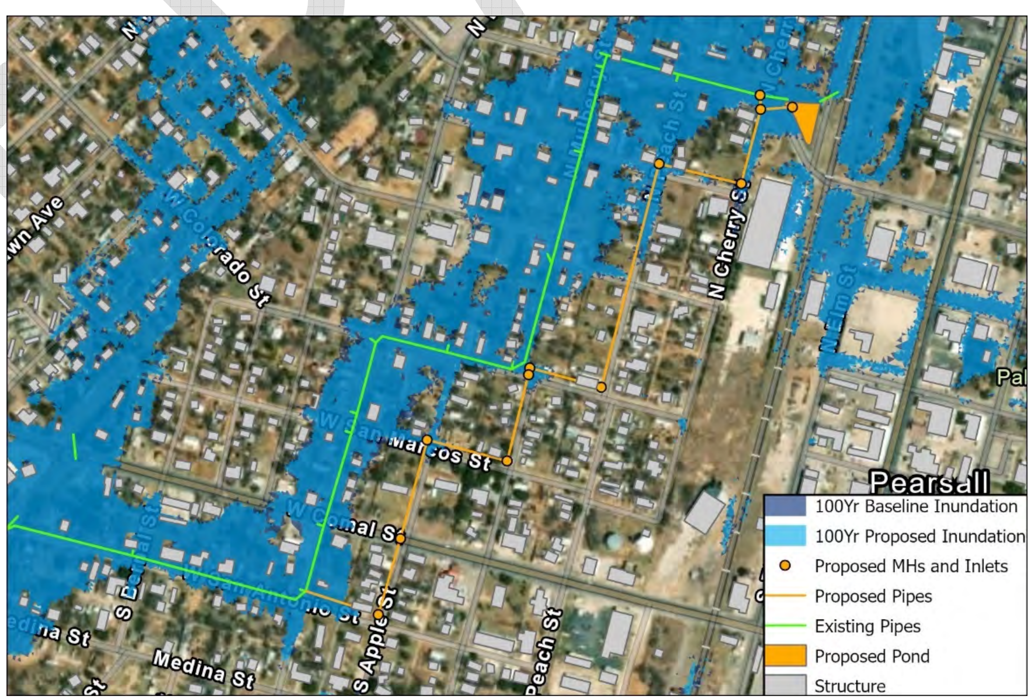
Table 6 summarizes the number of inundated commercial and residential structures for each analyzed storm event. This project is expected to provide reduction in structural flooding as outlined in Table 6.

Table 6. FH#2.1 Total Impacted Structures for Baseline and Proposed Conditions

Storm (Year)	Baseline	Proposed	Difference
2	22	21	-1
10	105	104	-1
25	163	156	-7
100	213	212	-1

Figure 3 displays the inundation boundary created by both the baseline and proposed condition model results.

Figure 3. FH#2.1 Storm sewer bypass improvements in Trinity Street Tributary from Trinity Street to Radio Road



FH#2.2: DETENTION PONDS IN THE PEARSALL HIGH SCHOOL GROUNDS.

This project proposes a series of detention ponds to mitigate the flooding issues. The proposed detention ponds are placed on Pearsall High School property in a low lying flood prone area. The ponds have approximately 11 acre-feet of combined storage. The outlet pipes are twin 18-inch diameter. There are two ponds in series with the upper pond discharging to the lower pond and the lower pond discharging to a ditch south of Maverick Drive.

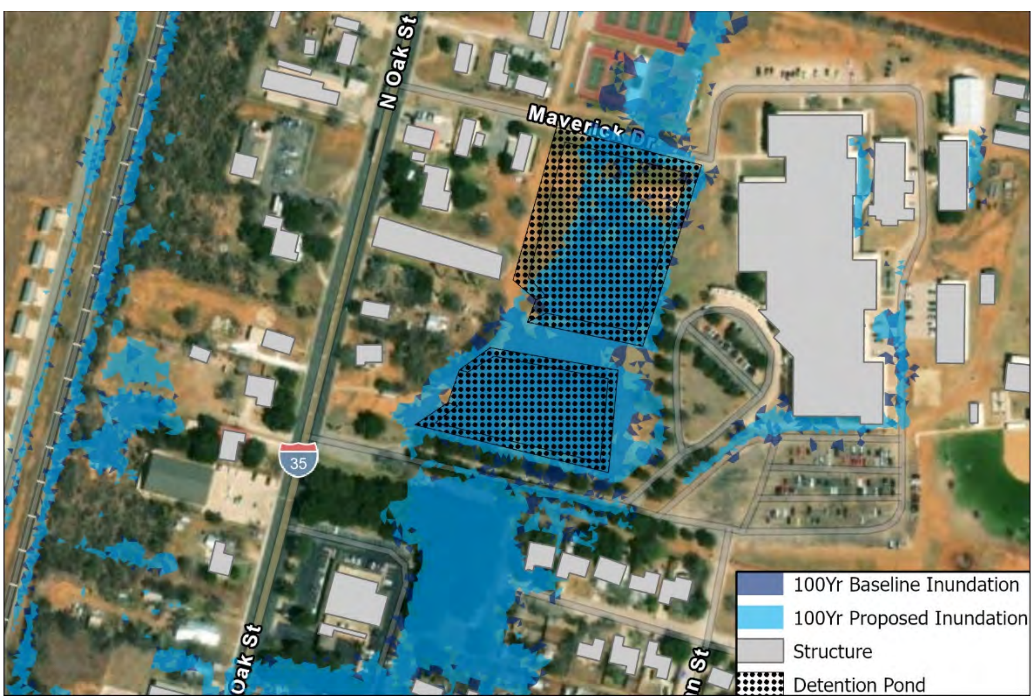
Table 7 summarizes the number of inundated commercial and residential structures for each analyzed storm event. This project is expected to provide reduction in structural flooding as outlined in Table 7.

Table 7. FH#2.2 Total Impacted Structures for Baseline and Proposed Conditions

Storm (Year)	Baseline	Proposed	Difference
2	22	22	-0
10	105	104	-1
25	163	153	-10
100	213	205	-8

Figure 4 displays the inundation boundary created by both the baseline and proposed condition model results.

Figure 4. FH#2.2 Baseline and Proposed Condition Model Inundation Boundary



FH#3.1: EXTENSION OF THE IMPROVEMENTS TO THE OPEN CHANNEL ALONG FM 1581

The project proposes conveyance improvements along FM 1581 including lining and widening of the existing channel. The culvert at W San Antonio is replaced with a 36-inch reinforced concrete pipe.

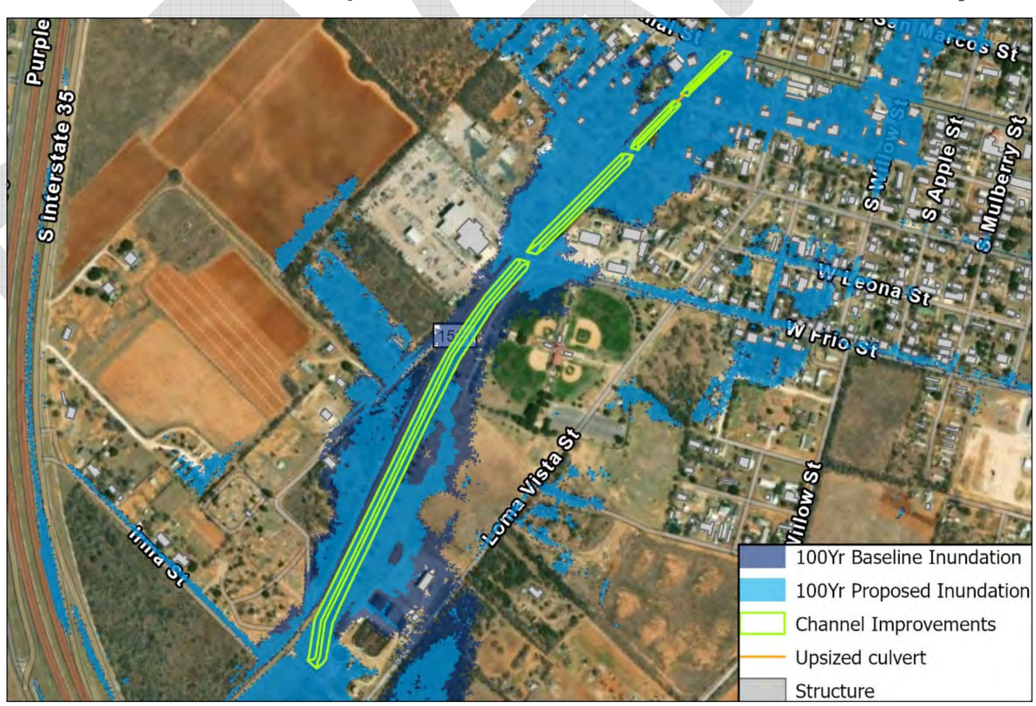
Table 8 summarizes the number of inundated commercial and residential structures for each analyzed storm event. This project is expected to provide reduction in structural flooding as outlined in Table 8.

Table 8. FH#3.1 Total Impacted Structures for Baseline and Proposed Conditions

Storm (Year)	Baseline	Proposed	Difference
2	22	21	-1
10	105	104	-1
25	163	155	-8
100	213	211	-2

Figure 5 displays the inundation boundary created by both the baseline and proposed condition model results.

Figure 5. FH#3.1 Baseline and Proposed Condition Model Inundation Boundary



Benefit Measurement

Per the TWDB, each FMP included in a regional flood plan is required to have a benefit cost analysis (BCA) performed. Some flood mitigation studies document a computed benefit cost ratio (BCR) and those can be incorporated into the regional flood plan. For situations where a BCR is not available for a project, TWDB has developed the BCA Input Tool to facilitate calculations of costs and benefits. The tool estimates flood impacts before and after implementation of the flood mitigation project for up to three recurrence interval flood events. The BCA considered the following project impacts: Residential Buildings, Commercial Structures, Critical Facilities, Street Flooding, Utility Outage, Agricultural Damage, Water Supply Benefits, and Recreational Benefits.

Benefit Inputs and Assumptions

In addition to the TWDB tool assumptions, the following assumptions were made to run the tool:

COST

HDR used 2023 costs to estimate the total cost for the Pearsall Drainage improvements as follows:

- FH#1.1: $2,438,000
- FH#2.1: $9,995,000
- FH#2.2: $1,331,000
- FH#3.1: $2,587,000

The 2023 estimated total project cost was input into the TWDB BCA Toolkit. The total cost includes all the required applicable TWDB FMP costs including basic engineering fees, special services such as surveying, environmental, geotech, etc., other costs such as land/easement acquisition and administration, fiscal services, and contingency. The following are the assumptions made for each cost:

- Design and Permitting – 15% of the estimated construction cost
- Environmental; archaeological & historical resources – $10,000
- Legal assistance; fiscal services & costs (bond counsel); outreach – 3% of the estimated construction cost
- Interest during construction (assume at 1 year) – 3.5%
- Contingency(s) – 35% of the estimated construction cost per the American Association of Cost Engineering (AACE) Class 4 Estimates for Feasibility Studies

Per the TWDB FMP cost requirements, all costs in the Plan should be reported using 2020 prices. A Construction Cost Index (CCI) factor of 0.87 was applied to convert the costs from 2023 to 2020 dollars, resulting in a project cost of the following.

- FH#1.1: $2,129,000
- FH#2.1: $8,724,000
- FH#2.2: $1,163,000
- FH#3.1: $2,258,000

CONSTRUCTION YEAR

Construction is assumed to start in the near future, dependent on funding. Construction year in the BCA was set to begin in 2025 and end in 2026 for each project.

RESIDENTIAL STRUCTURES

Residential structures are evaluated by the size and amount flooded for the baseline and proposed project conditions. The size categories in the BCA are classified as “Small Home,” “Average Home,” and “Large Home.” The TWDB guidelines give the following as typical sizes for each: “Small” = 1000 square feet, “Average” = 2,500 square feet, and “Large” = 5,000 square feet. For the residential structure analysis, the following size assumptions were made:

- Small: x < 2500 square feet
- Average: 2500 square feet < x <5000 square feet
- Large: x > 5000 square feet

The TWDB tool limits the total amount of residential buildings that can be assessed per project to 100 structures. For this project, more than 100 structures were impacted. Instead of looking at each individual structure’s damages for baseline and proposed conditions, the total amount of impacted structures within the same size category and inundation depth were totaled per condition analyzed. Inundation depths were rounded to the nearest inch.

COMMERCIAL STRUCTURES

Commercial building damages are determined by business type and size (square footage). With limited data on the type of commercial buildings, all commercial buildings were assumed to be Retail-Clothing. This type has the closest damages per square feet. to the average of all commercial types damages per square feet, as determined by the BCA assumptions. Inundation depths were rounded to the nearest inch.

Structures labeled as vacant or agriculture were not included in the BCA damages.

FLOODED STREETS

Streets are considered impassable if the flood depth is above 6 inches. The daily traffic count was estimated based on the TxDOT daily traffic count or the nearest adjacent road, as provided by the TxDOT TPP District Traffic Web Viewer[1].The additional time that the longest detour takes for an individual is calculated assuming a speed limit of 35 miles per hour (mph). The Normal Emergency Medical Services (EMS) response time for both baseline and proposed conditions is assumed to be 14.5 minutes, based on the rural mean value from Table 2 of the NIH JAMA Surgery study[2]. The EMS response time during a storm event is assumed to double for baseline conditions. For proposed conditions, the EMS response time is adjusted to the same percent difference between detour routes (pre- and post-project). The number of households and commercial

[1] https://txdot.maps.arcgis.com/apps/webappviewer/index.html?id=06fea0307dda42c1976194bf5a98b3a1

[2] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5831456/

structures impacted by EMS delay due to flooded streets is assumed to be the total number of residential and commercial structures inundated during the given storm event.

Benefit Result

The BCA Input Tool is intended to be used in conjunction with the Federal Emergency Management Agency (FEMA) BCA Toolkit 6.0, which calculates annual benefits from the information compiled in the TWDB BCA Input Tool. The annual benefits data are then inputted back into the TWDB BCA Input Tool to compute the resulting BCR for the project. The following table summarizes each of the impacts per storm and the final BCR for each of the Pearsall projects.

Figure 6. BCA Tool Results – Pearsall FH#1.1 Drainage Improvements FMP

Input Into BCA Toolkit

Project Useful Life	**30**

Event Damages	Baseline	Project
2 - year storm	**$1,075,818**	**$1,025,240**
10 - year storm	**$6,219,366**	**$6,125,311**
100 - year storm	**$14,511,907**	**$12,141,612**

Total Benefits from BCA Toolkit	$6,101,054
Other Benefits (Not Recreation)	$118,226
Recreation Benefits	-
Total Costs[1]	$3,758,799
Net Benefits	$2,460,481
Net Benefits with Recreation	$2,460,481
Final BCR	**1.7**
Final BCR with Recreation	**1.7**

1: BCA Costs in Figure 6 are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Figure 7. BCA Tool Results – Pearsall FH#2.1 Drainage Project FMP

Input Into BCA Toolkit

Project Useful Life **30**

Event Damages	Baseline	Project
2 - year storm	**$1,075,818**	**$1,025,240**
10 - year storm	**$6,219,366**	**$6,116,514**
100 - year storm	**$14,511,907**	**$14,439,908**

Total Benefits from BCA Toolkit	$537,721
Other Benefits (Not Recreation)	$0
Recreation Benefits	-
Total Costs[1]	$8,444,112
Net Benefits	-$7,906,391
Net Benefits with Recreation	-$7,906,391
Final BCR	**0.1**
Final BCR with Recreation	**0.1**

1: BCA Costs in Figure 7 are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Figure 8. BCA Tool Results – Pearsall FH#2.2 Drainage Project FMP

Input Into BCA Toolkit

Project Useful Life **30**

Event Damages	Baseline	Project
2 - year storm	**$1,075,818**	**$1,077,768**
10 - year storm	**$6,219,366**	**$6,085,495**
100 - year storm	**$14,511,907**	**$13,858,653**

Total Benefits from BCA Toolkit	$562,254
Other Benefits (Not Recreation)	$0
Recreation Benefits	-
Total Costs[1]	$1,124,904
Net Benefits	-$562,650
Net Benefits with Recreation	-$562,650
Final BCR	**0.5**
Final BCR with Recreation	**0.5**

1: BCA Costs in Figure 8 are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Figure 9. BCA Tool Results – Pearsall FH#3.1 Drainage Project FMP

Input Into BCA Toolkit

Project Useful Life	**30**	

Event Damages	Baseline	Project
2 - year storm	**$1,075,818**	**$1,025,240**
10 - year storm	**$6,219,366**	**$6,344,761**
100 - year storm	**$14,511,907**	**$14,368,368**

Total Benefits from BCA Toolkit	$646,089
Other Benefits (Not Recreation)	$0
Recreation Benefits	-
Total Costs[1]	$2,185,688
Net Benefits	-$1,539,599
Net Benefits with Recreation	-$1,539,599
Final BCR	**0.3**
Final BCR with Recreation	**0.3**

1: BCA Costs in Figure 9 are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Impact Analysis

An FMP is required to have no negative impacts in the neighboring area, either upstream or downstream of the project. No negative impact means that a project will not increase flood risk of surrounding properties. The increase in flood risk must be measured by the 100-year frequency storm water surface elevation and peak discharge using the best available data. No rise in water surface elevation or discharge is permissible, and the study area must be sufficiently large to demonstrate that proposed project conditions are equal to or less than the existing (baseline) conditions.

For the purposes of regional flood planning efforts, a determination of no negative impacts can be established if stormwater runoff does not increase inundation of infrastructure such as residential and commercial structures or exceed the design capacity of stormwater systems. According to the TWDB Exhibit C Technical Guidelines, all of the following requirements should be met to establish no negative impact, as applicable:

1. Stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement.

2. Stormwater does not increase inundation of storm drainage networks, channels, and roadways beyond design capacity.

3. Maximum increase of 1D Water Surface Elevation must round to 0.0 feet (<0.05 feet) measured along the hydraulic cross-section.

4. Maximum increase of 2D Water Surface Elevations must round to 0.3 feet (<0.35 feet) measured at each computation cell.

5. Maximum increase in hydrologic peak discharge must be <0.5 percent measured at computation nodes (sub-basins, junctions, reaches, reservoirs, etc.). This discharge restriction does not apply to a 2D overland analysis.

Because the Pearsall Drainage Improvements analysis was performed using a 2D modeling software, only requirements #1, #2, and #4 are applicable. In Table 5, 6, 7, and 8, the baseline conditions affected structures were compared to the proposed conditions affected structures. The comparison uses the regional geodatabase's structure feature class to measure expected flooding. Across all feature class elements no increase is observed, satisfying requirement #1. The maximum increase of the 2D water surface elevation when comparing baseline and proposed conditions is less than the 0.35 feet, satisfying both requirements #2 and #4. An evaluation of the pre- versus post- project conditions does not indicate increases in 100-year water surface elevations for neighboring properties and therefore satisfies the impact analysis requirements.

Flood Mitigation Project Technical Memorandum

Date: Thursday, June 08, 2023

To: Region 13 Flood Planning Group
c/o
Nueces River Authority

From: Bryan Martin, PE
HDR, Inc/
Firm No. 754
4401 W Gate Blvd Ste 400
Austin, TX 78745

Subject: FMP ID: 133000014
Project Sponsor: Crystal City
Project Name: Downtown Crystal City Regional Detention Pond Improvements

Methodologies and Procedures

1. Background

HDR Engineering, Inc. (HDR) advanced a flood mitigation project for the Crystal City, TX. This analysis was done to provide data for the 2023 Nueces Regional Flood Plan (the Plan) concerning potential Flood Mitigation Projects (FMPs) to be recommended in the 2023 Plan.

The project area is located in downtown Crystal City, in the area of flooding stretching from US Highway 83 east to FM 1433 road and south to E Val Verde Street. Flooding is caused by a large quantity of local drainage flowing into an inadequate storm drain network. The Crystal City Drainage Improvements (the Project) would reduce the amount of stormwater going into the existing pipes and reduce the total amount of structures flooded.

This memorandum documents the assumptions, methodologies and processes used to advance the FMP in accordance with the Texas Water Development Board (TWDB) Exhibit C Technical Guidelines for Regional Flood Planning FMP requirements.

2. Data Collection

All data were obtained as digital files in Geographic Information System (GIS) and Excel format. HDR gathered and compiled the following readily available geospatial data:

- National Oceanic and Atmospheric Administration (NOAA) - Atlas 14 Precipitation Frequency Data for Crystal City Texas (Table 1)

- Texas Natural Resources Information System (TNRIS) - United States Geological Survey (USGS) 1 meter resolution 2018 LiDAR-based digital elevation models (DEMs)
- United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) - Soil Survey Geographic Database (SSURGO) data for Zavala County
- TWDB – 2021 Texas Buildings with SVI and Estimated Population (TWDB, Center for Disease Control, Oak Ridge National Laboratory)
- Texas Department of Transportation (TxDOT) – 2016 TxDOT Roadways

Table 1. NOAA Precipitation Frequency Estimates (in inches) for Crystal City Texas

Duration	Average Recurrence Interval (years):			
	2	10	25	100
5-min:	0.539	0.825	1.00	1.28
15-min:	1.090	1.660	2.01	2.55
60-min:	2.000	3.060	3.73	4.75
2-hr:	2.370	3.780	4.73	6.34
3-hr:	2.560	4.190	5.34	7.39
6-hr:	2.900	4.850	6.30	8.96
12-hr:	3.250	5.430	7.06	10.10
24-hr:	3.610	5.990	7.77	11.10

3. Drainage Analysis

Distributed Hydrology

The methodology for the determination of storm water runoff is common between both Baseline- (also known as Existing) and Proposed- Conditions modeling. Infoworks ICM v2023.2 modeling software was used to prepare the rain-on-mesh approach for the 2-, 10-, 25-, and 100-year frequency storms. Hydrologic calculations were performed using Infoworks ICM software which applies designated rainfall, spatial distributions of hydrologic soil group, and corresponding constant infiltration rates within the 2D hydraulic domain.

INFILTRATION RATE

The infiltration rate was determined using SSURGO soil data for Crystal City Texas. Table 2and Table 3 summarize the type of soils found in the project area and the infiltration rates. Constant infiltration rates were applied spatially based on hydrologic soil group data.

Table 2. SSURGO Soils in Crystal City Texas

Soil Description	Hydraulic Soil Group	Condition
Bookout clay loam, 0 to 1 percent slopes	C	Well drained
Bookout clay loam, 1 to 3 percent slopes	C	Well drained
Brundage fine sandy loam, 0 to 1 percent slopes, occasionally flooded	D	Moderately well drained
Brundage fine sandy loam, frequently flooded	D	Moderately well drained
Brystal fine sandy loam, 1 to 3 percent slopes	B	Well drained
Chacon clay loam, 0 to 1 percent slopes	C	Well drained
Cochina clay, 0 to 1 percent slopes, frequently flooded	D	Moderately well drained
Cotulla clay, 0 to 3 percent slopes	D	Moderately well drained
Maverick clay loam, gently undulating	D	Well drained
Montell clay, 0 to 1 percent slopes	D	Moderately well drained
Pits	D	Well drained
Poteet fine sandy loam, frequently flooded	C	Moderately well drained
Pryor sandy clay loam, 1 to 3 percent slopes	C	Well drained
Tonio fine sandy loam, 0 to 1 percent slopes	B	Well drained
Tonio fine sandy loam, 1 to 3 percent slopes	B	Well drained
Verick fine sandy loam, 1 to 5 percent slopes	D	Well drained
Water	D	
Winterhaven silty clay loam, frequently flooded	B	Well drained
Winterhaven silty clay loam, rarely flooded, 0 to 1 percent slopes	B	Well drained
Winterhaven silty clay loam, rarely flooded, 1 to 3 percent slopes	B	Well drained

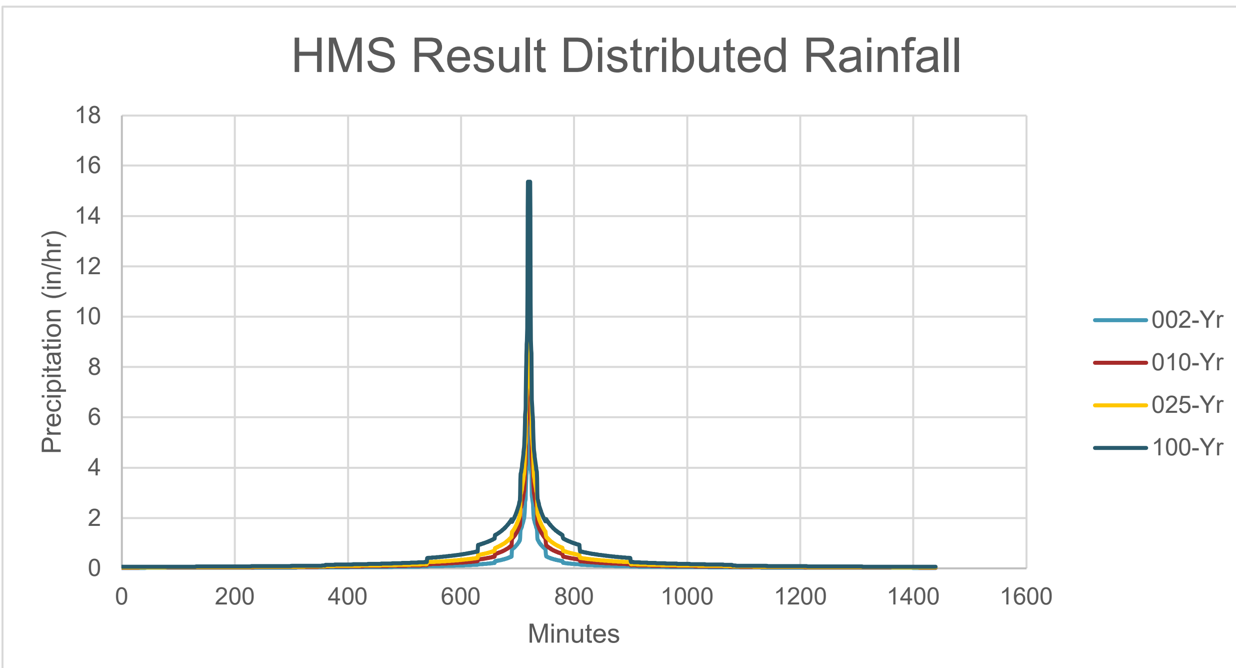
Table 3. Infiltration Model

Hydrologic Soil Group	Constant Infiltration Rate (in/hr)
A	0.35
B	0.23
C	0.1
D	0.02

RAINFALL

The rainfall data used in the ICM model were developed by inputting the Precipitation Frequency Estimates from NOAA (Table 1) into HEC-HMS v4.10 and running them with a generic basin. HEC-HMS calculates rainfall hyetographs that can then be imported into ICM. Figure 1displays the distributed rainfall per storm frequency for Crystal City, Texas:

Figure 1. HMS Result Distributed Rainfall for Crystal City



ROUGHNESS

The ICM model roughness component was created by combining the structure and pavement data with assigned Manning's N roughness values. The Manning's N values are based on engineering assessment of satellite imagery, TWDB building and TxDOT roadway data, the United States Army Corps of Engineers HEC-RAS Hydraulic Reference Manual, and the "Open Channel Hydraulics" (Chow, 1959) Manning's N for Channels table. Manning's N values are typically given in ranges to reflect the empirical nature of Manning's equation as well as the natural variability in land surface. An artificially high roughness value of 1.00 was used for structures to allow flow to enter structures with low velocity to represent flow conditions through structures. Table 4 summarizes the N values used:

Table 4. Manning's N Roughness Values

Description	Manning N Value
Light brush and trees	0.04-0.08
Structure	1.00
Impervious Area - Pavement (combined concrete and asphalt)	0.011 – 0.02
Meadow	0.055
Pasture, no brush	0.025 – 0.050
Pasture, no brush	0.025 – 0.050
Forest	0.08 – 0.12
Residential - Yard	0.045

Baseline Hydraulic Conditions

Components used in the ICM model were adjusted to run baseline conditions and facilitate the benefit-cost analysis (BCA) process as described below.

TERRAIN ADJUSTMENTS

To determine the damages for this problem area, structures need to be evaluated based on flood depths. It was assumed that structures would only flood once the water surface elevation is above the structure's finished floor elevation (which was assumed to be the lowest adjacent ground elevation plus an average slab height of 0.5 feet). Structures were adjusted in ICM by assigning a finished floor elevation to each structure.

POROUS POLYGON ELEMENT

Elements provide a break in the 2D mesh elements at the boundary definition. A nominal porosity is defined for each element. These modified elements do not allow rainfall to fall onto the to fall onto the structure element so that all calculated flooding within the structure elements is caused by external runoff. The exclusion of rainfall directly on structures is assumed to have a negligible effect on the distributed hydrology.

Proposed Hydraulic Conditions

Proposed project conditions were analyzed in the same manner as baseline conditions by using the ICM software with the same components and running the same storm events (2-, 10-, 25-, and 100-year). In proposed conditions, two detention ponds and a

24” outfall system was used to mitigate the flooding issues. One detention pond is located at the corner of N 7th Ave and Popeye Ln . The proposed detention is approximately 8 feet deep with 25 acre-feet of storage. The placement of this detention pond is located on what is assumed to be public school property and would most likely require property acquisition. The other pond is located at the city-owned Bexar Park, between E Bexar St. and E Chambers St, alongside N 4th St. Acquisition costs for this property were not included in the estimate. The proposed detention pond is approximately 10 feet deep with 17.5 acre-feet of storage. The outlet pipe is 24” in diameter and 3,500 feet long. The outlet pipe runs along E Holland St, N 4th St, and turns north at N 1st St, and outfalls west of the intersection between N 1st St and E Jackson St.

4. Results, Benefits, and Impacts

Results

Table 5 summarizes the number of inundated commercial and residential structures for each analyzed storm event:

Table 5. Total Impacted Structures for Baseline and Proposed Conditions

Storm Frequency Event (Years)	Baseline Conditions (structures)	Proposed Conditions (structures)	Difference (structures)
2	110	65	-45
10	176	112	-64
25	220	142	-78
100	279	185	-94

Figure 2 displays the inundation boundary created by both the baseline and proposed conditions model results.

Figure 2. Baseline and Proposed Condition Model Inundation Boundary

Benefit Measurement

Per the TWDB, each FMP included in a regional flood plan is required to have a benefit cost analysis (BCA) performed. Some flood mitigation studies document a computed benefit cost ratio (BCR) and those can be incorporated into the regional flood plan. For situations where a BCR is not available for a project, TWDB has developed the BCA Input Tool to facilitate calculations of costs and benefits. The tool estimates flood impacts before and after implementation of the flood mitigation project for up to three recurrence interval flood events. Project impacts evaluated in the BCA considered Residential and Commercial Structures.

In addition to the TWDB tool assumptions, the following assumptions were made to run the tool:

COST

HDR used 2023 costs to estimate the total cost for the Crystal City Drainage Improvements to be $3,443,499.69. The total cost includes all the required applicable TWDB FMP costs including basic engineering fees, special services such as surveying, environmental, geotech, etc., other costs such as land/easement acquisition and administration, fiscal services, and contingency. The following are the assumptions made for each cost;

- Design and Permitting - 15% of the estimated construction costs
- Environmental; archaeological & historical resources – $10,000
- Temporary and/or permanent easements; land acquisition - $2/ square foot
- Utility Relocation - $100,000

- Legal assistance; fiscal services & costs (bond counsel); outreach - 3% of estimated construction cost
- Interest during construction (assumed at 1 year) – 3.5%
- Contingency(s) - 35% of the estimated construction cost per the American Association of Cost Engineering (AACE) Class 4 Estimates for Feasibility Studies

Per the TWDB FMP cost requirements all costs should be using 2020 prices. A Construction Cost Index (CCI) factor of 0.87 was applied to convert the costs from 2023 to 2020 dollars, resulting in a total project cost of $3,006,000.

CONSTRUCTION YEAR

Construction is assumed to start in the near future, dependent on funding. The construction year in the BCA was set to begin in 2025 and end in 2026 for each project.

RESIDENTIAL STRUCTURES

Residential structures are evaluated by the size and amount flooded for the baseline and proposed project conditions. The size categories in the BCA are classified as "Small Home," "Average Home," and "Large Home." The TWDB guidelines give the following as typical sizes for each: "Small" = 1,000 square feet, "Average" = 2,500 square feet, and "Large" = 5,000 square feet. For the residential structure analysis the following size assumptions were made;

- Small: x <2,500 square feet
- Average: 2,500 square feet < x < 5,000 square feet
- Large: x >5,000 square feet

The TWDB tool limits the total amount of residential structures that can be assessed per project to 100 structures. For this project, more than 100 structures were impacted. Instead of looking at each individual structure's damages for baseline and proposed conditions, the total amount of impacted structures within the same size category and inundation depth were totaled per condition analyzed. Inundation depths were rounded to the nearest inch.

COMMERCIAL STRUCTURES

Commercial structure damages are determined by business type and size (square footage). With limited data on the type of commercial structures, all commercial structures were assumed to be Retail-Clothing. This type has the closest damages per square feet to the average of all commercial types damages per square feet as determined by the BCA assumptions. Inundation depths were rounded to the nearest inch.

Benefit Result

The BCA Input Tool is intended to be used in conjunction with the Federal Emergency Management Agency (FEMA) BCA Toolkit 6.0, which calculates annual benefits from the information compiled in the TWDB BCA Input Tool. The annual benefits data are then inputted back into the TWDB BCA Input Tool to compute the resulting BCR for the project. The following table summarizes each of the impacts per storm and the final BCR for the project.

Figure 3. BCA Tool Results – Crystal City Drainage Project FMP

Input Into BCA Toolkit

Project Useful Life	**30**

Event Damages	Baseline	Project
2 - year storm	**$7,545,196**	**$4,638,115**
10 - year storm	**$11,785,581**	**$7,645,986**
25 – year storm	**$14,512,325**	**$9,435,753**
100 - year storm	**$18,250,447**	**$11,985,521**

Total Benefits from BCA Toolkit	$23,538,214
Other Benefits (Not Recreation)	$42,545
Recreation Benefits	-
Total Costs[1]	$2,909,304
Net Benefits	$20,671,456
Net Benefits with Recreation	$20,671,456
Final BCR	**8.1**
Final BCR with Recreation	**8.1**

1: BCA Costs in Figure 3 are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Impact Analysis

An FMP is required to have no negative impacts in the neighboring area, either upstream or downstream of the project. No negative impact means that a project will not increase flood risk of surrounding properties. The increase in flood risk must be measured by the 100-year frequency storm water surface elevation and peak discharge using the best available data. No rise in water surface elevation or discharge is permissible, and the study area must be sufficiently large to demonstrate that proposed project conditions are equal to or less than the existing (baseline) conditions.

For the purposes of regional flood planning efforts, a determination of no negative impacts can be established if stormwater runoff does not increase inundation of infrastructure such as residential and commercial structures or exceed the design capacity of stormwater systems. According to the TWDB Exhibit C Technical Guidelines, all of the following requirements should be met to establish no negative impact, as applicable:

1. Stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement.

2. Stormwater does not increase inundation of storm drainage networks, channels, and roadways beyond design capacity.

3. Maximum increase of 1D Water Surface Elevation must round to 0.0 feet (<0.05 feet) measured along the hydraulic cross-section.

4. Maximum increase of 2D Water Surface Elevations must round to 0.3 feet (<0.35 feet) measured at each computation cell.

5. Maximum increase in hydrologic peak discharge must be <0.5 percent measured at computation nodes (sub-basins, junctions, reaches, reservoirs, etc.). This discharge restriction does not apply to a 2D overland analysis.

Because the Crystal City Drainage Improvements analysis was performed using a 2D modeling software, only requirements #1, #2, and #4 are applicable. In this analysis, baseline condition affected structures were compared to the proposed conditions affected structures. The comparison shows that the number of commercial and residential structures affected by the 100-year storm was reduced by 94 structures in proposed conditions and no flooding at existing structures was increased, satisfying requirement #1. The maximum increase of the 2D water surface elevation when comparing baseline and proposed conditions is less than the 0.35 feet, satisfying both requirements #2 and #4. An evaluation of the pre- versus post- project conditions does not indicate increases in 100-year water surface elevations for neighboring properties and therefore satisfies the impact analysis requirements.

Flood Mitigation Project Technical Memorandum

Date: Thursday, June 08, 2023

To: Region 13 Flood Planning Group
c/o
Nueces River Authority

From: Bryan Martin, PE
HDR, Inc/
Firm No. 754
4401 W Gate Blvd Ste 400
Austin, TX 78745

Subject: FMP ID: 133000015
Project Sponsor: City of Devine
Project Name: Burnt Boot Creek Drainage Improvements from Route 132 to Colonial Parkway

Methodologies and Procedures

1. Background

HDR Engineering, Inc. (HDR) advanced a flood mitigation project for the City of Devine, TX (the City). This analysis was done to provide data for the 2023 Nueces Regional Flood Plan (the Plan) concerning potential Flood Mitigation Projects (FMPs) to be recommended in the 2023 Plan.

The problem area is located along Burnt Boot Creek that traverses through the City during large rain events. Burnt Boot Creek overtops its banks flooding adjacent properties. Several crossings and adjacent roadways become inundated. The Devine Drainage Improvements (the Project) would reduce the number of structures flooded by constructing a new drainage channel/upstream stormwater detention pond.

This memorandum documents the assumptions, methodologies and processes used to advance the FMP in accordance with the Texas Water Development Board (TWDB) Exhibit C Technical Guidelines for Regional Flood Planning FMP requirements.

2. Data Collection

All data were obtained as digital files in Geographic Information System (GIS) and Excel format. HDR gathered and compiled the following readily available geospatial data:

- National Oceanic and Atmospheric Administration (NOAA) - Atlas 14 Precipitation Frequency Data for the City of Devine as shown in Table 1.
- Texas Natural Resources Information System (TNRIS) - United States Geological Survey (USGS) 1 meter resolution 2018 LiDAR-based digital elevation models (DEMs)

- United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) - Soil Survey Geographic Database (SSURGO) data for Atascosa County
- TWDB – 2021 Texas Buildings with SVI and Estimated Population (TWDB, Center for Disease Control (CDC), Oak Ridge National Laboratory (ORNL))
- Texas Department of Transportation (TxDOT) – 2016 TxDOT Roadways

Table 1. NOAA Precipitation Frequency Estimates (in inches) for Devine

Duration	Average Recurrence Interval (years):			
	2	10	25	100
5-min:	0.53	0.76	0.91	1.13
15-min:	1.06	1.52	1.80	2.25
60-min:	1.94	2.79	3.33	4.17
2-hr:	2.36	3.56	4.35	5.64
3-hr:	2.60	4.04	5.02	6.66
6-hr:	3.01	4.83	6.10	8.30
12-hr:	3.40	5.51	7.00	9.65
24-hr:	3.82	6.21	7.92	11.00

3. Drainage Analysis

Distributed Hydrology

The methodology for the determination of storm water runoff is common between both Baseline- and Proposed- Conditions modeling. Infoworks ICM v2023.2 modeling software was used to prepare the rain-on-mesh approach for the 2-, 10-, 25-, and 100-year frequency storms. Hydrologic calculations were performed using Infoworks ICM software which uses designated rainfall and spatial distributions of infiltration capability.

INFILTRATION RATE

The infiltration rate was determined using SSURGO soils data for Devine, Texas. Table 2 and Table 3 summarize the type of soils found in the project area and the infiltration rates. Constant infiltration rates were applied spatially based on hydrologic soil group data.

Table 2. SSURGO Soils in Devine

Soil Description	Hydraulic Soil Group	Condition
Sayers soils, frequently flooded	A	Somewhat excessively drained
Duval loamy fine sand, 0 to 5 percent slopes	B	Well drained
Sinton soils, frequently flooded	B	Well drained
Amphion sandy clay loam, 0 to 1 percent slopes	C	Well drained
Amphion sandy clay loam, 1 to 3 percent slopes	C	Well drained
Christine soils, occasionally flooded	C	Somewhat poorly drained
Floresville fine sandy loam, 1 to 3 percent slopes	C	Well drained

Floresville fine sandy loam, 1 to 5 percent slopes, eroded	C	Well drained
Hanis sandy clay loam, 1 to 3 percent slopes	C	Well drained
Hanis sandy clay loam, 3 to 5 percent slopes	C	Well drained
Miguel fine sandy loam, 1 to 3 percent slopes	C	Well drained
Nusil-Rhymes association, 0 to 5 percent slopes	C	Well drained
Poteet soils, occasionally flooded	C	Moderately well drained
Poth loamy fine sand, 0 to 3 percent slopes	C	Well drained
Webb fine sandy loam, 1 to 3 percent slopes	C	Well drained
Webb fine sandy loam, 3 to 5 percent slopes	C	Well drained
Wilco loamy fine sand, 0 to 3 percent slopes	C	Well drained
Wilco loamy fine sand, 3 to 5 percent slopes	C	Well drained
Dilley fine sandy loam, 1 to 5 percent slopes	D	Well drained
Elmendorf-Denhawken complex, 1 to 4 percent slopes	D	Well drained
Tiocano clay, cool, 0 to 1 percent slopes, occasionally ponded	D	Somewhat poorly drained
Tordia clay, 1 to 4 percent slopes	D	Well drained
Water	D	

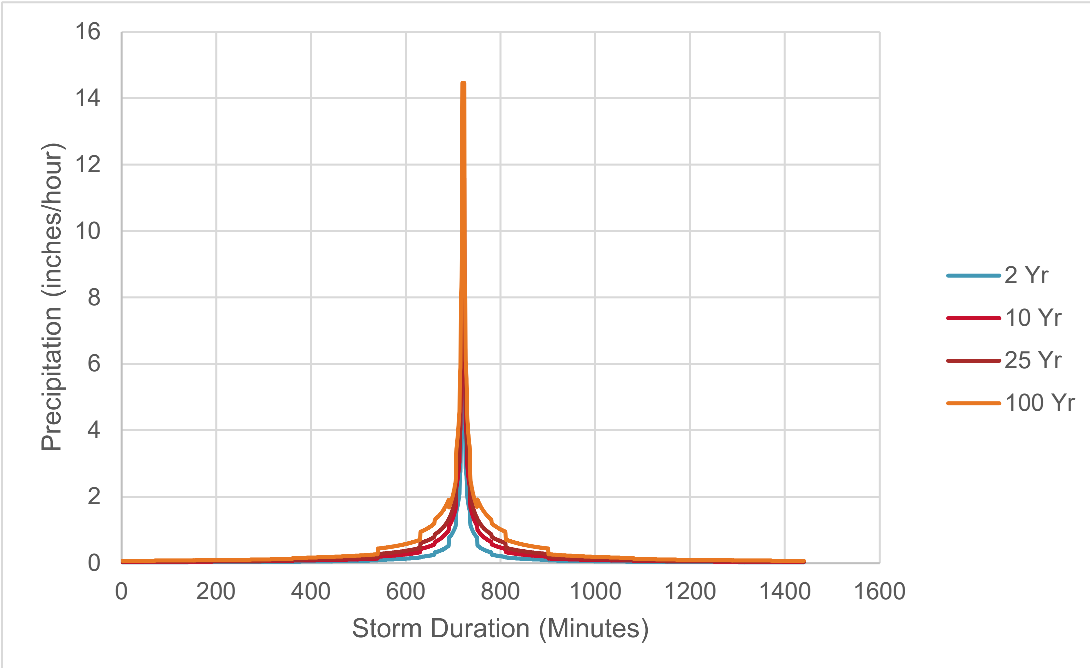
Table 3. Infiltration Model

Hydrologic Soil Group	Constant Infiltration Rate (in/hr)
A	0.35
B	0.23
C	0.1
D	0.02

RAINFALL

The rainfall data used in the ICM model was developed by inputting the Precipitation Frequency Estimates from NOAA (Table 1) into HEC-HMS v4.10 and running them with a generic basin. HEC-HMS calculates DSS rainfall hyetographs that can then be imported into ICM. Figure **Error! No text of specified style in document.**.a displays the distributed rainfall per storm frequency for Devine, Texas:

Figure Error! No text of specified style in document.**.a. HMS Result Distributed Rainfall for Devine**



ROUGHNESS

The ICM model roughness component was created by combining the structure and pavement data with assigned Manning's N roughness values. The Manning's N values are based on engineering assessment of satellite imagery, TWDB building and TxDOT roadway data, the United States Army Corps of Engineers HEC-RAS Hydraulic Reference Manual, and the "Open Channel Hydraulics" (Chow, 1959) Manning's N for Channels table. Manning's N values are typically given in ranges to reflect the empirical nature of Manning's equation as well as the natural variability in land surface. An artificially high roughness value of 1.00 was used for structures to allow flow to enter structures with low velocity to represent flow conditions through structures. Table 4 summarizes the N values used:

Table 4. Manning's N Roughness Values

Description	Manning's N Value
Structure	1.00
Forest	0.08 - 0.12
Light brush and trees	0.04 - 0.08
Impervious Area - Pavement (combined concrete and asphalt)	0.011 - 0.02

Baseline Hydraulic Conditions

Components used in the ICM model were adjusted to run baseline conditions and facilitate the benefit-cost analysis (BCA) process as described below.

TERRAIN ADJUSTMENTS

To determine the damages for this problem area, structures need to be evaluated based on flood depths. It was assumed that structures would only flood once the water surface elevation is above the structure's finished floor elevation (which was assumed to be the highest adjacent ground elevation plus an average slab height of 0.5 feet). Structures were adjusted in ICM by assigning a finished floor elevation to each structure."

POROUS POLYGON ELEMENT

Elements provide a break in the 2D mesh elements at the boundary definition. A nominal porosity is defined for each element. These modified elements do not allow rainfall to fall onto the structure element so that all calculated flooding within the structure elements is caused by external runoff. The omission of rainfall directly on structures is assumed to have a negligible effect on the distributed hydrology.

Proposed Hydraulic Conditions and Results

There are four projects proposed flood risk reduction benefit. Proposed project conditions were analyzed in kind with baseline conditions by using the ICM software with the same components and running the same storm events (2-, 10-, 25-, and 100-year). Proposed projects are outlined in the following sections;

- FH#1.1: Garcia & Wright Engineers Phase 1 and 2 Burnt Boot Creek Drainage Improvements.
- FH#1.2: Burnt Boot Creek Maximum Channel Conveyance.
- FH#2.1: Large Regional Detention Pond at Colonial Parkway.
- FH#2.2: Reduced Regional Detention Pond at Colonial Parkway.
- FH#3.1: Larger Stream Channel Passage at TX-132

FH#1.1: GARCIA & WRIGHT ENGINEERS PHASE 1 AND 2 BURNT BOOT CREEK DRAINAGE IMPROVEMENTS.

The project proposes stream channel and low water crossing conveyance improvements to mitigate the flooding issues along Burnt Boot Creek. The proposed channel alignment and low water crossing improvements were originally developed by Garcia & Wright Engineers. The proposed channel is approximately 5,700 feet in length, 110 feet in width, and approximately 4 feet deep. The new channel would extend from Howell Avenue (downstream extents) to Colonial Parkway (upstream extents). Low water crossings at Fay and Mesquite Avenues would be upsized with 8 – 10-foot by 6-foot box culverts. Low water crossings at Brown and McAnnelly Avenues would be demolished and abandoned. The proposed channel alignment traverses through privately held open land that would necessitate the need for drainage easement purchases.

Baseline and proposed conditions were analyzed for the total number of inundated commercial and residential structures for each storm event.

This project is expected to provide reduction in structural flooding as outlined in Table 5.

Table 5. FH#1.1 Total Impacted Structures for Baseline and Proposed Conditions

Storm (Year)	Baseline	Proposed	Difference
2	319	309	-10
10	464	458	-6
25	545	536	-9
100	668	651	-17

Figure 2a displays the project location and concept details.

Figure 2a. FH#1.1 Garcia & Wright Channel Phase 1 and 2.

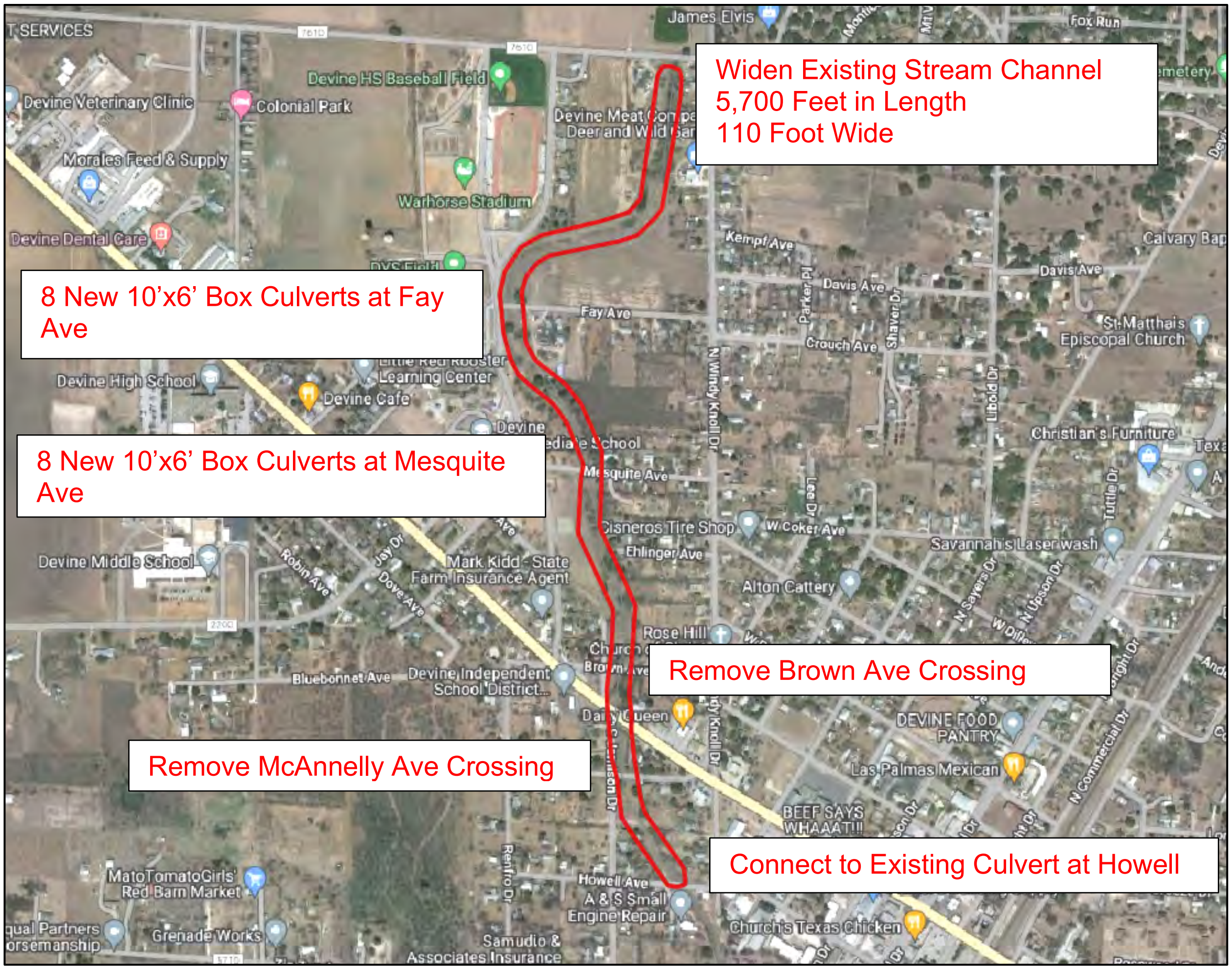
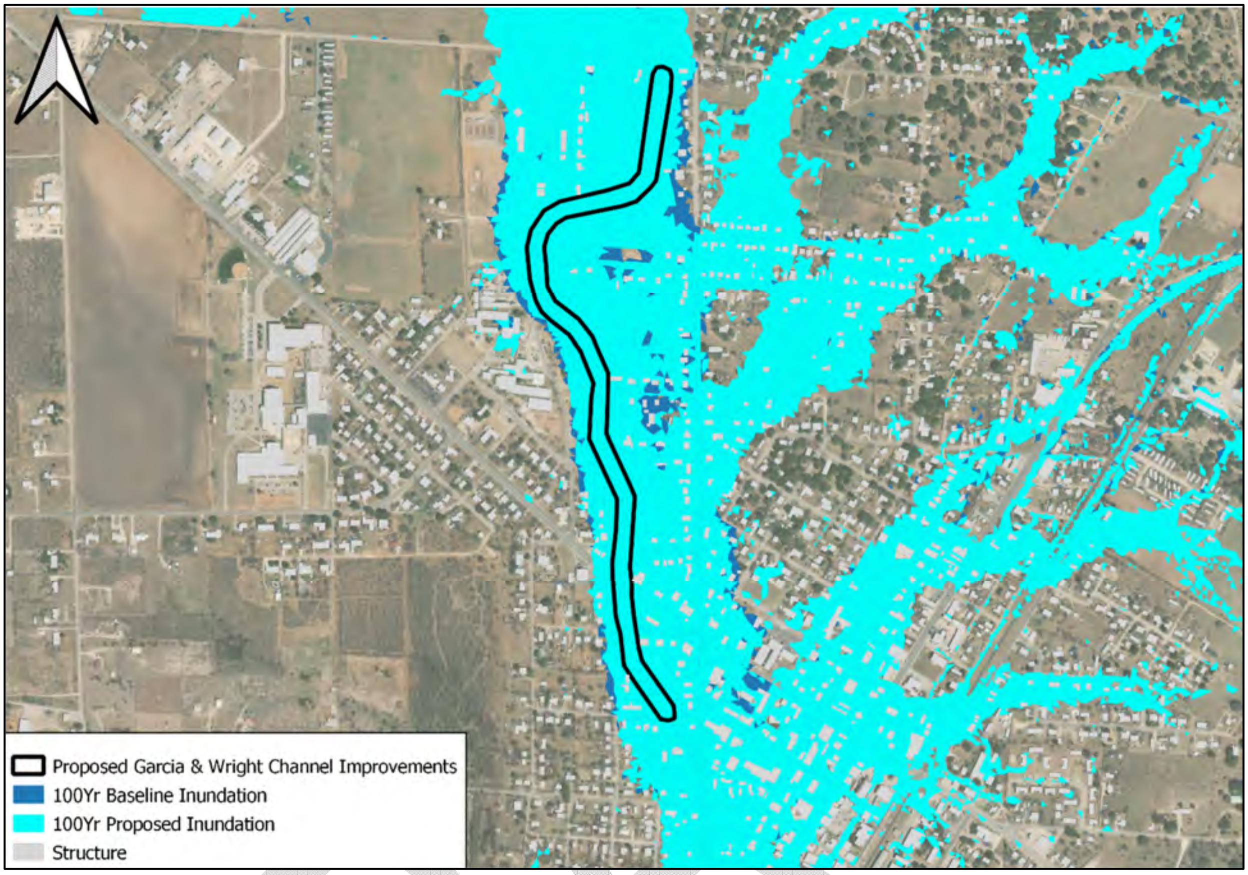


Figure 2b. FH#1.1 Garcia & Wright Channel Phase 1 and 2 100-Year Inundation.



FH#1.2: BURNT BOOT CREEK MAXIMUM CHANNEL CONVEYANCE.

Burnt Boot Creek Maximum Channel Conveyance proposes maximizing the available full width and length of the Burnt Boot Creek from Route 132 to Colonial Parkway. The total length of the channel conveyance improvements would be approximately 9,000 feet in length, 120 feet in width, and approximately 6 to 9 feet deep depending on location. This channel would be approximately double the proposed length of the proposed Garcia & Wright Engineering channel. This proposed channel would extend from Route 132 (downstream extents) to Colonial Parkway (upstream extents). New bridges would be installed at Fay, Hondo, and Zig Zag Avenues. Low Water Crossings at Mesquite, Brown, McAnnelly, and Howell Avenues would be demolished and abandoned.

Baseline and proposed conditions were analyzed. The following table summarizes the total number of inundated commercial and residential structures for each storm event.

This project is expected to provide reduction in structural flooding as outlined in Table 6.

Table 6. FH#1.2 Total Impacted Structures for Baseline and Proposed Conditions

Storm (Year)	Baseline	Proposed	Difference
2	319	301	-18
10	464	420	-44
25	545	494	-51
100	668	594	-74

Figure 3a displays the project location and concept details. Figure 3b displays the 100-year flood extents of baseline and proposed conditions.

Figure 3a. FH#1.2 Burnt Boot Creek Maximum Channel.

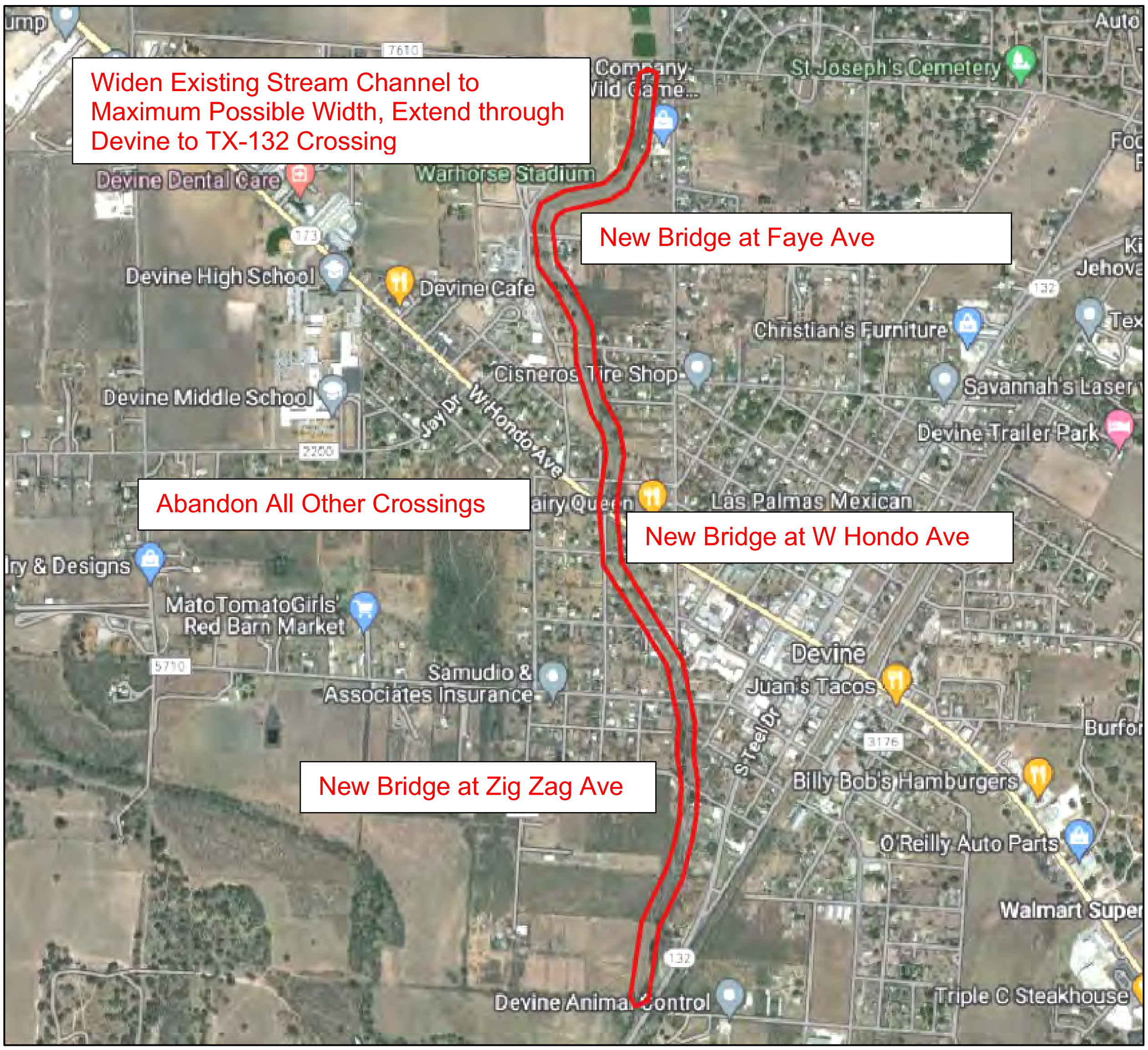
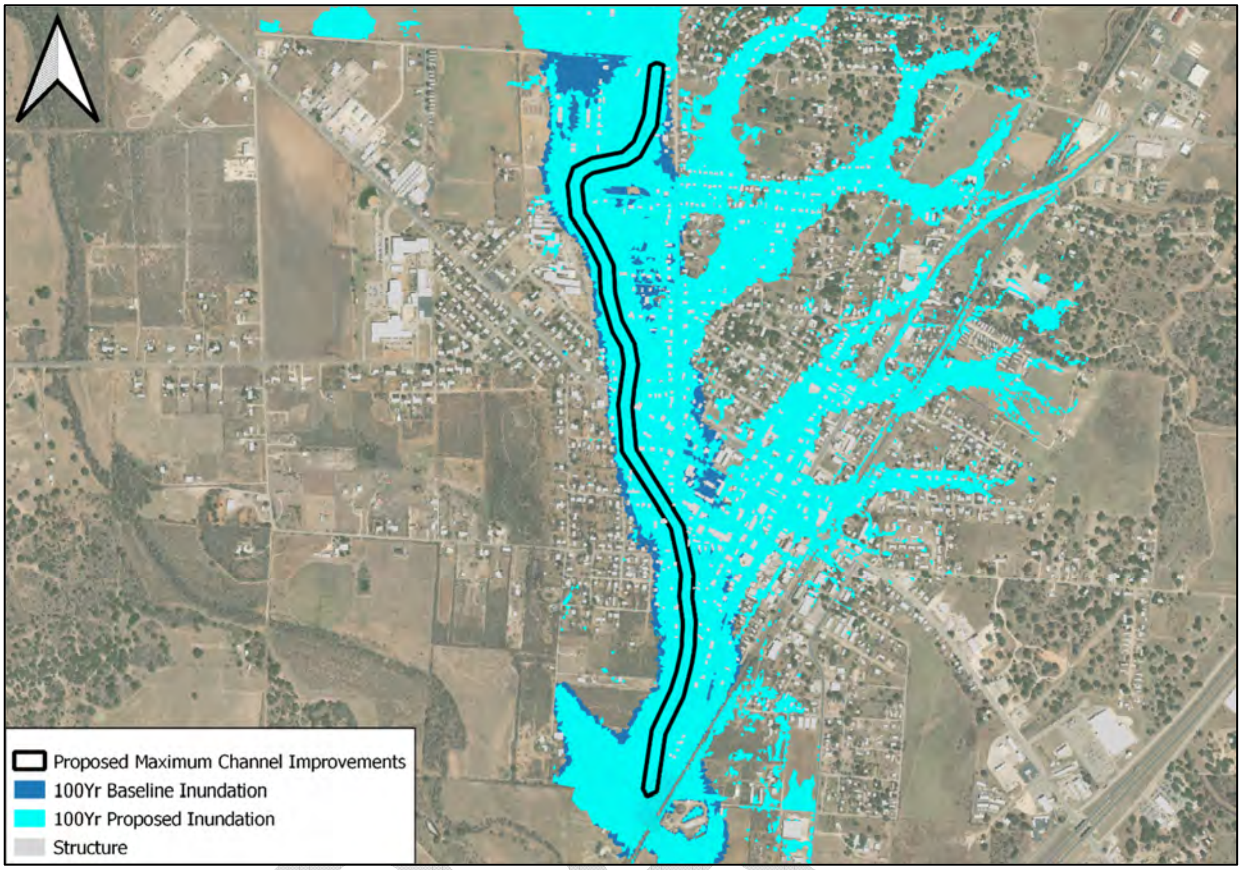


Figure 3b. FH#1.2 Burnt Boot Creek Maximum Channel 100 Year Inundation.



FH#2.1: LARGE REGIONAL DETENTION POND AT COLONIAL PARKWAY.

This project proposes a large detention pond at Colonial Parkway to mitigate the flooding issues. The placement of the detention ponds is located on privately owned property within a low lying flood prone area in a FEMA regulated floodway. The pond has approximately 1,300 acre-feet of storage. The outlet from the pond would include a control structure with twin 10 foot by 5 foot box culverts. The construction of the detention pond would necessitate the need for full property buyouts of eight (8) privately held properties.

Baseline and proposed conditions were analyzed. Table 7 summarizes the total number of inundated commercial and residential structures for each storm event.

This project is expected to provide reduction in structural flooding as outlined in Table 7.

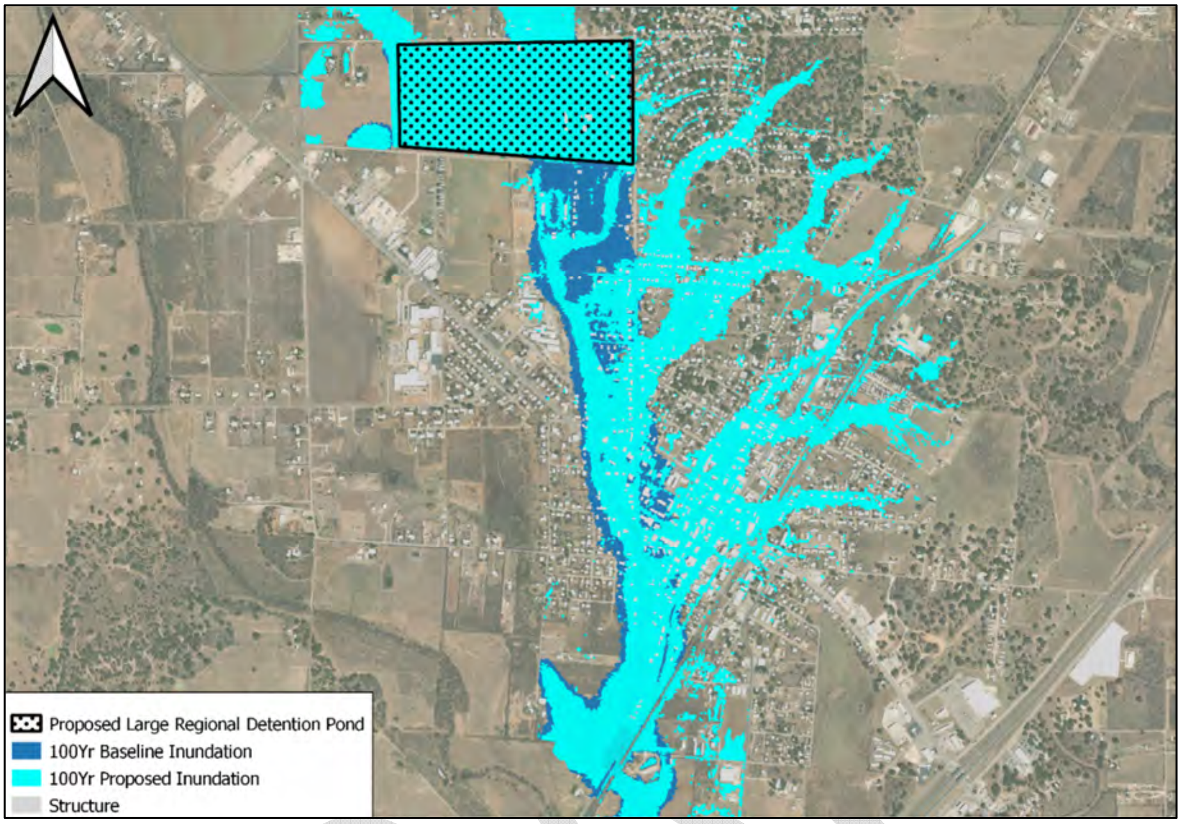
Table 7. FH#2.1 Total Impacted Structures for Baseline and Proposed Conditions

Storm (Year)	Baseline	Proposed	Difference
2	319	296	-23
10	464	426	-38
25	545	490	-55
100	668	590	-78

Figure 4a displays the project location and concept details. Figure 4b displays the 100-year flood extents of baseline and proposed conditions.

Figure 4a. FH#2.1 Large Detention Pond at Colonial Parkway.

Figure 4b. FH#2.1 Large Detention Pond at Colonial Parkway 100 Year Inundation.



FH#2.2: REDUCED SIZE REGIONAL DETENTION POND AT COLONIAL PARKWAY.

This project proposes a detention pond at Colonial Parkway to mitigate the flooding issues. Pond is located in the same location as FH#2.1 but with a reduced footprint. The placement of the detention ponds is located on privately owned property within a low lying flood prone area in FEMA regulated floodway. The pond has approximately 500 acre-feet of storage. The outlet from the pond would include a control structure with twin 10 foot by 5 foot box culverts.

Baseline and proposed conditions were analyzed. Table 8 summarizes the total number of inundated commercial and residential structures for each storm event.

This project is expected to provide reduction in structural flooding as outlined in Table 8.

Table 8. FH#2.2 Total Impacted Structures for Baseline and Proposed Conditions

Storm (Year)	Baseline	Proposed	Difference
2	319	296	-23
10	464	425	-39
25	545	498	-47
100	668	622	-46

Figure 5a displays the project location and concept details. Figure 5b displays the 100-year flood extents of baseline and proposed conditions.

Figure 5a. FH#2.2 Reduced Detention Pond at Colonial Parkway.

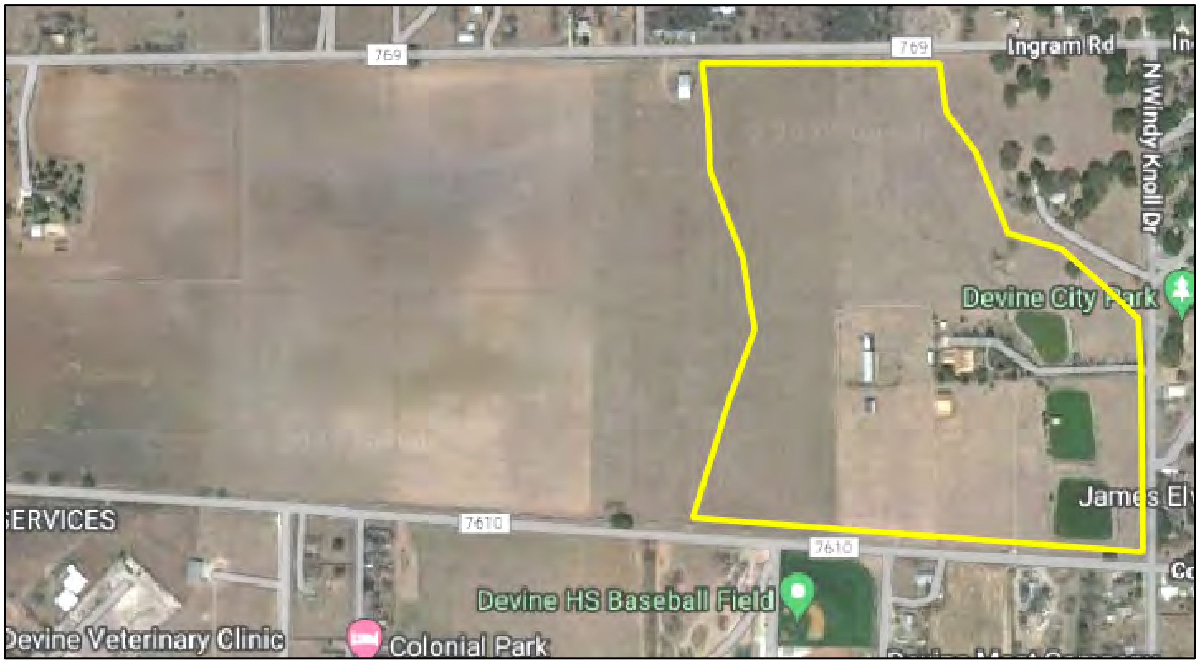
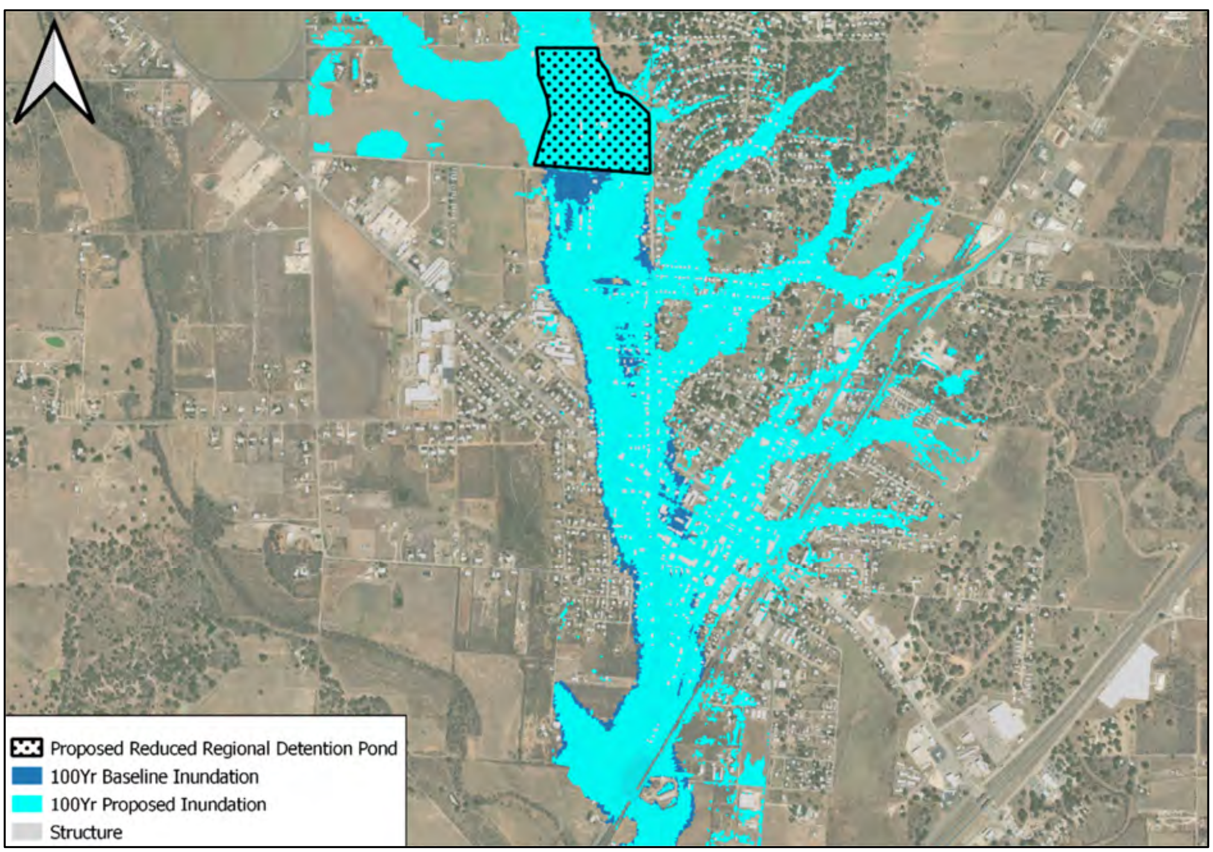


Figure 5b. FH#2.2 Reduced Detention Pond at Colonial Parkway 100 Year Inundation.



FH#3.1: LARGER STREAM CHANNEL PASSAGE AT TX-132

This project proposes widening the Burnt Boot Creek stream channel passage at TX-132. Currently the stream channel becomes constricted under the TX-132 bridge. City officials requested this crossing be analyzed as part of the study. This project would increase the distance of the bridge to widen the stream passage to roughly the same width as the existing railroad bridge.

Baseline and proposed conditions were analyzed. Table 9 summarizes the total number of inundated commercial and residential structures for each storm event.

Table 9. FH#3.1 Total Impacted Structures for Baseline and Proposed Conditions

Storm (Year)	Baseline	Proposed	Difference
2	319	319	0
10	464	464	0
25	545	545	0
100	668	668	0

The Figure 6a displays the project location and concept details. Figure 6b displays the 100-year flood extents of baseline and proposed conditions.

Figure 6a. FH#3.1 Larger Stream Channel Passage at TX-132

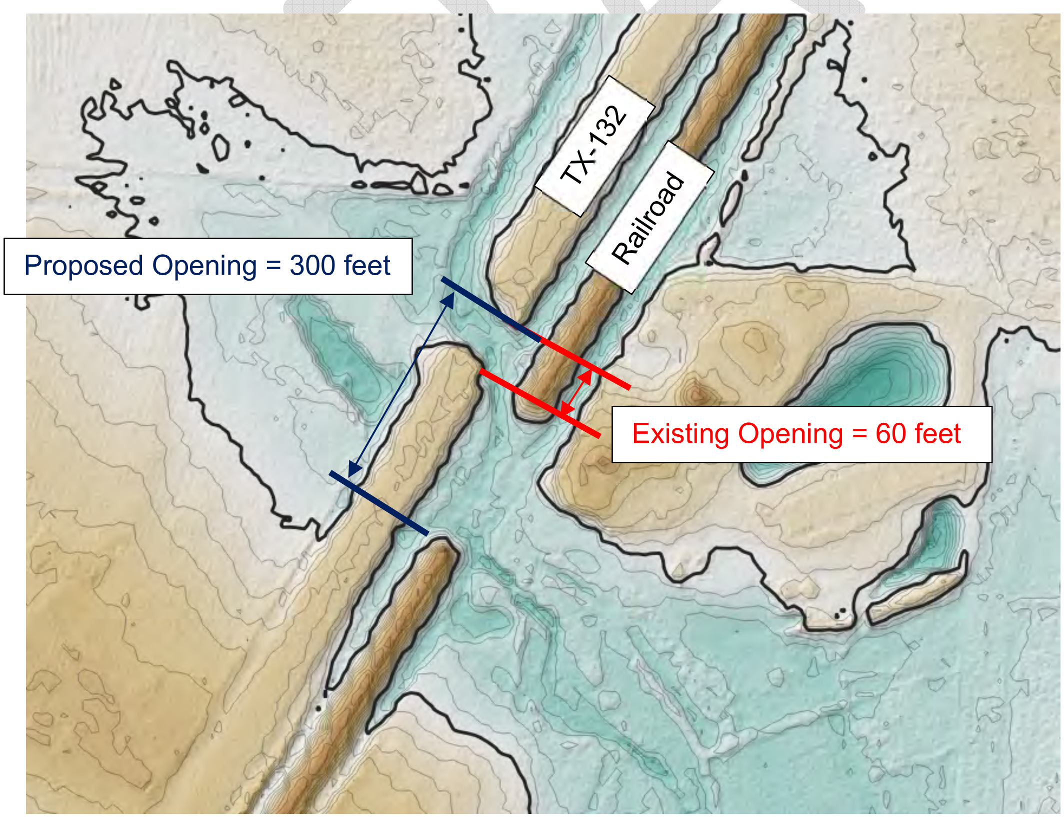
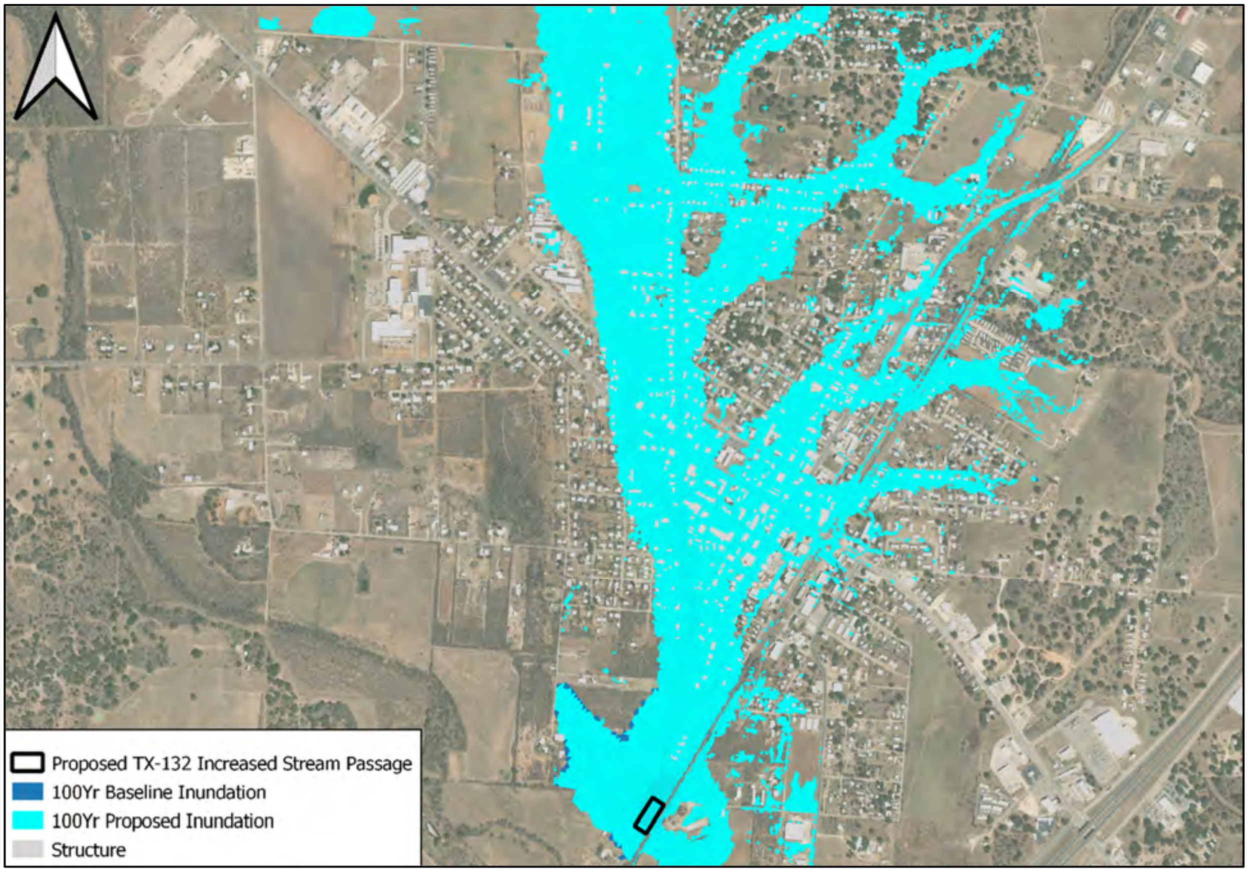


Figure 56. FH#3.1 Larger Stream Channel Passage at TX-132 100 Year Inundation



4. Benefit Measurement

Per the TWDB, each FMP included in a regional flood plan is required to have a benefit cost analysis (BCA) performed. Some flood mitigation studies document a computed benefit cost ratio (BCR) and those can be incorporated into the regional flood plan. For situations where a BCR is not available for a project, TWDB has developed the BCA Input Tool to facilitate calculations of costs and benefits. The tool estimates flood impacts before and after implementation of the flood mitigation project for up to three recurrence interval flood events. The BCA considered the following project impacts: Residential Structures, Commercial Structures, Critical Facilities, Street Flooding, Utility Outage, Agricultural Damage, Water Supply Benefits, and Recreational Benefits.

Benefit Inputs and Assumptions

In addition to the TWDB tool assumptions, the following assumptions were made to run the tool:

COST

HDR used 2023 costs to estimate the total cost for the Devine Drainage improvements as follows:

- FH#1.1: $3,000,000
- FH#1.2: $14,500,000

- FH#2.1: $54,300,000
- FH#2.2: $11,000,000
- FH#3.1: Not costed, no flood reduction benefit

The 2023 estimated total project cost was input into the TWDB BCA Toolkit. The total cost includes all the required applicable TWDB FMP costs including basic engineering fees, special services such as surveying, environmental, geotech, etc., other costs such as land/easement acquisition and administration, fiscal services, and contingency. The following are the assumptions made for each cost.

- Design and Permitting - 15% of the estimated construction cost
- Environmental; archaeological & historical resources – $10,000
- Legal assistance; fiscal services & costs (bond counsel); outreach - 3% of the estimated construction cost
- Interest during construction (assume at 1 year) – 3.5%
- Contingency(s) - 35% of the estimated construction cost per the American Association of Cost Engineering (AACE) Class 4 Estimates for Feasibility Studies

Per the TWDB FMP cost requirements, all costs in the Plan should be reported using 2020 prices. A Construction Cost Index (CCI) factor of 0.87 was applied to convert the costs from 2023 to 2020 dollars, resulting in a project cost of the following:

- FH#1.1: $2,600,000
- FH#1.2: $12,600,000
- FH#2.1: $47,300,000
- FH#2.2: $9,600,000
- FH#3.1: Not costed, no flood reduction benefit

CONSTRUCTION YEAR

Construction is assumed to start in the near future, dependent on funding. Construction year in the BCA was set to begin in 2025 and end in 2026 for each project.

RESIDENTIAL STRUCTURES

Residential structures are evaluated by the size and amount its flooded for the baseline and proposed project conditions. The size categories in the BCA are classified as “Small Home,” “Average Home,” and “Large Home.” The TWDB guidelines give the following as typical sizes for each: “Small” = 1,000 square feet, “Average” = 2,500 square feet, and “Large” = 5,000 square feet. For the residential structure analysis, the following size assumptions were made:

- Small: x < 2,500 square feet
- Average: 2,500 square feet< x <5,000 square feet
- Large: x > 5,000 square feet

The TWDB tool limits the total amount of residential structures that can be assessed per project to 100 structures. For this project, more than 100 structures were impacted. Instead of looking at each individual structure's damages for baseline and proposed conditions, the total amount of impacted structures within the same size category and inundation depth were totaled per condition analyzed. Inundation depths were rounded to the nearest inch.

COMMERCIAL STRUCTURES

Commercial structure damages are determined by business type and size (square footage). With limited data on the type of commercial structures, all commercial structures were assumed to be Retail-Clothing. This type has the closest damages per square feet to the average of all commercial types damages per square feet, as determined by the BCA assumptions. Inundation depths were rounded to the nearest inch.

Structures labeled as vacant or agriculture were not included in the BCA damages.

Benefit Result

The BCA Input Tool is intended to be used in conjunction with the Federal Emergency Management Agency (FEMA) BCA Toolkit 6.0, which calculates annual benefits from the information compiled in the TWDB BCA Input Tool. The annual benefits data are then inputted back into the TWDB BCA Input Tool to compute the resulting BCR for the project. The following table summarizes each of the impacts per storm and the final BCR for each of the Devine projects, except FH#3.1 as this project did not have any flood reduction benefit.

Figure 6. BCA Tool Results – Devine FH#1.1 Drainage Improvements FMP

Input Into BCA Toolkit

Project Useful Life	**30**

Event Damages	Baseline	Project
2 - year storm	**$15,704,893**	**$14,952,924**
10 - year storm	**$24,232,343**	**$23,367,507**
100 - year storm	**$37,391,153**	**$35,811,871**

Total Benefits from BCA Toolkit	$5,553,977
Other Benefits (Not Recreation)	-
Recreation Benefits	-
Total Costs[1]	$2,619,000
Net Benefits	$2,934,977
Net Benefits with Recreation	$2,934,977
Final BCR	**2.1**
Final BCR with Recreation	**2.1**

- 1: BCA Costs in Figure 3 are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Figure 7. BCA Tool Results – Devine FH#1.2 Drainage Project FMP

Input Into BCA Toolkit

Project Useful Life	**30**

Event Damages	Baseline	Project
2 - year storm	**$15,704,893**	**$14,405,301**
10 - year storm	**$24,232,343**	**$20,691,577**
100 - year storm	**$37,391,153**	**$30,318,440**

Total Benefits from BCA Toolkit	$6,502,685
Other Benefits (Not Recreation)	-
Recreation Benefits	-
Total Costs[1]	$12,635,000
Net Benefits	($6,132,315)
Net Benefits with Recreation	($6,132,315)
Final BCR	**0.5**
Final BCR with Recreation	**0.5**

- 1: BCA Costs in Figure 3 are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Figure 8. BCA Tool Results – Devine FH#2.1 Drainage Project FMP

Input Into BCA Toolkit

Project Useful Life	**30**

Event Damages	Baseline	Project
2 - year storm	**$15,704,893**	**$14,061,506**
10 - year storm	**$24,232,343**	**$20,926,331**
100 - year storm	**$37,391,153**	**$30,083,741**

Total Benefits from BCA Toolkit	$6,502,623
Other Benefits (Not Recreation)	-
Recreation Benefits	-
Total Costs[1]	$47,351,000
Net Benefits	($40,848,315)
Net Benefits with Recreation	($40,848,315)
Final BCR	**0.1**
Final BCR with Recreation	**0.1**

- 1: BCA Costs in Figure 3 are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Figure 9. BCA Tool Results – Devine FH#2.2 Drainage Project FMP

Input Into BCA Toolkit

Project Useful Life	**30**

Event Damages	Baseline	Project
2 - year storm	**$15,704,893**	**$14,061,506**
10 - year storm	**$24,232,343**	**$20,875,753**
100 - year storm	**$37,391,153**	**$33,042,314**

Total Benefits from BCA Toolkit	$4,760,741
Other Benefits (Not Recreation)	-
Recreation Benefits	-
Total Costs[1]	$9,577,000
Net Benefits	($4,816,259)
Net Benefits with Recreation	($4,816,259)
Final BCR	**0.5**
Final BCR with Recreation	**0.5**

- 1: BCA Costs in Figure 3 are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

5. Impact Analysis

An FMP is required to have no negative impacts on the study area due to its implementation. No negative impact means that a project will not increase flood risk of surrounding properties. The increase in flood risk must be measured by the 100-year frequency storm water surface elevation and peak discharge, using the best available data. No rise in water surface elevation or discharge is permissible, and the study area must be sufficiently large to demonstrate that proposed project conditions are equal to or less than the existing (baseline) conditions.

For the purposes of regional flood planning efforts, a determination of no negative impacts can be established if stormwater runoff does not increase inundation of infrastructure such as residential and commercial and structures or exceed the design capacity of stormwater systems. According to the TWDB Exhibit C Technical Guidelines, all of the following requirements should be met to establish no negative impact, as applicable:

1. Stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement.

2. Stormwater does not increase inundation of storm drainage networks, channels, and roadways beyond design capacity.

3. Maximum increase of 1D Water Surface Elevation must round to 0.0 feet (<0.05 feet) measured along the hydraulic cross-section.

4. Maximum increase of 2D Water Surface Elevations must round to 0.3 feet (<0.35 feet) measured at each computation cell.

5. Maximum increase in hydrologic peak discharge must be <0.5 percent measured at computation nodes (sub-basins, junctions, reaches, reservoirs, etc.). This discharge restriction does not apply to a 2D overland analysis.

Because the Devine Drainage Improvements analysis was performed using 2D modeling software, only requirements #1, #2, and #4 are applicable. Water surface elevation rasters were extracted from the model for baseline existing conditions and the proposed project conditions for the 100 year event. Proposed WSEs were compared to baseline WSEs to identify any increases in WSE exceeding 0.35 feet. Figures 10 through 13 show locations where water surface elevations exceed 0.35 feet as indicated in Blue.

Figure 10. Impact Analysis - Devine FH#1.1 Drainage Project FMP

Figure 11. Impact Analysis - Devine FH#1.2 Drainage Project FMP

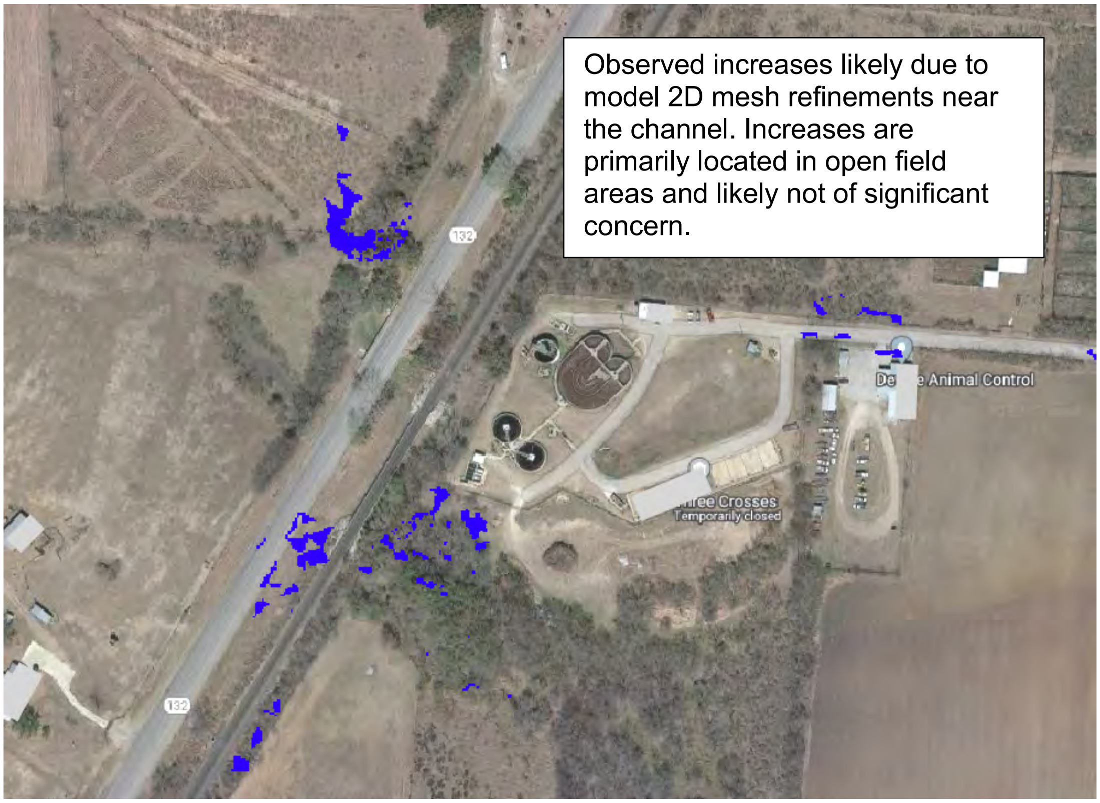
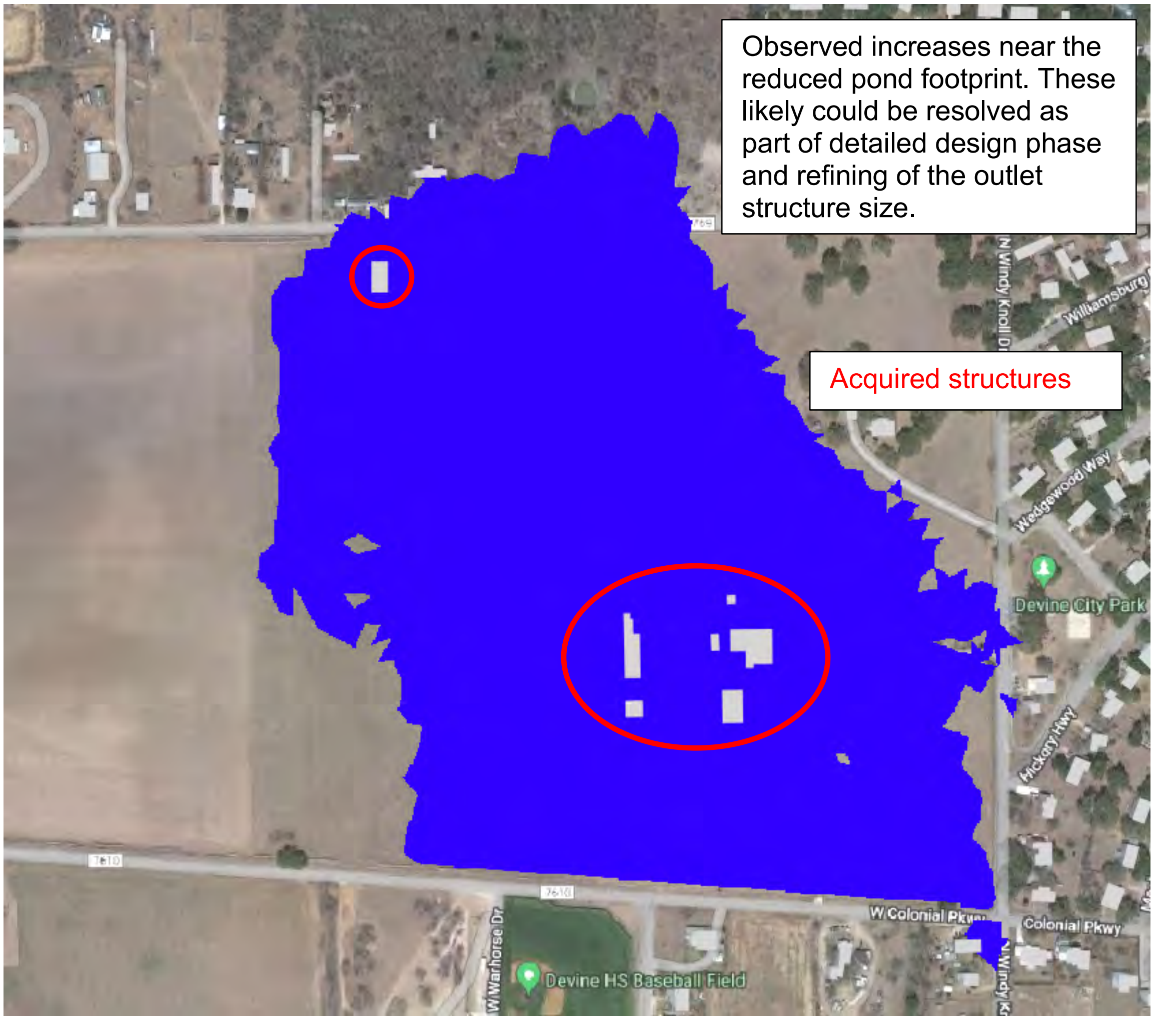


Figure 12. Impact Analysis - Devine FH#2.1 Drainage Project FMP

Figure 13. Impact Analysis - Devine FH#2.1 Drainage Project FMP



6. Recommendation

None of the alternatives presented in this memo are officially approved by City officials. The City reviewed each of the alternatives and is most in favor of FH 1.2 (Maximum Channel) and FH 2.2 (Reduced Pond). However, official project sponsorship for each of these projects from City council are not yet obtained at the time this report was authored. Each of these projects are similar in project cost and BCR value. Therefore, it is recommended that the larger project (project FH 1.2) with an estimated cost of 14.5 million be pursued for potential funding. Other alternatives, if pursued, would require additional analysis or modification to determine no negative impact. It is also confirmed that project FH 1.2 has no negative impact. It should be noted with project FH 1.2, due to the significant amount of in-stream channel work necessary, Section 404 permitting with the US Army Corps of Engineers is likely required. This is a hurdle that will likely require additional design considerations to ensure proper adherence with Federal Clean Water Act requirements. In the event the project is funded, the City could also potentially explore combining projects alternatives 1.2 and 2.2 into a singular project each with reduced scope and size. For example, the channel widening could be reduced, and the detention pond could be made smaller for a blended storage/conveyance project. This additional combined analysis was beyond the scope and budget available for this FMP analysis.

Flood Mitigation Project Technical Memorandum

Date: Wednesday, June 07, 2023

To: Region 13 Flood Planning Group
c/o
Nueces River Authority

From: Sarah West, PE, CFM
Freese and Nichols, Inc
800 N. Shoreline Blvd., Suite 1600N
Corpus Christi, Texas 78401

Subject: FMP ID's: 133000016, 133000017
Project Sponsor: Corpus Christi
Project Names:
- Kinney Street Pump Station Inlet Modifications
- Power Street Pump Station Improvements

Methodologies and Procedures

1. Background

Freese and Nichols, Inc. (FNI) advanced two flood mitigation projects for the City of Corpus Christi. This analysis was done to provide data for the 2023 Nueces Regional Flood Plan (the Plan) concerning potential Flood Mitigation Projects (FMPs) to be recommended in the 2023 Plan.

The project area covers an area bounded by Highway 181 and Upper Broadway Street to the west, by Harbor Bridge to the north, by the seawall to the east, and by Furman Avenue to the south. This boundary encloses a lower area contained by a bluff to the west and the seawall to the east. The area's low elevation leads to frequent flood inundation, which is removed via the Kinney Street and Power Street Pump Stations. The Kinney Street Pump Station Inlet Modifications project will provide relief to Kinney Street and Water Street during frequent storm events by enlarging the existing inlet structure to the north and incorporating a baffle to improve flow efficiency from the northern inlet structure to the pump station. Additionally, the Power Street Pump Station Improvements project will improve upstream drainage throughout the basin by increasing the existing box inlet feeding the pump station to reduce what is currently significant head loss.

This memorandum documents the assumptions, methodologies and processes used to advance the FMP in accordance with the Texas Water Development Board (TWDB) Exhibit C Technical Guidelines for Regional Flood Planning FMP requirements.

2. Data Collection

Data for these projects were obtained from the stakeholder and consisted of a Technical Memorandum, "Downtown Drainage Kinney & Power Street Pump Station

Improvements, City Project No. E16320" and a set of XPSWMM models reflecting proposed conditions.

3. Drainage Analysis

Drainage analysis was performed by AECOM using XPSWMM, and the results of that analysis can be found within the Technical Memorandum. The modeling data received from the City solely represented proposed conditions and multiple projects modeled together. Therefore, FNI used the provided models to obtain baseline-project conditions and results of the proposed projects individually.

To generate inundation rasters for the 100-year event, proposed geometry was reverted to existing geometry to create an "existing" model, and the improvements specific to the Kinney Street and Power Street Pump Station projects noted in the Technical Memorandum were implemented. Figure 1 and 2 display the baseline- and post-project inundation extents for the two projects.

Figure 1. Model Inundation Boundary
(Kinney Street Pump Station Inlet Modifications)

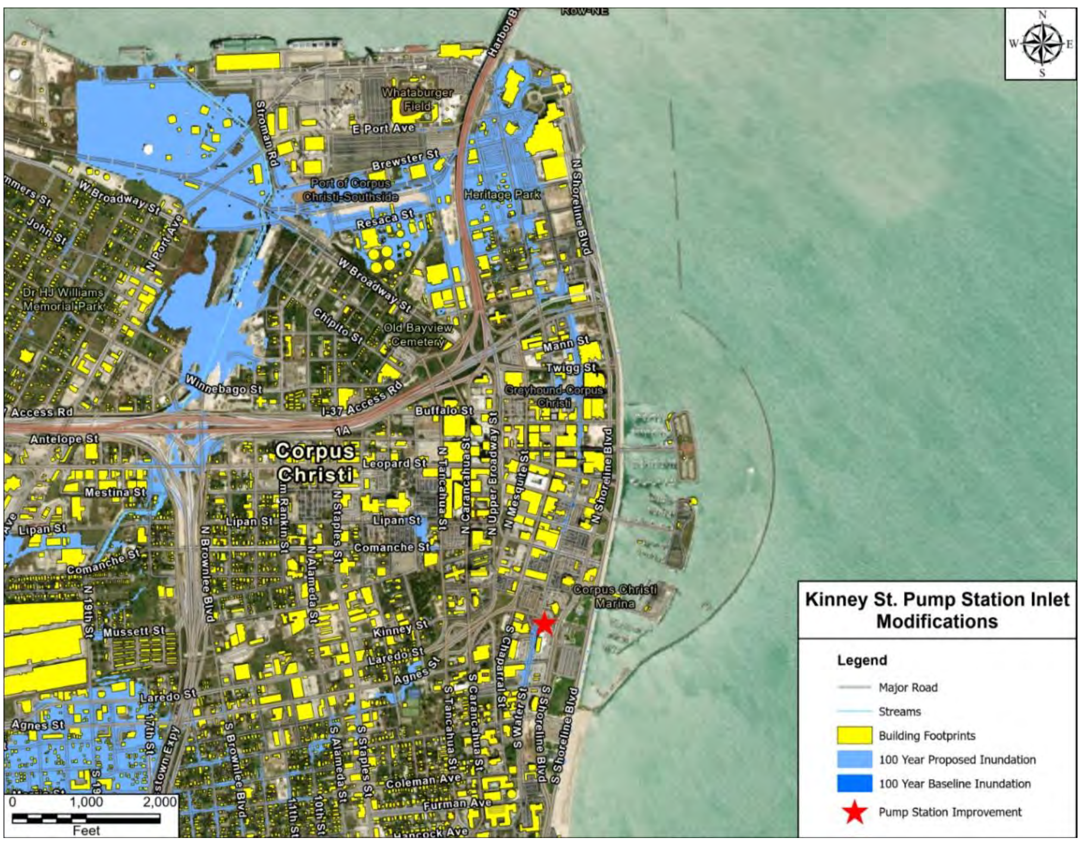
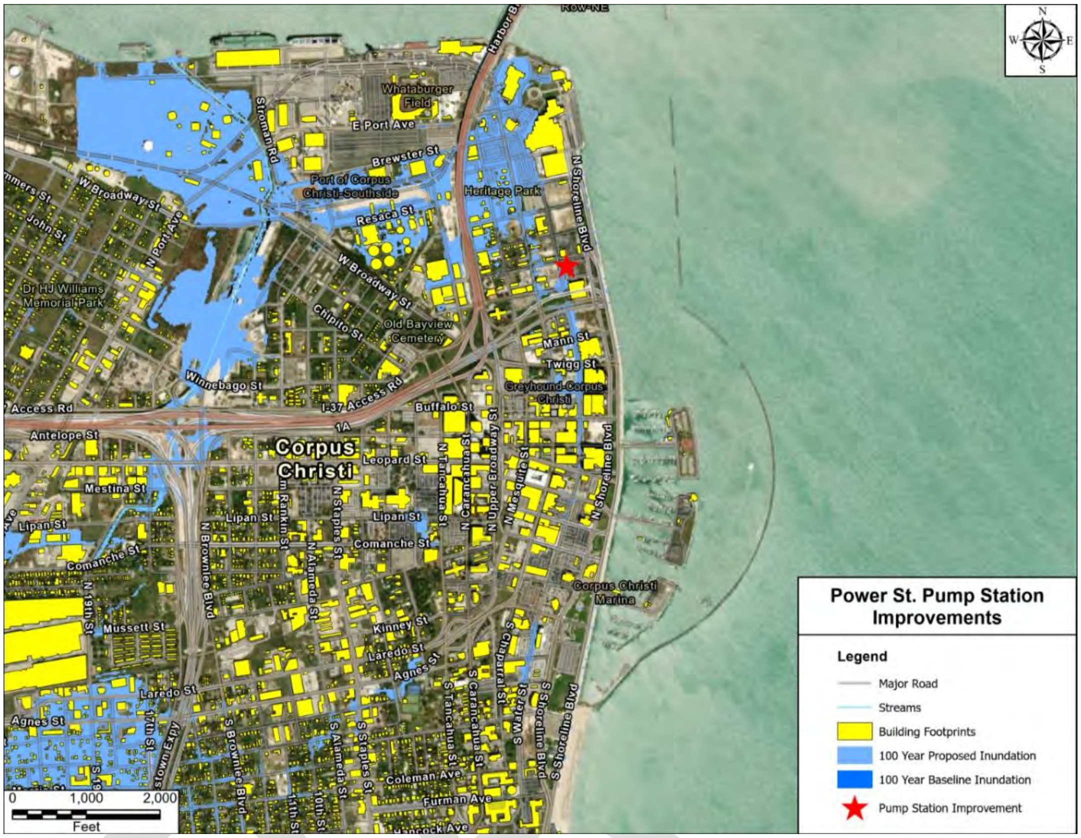


Figure 2. Model Inundation Boundary (Power Street Pump Station Inlet Modifications)



4. Results, Benefits, and Impacts

Results

Baseline and proposed conditions were analyzed. Table 1 and Table 2 summarize the total number of inundated commercial and residential structures for the 100-year storm event.

Table 1. Total Impacted Structures for Baseline and Proposed Conditions (Kinney Street Pump Station Inlet Modifications)

Storm Frequency Event (Years)	Baseline Conditions (structures)	Proposed Conditions (structures)	Difference (structures)
100	63	63	0

Table 2. Total Impacted Structures for Baseline and Proposed Conditions (Power Street Pump Station Improvements)

Storm Frequency Event (Years)	Baseline Conditions (structures)	Proposed Conditions (structures)	Difference (structures)
100	63	63	0

Benefit Measurement

Per the TWDB, each FMP included in a regional flood plan is required to have a benefit cost analysis (BCA) performed. Some flood mitigation studies document a computed benefit cost ratio (BCR), and those can be incorporated into the regional flood plan. For situations where a BCR is not available for a project, TWDB has developed the BCA Input Tool to facilitate the calculation of costs and benefits. The tool estimates flood impacts before and after implementation of the FMP for up to three recurrence interval flood events.

Since a BCR or BCA was not included in the AECOM technical memorandum, FNI prepared BCA's for these two pump station projects. The BCA's considered the following project impacts:

- Residential Buildings
- Commercial Structures

In addition to the TWDB tool assumptions, the following section describes other assumptions which were applied during the BCA.

COST

FNI used Opinion of Probable Constructions Cost breakdowns included within the Technical Memorandum and escalated these breakdowns to September 2020 costs in conformance with TWDB FMP cost requirements. Escalation was achieved using a Construction Cost Index (CCI) factor of 1.015 for Kinney Street Pump Station and 1.009 for Power Street Pump Station resulting in a cost of $449,100 and $874,700, respectively. These 2020 estimated total costs were used in the BCA. The total costs include all the required applicable TWDB FMP costs including basic engineering fees; special services such as surveying, environmental, and geotechnical; and other costs such as land/easement acquisition and administration, fiscal services, and contingency.

CONSTRUCTION YEAR

Construction is assumed to start in the near future, dependent on funding. The project's construction period in the BCA was set to begin in 2026 and end in 2027. Construction start was assumed to be 2026 for all projects and the duration was determined assuming the contractor is expending $500,000 of effort per month against the escalated project costs listed above.

RESIDENTIAL STRUCTURES

Residential structures are evaluated by the size and flood depth for the baseline and proposed project conditions. The size categories in the BCA are classified as “Small Home,” “Average Home,” and “Large Home.” The TWDB guidelines give the following as typical sizes for each; “Small” = 1000 sq.ft., “Average” = 2,500 sq.ft., and “Large” = 5,000 sq.ft. For residential structure analyses, the following size assumptions were made:

- Small: x <2500 sq.ft.
- Average: 2500 sq.ft.< x <5000 sq.ft.
- Large: x >5000 sq.ft.

Inundation depths were rounded to the nearest inch.

COMMERCIAL STRUCTURES

Commercial building damages are determined by business type and size (square footage). A combination of ArcGIS and Google Earth were used to determine the commercial building type for each structure based on readily available visuals. Inundation depths were rounded to the nearest inch.

Benefit Result

The BCA Input Tool is intended to be used in conjunction with the Federal Emergency Management Agency (FEMA) BCA Toolkit 6.0, which calculates annual benefits from the information compiled in the TWDB BCA Input Tool. The annual benefits data are then input back into the TWDB BCA Input Tool to compute the resulting BCR for the project. Figure 3Figure 4 summarize each of the impacts per storm and the final BCR for each project.

Figure 3. BCA Tool Results – Kinney Street Pump Station Inlet Modifications FMP[1]

Input Into BCA Toolkit

Project Useful Life	**30**

Event Damages	Baseline	Project
100 - year storm	**$170,983**	**$119,333**

Total Benefits from BCA Toolkit	$6,415
Other Benefits (Not Recreation)	$0
Recreation Benefits	-
Total Costs	$394,088
Net Benefits	-$387,673
Net Benefits with Recreation	-$387,673
Final BCR	**0.016**
Final BCR with Recreation	**0.016**

[1] BCA Costs are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Figure 4. BCA Tool Results – Power Street Pump Station Improvements FMP[2]

Input Into BCA Toolkit		
Project Useful Life	**30**	
Event Damages	**Baseline**	**Project**
100 - year storm	**$1,006,947**	**$970,558**
Total Benefits from BCA Toolkit	$4,517	
Other Benefits (Not Recreation)	$0	
Recreation Benefits	-	
Total Costs	$690,660	
Net Benefits	-$686,143	
Net Benefits with Recreation	-$686,143	
Final BCR	**0.007**	
Final BCR with Recreation	**0.007**	

[2] BCA Costs are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Impact Analysis

An FMP is required to have no negative impacts in the neighboring area, either upstream or downstream of the project. No negative impact means that a project will not increase flood risk of surrounding properties. The increase in flood risk must be measured by the 100-year frequency storm water surface elevation and peak discharge, using the best available data. No rise in water surface elevation or discharge is permissible, and the study area must be sufficiently large to demonstrate that proposed project conditions are equal to or less than the existing (baseline) conditions.

For the purposes of regional flood planning efforts, a determination of no negative impacts can be established if stormwater runoff does not increase inundation of infrastructure such as residential and commercial structures or exceed the design capacity of stormwater systems. According to the TWDB Exhibit C Technical Guidelines, all of the following requirements should be met to establish no negative impact, as applicable:

1. Stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement.

2. Stormwater does not increase inundation of storm drainage networks, channels, and roadways beyond design capacity.

3. Maximum increase of 1D Water Surface Elevation must round to 0.0 feet (<0.05 ft) measured along the hydraulic cross-section.

4. Maximum increase of 2D Water Surface Elevations must round to 0.3 feet (<0.35 ft) as measured at each computation cell.

5. Maximum increase in hydrologic peak discharge must be <0.5 percent measured at computation nodes (sub-basins, junctions, reaches, reservoirs, etc.). This discharge restriction does not apply to a 2D overland analysis.

Because the Kinney Street Pump Station Inlet Modifications and Power Street Pump Station Improvements projects analyses were performed using a 2D modeling software, only requirements #1, #2, and #4 are applicable. During review of the inundation rasters produced by each model, it was found that one structure indicated a negative impact. However, the negative impact consisted of a one-inch increase in inundation depth and showed instability at a node nearby. Due to the limited nature of the depth increase and the instability noted near the building, it was determined that the negative impact was more representative of model noise than a negative impact. Comparison of baseline and post-project condition structure inundation in Table 1 and Table 2 shows that the number of structures affected by the 100-year storm was not reduced, but also not increased. Additionally, an evaluation of the baseline- versus post- project conditions does not indicate increases in 100-year water surface elevations for neighboring properties, indicating that requirement #1 is satisfied. The maximum increase of the 2D water surface elevation when comparing baseline and proposed conditions was determined to be less than 0.35 feet based on inundation raster comparison, satisfying both requirements #2 and #4.

Flood Mitigation Project Technical Memorandum

Date: Wednesday, June 07, 2023

To: Region 13 Flood Planning Group
c/o
Nueces River Authority

From: Sarah West, PE, CFM
Freese and Nichols, Inc
800 N. Shoreline Blvd., Suite 1600N
Corpus Christi, Texas 78401

FMP ID's: 133000028, 133000027, 133000029, 133000019, 133000018, 133000020, 133000025, 133000024, 133000026, 133000021, 133000022, 133000023, 133000030

Project Sponsors:

- City of Robstown
- City of Banquete
- City of Agua Dulce
- City of Bishop
- City of Driscoll
- City of Corpus Christi

Subject: Project Names:

- Risk Area 01 - Ranch and Cyndie Park
- Risk Area 03 - Indian Trails
- Risk Area 04 - Ranch Banquete
- Risk Area 05 - Banquete
- Risk Area 06 - Agua Dulce
- Risk Area 07 - La Paloma Ranch
- Risk Area 11 - Callicoate Farms
- Risk Area 19 - Driscoll
- Risk Area 20 - Fiesta Ranch
- Risk Area 26 - Balchuck Ln & Digger Ln
- Risk Area 27 - Nottingham Acres
- Risk Area 28 - South Prairie Estates

Methodologies and Procedures

1. Background

Freese and Nichols, Inc. (FNI) advanced thirteen flood mitigation projects for Nueces, Jim Wells, and Kleberg Counties, as well as Nueces County Drainage District No. 2. This analysis was done to provide data for the 2023 Nueces Regional Flood Plan (the Plan) concerning potential Flood Mitigation Projects (FMPs) to be recommended in the 2023 Plan.

The benefit areas consist of the following municipalities: Robstown, Banquete, Agua Dulce, Bishop, Driscoll, and Corpus Christi. These projects were identified for each city as a part of the Tri-County Master Drainage Plan effort currently underway by Halff

Associates, Inc. (Halff) and International Consulting Engineers (ICE). Each project was developed for the purpose of reducing flood inundation to structures associated with inadequate drainage, storage, and channel conveyance through the implementation of ditch networks, regional detention facilities, bridges, and channel and culvert improvements.

This memorandum documents the assumptions, methodologies and processes used to advance these FMPs in accordance with the Texas Water Development Board (TWDB) Exhibit C Technical Guidelines for Regional Flood Planning FMP requirements.

2. Data Collection

Data for these projects was obtained from the consultants Halff and ICE in the form of single-page Project Summaries, HEC-RAS models, 100- and 500-year rasters (as available), models, Opinions of Probable Construction Costs (OPCCs), and Benefit Cost Analyses (BCAs).

3. Drainage Analysis

Drainage Analyses were performed by Halff and ICE using HEC-RAS. **Error! Reference source not found.** through **Error! Reference source not found.** display the resulting post-project inundation extents for the 13 Tri-County projects based on the 25-year storm event.

Figure 1. Proposed Conditions Model Inundation Boundary (Risk Area 1 – Ranch and Cyndie Park)

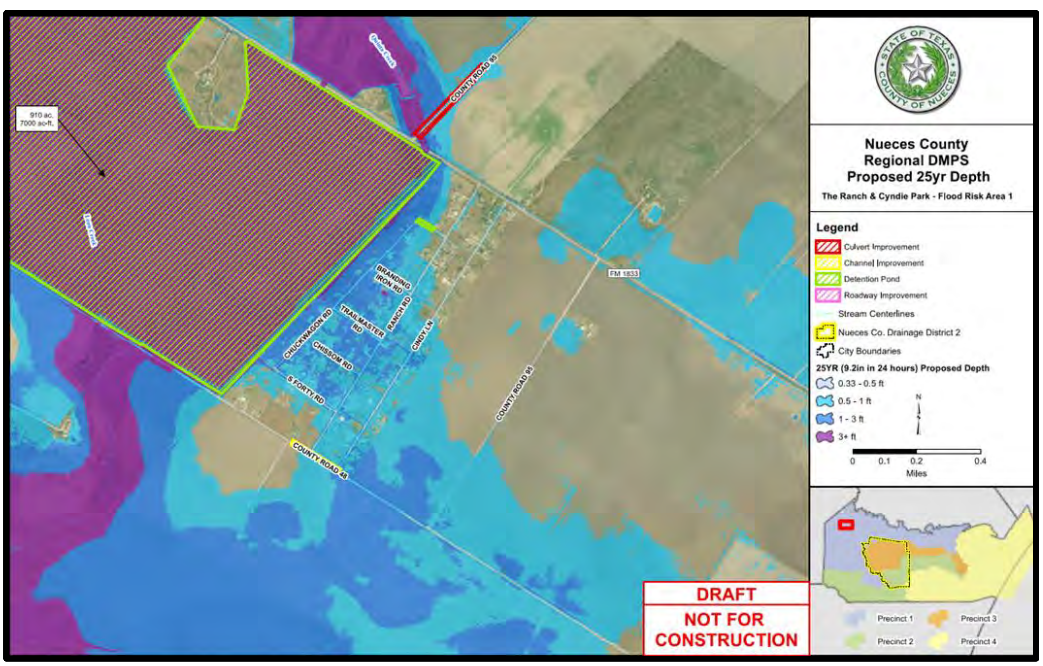


Figure 2. Proposed Conditions Model Inundation Boundary (Risk Area 3 – Indian Trails)

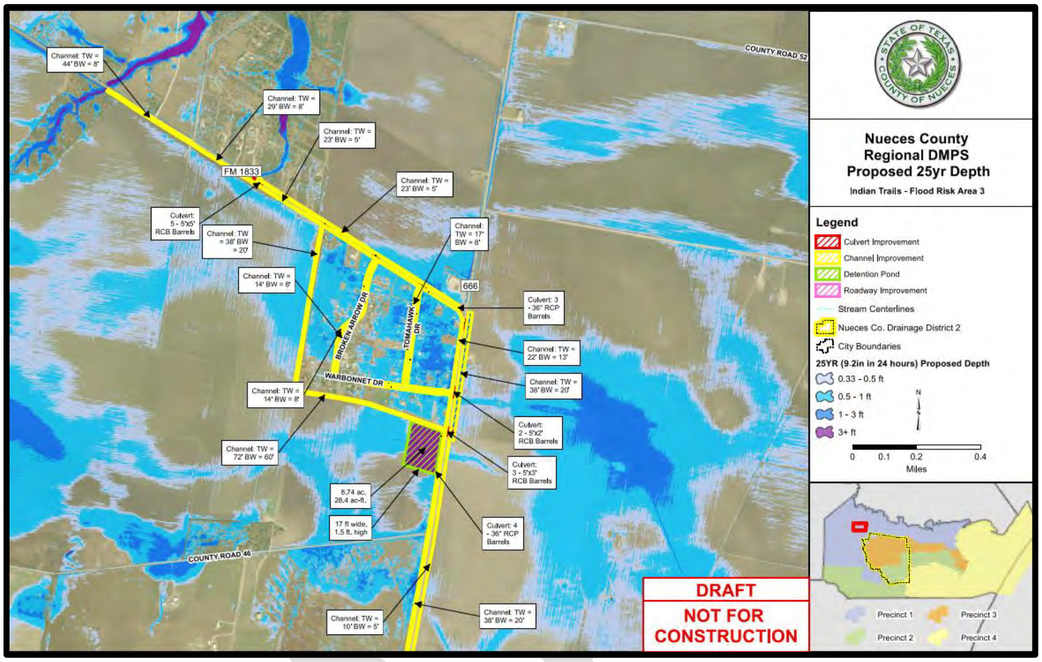


Figure 3. Proposed Conditions Model Inundation Boundary (Risk Area 4 – Ranch Banquete)

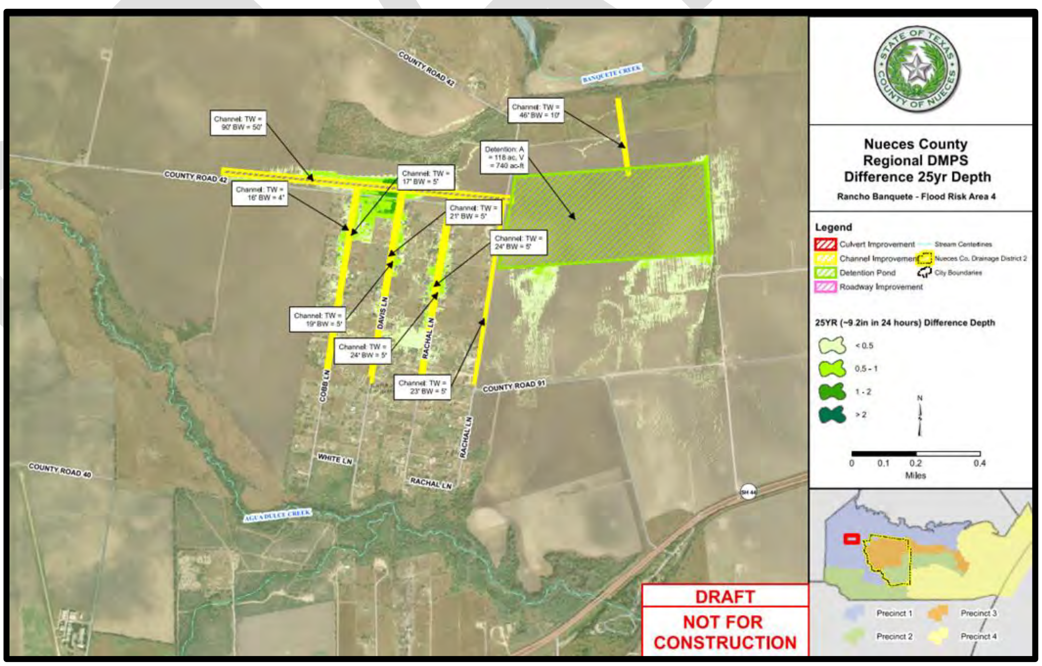


Figure 4. Proposed Conditions Model Inundation Boundary (Risk Area 5 – Banquete)

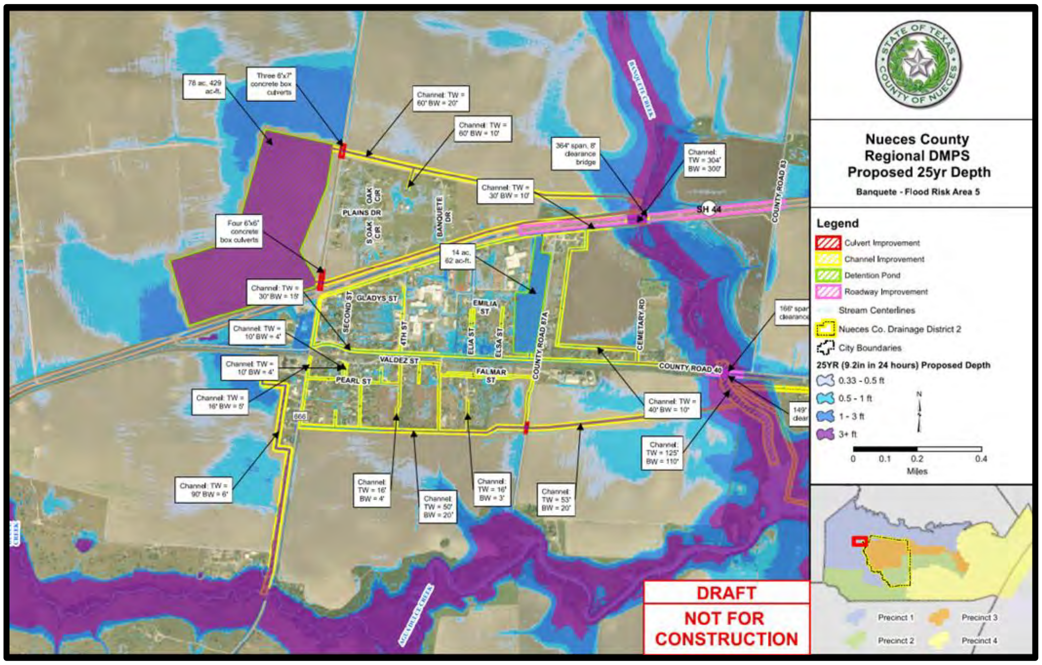


Figure 5. Proposed Conditions Model Inundation Boundary (Risk Area 6 – Agua Dulce)

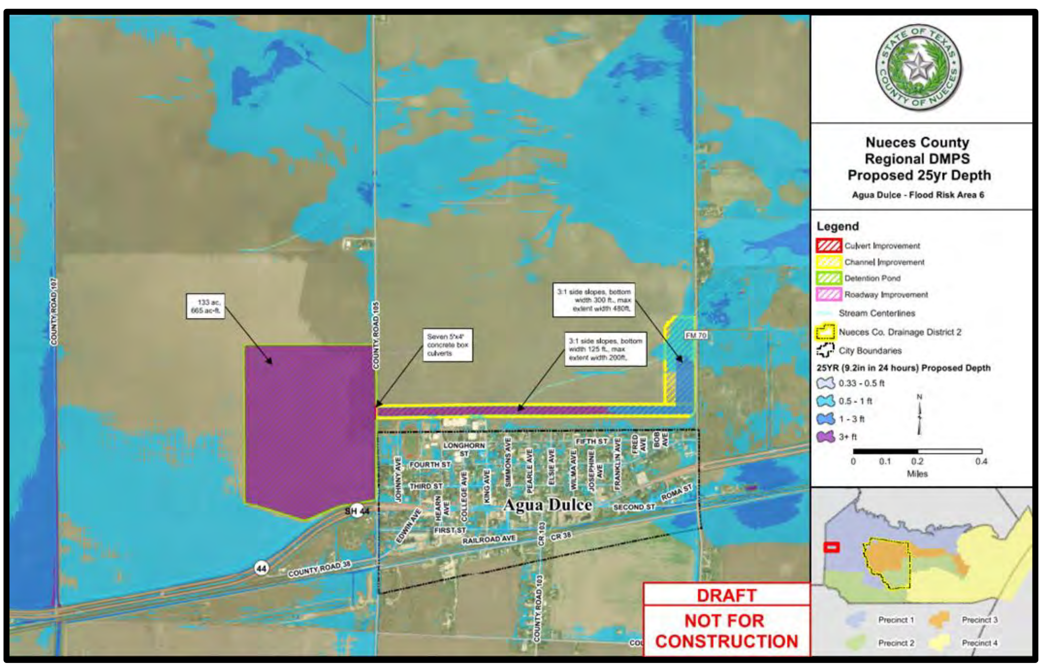


Figure 6. Proposed Conditions Model Inundation Boundary (Risk Area 7 – La Paloma Ranch)

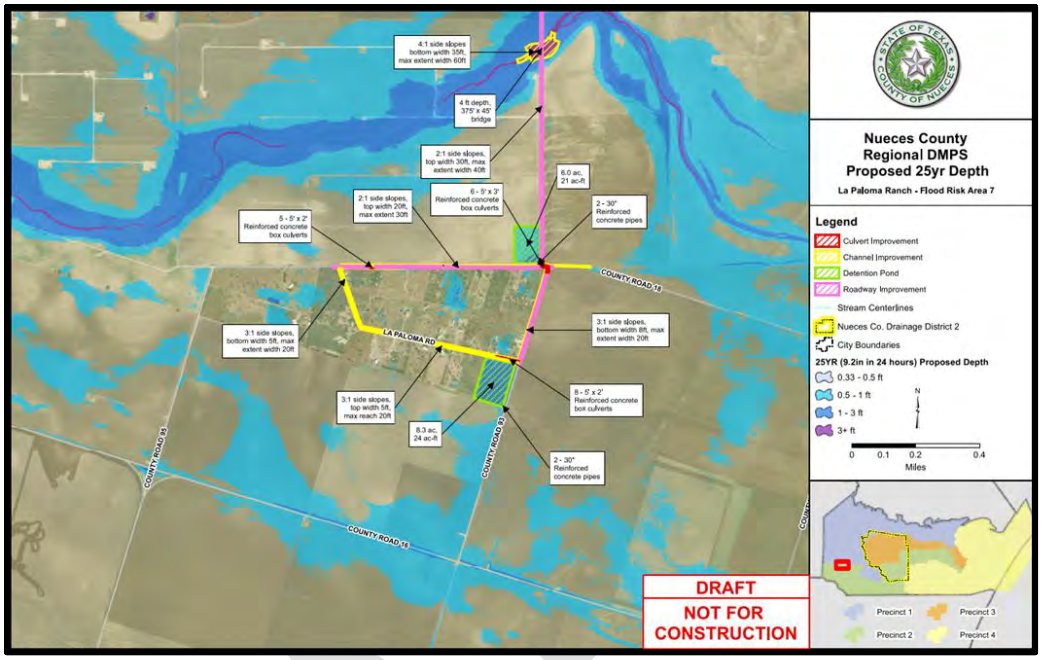


Figure 7. Proposed Conditions Model Inundation Boundary (Risk Area 11 – Callicoate Farms)

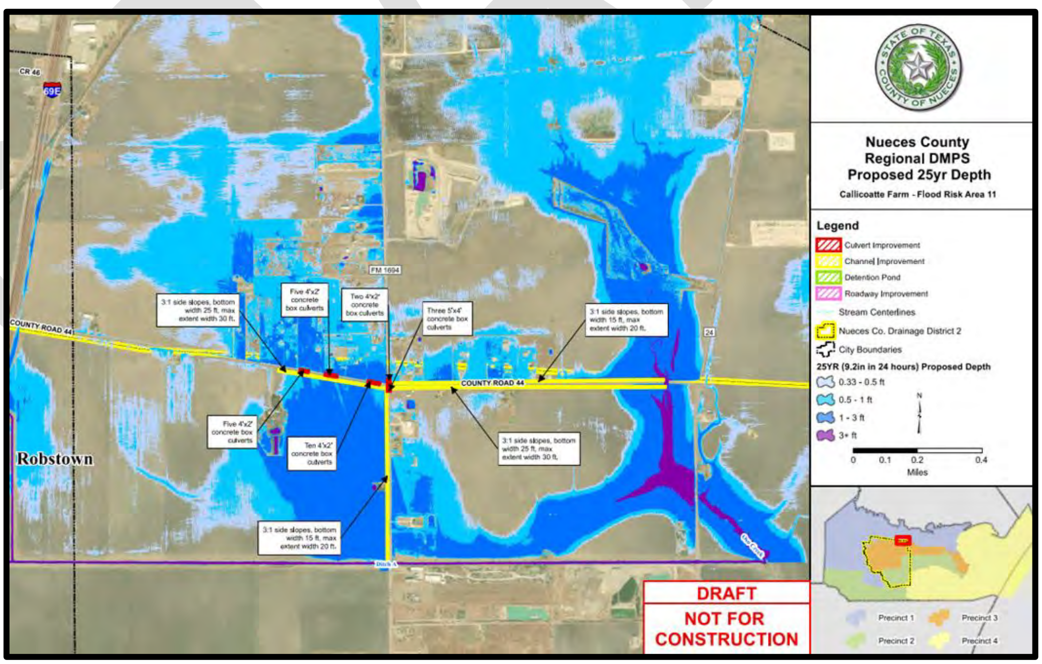


Figure 8. Proposed Conditions Model Inundation Boundary (Risk Area 19 – Driscoll)

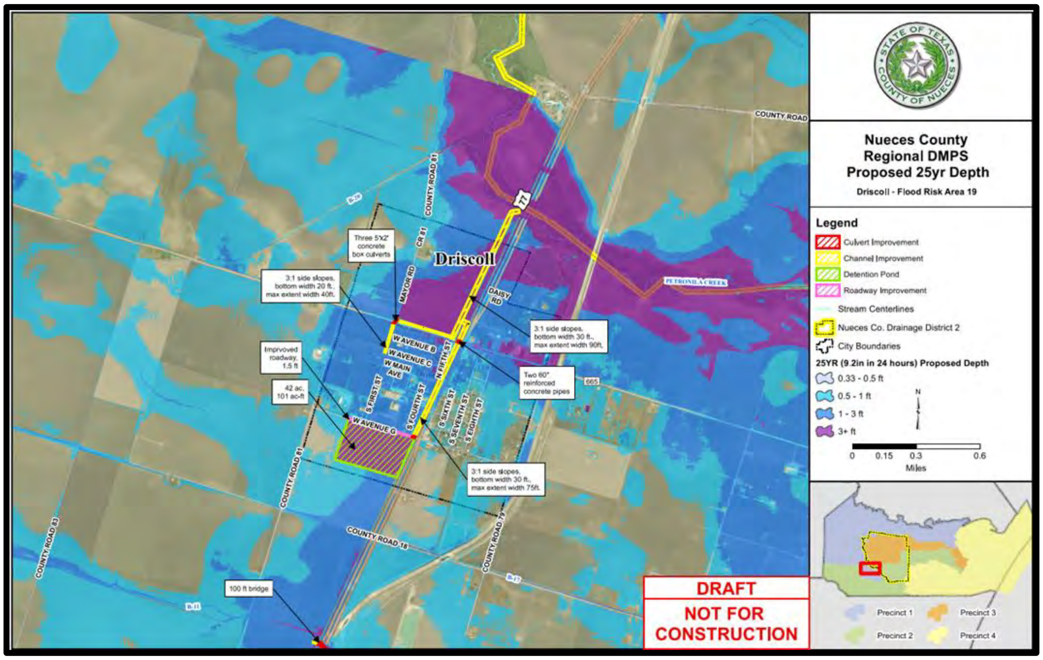


Figure 9. Proposed Conditions Model Inundation Boundary (Risk Area 20 – Fiesta Ranch)

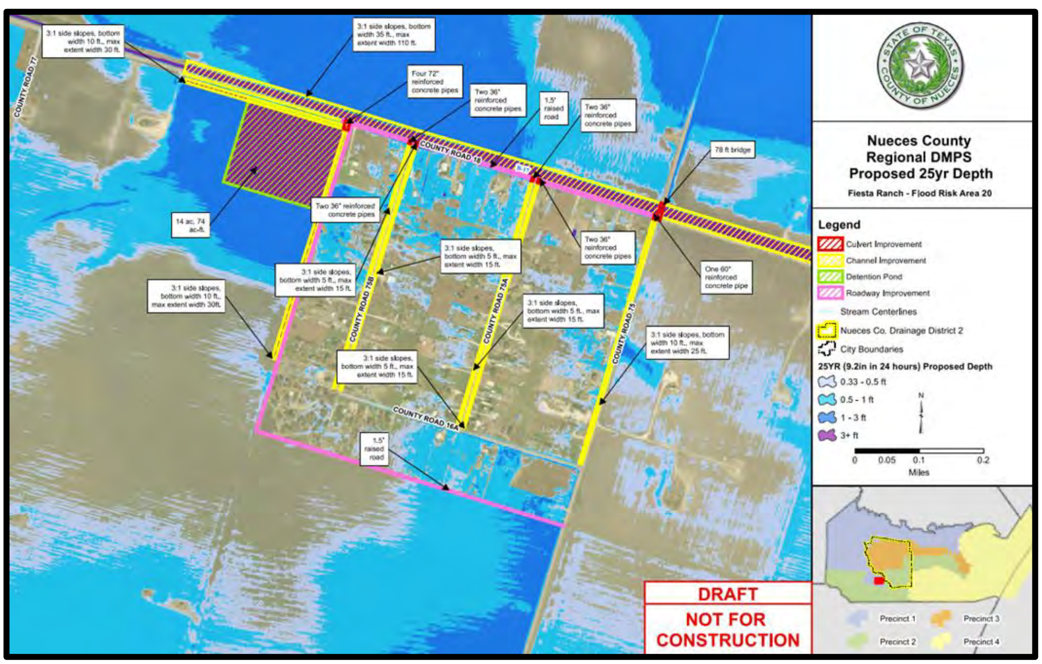


Figure 10. Proposed Conditions Model Inundation Boundary (Risk Area 26 – Balchuck Ln and Digger Ln)

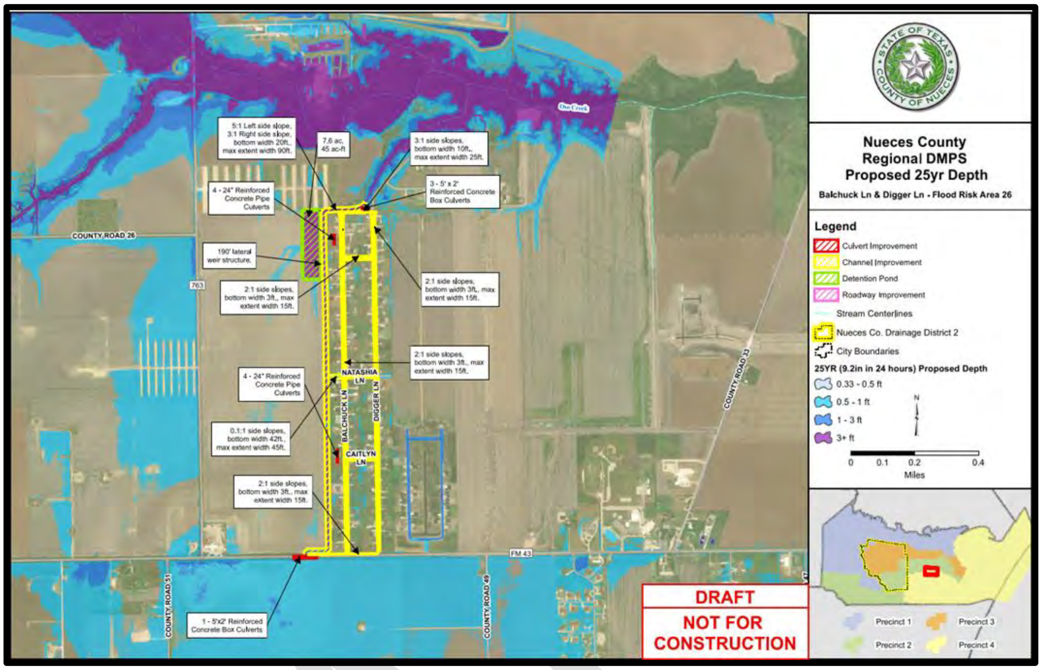


Figure 11. Proposed Conditions Model Inundation Boundary (Risk Area 27 – Nottingham Acres)

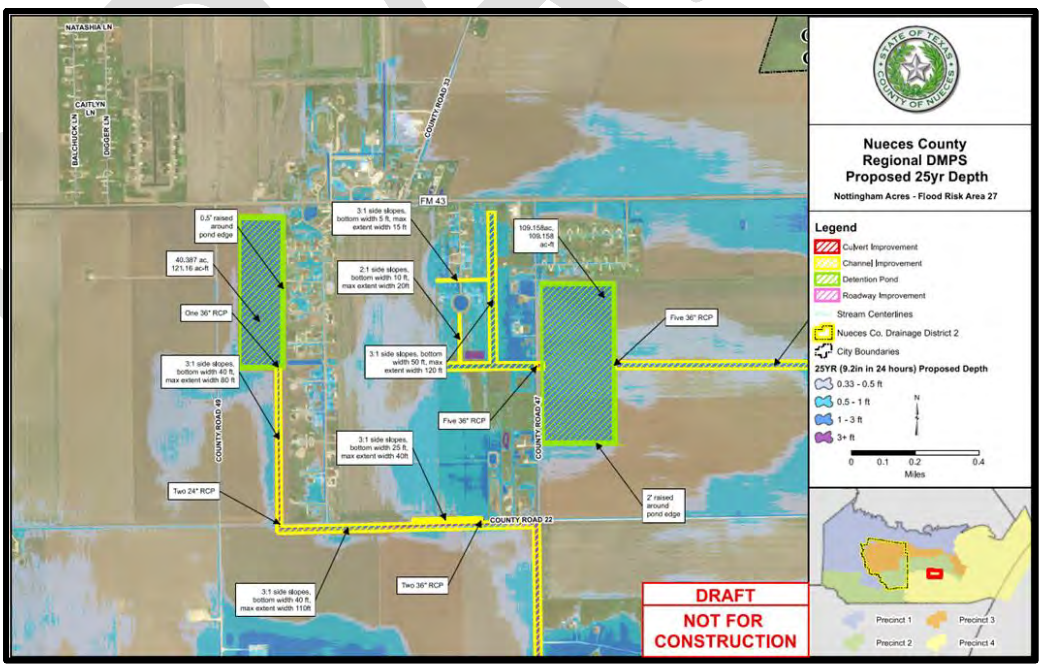


Figure 12. Proposed Conditions Model Inundation Boundary (Risk Area 28 – South Prairie Estates)

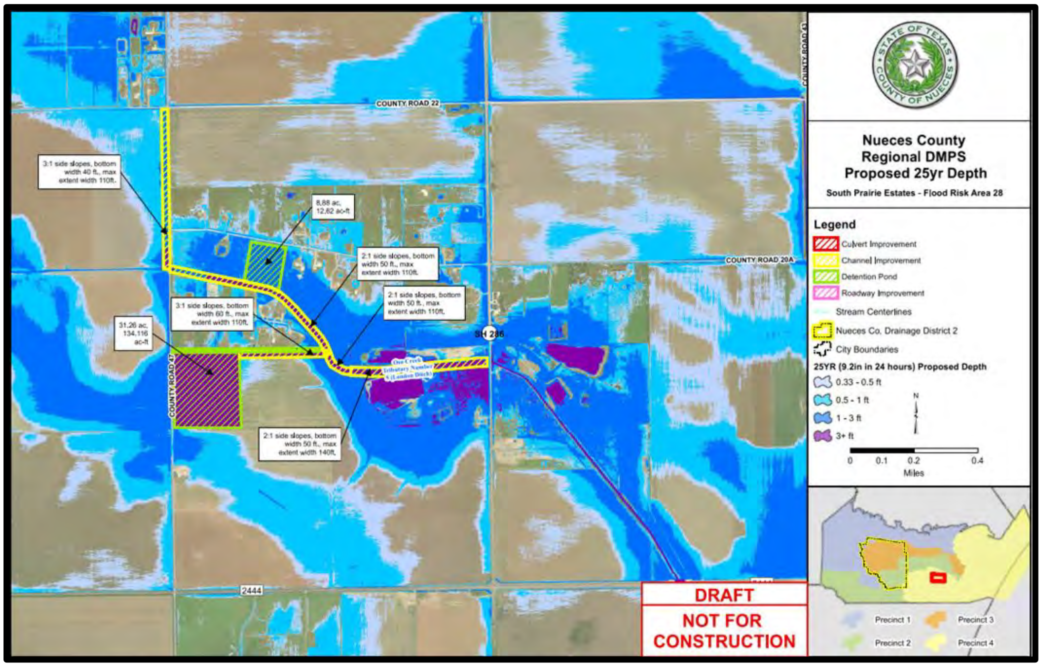
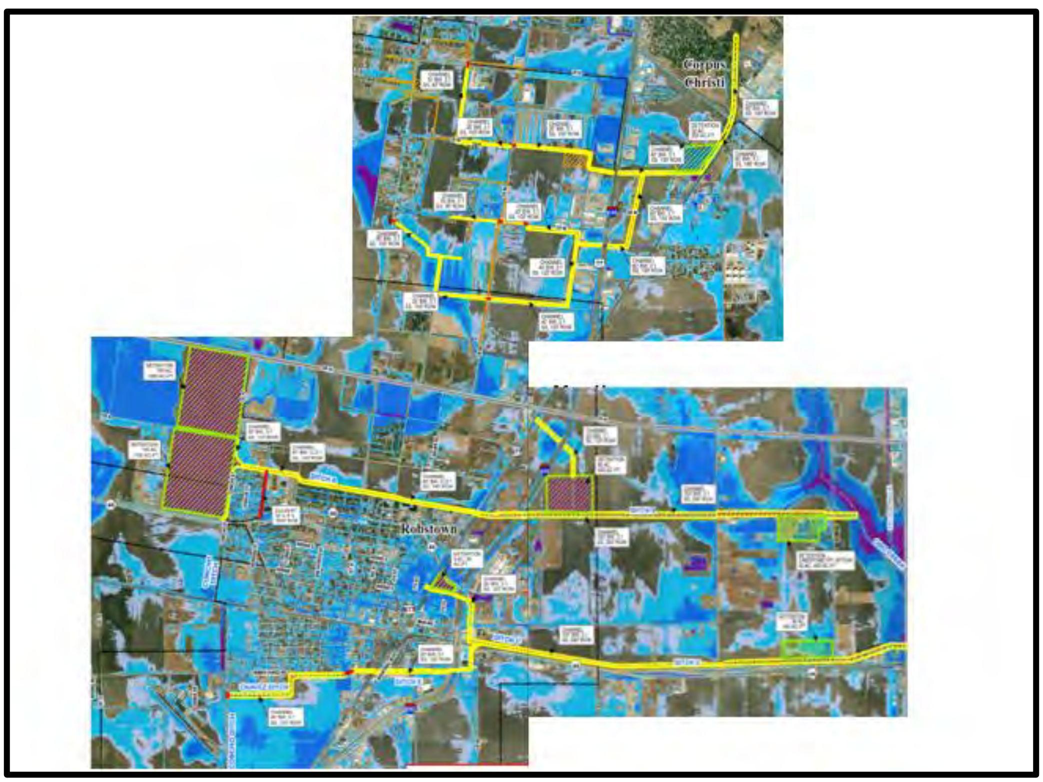


Figure 13. Proposed Conditions Model Inundation Boundary (North Robstown, West Robstown, & East Robstown Drainage Improvements)



4. Results, Benefits, and Impacts

Results

Baseline and proposed conditions were analyzed, and Table 1 through Table 13 summarize the total number of inundated commercial and residential structures for the 100-year storm event for all thirteen projects. The project developed by ICE (North Robstown, West Robstown, & East Robstown Drainage Improvements) also included results from the 500-year storm event.

Table 1. Total Impacted Structures for Baseline and Proposed Conditions (Risk Area 1 – Ranch and Cyndie Park)

Storm Frequency Event (Years)	Baseline Conditions (structures)	Proposed Conditions (structures)	Difference (structures)
100	104	1	(103)

Table 2. Total Impacted Structures for Baseline and Proposed Conditions (Risk Area 3 – Indian Trails)

Storm Frequency Event (Years)	Baseline Conditions (structures)	Proposed Conditions (structures)	Difference (structures)
100	51	6	(45)

Table 3. Total Impacted Structures for Baseline and Proposed Conditions (Risk Area 4 – Ranch Banquete)

Storm Frequency Event (Years)	Baseline Conditions (structures)	Proposed Conditions (structures)	Difference (structures)
100	95	17	(78)

Table 4. Total Impacted Structures for Baseline and Proposed Conditions (Risk Area 5 – Banquete)

Storm Frequency Event (Years)	Baseline Conditions (structures)	Proposed Conditions (structures)	Difference (structures)
100	178	86	(92)

Table 5. Total Impacted Structures for Baseline and Proposed Conditions (Risk Area 6 – Agua Dulce)

Storm Frequency Event (Years)	Baseline Conditions (structures)	Proposed Conditions (structures)	Difference (structures)
100	215	41	(174)

Table 6. Total Impacted Structures for Baseline and Proposed Conditions (Risk Area 7 – La Paloma Ranch)

Storm Frequency Event (Years)	Baseline Conditions (structures)	Proposed Conditions (structures)	Difference (structures)
100	13	2	(11)

Table 7. Total Impacted Structures for Baseline and Proposed Conditions (Risk Area 11 – Callicoate Farms)

Storm Frequency Event (Years)	Baseline Conditions (structures)	Proposed Conditions (structures)	Difference (structures)
100	46	2	(44)

Table 8. Total Impacted Structures for Baseline and Proposed Conditions (Risk Area 19 – Driscoll)

Storm Frequency Event (Years)	Baseline Conditions (structures)	Proposed Conditions (structures)	Difference (structures)
100	311	70	(241)

Table 9. Total Impacted Structures for Baseline and Proposed Conditions (Risk Area 20 – Fiesta Ranch)

Storm Frequency Event (Years)	Baseline Conditions (structures)	Proposed Conditions (structures)	Difference (structures)
100	69	29	(40)

Table 10. Total Impacted Structures for Baseline and Proposed Conditions (Risk Area 26 – Balchuck Ln and Digger Ln)

Storm Frequency Event (Years)	Baseline Conditions (structures)	Proposed Conditions (structures)	Difference (structures)
100	57	18	(39)

Table 11. Total Impacted Structures for Baseline and Proposed Conditions (Risk Area 27 – Nottingham Acres)

Storm Frequency Event (Years)	Baseline Conditions (structures)	Proposed Conditions (structures)	Difference (structures)
100	67	13	(54)

Table 12. Total Impacted Structures for Baseline and Proposed Conditions (Risk Area 28 – South Prairie Estates)

Storm Frequency Event (Years)	Baseline Conditions (structures)	Proposed Conditions (structures)	Difference (structures)
100	32	4	(28)

Table 13. Total Impacted Structures for Baseline and Proposed Conditions (North Robstown, West Robstown, & East Robstown Drainage Improvements)

Storm Frequency Event (Years)	Baseline Conditions (structures)	Proposed Conditions (structures)	Difference (structures)
100	3643	3634	(9)
500	3652	3646	(6)

Benefit Measurement

Per the TWDB, each FMP included in a regional flood plan is required to have a benefit cost analysis (BCA) performed. Some flood mitigation studies document a computed benefit cost ratio (BCR), and those can be incorporated into the regional flood plan. For situations where a BCR is not available for a project, TWDB has developed the BCA Input Tool to facilitate the calculation of costs and benefits. The tool estimates flood impacts before and after implementation of the FMP for up to three recurrence interval flood events.

Halff and ICE provided BCA documentation for each of the 13 Tri-County projects. The BCAs considered the following project impacts:

- Residential Buildings
- Commercial Structures
- Street Flooding
- Utility Outages

In addition to the TWDB tool assumptions, the following section describes other assumptions which were applied during the BCA.

COST

Halff and ICE provided costs to FNI, which were supported by Opinion of Probable Constructions Cost breakdowns and were de-escalated to September 2020 costs in conformance with TWDB FMP cost requirements. De-escalation was achieved using a Construction Cost Index (CCI) factor of 0.87 for each project. Resulting project costs are as follows:

- Risk Area 1 – Ranch and Cyndie Park: $421,681,170
- Risk Area 3 – Indian Trails: $33,392,340
- Risk Area 4 – Ranch Banquete: $55,453,800
- Risk Area 5 – Banquete: $64,693,200
- Risk Area 6 – Agua Dulce: $93,479,760
- Risk Area 7 – La Paloma Ranch: $23,031,510
- Risk Area 11 – Callicoate Farms: $6,056,940
- Risk Area 19 – Driscoll: $73,965,660
- Risk Area 20 – Fiesta Ranch: $35,398,560
- Risk Area 26 – Balchuck Ln and Digger Ln: $19,160,010
- Risk Area 27 – Nottingham Acres: $49,134,990
- Risk Area 28 – South Prairie Estates: $34,515,510
- North, West, & East Robstown Drainage Improvements – $62,344,000

These 2020 estimated total costs were used in the BCA's developed by Halff and ICE. The total costs include all the required applicable TWDB FMP costs including basic engineering fees; special services such as surveying, environmental, and geotechnical; and other costs such as land/easement acquisition and administration, fiscal services, and contingency.

CONSTRUCTION YEAR

Construction is assumed to start in the near future, dependent on funding. Construction start was assumed to be 2026 for all projects and the duration was determined assuming the contractor is expending $500,000 of effort per month against the de-escalated projects costs listed above. Due to the size of the Risk Area 1 project, it was assumed that four contractors would be expending $500,000 of effort per month against its de-escalated project cost listed above. The resulting project durations are listed below:

- Risk Area 1 – 2026 to 2044
- Risk Area 3 – 2026 to 2032
- Risk Area 4 – 2026 to 2035
- Risk Area 5 – 2026 to 2037
- Risk Area 6 – 2026 to 2042
- Risk Area 7 – 2026 to 2030
- Risk Area 11 – 2026 to 2027
- Risk Area 19 – 2026 to 2038
- Risk Area 20 – 2026 to 2032
- Risk Area 26 – 2026 to 2029
- Risk Area 27 – 2026 to 2034
- Risk Area 28 – 2026 to 2032
- North, West, & East Robstown Drainage Improvements – 2026 to 2036

RESIDENTIAL STRUCTURES

Residential structures are evaluated by the size and flood depth for the baseline and proposed project conditions. The size categories in the BCA are classified as "Small Home," "Average Home," and "Large Home." The TWDB guidelines give the following as typical sizes for each; "Small" = 1000 sq.ft., "Average" = 2,500 sq.ft., and "Large" = 5,000 sq.ft. For residential structure analyses, the following size assumptions were made:

- Small: x <2500 sq.ft.
- Average: 2500 sq.ft.< x <5000 sq.ft.
- Large: x >5000 sq.ft.

The TWDB tool limits the total amount of residential buildings that can be assessed per project to 100 structures. For this project, more than 100 structures were impacted. Instead of looking at each individual structure's damages for baseline and proposed conditions, the total amount of impacted structures within the same size category and inundation depth were totaled per condition analyzed. Inundation depths were rounded to the nearest inch.

COMMERCIAL STRUCTURES

Commercial building damages are determined by business type and size (square footage). Impacted commercial structures were reviewed to determine the commercial building type for each structure. Inundation depths were rounded to the nearest inch.

FLOODED STREETS

Streets are considered impassable if the flood depth is above 6 inches. The Normal Emergency Medical Services (EMS) response time for both baseline and proposed conditions is assumed to be 7 minutes, based on the urban mean value from Table 2 of the NIH JAMA Surgery study (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5831456/). Daily traffic count, detour mileage, detour time, and EMS storm event response times were determined based on TWDB guidance, previous Regional Flood Planning experience, and engineering judgement. The number of households impacted by EMS delay due to flooded streets is assumed to be the total number of residential buildings inundated during the given storm event. Number of commercial buildings impacted by EMS delay due to flooded streets is assumed to be the total number of commercial buildings inundated during the given storm event.

UTILITY OUTAGES

The BCA developed by ICE (North Robstown, West Robstown, & East Robstown Drainage Improvements) also included Utility Outages in the BCA calculation. The other twelve Tri-County projects did not include this component. On May 19, 2021, a significant storm event impacted the City of Robstown and resulted in utility (electrical, water, wastewater, and gas) outages. This storm approximated a 50-year storm event, and was used as the basis for the utility outage assumptions. The event impacted all of Robstown and several neighborhoods were flooded for a few days, and basic utilities were interrupted for hours and in some cases days. The number of customers benefitting from utility outage reduction was assumed to be 10,000 to mirror the 2021 population of Robstown, which was 10,157. This number of benefited customers was applied for electrical, potable water, and wastewater utility types in the BCA worksheet. The outage duration in days was determined based on the May 19, 2021, storm event, and then extended or reduced based on the storm event being analyzed in the BCA. Since the storm of reference approximated a 50-year storm event, the more frequent event (25-year) assumed fewer days of outages, and less frequent events (100-year and 500-year) assumed more days of outages for the baseline scenario. For all storm events in the BCA calculation, implementation of proposed project improvements indicated that outage durations would be reduced to one day.

Benefit Result

The BCA Input Tool is intended to be used in conjunction with the Federal Emergency Management Agency (FEMA) BCA Toolkit 6.0, which calculates annual benefits from the information compiled in the TWDB BCA Input Tool. The annual benefits data are then input back into the TWDB BCA Input Tool to compute the resulting BCR for the project. Figure 14 through Figure 26 summarize each of the impacts per storm and the final BCR for each project.

Figure 14. BCA Tool Results – Tri-County Drainage Master Plan FMPs (Risk Area 1 – Ranch and Cyndie Park)[1]

Input Into BCA Toolkit

Project Useful Life	**30**	

Event Damages	Baseline	Project
25 - year storm	**$12,098,929**	**$9,795,997**
100 - year storm	**$14,058,190**	**$13,460,246**

Total Benefits from BCA Toolkit	$654,552
Other Benefits (Not Recreation)	$879,136
Recreation Benefits	$0
Total Costs	$223,637,339
Net Benefits	-$222,103,651
Net Benefits with Recreation	-$222,103,651
Final BCR	**0.007**
Final BCR with Recreation	**0.007**

[1] BCA Costs are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Figure 15. BCA Tool Results – Tri-County Drainage Master Plan FMPs (Risk Area 3 – Indian Trails)[2]

Input Into BCA Toolkit

Project Useful Life	**30**	

Event Damages	Baseline	Project
25 - year storm	**$5,516,917**	**$3,922,351**
100 - year storm	**$6,072,815**	**$4,937,004**

Total Benefits from BCA Toolkit	$657,530
Other Benefits (Not Recreation)	$252,451
Recreation Benefits	-
Total Costs	$22,454,985
Net Benefits	-$21,545,004
Net Benefits with Recreation	-$21,545,004
Final BCR	**0.041**
Final BCR with Recreation	**0.041**

[2] BCA Costs are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Figure 16. BCA Tool Results – Tri-County Drainage Master Plan FMPs (Risk Area 4 – Ranch Banquete)[3]

Input Into BCA Toolkit

Project Useful Life **30**

Event Damages	Baseline	Project
25 - year storm	**$6,599,362**	**$4,604,198**
100 - year storm	**$11,284,891**	**$9,228,522**

Total Benefits from BCA Toolkit	$1,041,168
Other Benefits (Not Recreation)	$206,075
Recreation Benefits	-
Total Costs	$34,019,066
Net Benefits	-$32,771,823
Net Benefits with Recreation	-$32,771,823
Final BCR	**0.037**
Final BCR with Recreation	**0.037**

[3] BCA Costs are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Figure 17. BCA Tool Results – Tri-County Drainage Master Plan FMPs (Risk Area 5 – Banquete)[4]

Input Into BCA Toolkit

Project Useful Life	**30**

Event Damages	Baseline	Project
25 - year storm	**$14,152,312**	**$6,781,686**
100 - year storm	**$18,217,288**	**$9,333,796**

Total Benefits from BCA Toolkit	$4,117,965
Other Benefits (Not Recreation)	$238,939
Recreation Benefits	$0
Total Costs	$37,400,486
Net Benefits	-$33,043,582
Net Benefits with Recreation	-$33,043,582
Final BCR	**0.116**
Final BCR with Recreation	**0.116**

[4] BCA Costs are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Figure 18. BCA Tool Results – Tri-County Drainage Master Plan FMPs (Risk Area 6 – Agua Dulce)[5]

Input Into BCA Toolkit

Project Useful Life	**30**

Event Damages	Baseline	Project
25 - year storm	**$16,667,562**	**$7,064,956**
100 - year storm	**$20,011,288**	**$13,740,766**

Total Benefits from BCA Toolkit	$3,910,883
Other Benefits (Not Recreation)	$191,355
Recreation Benefits	$0
Total Costs	$49,576,709
Net Benefits	-$45,474,471
Net Benefits with Recreation	-$45,474,471
Final BCR	**0.083**
Final BCR with Recreation	**0.083**

[5] BCA Costs are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Figure 19. BCA Tool Results – Tri-County Drainage Master Plan FMPs (Risk Area 7 – La Paloma Ranch)[6]

Input Into BCA Toolkit

Project Useful Life	**30**

Event Damages	**Baseline**	**Project**
25 - year storm	**$771,391**	**$766,465**
100 - year storm	**$1,084,582**	**$913,725**

Total Benefits from BCA Toolkit	$50,170
Other Benefits (Not Recreation)	$46,140
Recreation Benefits	-
Total Costs	$16,496,417
Net Benefits	-$16,400,107
Net Benefits with Recreation	-$16,400,107
Final BCR	**0.006**
Final BCR with Recreation	**0.006**

[6] BCA Costs are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Figure 20. BCA Tool Results – Tri-County Drainage Master Plan FMPs (Risk Area 11 – Callicoate Farms)[7]

Input Into BCA Toolkit

Project Useful Life	**30**

Event Damages	Baseline	Project
25 - year storm	**$3,785,165**	**$3,578,559**
100 - year storm	**$4,757,467**	**$4,505,981**

Total Benefits from BCA Toolkit	$145,173
Other Benefits (Not Recreation)	$24,454
Recreation Benefits	-
Total Costs	$4,782,539
Net Benefits	-$4,612,912
Net Benefits with Recreation	-$4,612,912
Final BCR	**0.035**
Final BCR with Recreation	**0.035**

[7] BCA Costs are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Figure 21. BCA Tool Results – Tri-County Drainage Master Plan FMPs (Risk Area 19 – Driscoll)[8]

Input Into BCA Toolkit		
Project Useful Life	**30**	
Event Damages	**Baseline**	**Project**
25 - year storm	**$19,111,549**	**$16,243,728**
100 - year storm	**$27,671,809**	**$22,380,728**
Total Benefits from BCA Toolkit	$2,119,539	
Other Benefits (Not Recreation)	$69,611	
Recreation Benefits	$0	
Total Costs	$41,533,970	
Net Benefits	-$39,344,820	
Net Benefits with Recreation	-$39,344,820	
Final BCR	**0.053**	
Final BCR with Recreation	**0.053**	

[8] BCA Costs are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Figure 22. BCA Tool Results – Tri-County Drainage Master Plan FMPs (Risk Area 20 – Fiesta Ranch)[9]

Input Into BCA Toolkit

Project Useful Life	**30**	

Event Damages	Baseline	Project
25 - year storm	**$6,557,531**	**$2,607,580**
100 - year storm	**$7,756,761**	**$3,626,994**

Total Benefits from BCA Toolkit	$2,022,636
Other Benefits (Not Recreation)	$59,879
Recreation Benefits	-
Total Costs	$23,804,086
Net Benefits	-$21,721,570
Net Benefits with Recreation	-$21,721,570
Final BCR	**0.087**
Final BCR with Recreation	**0.087**

[9] BCA Costs are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Figure 23. BCA Tool Results – Tri-County Drainage Master Plan FMPs (Risk Area 26 – Balchuck Ln and Digger Ln)[10]

Input Into BCA Toolkit

Project Useful Life	**30**	

Event Damages	Baseline	Project
25 - year storm	**$4,060,741**	**$3,029,619**
100 - year storm	**$7,893,219**	**$5,178,853**

Total Benefits from BCA Toolkit	$969,829
Other Benefits (Not Recreation)	$53,309
Recreation Benefits	-
Total Costs	$14,171,325
Net Benefits	-$13,148,187
Net Benefits with Recreation	-$13,148,187
Final BCR	**0.072**
Final BCR with Recreation	**0.072**

[10] BCA Costs are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Figure 24. BCA Tool Results – Tri-County Drainage Master Plan FMPs (Risk Area 27 – Nottingham Acres)[11]

Input Into BCA Toolkit

Project Useful Life **30**

Event Damages	Baseline	Project
25 - year storm	**$9,018,289**	**$5,724,843**
100 - year storm	**$10,834,022**	**$8,276,585**

Total Benefits from BCA Toolkit	$1,434,572
Other Benefits (Not Recreation)	$374,407
Recreation Benefits	-
Total Costs	$31,067,815
Net Benefits	-$29,258,836
Net Benefits with Recreation	-$29,258,836
Final BCR	**0.058**
Final BCR with Recreation	**0.058**

[11] BCA Costs are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Figure 25. BCA Tool Results – Tri-County Drainage Master Plan FMPs (Risk Area 28 – South Prairie Estates)[12]

Input Into BCA Toolkit

Project Useful Life	**30**	

Event Damages	Baseline	Project
25 - year storm	**$2,610,806**	**$2,269,235**
100 - year storm	**$4,076,991**	**$3,472,403**

Total Benefits from BCA Toolkit	$224,595
Other Benefits (Not Recreation)	$143,625
Recreation Benefits	-
Total Costs	$23,210,271
Net Benefits	-$22,842,051
Net Benefits with Recreation	-$22,842,051
Final BCR	**0.016**
Final BCR with Recreation	**0.016**

[12] BCA Costs are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Figure 26. BCA Tool Results – Tri-County Drainage Master Plan FMPs (North Robstown, West Robstown, & East Robstown Drainage Improvements)[13]

Input Into BCA Toolkit

Project Useful Life: **30**

Event Damages	Baseline	Project
25 - year storm	**$414,435,799**	**$366,754,538**
100 - year storm	**$471,410,149**	**$399,404,199**
500 - year storm	**$527,432,615**	**$451,042,140**

Total Benefits from BCA Toolkit	$34,841,129
Other Benefits (Not Recreation)	$1,255,834
Recreation Benefits	-
Total Costs	$33,526,539
Net Benefits	$2,570,424
Net Benefits with Recreation	$2,570,424
Final BCR	**1.077**
Final BCR with Recreation	**1.077**

13 BCA Costs are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Impact Analysis

An FMP is required to have no negative impacts in the neighboring area, either upstream or downstream of the project. No negative impact means that a project will not increase flood risk of surrounding properties. The increase in flood risk must be measured by the 100-year frequency storm water surface elevation and peak discharge, using the best available data. No rise in water surface elevation or discharge is permissible, and the study area must be sufficiently large to demonstrate that proposed project conditions are equal to or less than the existing (baseline) conditions.

For the purposes of regional flood planning efforts, a determination of no negative impacts can be established if stormwater runoff does not increase inundation of infrastructure such as residential and commercial structures or exceed the design capacity of stormwater systems. According to the TWDB Exhibit C Technical Guidelines, all of the following requirements should be met to establish no negative impact, as applicable:

1. Stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement.

2. Stormwater does not increase inundation of storm drainage networks, channels, and roadways beyond design capacity.

3. Maximum increase of 1D Water Surface Elevation must round to 0.0 feet (<0.05 ft) measured along the hydraulic cross-section.

4. Maximum increase of 2D Water Surface Elevations must round to 0.3 feet (<0.35 ft) as measured at each computation cell.

5. Maximum increase in hydrologic peak discharge must be <0.5 percent measured at computation nodes (sub-basins, junctions, reaches, reservoirs, etc.). This discharge restriction does not apply to a 2D overland analysis.

Because the Tri-County Drainage Master Plan project analyses were performed using a 2D modeling software, only requirements #1, #2, and #4 are applicable. Comparison of baseline and proposed condition structure inundation in Table 1 through Table 13 shows that the number of structures affected by the 100-year storm was reduced for each project. Additionally, an evaluation of the baseline- versus post- project conditions does not indicate increases in 100-year water surface elevations for neighboring properties, indicating that requirement #1 is satisfied. In most cases, the maximum increase of the 2D water surface elevation when comparing baseline and proposed conditions is less than 0.35 feet. In those instances where an increase in the 2-D water surface elevation exceeded 0.35, review of the model indicated that the excessive rise could be attributed to model noise, increased elevations in channels with improved conveyance, or be remediated by project refinement. Documentation of “no negative impacts” or the ability to mitigate any impacts was provided by Halff and ICE in one-page summary reports they prepared for their respective FMP’s. Accordingly, it was determined that requirements #2 and #4 were both satisfied.

Flood Mitigation Project Technical Memorandum

Date: Wednesday, June 07, 2023

To: Region 13 Flood Planning Group
c/o
Nueces River Authority

From: Sarah West, PE, CFM
Freese and Nichols, Inc
800 N. Shoreline Blvd., Suite 1600N
Corpus Christi, Texas 78401

Subject: FMP ID's: 133000031, 133000033, 133000037, 133000035
Project Sponsors: City of Gregory, City of Odem, City of Taft, City of Sinton
Project Names:

- Citywide Stormwater Drainage Improvements – Gregory
- Citywide Stormwater Drainage Improvements – Odem
- Citywide Stormwater Drainage Improvements – Taft
- Citywide Stormwater Drainage Improvements – Sinton

Methodologies and Procedures

1. Background

Freese and Nichols, Inc. (FNI) advanced four flood mitigation projects for the County of San Patricio. This analysis was done to provide data for the 2023 Nueces Regional Flood Plan (the Plan) concerning potential Flood Mitigation Projects (FMPs) to be recommended in the 2023 Plan.

The benefit areas consist of the cities of Gregory, Odem, Taft, and Sinton. Projects were identified for each of these cities as a part of the San Patricio County Drainage Master Plan effort currently underway by CDM Smith. Individual projects for each city were developed based on stakeholder input and modeling results. The project benefits associated with each City assume that all projects developed for that City will be implemented. Accordingly, in lieu of advancing each individual project as a separate FMP, each set of projects for a given city was combined into a single, city-wide FMP.

These projects would work to improve the LOS of roads and reduce inundated structures through the implementation of improvements such as drainage ditches, storm sewers, levees, culverts, and storage.

This memorandum documents the assumptions, methodologies and processes used to advance these FMPs in accordance with the Texas Water Development Board (TWDB) Exhibit C Technical Guidelines for Regional Flood Planning FMP requirements.

2. Data Collection

Data for these projects was obtained from the stakeholder's consultant, CDM Smith, and consisted of "Section 7 – Improvements and Alternatives Analysis" from their in-progress report, Opinion of Probable Construction Costs (OPCCs), PCSWMM models, and 100-year rasters for each city-wide project.

3. Drainage Analysis

Drainage Analysis was performed by CDM Smith using PCSWMM. Figure 1 through Figure 4 display the resulting baseline-project and post-project inundation extents for the four San Patricio County projects.

**Figure 1. Model Inundation Boundary
(Citywide Stormwater Drainage Improvements - Gregory)**

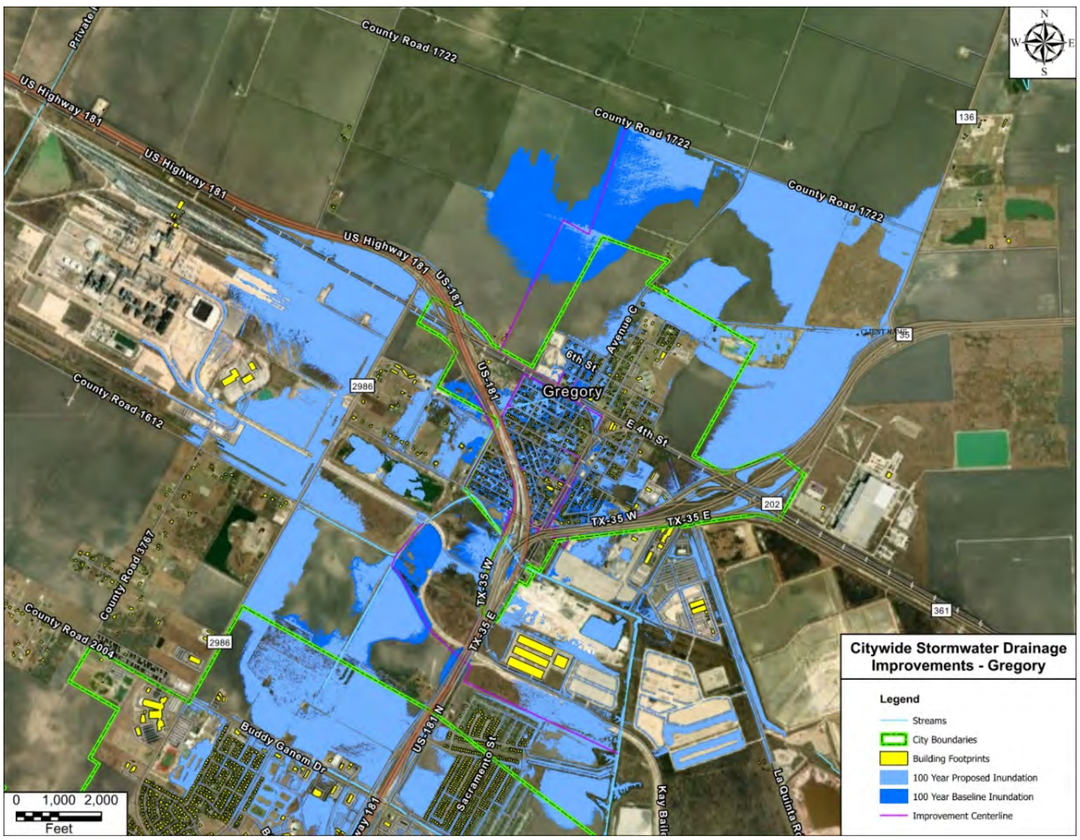


Figure 2. Model Inundation Boundary (Citywide Stormwater Drainage Improvements - Odem)

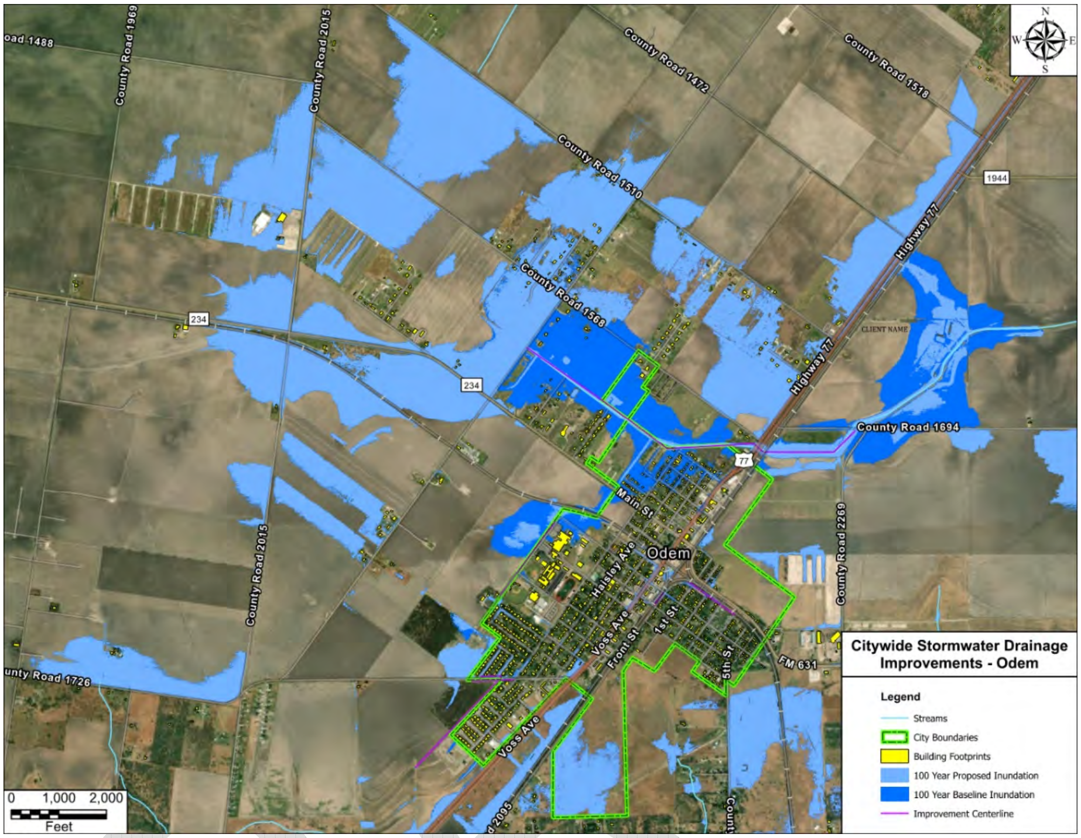


Figure 3. Model Inundation Boundary (Citywide Stormwater Drainage Improvements - Taft)

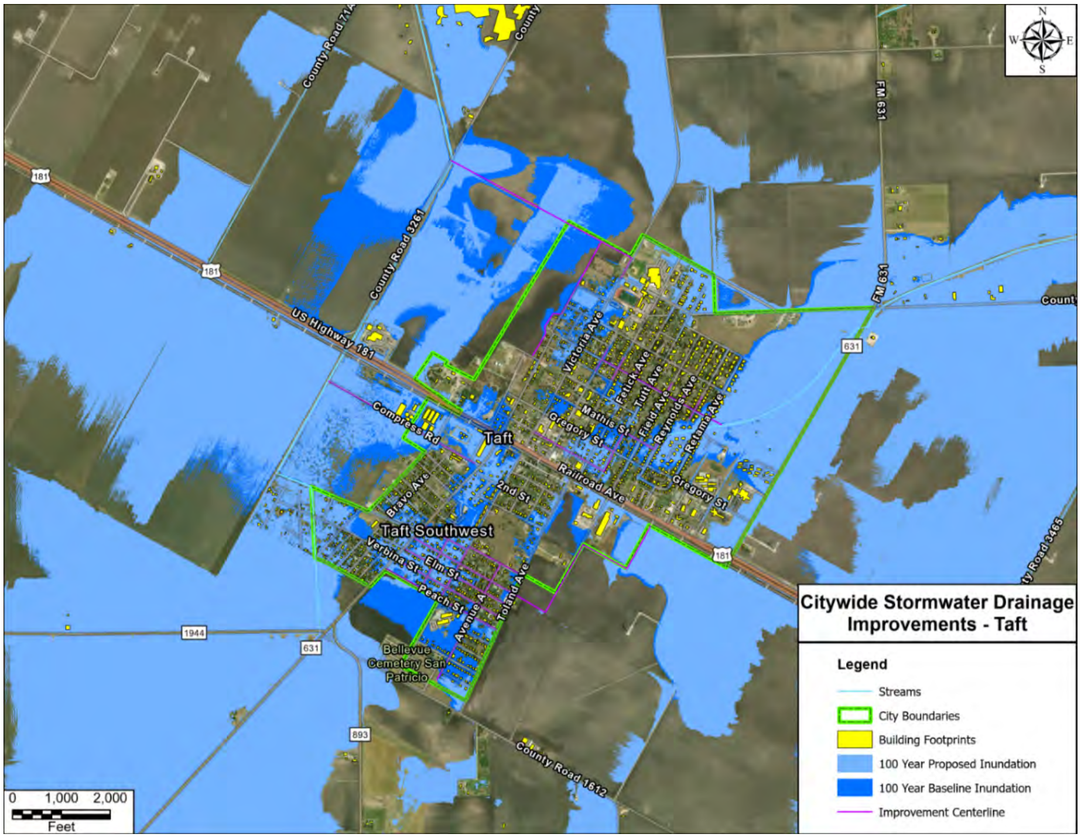
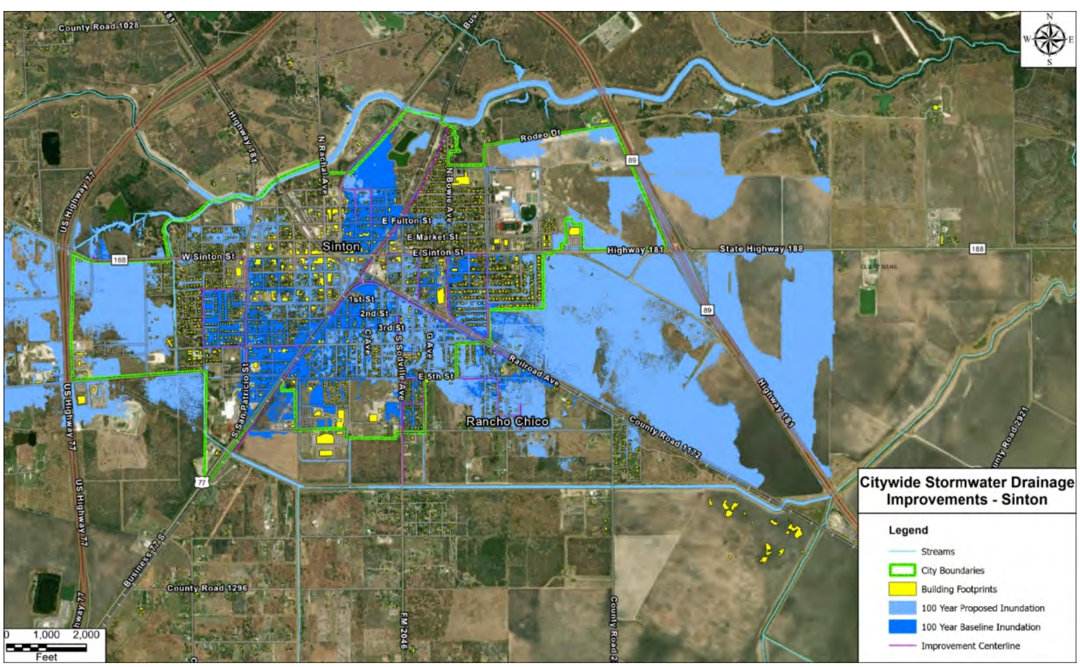


Figure 4. Model Inundation Boundary (Citywide Stormwater Drainage Improvements - Sinton)



4. Results, Benefits, and Impacts

ResultsTable 4 summarize the total number of inundated commercial and residential structures for the 100-year storm event.

Table 1. Total Impacted Structures for Baseline and Proposed Conditions (Citywide Stormwater Drainage Improvements - Gregory)

Storm Frequency Event (Years)	Baseline Conditions (structures)	Proposed Conditions (structures)	Difference (structures)
100	470	439	(31)

Table 2. Total Impacted Structures for Baseline and Proposed Conditions (Citywide Stormwater Drainage Improvements - Odem)

Storm Frequency Event (Years)	Baseline Conditions (structures)	Proposed Conditions (structures)	Difference (structures)
100	137	77	(60)

Table 3. Total Impacted Structures for Baseline and Proposed Conditions (Citywide Stormwater Drainage Improvements - Taft)

Storm Frequency Event (Years)	Baseline Conditions (structures)	Proposed Conditions (structures)	Difference (structures)
100	848	733	(115)

Table 4. Total Impacted Structures for Baseline and Proposed Conditions (Citywide Stormwater Drainage Improvements - Sinton)

Storm Frequency Event (Years)	Baseline Conditions (structures)	Proposed Conditions (structures)	Difference (structures)
100	1266	868	(398)

Benefit Measurement

Per the TWDB, each FMP included in a regional flood plan is required to have a benefit cost analysis (BCA) performed. Some flood mitigation studies document a computed benefit cost ratio (BCR), and those can be incorporated into the regional flood plan. For situations where a BCR is not available for a project, TWDB has developed the BCA Input Tool to facilitate the calculation of costs and benefits. The tool estimates flood impacts before and after implementation of the FMP for up to three recurrence interval flood events.

Since a BCR or BCA was not provided by CDM Smith, FNI prepared BCA's for the four San Patricio County projects. The BCA's considered the following project impacts:

- Residential Buildings
- Commercial Structures

In addition to the TWDB tool assumptions, the following section describes other assumptions which were applied during the BCA.

COST

FNI used Opinion of Probable Constructions Cost breakdowns provided by CDM Smith and de-escalated these breakdowns to September 2020 costs in conformance with TWDB FMP cost requirements. De-escalation was achieved using a Construction Cost Index (CCI) factor of 0.916 for each project. The Gregory, Odem, Taft, and Sinton projects were accordingly determined to be $25,079,300, $25,210,000, $32,942,200, and $103,189,700, respectively. These 2020 estimated total costs were used in the BCA. The total costs include all the required applicable TWDB FMP costs including basic engineering fees; special services such as surveying, environmental, and geotechnical; and other costs such as land/easement acquisition and administration, fiscal services, and contingency.

CONSTRUCTION YEAR

Construction is assumed to start in the near future, dependent on funding. Construction start was assumed to be 2026 for all projects and the duration was determined assuming the contractor is expending $500,000 of effort per month against the de-escalated projects costs listed above. The resulting project durations are listed below:

- Gregory – 2026 to 2031
- Odem – 2026 to 2031
- Taft – 2026 to 2032
- Sinton – 2026 to 2044

RESIDENTIAL STRUCTURES

Residential structures are evaluated by the size and flood depth for the baseline and proposed project conditions. The size categories in the BCA are classified as "Small Home," "Average Home," and "Large Home." The TWDB guidelines give the following as typical sizes for each; "Small" = 1000 sq.ft., "Average" = 2,500 sq.ft., and "Large" = 5,000 sq.ft. For residential structure analyses, the following size assumptions were made:

- Small: x <2500 sq.ft.
- Average: 2500 sq.ft.< x <5000 sq.ft.
- Large: x >5000 sq.ft.

The TWDB tool limits the total amount of residential buildings that can be assessed per project to 100 structures. For three of the four projects, more than 100 structures were impacted. To maintain structure traceability, multiple spreadsheets were created to capture the structure size and inundations for each unique structure, and the totals for each spreadsheet were entered into a top-level spreadsheet for calculation of overall project benefits. Inundation depths were rounded to the nearest inch.

COMMERCIAL STRUCTURES

Commercial building damages are determined by business type and size (square footage). A combination of ArcGIS and Google Earth were used to determine the commercial building type for each structure based on readily available visuals. Inundation depths were rounded to the nearest inch.

Benefit Result

The BCA Input Tool is intended to be used in conjunction with the Federal Emergency Management Agency (FEMA) BCA Toolkit 6.0, which calculates annual benefits from the information compiled in the TWDB BCA Input Tool. The annual benefits data are then input back into the TWDB BCA Input Tool to compute the resulting BCR for the project. Figure 5 through Figure 8 summarize each of the impacts per storm and the final BCR for each project.

Figure 5. BCA Tool Results – Gregory FMP[1]

Input Into BCA Toolkit

Project Useful Life	**30**

Event Damages	Baseline	Project
100 - year storm	**$34,464,839**	**$26,994,339**

Total Benefits from BCA Toolkit	$927,005
Other Benefits (Not Recreation)	$17,409
Recreation Benefits	-
Total Costs	$18,361,853
Net Benefits	-$17,417,439
Net Benefits with Recreation	-$17,417,439
Final BCR	**0.051**
Final BCR with Recreation	**0.051**

[1] BCA Costs are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Figure 6. BCA Tool Results – Odem FMP[2]

Input Into BCA Toolkit

Project Useful Life	**30**

Event Damages	Baseline	Project
100 - year storm	**$8,569,312**	**$3,225,168**

Total Benefits from BCA Toolkit	$663,152
Other Benefits (Not Recreation)	$588
Recreation Benefits	-
Total Costs	$17,492,716
Net Benefits	- $16,828,976
Net Benefits with Recreation	- $16,828,976
Final BCR	**0.038**
Final BCR with Recreation	**0.038**

[2] BCA Costs are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Figure 7. BCA Tool Results – Taft FMP[3]

Input Into BCA Toolkit		
Project Useful Life	**30**	
Event Damages	**Baseline**	**Project**
100 - year storm	**$76,843,226**	**$53,769,810**
Total Benefits from BCA Toolkit	$2,863,163	
Other Benefits (Not Recreation)	$3,037	
Recreation Benefits	-	
Total Costs	$22,616,663	
Net Benefits	- $19,750,463	
Net Benefits with Recreation	- $19,750,463	
Final BCR	**0.127**	
Final BCR with Recreation	**0.127**	

[3] BCA Costs are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Figure 8. BCA Tool Results – Sinton FMP[4]

Input Into BCA Toolkit

Project Useful Life	**30**

Event Damages	Baseline	Project
100 - year storm	**$107,137,472**	**$50,920,654**

Total Benefits from BCA Toolkit	$6,975,904
Other Benefits (Not Recreation)	$0
Recreation Benefits	-
Total Costs	$55,042,524
Net Benefits	-$48,066,620
Net Benefits with Recreation	-$48,066,620
Final BCR	**0.127**
Final BCR with Recreation	**0.127**

[4] BCA Costs are calculated using the TWDB BCA Toolkit for the purpose of assigning a project BCR and may differ from 2020 project costs estimated based on engineering assessment and CCI factors.

Impact Analysis

An FMP is required to have no negative impacts in the neighboring area, either upstream or downstream of the project. No negative impact means that a project will not increase flood risk of surrounding properties. The increase in flood risk must be measured by the 100-year frequency storm water surface elevation and peak discharge, using the best available data. No rise in water surface elevation or discharge is permissible, and the study area must be sufficiently large to demonstrate that proposed project conditions are equal to or less than the existing (baseline) conditions.

For the purposes of regional flood planning efforts, a determination of no negative impacts can be established if stormwater runoff does not increase inundation of infrastructure such as residential and commercial structures or exceed the design capacity of stormwater systems. According to the TWDB Exhibit C Technical Guidelines, all of the following requirements should be met to establish no negative impact, as applicable:

1. Stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement.

2. Stormwater does not increase inundation of storm drainage networks, channels, and roadways beyond design capacity.

3. Maximum increase of 1D Water Surface Elevation must round to 0.0 feet (<0.05 ft) measured along the hydraulic cross-section.

4. Maximum increase of 2D Water Surface Elevations must round to 0.3 feet (<0.35 ft) as measured at each computation cell.

5. Maximum increase in hydrologic peak discharge must be <0.5 percent measured at computation nodes (sub-basins, junctions, reaches, reservoirs, etc.). This discharge restriction does not apply to a 2D overland analysis.

Projects for the Cities of Gregory, Odem, Taft, and Sinton within the San Patricio County Drainage Master Plan were checked for downstream impacts under the 100-year storm event by CDM Smith. No downstream impacts were found, and a Certification of No Negative Impacts letter was provided by the design engineer as documentation for each City. Please see the San Patricio County Drainage Master Plan for documentation of the modeling analysis and results.

Amended 2023 San Antonio Regional Flood Plan - Project Narrative

Project Name:	**Old Frio City Road at North Prong Creek Bridge**
FMP ID:	**133000038**
Project Sponsor:	**Bexar County**
Date:	**3/3/2023**

Flood Mitigation Project Technical Memorandum

Date:	Thursday, June 08, 2023
To:	Region 13 Flood Planning Group c/o Nueces River Authority
From:	Bryan Martin, PE HDR, Inc/ Firm No. 754 4401 W Gate Blvd Ste 400 Austin, TX 78745
Subject:	FMP ID: 133000038 Project Sponsor: Bexar County Project Name: Old Frio City Road at North Prong Creek Bridge

BACKGROUND INFORMATION:

This FMP was advanced through the San Antonio Regional Flood Planning group as part of Task 12 Amendments. Upon further review, it was determined that this FMP is located primarily within the Nueces River boundary and will be added to the Region 13 plan.

As part of the amended 2023 San Antonio Regional Flood Plan (the Plan), Task 12 expands on previously identified FMXs from the Plan dated January 10th, 2023. The Old Frio City Road at North Prong Creek Bridge, FME ID 121000163, from the 2022 Bexar County Line LWC Engineering Study was further developed during Task 12. This project is sponsored by Bexar County.

The problem area is located in Bexar County, close to the border with Medina and Atascosa Counties. At the intersection of Old Frio City Road and North Prong Creek, just after Unnamed Trib to North Prong Atascosa River confluences with Unnamed Trib 5 in North Prong Creek. Currently there is a low water crossing (LWC) at Old Frio City Road is composed of five 24" RCP. The LWC is undersized which results in overtopping during the 10-, 25-, 50-, and 100-Yr storm events. When the structure overtops it cuts off a main connection route for the nearby neighborhood.

The Task 12 work that was completed for the Old Frio City Road at North Prong Creek Bridge project was a drainage analysis, cost estimate, impact analysis, and a Benefit Cost Analysis (BCA).

PROPOSED PROJECT SCOPE

Refer to the Amended Flood Plan Technical Memo for documented assumptions and methodologies on drainage analysis to determine a feasible solution.

Amended 2023 San Antonio Regional Flood Plan - Project Narrative

Project Name: Old Frio City Road at North Prong Creek Bridge
FMP ID: 133000038
Project Sponsor: Bexar County
Date: 3/3/2023

This project will eliminate overtopping of Old Frio City Road and provide 100-Yr conveyance design, removing structures from the existing conditions floodplain extents. Proposed improvements consist of channel regrading, increasing the road elevation and adding a bridge. The proposed road profile will increase 4ft from existing. The existing five 24" RCP will be replaced with a 250ft wide bridge with a 4ft high opening.

PROPOSED PROJECT SCOPING COST

Refer to the Amended Flood Plan Technical Memo for documented assumptions and methodologies on project costs.

The estimated the project cost for the Old Frio City Road at North Prong Creek Bridge is $3,018,000, as calculated using 2020 prices. The cost includes all the required applicable TWDB FMP, costs including basic engineering fees, special services such as surveying, environmental, geotech, etc., other costs such as land/easement acquisition and administration, fiscal services, and contingency. See attached Cost Summary for cost breakdown. If there are underground utilities that require adjustments, this may increase depending upon any additional adjustments required. At this time, funding for the project has not been identified or approved.

PROPOSED PROJECT BENEFITS

This project will eliminate overtopping at Old Frio City Road and improve the level of service by providing a 100-Yr conveyance design.

Refer to the Amended Flood Plan Technical Memo for documented BCA assumptions and methodologies.

The 10-, 25-, 100-Yr benefits that were evaluated for this project include; LWC improvements. The resulting benefit cost analysis was 0.1. The Table 1 below summarizes the components calculated in the TWDB BCA Tool. Costs may differ from previously reported cost because they are adjusted to the year of construction, assumed 2025-2026.

Table 1: TWDB BCA Toolkit

Input Into BCA Toolkit		
Project Useful Life	**30**	
Event Damages	**Baseline**	**Project**
10 - year storm	**$299,403**	**$0**
25 - year storm	**$191,618**	**$0**
100 - year storm	**$215,570**	**$0**
Total Benefits from BCA Toolkit	$280,742	
Other Benefits (Not Recreation)	$0	

Recreation Benefits	-
Total Costs	$2,901,203
Net Benefits	-$2,620,461
Net Benefits with Recreation	-$2,620,461
Final BCR	**0.1**
Final BCR with Recreation	**0.1**

IMPACT ANALYSIS

Refer to the Amended Flood Plan Technical Memo for documented assumptions and methodologies on impact analysis.

Existing and proposed conditions were analyzed for impact, the impacts that were evaluated are the water surface elevations (WSE) and velocities +/-2000ft of this project area. The WSE and velocities were compared in the HEC-RAS v5.0.5 model, see attached digital submittal for the HEC-RAS Existing vs Proposed Results Comparison Summary - the proposed conditions showed reduced levels with both components. From the RAS results, the total inundated boundary was reduced in proposed conditions, see attached Exhibits for existing and proposed project layouts and WSE comparison. Flooded depths over the road were evaluated in the BCA, reduced impacts show lower flooded depths in proposed conditions. The following Table 2 summarizes the level of service pre- and post-project:

Table 2: Level of Service Existing Vs. Proposed

Condition	Level of Service	100-Yr Depth Over Road (ft)
Existing	< 10-Yr	1.9 ft
Proposed	100-Yr	0 ft

(See full list of roadway crossing impacts in the attached BCA results)

PROJECT RISKS

ROW/Real Estate Acquisition:

No, land acquisition is not required for this project.

Utilities Coordination:

No, currently there are no evident utility conflicts. During the design phase, utility conflicts should be further evaluated.

Permitting/Environmental:

No permits will be required.

Stakeholder coordination:

Due to the road improvement and local surrounding community there will be various stakeholders involved in the process.

MITIGATION OF RISKS

Utility Coordination:

If utility conflicts are found, the utility coordinator will need to closely work with the affected utility companies to ensure timely completion of the proposed project. The project manager and contractor should minimize, as much as feasible, the amount of disruption of services and travel.

Permitting/Environmental:

If permits do arise during the design, coordination and permitting process should be started early on to avoid schedule delays.

Stakeholder Coordination:

Old Frio City Road is the main access for several residential properties. Road reconstruction will cause traffic disruptions and inconveniences for locals due to limited alternative access points. Public meetings and flyers will help communicate construction impacts to affected businesses of any service interruption or inconvenience. The businesses near the project limits should be notified several weeks before the construction start date. Construction phasing and traffic control will be an important design component for this project.

NATURE BASED SOLUTION (NBS) CONSIDERATION

The proposed project employs a bridge instead of a low water crossing. Using a bridge benefits the natural ecosystem by allowing more sediment transport, passage of aquatic organisms and does not impound water. The larger opening also allows for natural substrate to cover the culvert bottom to allow for aquatic organism passage. Changes to the geometry may impact velocities, a natural channel design is recommended to offset the potential impacts.

Landscaping cost (3% of total construction cost) was factored into the total cost for potential channel stabilization and NBS solutions.

INTERRELATED PROJECTS

There are no interrelated projects.