Lower Colorado-Lavaca
REGIONAL FLOOD
PLANNING GROUP
REGION 10

Flood Management Evaluation Memorandum

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DATE: April 12, 2023

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PROJECT: LCRA Contract No. 5809
Halff AVO 43796.001
HDR PN 10304676

This document is released for the purposes of interim review only by:
Paul Shattuck
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SUBJECT: **FME ID: 101000167**
Project Sponsor: City of Marble Falls
Project Name: Broadway Avenue at Backbone Creek Low Water Xing Upgrade

On September 15, 2022, the Lower Colorado-Lavaca Regional Flood Planning Group (RFPG) approved the evaluation of this Flood Management Evaluation (FME) to identify, evaluate and recommend additional potentially feasible Flood Mitigation Projects (FMP).

Introduction

The purpose of this FME was to perform a flood mitigation alternatives analysis and select a preferred solution for final design to replace/upgrade the Broadway Street bridge crossing at Backbone Creek within the City of Marble Falls as shown in Figure 1 below. The Broadway Street bridge is one of the most commonly closed low water crossings in Marble Falls and in located in a Zone AE special flood hazard with a designated floodway. It is a heavily trafficked street, providing an alternative route to the US 281/1431 intersection, as well as a frequented route for emergency response vehicles which are stationed nearby. Existing conditions model results indicate the Broadway Street bridge crossing incapable passing the 2-Year event without roadway overtopping. Alternatives analysis will include upsizing of the bridge crossing to allow for greater level-of-service vehicular traffic.

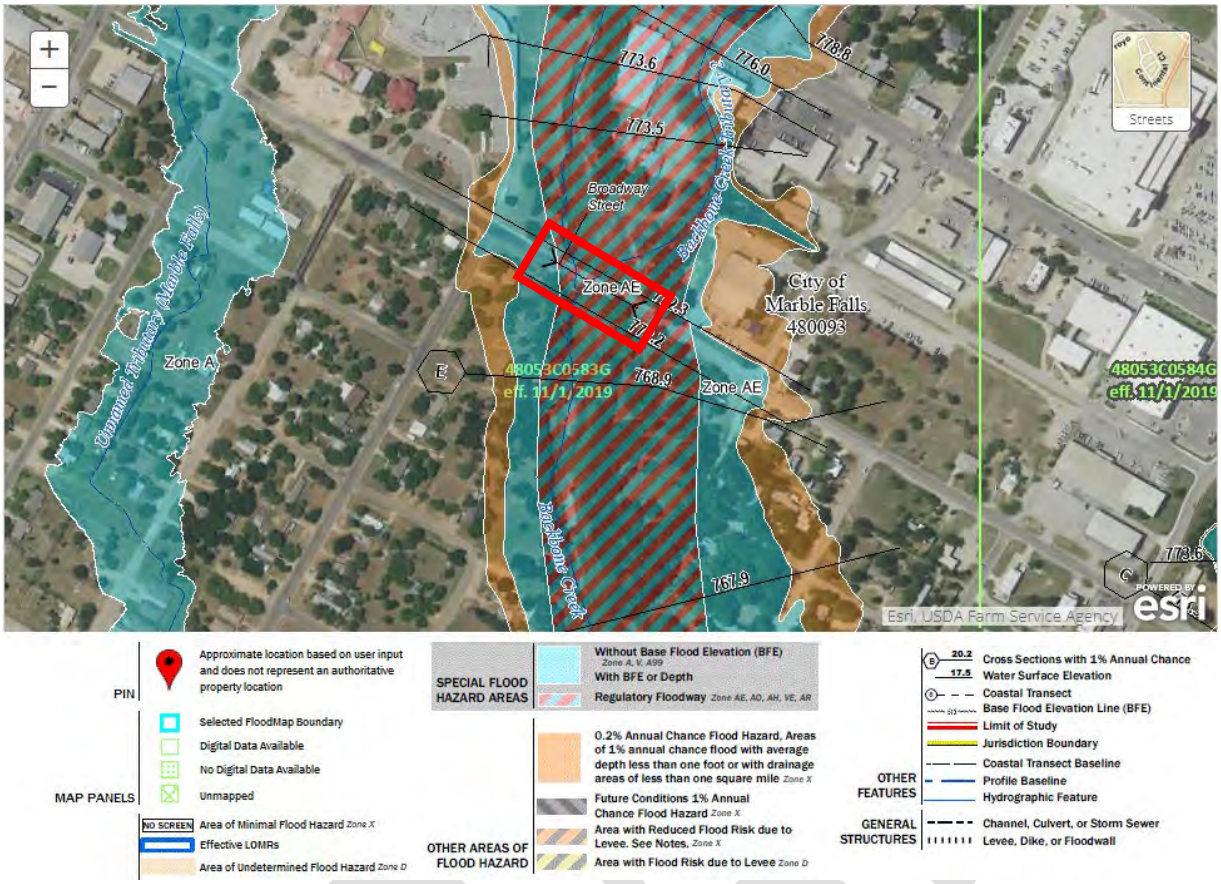

Figure 1: Study Area Location of the Broadway Street Low Water Crossing

Modeling Analysis

The following sections provide an overview of the data, hydrologic analysis, and hydraulic analysis used to evaluate the existing condition and proposed project flood risk.

Data Collection and Site Visits

A one-meter resolution bare-earth ground digital elevation model (DEM) was created for the project area using a combination of 2019 United States Geological Survey LiDAR data (USGS 2019) and 2020 Texas Strategic Mapping (StratMap) Program LiDAR data from North and Central Texas (StratMap 2020). The processed DEM was used to update the existing conditions model 1-D HEC-RAS cross sections near Broadway Street and to provide a starting point in the development of proposed improvement model cross sections. In addition to the desktop DEM processing in GIS, a field reconnaissance of the Broadway Street bridge crossing was performed by HDR staff to inspect surface level features and related infrastructure potentially impacted by proposed crossing improvements.

Hydrology

A HEC-HMS hydrologic model of Backbone Creek, which includes Whitman Branch, was provided to HDR from Halff Associates and is considered best the available model. This model was developed circa 2014 as part of a flood study by Halff Associates for the City of Marble Falls. This HEC-HMS model is believed to be the source of, and to match the regulatory model for Backbone Creek because the model output matches regulatory HEC-RAS hydraulic model flow inputs. The model includes basin models representing both existing and fully developed

conditions of Backbone Creek. Only the fully developed basin model was used for this FMP. The provided HMS model was updated to include Atlas 14 rainfall.

- Modeling Software: HEC-HMS version 3.5
- Rainfall Data: NOAA Atlas 14, 24-hour duration, frequency storm temporal distribution
- Initial Losses: Not revised or verified for this study. Basin model representing ultimate / fully developed conditions was used.
- Hydrograph Approach: NRCS TR-55 unit hydrograph. This methodology was not revised or verified for this study.
- Routing: Provided model utilizes Modified Puls and Muskingum Cunge reach routing methodologies. These values were not revised or verified for this study.
- Areal Reduction: Depth-Area reduction of the rainfall data was calculated internally within HEC-HMS using the storm area of the Backbone Creek watershed of 31.605 square miles approximately at the point of interest of the Broadway Street and 10th Street bridges.

HEC-HMS NOAA Atlas 14 rainfall inputs and corresponding peak flows in the HEC-RAS model are provided in Table 1.

Table 1: HEC-HMS Rainfall Input Values and Calculated Peak Flows (Future Conditions Land Use)

Rain Event	2YR	10YR	25YR	100YR
Rainfall (inches)	3.76	6.13	7.91	11.30
HEC-RAS XS Station	Peak Flows (cfs)			
13725	7950	19260	26730	36560
12132	8190	19750	27360	38440
8144	8190	19750	27350	38470
6481	8180	19730	27300	38450
6119	8240	19860	27480	38880
5366	8330	20060	27760	39790
4835	8320	20010	27700	39790
3426	8310	19900	27560	39710
2397	9370	21710	30710	48180
838	9350	21670	30570	48090

Hydraulics

An Existing Conditions 1-D HEC-RAS model previously developed by TWDB Flood Protection Planning Study in 2014 for Backbone Creek served as a starting point for the hydraulic modeling efforts for Broadway Street bridge analysis. Model cross sections in the immediate vicinity of the bridge (approximately 500 feet upstream and downstream) were reviewed and updated using the processed DEM as previously discussed. Peak flows from the HEC-HMS model were entered into the HEC-RAS model to simulate existing conditions (based on future land use hydrology) and bridge alternatives flood inundation depths and extents. The remainder of the HEC-RAS hydraulic cross sections outside of the immediate project area were left unchanged. The downstream boundary condition at the outlet of Backbone Creek entering the Colorado River was also left unchanged and assumes a normal depth condition friction slope of 0.0053.

Existing Condition Flood Risk

Figure 2 shows the existing conditions water surface profile for the 2, 10, 25 and 100 year, 24-hour duration rain events at the Broadway Street and 10th Street bridges. As shown on Figure 3, the Broadway Street bridge is overtopped during the 2-year event while the 10th Street Bridge is overtopped during the 10-year event. Within Marble Falls critical lifeline services (emergency management services, fire, and police) are divided on opposite sides of Backbone Creek cutting off services to residents and businesses during flood events.

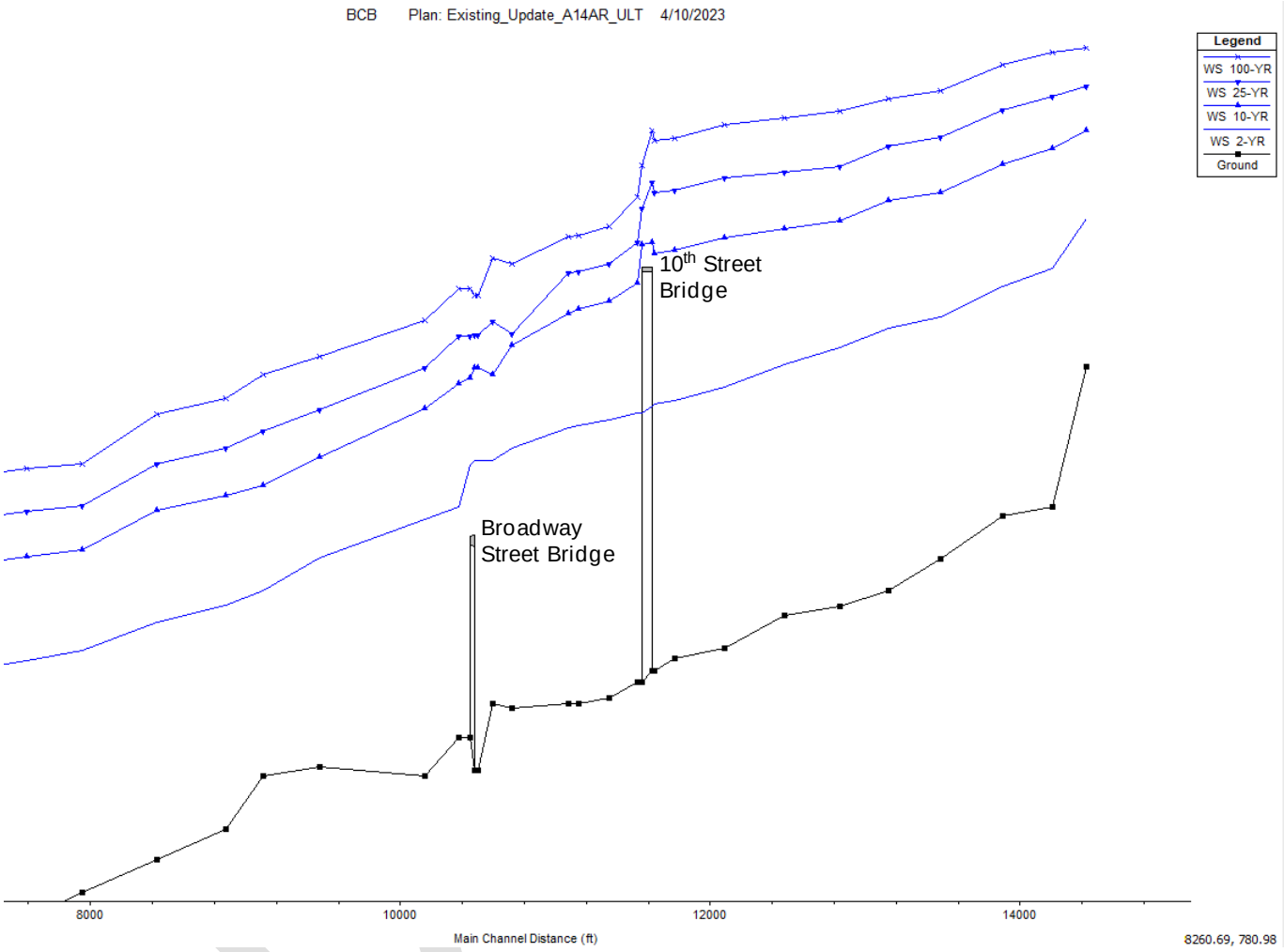

Figure 2: Existing Condition Flood Risk – Water Surface Elevation Profile for the 2, 10, 25, and 100-Year, 24-Hour Rain Events

Based on results from the HEC-RAS model, existing flow capacity of the Broadway Street Bridge and the 10th Street Bridge without experiencing roadway overtopping are equal to approximately 6,000 cfs and 17,000 cfs, respectively.

Figure 3 shows the existing conditions 100-year event flood inundation extents with adjacent building footprint near the project study area.

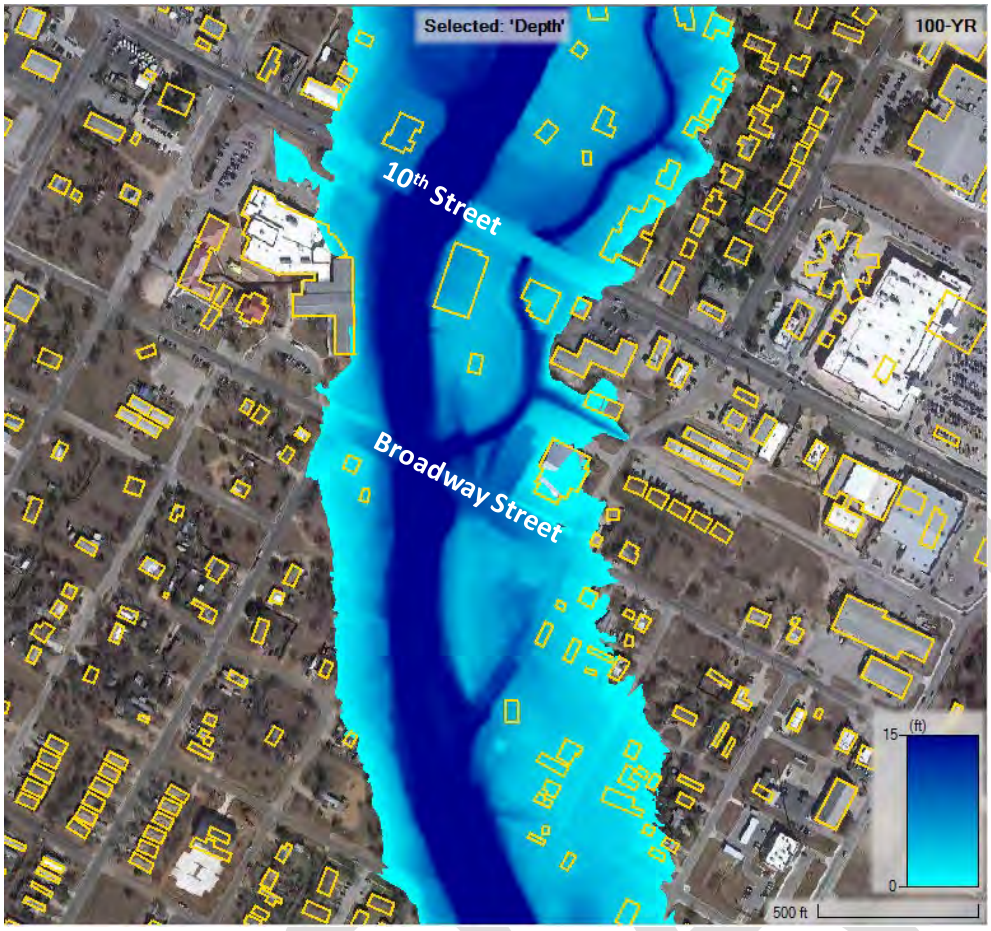

Figure 3: Existing Condition 100-Year Flood Inundation Extents

Proposed Improvements

Proposed improvements for the project area include full replacement of the existing Broadway Street bridge, stream channel improvements, and increasing conveyance and storage in the adjacent floodplains. The proposed bridge selected for the modeling analysis is based on Texas Department of Transportation Prestressed Concrete Slab Beam Spans for a 28' wide roadway (SPSB-28) with 50-foot-long spans and 2-foot-wide piers at the ends of each span. The bridge deck includes a 32-inch rail on top of the deck as per Texas Department of Transportation Type T221 Traffic Rail. The existing bridge is approximately 150 feet in length with the top of the bridge deck at an elevation of 763.5 feet. The new bridge deck length will be increased to approximately 350 feet be raised up 10.5 feet to elevation 773. To cover the 350-foot distance of the new bridge, approximately seven 50-foot concrete spans and seven rows of bridge piers will be needed. Included as part of the bridge replacement are raising and repaving the existing road approach sections from intersection to intersection to match the bridge deck elevation of 773 feet, replacing existing sidewalks and raising manhole rim elevations near the intersection with Avenue S, and installing a new retaining wall to protect and maintain access to an existing sewage pump station near Avenue Q. A schematic of the proposed bridge improvements is shown in Figure 4.

The proposed project increases the maximum flow capacity of the bridge at Broadway Street without roadway overtopping to approximately 39,000 cfs (from approximately 6,000 cfs in Existing Conditions).

Figure 4: Proposed Bridge Improvements

As previously mentioned, the proposed project includes stream channel and floodplain improvements to increase conveyance capacity and floodplain storage. The Existing Condition and Post-Project DEMs are shown in Figure 5. The total excavated soil quantity as part of the proposed project is equal to approximately 35,500 cubic yards.

Existing water and sewer utilities were obtained and reviewed from Marble Falls. It assumed that utility relocations will not be needed as part of the project as it appears that existing infrastructure is below the bottom of the existing stream channel. All proposed stream channel and floodplain grading improvements are proposed to be above this elevation therefore not impacting existing subsurface water and sewer utilities. However this assumption should be confirmed via survey under future design work.

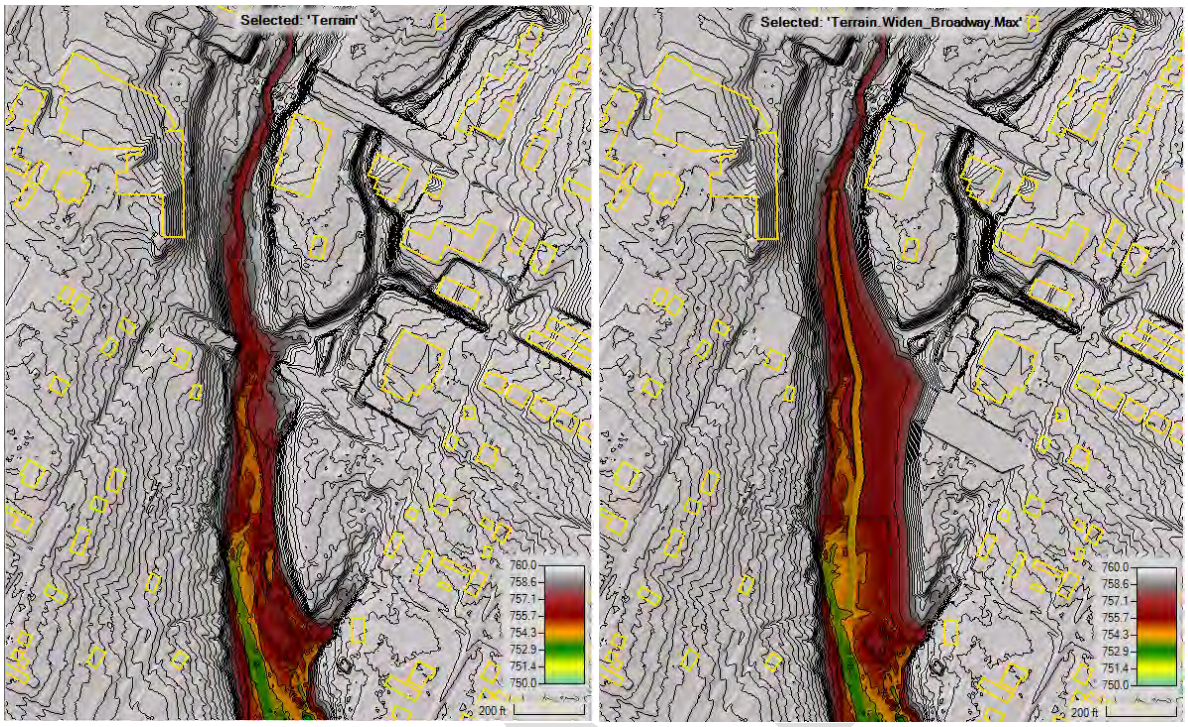

Figure 5: Existing Conditions (Left) and Post Conditions (Right) Stream Channel and Floodplain Conveyance Improvements

Project Benefits

Project benefits were evaluated for three categories: flood risk reduction to residential and commercial buildings, low water crossing damages, and flooded streets detours due to hours impassible over Backbone Creek.

Table 2 and Figure 6 indicates the flood risk reduction benefits to commercial and residential buildings for the 2-, 10-, 25-, and 100-year events. As shown in Table 2, adjacent flood reduction benefits are minimal for the proposed project.

Table 2: Risk Reduction Benefits

Flood Risk Condition	Reduction in the Number of Flooded Commercial Buildings	Reduction in the Number of Flooded Residential Buildings
50% Annual Chance (2-year)	0	0
10% Annual Chance (10-year)	0	0
4% Annual Chance (25-year)	0	0
Existing Condition 1% Annual Chance (100-year)	2	1

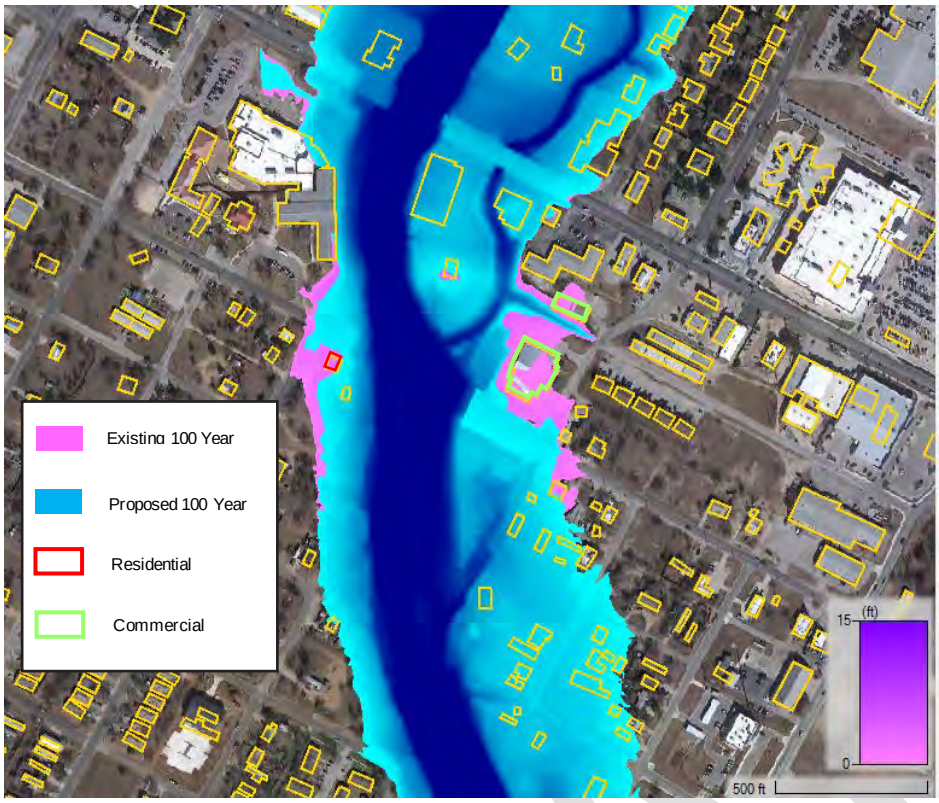

Figure 5: Flood Risk Reduction Benefits for the 100-Year Event

To determine low water crossing damages and flooded streets project benefits an understanding of the hours impassible for the project area is needed. Hours impassible for Broadway Street and 10th Street bridges was calculated by comparing the maximum flow capacity without overtopping of each bridge (existing conditions and proposed project) and the design storm hydrograph output from HEC-HMS. Any hydrographs flows exceeding the flow capacity of the bridge were considered as impassible. The timing analysis is based on a design storm hydrograph and actual hydrograph durations are expected to differ. The impassible hours calculation results are shown in Table 3.

Table 3: Total Hours Impassible Reduction Benefits

Flood Risk Condition	Broadway Street		10th Street	
	Hours Impassible During Existing Conditions	Hours Impassible During Proposed Conditions	Hours Impassible During Existing Conditions	Hours Impassible During Proposed Conditions
50% Annual Chance (2-year)	1.3	0	0	0
10% Annual Chance (10-year)	3.3	0	1.4	0
4% Annual Chance (25-year)	4.2	0	2.3	1.5
Existing Condition 1% Annual Chance (100-year)	6.2	0	3.2	3.1

In addition to hours impassible low water crossing damages and flooded streets benefits require total vehicular traffic counts for the project area. A total daily vehicular traffic count of 18,478 cars was used for the analysis. Total vehicular counts were determined using Texas Department of Transportation State Wide Traffic Counts Web Map for TX-1431 (10th Street).

Finally the detour route is needed to determine the flooded streets benefits. The detour route for Marble Falls Emergency Services, fire, and police to access the opposite banks of Backbone Creek would require approximately 16 additional miles for a total of 28 minutes. The detour route is shown in Figure 6. The proposed project would eliminate this detour up to approximately the 25-year event.

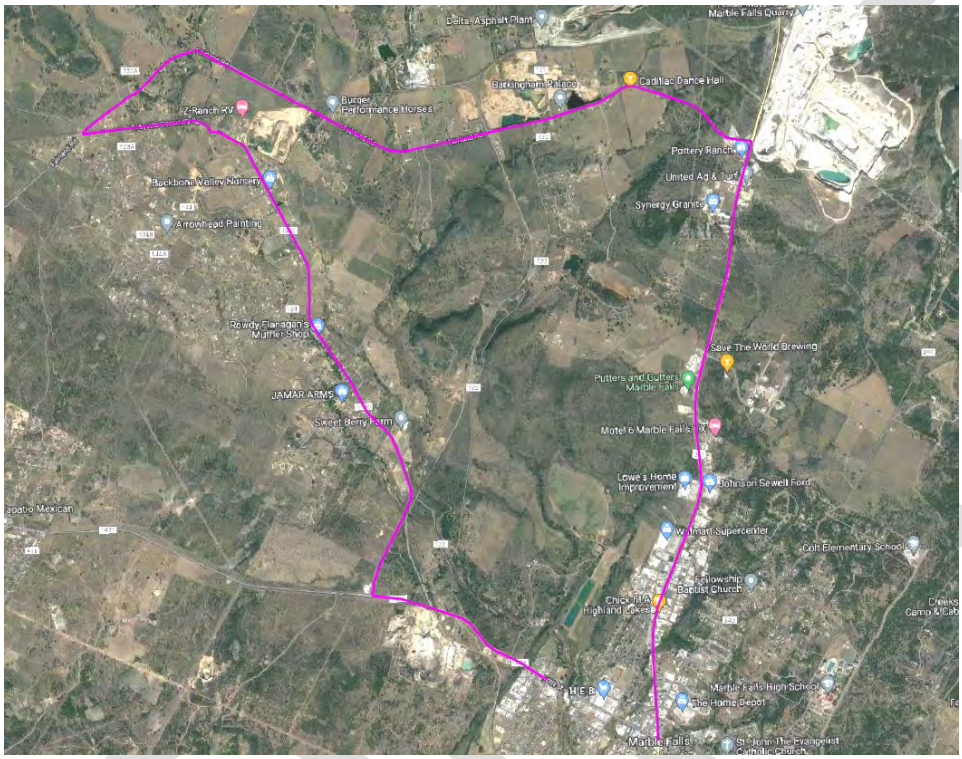

Figure 5: Detour Route for Emergency Management Services, Fire, and Police

Each of the above benefit assumptions were used as inputs in the cost benefit analysis spreadsheets.

Estimate of Probable Cost

The proposed project is estimated to cost $5,234,400 in 2023 dollars. Cost of the project include construction costs, land acquisition (assume assessed value using Burnet Central Appraisal District data multiplied by three to account for cost uncertainties), design and permitting (15%), and contingency (35%). An itemized breakdown of the cost estimate is provided in Table 4.

Table 4: Itemized Cost Estimate for the Proposed Project

Materials/Facilities/Services	$/Unit	Unit	Quantity	Construction	Acquisition	2023 Cost	2020 Cost (adjusted using ENR CCI)
Silt Fence for Erosion Control	$ 6.00	LF	2400	$ 14,400.00		$ 14,400.00	$ 12,568.14
Preparing the Right of Way	$ 20,000.00	LS	1	$ 20,000.00		$ 20,000.00	$ 17,455.75
Remove Existing Bridge/Road/Sidewalk	$ 15.00	SY	3800	$ 57,000.00		$ 57,000.00	$ 49,748.88
Floodplain Tree Removal/Clearing of Brush	$ 500.00	EA	50	$ 25,000.00		$ 25,000.00	$ 21,819.68
Relocate Overhead Electrical Utilities	$ 10,000.00	EA	2	$ 20,000.00		$ 20,000.00	$ 17,455.75
Excavation (Floodplain and New Stream Channel)	$ 10.00	CY	35500	$ 355,000.00		$ 355,000.00	$ 309,839.52
Embankments	$ 10.00	CY	0	$ -		$ -	$ -
MSE Retaining Wall Near Existing Pump Station	$ 60.00	SF	700	$ 42,000.00		$ 42,000.00	$ 36,657.07
Bridge (All Structural Elements)	$ 150.00	SF	12600	$ 1,890,000.00		$ 1,890,000.00	$ 1,649,568.16
Replace Asphalt Pavement for Road Approach	$ 110.00	SY	1300	$ 143,000.00		$ 143,000.00	$ 124,808.60
Replace Sidewalk West Side Only	$ 70.00	SY	300	$ 21,000.00		$ 21,000.00	$ 18,328.54
Raise Manholes	$ 1,000.00	EA	2	$ 2,000.00		$ 2,000.00	$ 1,745.57
Seeding of Floodplain and Embankments (STRAW/HAY MLCH SEED(PERM)(RURAL)(CLAY))	$ 0.57	SY	30400	$ 17,328.00		$ 17,328.00	$ 15,123.66
Tree plantings in floodplain	$ 300.00	EA	50	$ 15,000.00		$ 15,000.00	$ 13,091.81
Soil Retention Blanket Class A; Type G	$ 5.00	SY	8200	$ 41,000.00		$ 41,000.00	$ 35,784.28
Care of Surface Water	$ 60,000.00	LS	1	$ 60,000.00		$ 60,000.00	$ 52,367.24
Traffic Control	$ 80,000.00	LS	1	$ 80,000.00		$ 80,000.00	$ 69,822.99
TOTAL CONSTRUCTION COST				$ 2,802,728.00	$ -	**$ 2,802,728.00**	**$ 2,446,185.65**
Design and Permitting (15% construction cost)	15%					$ 420,409.20	$ 366,927.85
CLOMR/LOMR Preparation and Fees	$50,000	LS				$ 50,000.00	$ 43,639.37
Environmental; archaeological & historical resources	$ 60,000.00	LS				$ 60,000.00	$ 52,367.24
Temporary and/or permanent easements; land acquisition	$ 424,781.61	LS				$ 424,781.61	$ 370,744.03
Mobilization	11%					$ 308,300.08	$ 269,080.42
Legal assistance; fiscal services & costs (bond counsel); outreach; land acquisition (3% construction cost)	3%					$ 84,081.84	$ 73,385.57
Interest during construction (*assume 1Yr)	3.5%					$ 98,095.48	$ 85,616.50
Inspection; pilot testing; warranty; manuals	$ 5,000.00	LS				$ 5,000.00	$ 4,363.94
Contingency(s) (35% construction cost)	35%					$ 980,954.80	$ 856,164.98
TOTAL ADDITIONAL COST						**$ 2,431,623.01**	$ 2,122,289.89
TOTAL COST						**$ 5,234,351.01**	$ 4,568,475.54

Project Constraints

Restraints include uncertainties with existing water, sewer, and overhead electrical utility conflicts. Within the project area are an existing sewage pump station, a sanitary sewer stream crossing, and potable water mains. The buried elevations and condition of this infrastructure is unknown. Costs associated with relocating this infrastructure are not included as part of the estimate and is assumed that the proposed project (new bridge and grading) can work around and accommodate this infrastructure as necessary. Channel modifications must also be refined to support authorization under a USACE Section 404 permit.

Benefit Cost Analysis

A cost benefit analysis was performed using TWDB BCA workbook version 2 and FEMA's BCA Excel Add-in Tool. From the spreadsheets it was determined that the Low Water Crossing benefits have the most significant impact on the benefit cost ratio (BCR). Small adjustments to existing depth of flooding over roadway significantly impact whether this project exceeds a required BCR value of 1.0. This issue is illustrated in Tables 4a and 4b. By adjusting the existing depth of flooding over the roadway from 48-inches to 42-inches the BCR value passes the 1.0 threshold. However, the existing flooding depth on Broadway Street bridge is estimated to be more than 48-inches (see Figure 2).

Table 4a: BCR with 48-inch Existing Flood Depth

Input Into BCA Toolkit		
Project Useful Life	30	
Event Damages	**Baseline**	**Project**
100 - year storm	$4,781,872	$0
25 - year storm	$3,245,828	$0
10 - year storm	$2,052,509	$0
Total Benefits from BCA Toolkit	$3,981,751	
Other Benefits (Not Recreation)	$52,113	
Recreation Benefits	-	
Total Costs	$5,596,579	
Net Benefits	-$1,562,715	
Net Benefits with Recreation	-$1,562,715	
Final BCR	**0.7**	
Final BCR with Recreation	**0.7**	

Table 4b: BCR with 42-inch Existing Flood Depth

Input Into BCA Toolkit		
Project Useful Life	30	
Event Damages	**Baseline**	**Project**
100 - year storm	$9,142,204	$0
25 - year storm	$6,366,908	$0
10 - year storm	$4,026,133	$0
Total Benefits from BCA Toolkit	$7,744,272	
Other Benefits (Not Recreation)	$52,113	
Recreation Benefits	-	
Total Costs	$5,596,579	
Net Benefits	$2,199,806	
Net Benefits with Recreation	$2,199,806	
Final BCR	**1.4**	
Final BCR with Recreation	**1.4**	

Given this significant change in BCR result, both methods were presented for consideration. It is recommended that the Low Water Crossing methodology and results be reviewed with TWDB and Marble Falls to determine most appropriate inputs for achieving desired results for the proposed project.

No Negative Impact

In accordance with the *TWDB Technical Guidelines for Regional Flood Planning*, "No Negative Impact means that a project will not increase flood risk of surrounding properties. Using best available data, the increase in flood risk must be measured by the 1 percent annual chance event water surface elevation and peak discharge. It is recommended that no rise in water surface elevation or discharge should be permissible and that the analysis

extent must be vast enough to prove proposed project conditions are equal to or less than the existing conditions."

The maximum water surface elevation results in HEC-RAS were extracted for the cross sections within the entire model domain during Existing and Proposed Conditions. Results are presented in Table 4 and indicate no rise throughout the model domain. It should be noted that as part of this evaluation the hydrologic routing impacts of increased velocities through the cross sections due to the proposed channel modifications. As part of detailed design, any future channel modifications will require considerations for potential increased velocities and sheer stresses.

Table 4: HEC-RAS Maximum Water Surface Elevation Existing and Proposed Condition for 100-Year Event

River Station Cross Section	W.S. Elev (ft)		Proposed - Existing (ft)	River Station Cross Section	W.S. Elev (ft)		Proposed - Existing (ft)
	Existing	Proposed			Existing	Proposed	
13725	784.81	784.81	0.00	8144	766.82	766.82	0.00
13507	784.62	784.61	-0.01	7783	766.64	766.64	0.00
13183	784.1	784.08	-0.02	7241	766.09	766.09	0.00
12785	782.99	782.95	-0.04	7120	766.05	766.05	0.00
12448	782.6	782.01	-0.59	7067	765.95	765.95	0.00
12132	782.06	782.01	-0.05	6834	765.1	765.1	0.00
11777	781.78	781.73	-0.05	6481	764.51	764.51	0.00
11391	781.52	781.46	-0.06	6119	764.22	764.22	0.00
11069	780.93	780.86	-0.07	5918	764.14	764.14	0.00
10938	780.79	780.71	-0.08	5824	762.77	762.77	0.00
10828	778.37	778.22	-0.15	5366	761.79	761.79	0.00
10643	777.12	776.85	-0.27	4835	760.87	760.87	0.00
10520	776.71	775.86	-0.85	4336	760.36	760.36	0.00
10452	776.64	776.04	-0.60	4250	759.95	759.95	0.00
10319	775.53	770.4	-5.13	4163	759.81	759.81	0.00
10188	775.79	771.88	-3.91	3960	759.74	759.74	0.00
10088	774.09	772.42	-1.67	3426	757.98	757.98	0.00
9965	774.41	771.31	-3.10	2548	757.11	757.11	0.00
9748	773.09	770.9	-2.19	2397	755.65	755.65	0.00
9430	771.49	770.5	-0.99	2311	755.69	755.69	0.00
9314	770.68	770.39	-0.29	1933	754.75	754.75	0.00
9068	769.67	769.67	0.00	838	752.78	752.78	0.00
8627	768.99	768.99	0.00	197	747.89	747.89	0.00

Mitigation Measures

The preliminary modeling confirms the following:

- The proposed project increases the level of service for the crossing Backbone Creek within Marble Falls to approximately the 25-year event.
- The proposed project does not increase inundation in areas beyond the public right-of-way, project property, or easement.
- Meets the maximum increase criteria of 1D Water Surface Elevation rounds to 0.0 feet (< 0.05ft) measured along the hydraulic cross-section within the right-of-way.
- The BCR value is primarily dependent on Low Water Crossing benefit calculations. Results fluctuate and it is recommended for further discussion with TWDB.

As the projects are advanced, the impact analysis should be updated to reflect final design and confirm no negative impacts.

Technical Memorandum Attachments

Attachment 1. TWDB-Required Tables

- Table 16: Recommended Flood Mitigation Projects
- Geodatabase Table: Project Details

Attachment 2. Flood Mitigation Project

- FMP Summary Sheet
- Cost Estimate
- Benefit Cost Ratio

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Attachment 1

TWDB-Required Tables

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Attachment 2

Flood Mitigation Project