Gatesville
Master Drainage Plan

Final Report

Submitted to:

Texas Water Development Board
Contract Administration
1700 North Congress Avenue
Austin, TX 78701

Submitted by:

Walker Partners
823 Washington Avenue, Suite 100
Waco, TX 76701

May 2023

This Document is Released for the Purpose of Interim Review Under the Authority of Professional Engineer CURTIS BEITEL, P.E. #83213

Walker Partners, LLC
TBPE Registration No. F-8053

Executive Summary ES-1

1.0 Introduction 1

1.1 Purpose 2

1.2 Scope of Work 2

1.3 Study Area Delineation 4

2.0 Data Collection 5

2.1 Previous Studies and Reports 5

2.1.1 FEMA Effective Study 5

2.1.2 Previous Studies / Reports 6

2.2 Topographic Data 8

2.3 Field Survey 8

2.4 Historic Flooding Reports 9

3.0 Study Methodology 10

3.1 Hydrology 10

3.1.1 Drainage Area Delineation 10

3.1.2 Precipitation 10

3.1.3 Soils and Land Use 11

3.1.4 Time of Concentration 12

3.1.5 Hydrologic Channel Routing 12

3.3 Hydraulics **12**

3.3.1 Cross Section Development 13

3.3.2 Hydraulic Structures 14

3.3.3 Boundary Conditions 15

3.3.4 Manning's Roughness Coefficients 15

3.3.5 Ineffective Flow Areas 16

3.4 Economic Analysis **16**

4.0 Hydrology 17

4.1 Watershed Parameters **17**

4.1.1 Drainage Area Delineation 17

4.1.2 Soils and Land Use 17

4.1.3 Time of Concentration 18

4.1.4 Hydrologic Channel Routing 18

4.2 Peak Flow Rates **18**

5.0 Hydraulics and Floodplain Mapping 20
5.1 Hydraulic Model Results 20
5.2 Floodplain Mapping 21
6.0 Problem Area Evaluation 22
6.1 Problem Area Identification 22
6.2 Dodd Branch Problem Areas 23
6.2.1 01 Kalyn Siebert on US 84 23
6.2.2 02 FM 2412 Crossing 24
6.2.3 03 Moccasin Bend Road Crossing 25
6.3 Leon River Problem Areas 26
6.3.1 04 East Leon Street 26
6.3.2 05 Faunt Le Roy Park 27
6.3.3 06 Leon Wastewater Treatment Plant 28
6.3.4 07 Raby Park 29
6.3.5 08 Shady Lane Channel 30
6.3.6 09 Golf Course Road and Lovers Lane 31
6.4 Stream CG-2 Problem Areas 32
6.4.1 10 Straws Mill Road Low Water Crossing 32
6.4.2 11 SH 36 and Arrowood Crossing 33
6.4.3 12 At US 84 Crossing 34
6.5 Stillhouse Branch Problem Areas 35
6.5.1 13 Mears Drive and 28th Street 35
6.5.2 14 FM 929 Crossing 36
6.5.3 15 Stillhouse Wastewater Treatment Plant 37
6.5.4 16 Sun Valley Neighborhood 38
6.6 Problem Area Evaluation Summary 39
7.0 Mitigation Solutions 40
7.1 Mitigation Strategies 40
7.1.1 Regional Detention 40
7.1.2 Channel Improvements 40
7.1.3 Bridge and Culvert Improvements 40
7.1.4 Property Acquisitions 41
7.1.5 Flood Warning Systems 41
7.2 Conceptual Mitigation Solutions 41
7.2.1 01 East Leon Street 41
7.2.2 02 Leon Wastewater Treatment Plant 43
7.2.3 03 Straws Mill Road Low Water Crossing 44
7.2.4 04 SH 36 and Arrowood Crossing 46
7.2.5 05 FM 929 Crossing 48
7.2.6 06 Sun Valley Neighborhood 49

8.0 Conclusions and Recommendations................................51
8.1 Public Meetings and Workshops................................51
8.2 Ranking of Solutions................................51
8.3 Recommendations................................52
9.0 Acknowledgements................................54
10.0 References................................55

List of Figures

1-1 Coryell Creek - Leon River HUC-10 Watershed................................4
1-2 HUC-10 Watersheds Downstream of Lake Proctor................................4
3-2 TIN Used to Cut Cross Sections................................14
6-1 Kalyn Siebert on US 84................................23
6-2 FM 2412 Crossing................................24
6-3 Moccasin Bend Road Crossing................................25
6-4 East Leon Street................................26
6-5 Faunt Le Roy Park................................27
6-6 Leon Wastewater Treatment Plant................................28
6-7 Raby Park................................29
6-8 Shady Lane Channel................................30
6-9 Golf Course Road and Lovers Lane................................31
6-10 Straws Mill Road Low Water Crossing................................32
6-11 SH 36 and Arrowood Lane................................33
6-12 At US 84 Crossing................................34
6-13 Mears Drive and 28th Street................................35
6-14 FM 929 Crossing................................36
6-15 Stillhouse Wastewater Treatment Plant................................37
6-16 Sun Valley Neighborhood................................38
7-1 East Leon Street Levee Alternative................................42
7-2 Leon Wastewater Treatment Plant Parapet Wall................................43
7-3 Straws Mill Road Low Water Crossing................................44
7-4A Arrowood Lane Culvert Replacement – 10% ACE................................46
7-4B SH 36 Culverts – 1% ACE................................47
7-5 FM 929 Culverts and Channel – 1% ACE................................48
7-6 Sun Valley Neighborhood Levee Alternative................................49
8-1 Summary of Recommended CIP Solutions................................53

List of Tables

1-1 Hydraulic Model Study Reach Lengths....1
2-1 Summary of Previous Studies/Reports....5
2-2 Summary of Recent Flood Events....9
3-1 Depth-Duration-Frequency Data....11
3-2 Overbank Land Use Manning's n-Values....15
4-1 FIS Peak Discharge Comparison – Leon River....18
4-2 FIS Peak Discharge Comparison – Stillhouse Branch....19
4-3 FIS Peak Discharge Comparison – Other Study Streams....19
4-4 FIS Discharge Comparison – Other Watersheds in HUC 10....19
5-1 FIS Comparison – Leon River....20
5-2 FIS Comparison – Stillhouse Branch....20
5-3 FIS Comparison – Stream CG-2 and Stream CG-4....21
6-1 Problem Area Evaluation Summary....39
8-1 List of Public Meetings....51
8-2 Summary of Mitigation Solutions....52

Appendices

Appendix A – Data Collection

A-1 Field Survey Points

Appendix B – Hydrology

B-1A Sub-basin Delineation and Flow Paths (HUC-10), B-1B (Citywide)
B-2A Soils (HUC 10), B-2B (Citywide)
B-3 Land Use
B-4A Impervious Cover Percentage (HUC 10), B-4B (Citywide)
B-5 Time of Concentration Calculations
B-6 Sub-basin Peak Discharge

Appendix C – Hydraulics and Floodplain Mapping

C-1 Hydraulic Work Map – Leon River A
C-2 Hydraulic Work Map – Dodd Branch A
C-3 Hydraulic Work Map – Dodd Branch B
C-4 Hydraulic Work Map – Dodd Branch C
C-5 Hydraulic Work Map – Stillhouse Branch A
C-6 Hydraulic Work Map – Stillhouse Branch B
C-7 Hydraulic Work Map – Stream CG-4
C-8 Hydraulic Work Map – Stream CG-5 A
C-9 Hydraulic Work Map – Stream CG-5 B
C-10 Hydraulic Work Map – Stream CG-3 A
C-11 Hydraulic Work Map – Stream CG-3 B
C-12 Hydraulic Work Map – Leon River B
C-13 Hydraulic Work Map – Leon River C
C-14 Hydraulic Work Map – Leon River D
C-15 Hydraulic Work Map – Stream CG-2 A
C-16 Hydraulic Work Map – Stream CG-2 B

C-17 Hydraulic Work Map – Stream CG-2 C
C-18 Hydraulic Work Map – Stillhouse Branch C
C-19 MDP vs. FEMA 1% Floodplain – Leon River A
C-20 MDP vs. FEMA 1% Floodplain – Dodd Branch A
C-21 MDP vs. FEMA 1% Floodplain – Dodd Branch B
C-22 MDP vs. FEMA 1% Floodplain – Dodd Branch C
C-23 MDP vs. FEMA 1% Floodplain – Stillhouse Branch A
C-24 MDP vs. FEMA 1% Floodplain – Stillhouse Branch B
C-25 MDP vs. FEMA 1% Floodplain – Stream CG-4
C-26 MDP vs. FEMA 1% Floodplain – Stream CG-5 A
C-27 MDP vs. FEMA 1% Floodplain – Stream CG-5 B
C-28 MDP vs. FEMA 1% Floodplain – Stream CG-3 A
C-29 MDP vs. FEMA 1% Floodplain – Stream CG-3 B
C-30 MDP vs. FEMA 1% Floodplain – Leon River B
C-31 MDP vs. FEMA 1% Floodplain – Leon River C
C-32 MDP vs. FEMA 1% Floodplain – Leon River D
C-33 MDP vs. FEMA 1% Floodplain – Stream CG-2 A
C-34 MDP vs. FEMA 1% Floodplain – Stream CG-2 B
C-35 MDP vs. FEMA 1% Floodplain – Stream CG-2 C
C-36 MDP vs. FEMA 1% Floodplain – Stillhouse Branch C

Appendix D – Conceptual Mitigation Solutions

D-1A East Leon Street – Levee Alternative
D-1B East Leon Street – Buyout Alternative
D-2 Leon Wastewater Treatment Plant
D-3 Straws Mill Road Low Water Crossing
D-4A Arrowood Lane Culvert Replacement
D-4B SH 36 Culverts
D-5F M 929 Culverts and Channel Improvements
D-6A Sun Valley Neighborhood – Levee Alternative
D-6B Sun Valley Neighborhood – Buyout Alternative

Appendix E – Digital Data on TWDB FIF Cat 1 Project One-Drive

40021_Gatesville_Master_Drainage_Plan
  01_TechnicalReport
    01_Final - Final Report.pdf, Final Report.doc
  02_Models
    01_Hydrologic - 08_40021_HECHMSVer4.9_Leon_River_Basin
    02_Hydraulic - 08_40021_HECRASVer6.2_Leon_River_Basin
  03_GIS
    01_ElevationData
    02_ShpFiles - 08_40021_GatesvilleMDP.gdb, utilities
    03_MapsandFigures - Gatesville_MDP.mxd
  04_Supporting
    01 Public_Outreach
    02 References - LIDAR QC Report, Leon WPP, etc.
    03 USACE - Leon River RAS original

List of Acronyms Used

ACE	Annual Chance Exceedance
AEP	Annual Exceedance Probability
BCA	Benefit-Cost Analysis
cfs	Cubic Feet per Second
CIP	Capital Improvement Program
CN	Curve Number
CCAD	Coryell County Appraisal District
DS	Downstream
DTM	Digital Terrain Model
FEMA	Federal Emergency Management Agency
FFE	Finished Floor Elevation
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
fps	feet per second
GIS	Geographic Information System
GPS	Global Positioning Systems
HEC	USACE Hydrologic Engineering Center
HMS	Hydraulic Modeling System
IFA	Ineffective Flow Area
LiDAR	Light Detection and Ranging
LOB	Left Over Bank
NAD 83	North American Datum of 1983
NAVD 88	North American Vertical Datum of 1988
NFIP	National Flood Insurance Program
NGVD	National Geodetic Vertical Datum
NLCD	National Land Cover Database
NRCS	Natural Resources Conservation Service
RAS	River Analysis System
RCB	Reinforced Concrete Box Culvert
ROB	Right Over Bank
ROW	Right of Way
RS	River Station (Cross Section)
SCS	Soil Conservation Service
SSURGO	Soil Survey Geographic Database
TNRIS	Texas Natural Resources Information System
TR-55	USDA Technical Release 55
TWDB	Texas Water Development Board
TxDOT	Texas Department of Transportation
US	Upstream
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WOTUS	Waters of the U.S.
WSEL	Water Surface Elevation
XS	Cross Section

Executive Summary

As is the case for any city, past development decisions have resulted in recurring flooding in areas of the City of Gatesville (City). Both City parks – Faunt Le Roy and Raby – are regularly closed during flooding events, and recent development upstream of Business US 84 has increased runoff resulting in flooding along a channel south of downtown. To establish a path forward to mitigate flooding issues, the City applied for a grant under Category 1 of the Flood Infrastructure Fund and retained Walker Partners to prepare a Master Drainage Plan.

The purpose of this Master Drainage Plan was multi-fold:

- Gather and record historical information regarding flooding within the 1207020109: Coryell Creek – Leon River watershed;
- Analyze the watershed to determine the current peak discharges;
- Establish accurate digital mapping of the limits of the 100-year floodplain;
- Evaluate the adequacy and safety of existing drainage infrastructure including bridges, culverts, channels, and other facilities/structures;
- Identify local and regional (structural and non-structural) flood mitigation projects to provide long-term, sustainable flood protection measures;
- Recommend a Capital Improvement Program to plan and construct new improvement projects to protect the public against flood damage and injury, including loss of human life.

"State-of-the-art" computerized hydrologic and hydraulic modeling techniques were utilized to create new floodplain maps based upon modern-day urbanization and land use. This floodplain analysis revealed 16 potential flood-prone areas. For each of these problem areas, both structural and non-structural mitigation strategies were analyzed to protect public safety and property.

The non-structural mitigation strategies considered by the project team include the following:

- Property acquisition (buy-outs)
- Flood warning systems

The structural mitigation strategies considered for each identified flooding area include the following:

- Regional Detention;
- Conveyance Improvements –
  - Channelization Improvements
  - Bridge/Culvert Improvements
- Earthen Levee Improvements and Parapet Walls

Economic analyses were conducted for the various mitigation strategies analyzed for each flood-prone area and the "best value" solution has been recommended at each site. Since they are proposed to be incorporated in the State Flood Plan and funded by the Flood Infrastructure Fund (FIF), detailed benefit-cost analyses were performed for the Sun Valley Neighborhood and Straws Mill Road sites. TWDB's abridged data was provided to describe the flood risk at the other locations. A summary of the recommended flood mitigation solutions, along with the estimated project costs and responsible entities, are shown in **Table ES-1** below:

Table ES-1: Summary of Mitigation Solutions.

Flood-Prone Area	Recommended Solution	Estimated Cost	Responsible Entity	BC Ratio	Funding Source
East Leon Street	Acquire or raise 10 houses	$1,425,405	City of Gatesville	N/A	FEMA Hazard Mitigation or Increased Cost of Compliance
Leon Wastewater Treatment Plant	Construct a parapet wall to add 2 feet to the ring embankment	$642,100	City of Gatesville	N/A	CWSRL grant
Straws Mill Road Low Water Crossing	Raise roadway by 5 feet and enlarge culverts	$1,021,710	City of Gatesville; Coryell County	1.81	FIF Project grant
Arrowood Lane **SH 36**	Replace the bridge crossing Add 2 8'x8' culverts	$982,192 $328,140	Coryell County, City of Gatesville	N/A N/A	CDBG-DR grant TXDOT
FM 929 crossing	Replace and add culverts, widen downstream channel	$1,535,250	TXDOT and City of Gatesville	N/A	General TXDOT
Sun Valley Neighborhood	Construct an earthen levee	$1,594,294	City of Gatesville	1.38	FIF Project grant
Total Proposed	**Mitigation Cost**	$7,529,091			

1.0 Introduction

Sound regional planning brought forth Lake Proctor and Lake Belton – flood control lakes along the Leon River which have tamed the river for almost 70 years. Now, however, planning is needed for the urbanized watersheds, streams, and tributaries that flow into the Leon River. Gatesville, like most major cities, has experienced urban sprawl since the early 1960's. The City of Gatesville Master Drainage Plan will evaluate and develop solutions for recurring flooding.

The City of Gatesville contains portions of four major, regional watersheds, all within the Leon River basin. Two of these watersheds, the Stillhouse Branch and the Dodd Branch converge with the Leon River just upstream of the US Highway 84 crossing. Detailed hydraulic modeling was performed for 28 stream miles of the Leon River, Stillhouse Branch and its tributaries and the Dodd Branch within the municipal limits and ETJ of Gatesville, as described in **Table 1-1** below and in red in **Figure 1-1** on the next page, along with detailed hydrologic modeling of the entire Coryell Creek – Leon River HUC-10 watershed (1207020109: Coryell Creek – Leon River) approximately 46 square miles.

Table 1-1 – Hydraulic Model Study Reach Lengths.

Stream Name	Downstream Limit	Upstream Limit	Effective Zone	Length (miles)
Leon River	Approximately 5,900 ft. DS of HWY 36	Confluence with Stillhouse Branch	AE	13.2
Stillhouse Branch	Confluence with Leon River	Highway 36	AE A	1.8 2.2
CG-3	Confluence with Stillhouse Branch	Highway 36	A	1.6
CG-4	Confluence with Stillhouse Branch	Coryell City Road	AE	0.2
CG-5 (new)	Confluence with Stillhouse Branch	Highway 36	A	1.6
CG-5A (new)	Confluence with Stream CG-5	Northern Avenue	A	0.4
CG-7 (new)	Confluence with Stillhouse Branch	Highway 36	A	0.3
CG-2	Confluence with Leon River	Highway 84	AE A	1.5 1.5
CG-2A (new)	Confluence with Stream CG-2	Highway 84	A	0.3
Dodd Branch	Confluence with Leon River	Highway 84	A	3.4
		Total Length in	**(miles) =**	**28.0**

1.1 Purpose

The City of Gatesville applied for a Flood Infrastructure Fund grant from the Texas Water Development Board and retained Walker Partners to evaluate the City of Gatesville's major "riverine" drainage systems and publish Gatesville's first Master Drainage Plan. The purpose of this flood protection planning effort is to:

1. Gather and record historical information regarding flooding within the Leon River drainage basin, particularly flooding which jeopardizes public safety (including loss of human life) and causes financial damage to private properties;
2. Analyze the Coryell Creek – Leon River HUC-10 watershed to determine the current flooding conditions;
3. Update the inundation limits of the 100-year floodplain of the Leon River and its major tributaries within the city limits of Gatesville based upon urbanization as is exists today;
4. Evaluate the adequacy and safety of existing drainage infrastructure including bridges, culverts, channels, and other facilities / structures;
5. Identify local and regional (structural and non-structural) flood mitigation projects to provide long-term, sustainable flood protection measures;
6. Recommend a Capital Improvement Program to maintain and manage the existing drainage infrastructure as well as to plan and construct new improvement projects to protect the public against flood damage and injury, including loss of human life.

1.2 Scope of Work

The Gatesville Master Drainage Plan was structured to address the flooding issues that exist within the planning area; to develop updated hydrologic and hydraulic models to evaluate potential structural and non-structural flood protection measures; and to involve the general public in the development of a regional flood protection plan. The scope of work is divided into five primary tasks, as described below.

Task 1 – Field Survey

Field survey cross-sections of selected drainage channels to be used in preparing a hydraulic model to determine water surface elevations and areas of inundation. The preliminary cross section layout was based on an initial field reconnaissance visit. Based on this preliminary layout, field surveys were conducted to obtain channel cross sections, establish horizontal and vertical control datums, and obtain the physical dimensions of hydraulic and flood-control structures. Vertical control was based upon the North American Vertical Datum of 1988 (NAVD88). The 2018 LIDAR panels from the Texas Natural Resources Information System were processed to prepare terrain surfaces of the drainage channels with elevation contours at 1-foot intervals. Field survey also included surveying the finished floor elevations of up to 10 insurable structures.

Task 2 – Hydrologic Modeling

The hydrologic model includes the entire Coryell Creek – Leon River (1207020109) HUC-10 watershed shown in **Figure 1-1** below. Collect data necessary to evaluate the drainage areas and construct a computer hydrology model. HEC-HMS (version 4.10) by the U.S. Army Corps of Engineers (USACE) was utilized to model the 5-, 10-, 25-, 50-, 100-, and 500-year storm events. Hydrologic analyses were based on the latest Atlas 14 rainfall data.

Task 3 – Hydraulic Analysis

Hydraulic analyses were performed for each stream segment listed in **Table 1-1** above, including surveyed cross sections and surveyed hydraulic structures, using the peak discharges computed in Task 2 above. HEC-RAS (version 6.2) by the USACE was used to perform the hydraulic modeling of the 10-, 2-, 1-, and 0.2-percent-annual-chance events. Hydraulic analyses included the determination of water surface profiles for creeks and hydraulic capacities of culverts, bridges, and other hydraulic structures as needed at selected locations. This task did not include development of floodway hydraulic models or any modifications to regulatory floodway boundaries. The HEC-RAS model of the Leon River provided by the Fort Worth District USACE was incorporated by updating the peak discharge values. This task also did not include submittal of the updated models and floodplain mapping to FEMA as a Letter of Map Revision to update the effective FIRM maps.

Task 4 – Model Proposed Improvements

Known problem areas were identified through a regional workshop with City engineering, maintenance, and emergency management staff. The majority of the problem areas were identified initially in the data collection phase and through discussions with City staff. Other problem areas were identified based on updated floodplain mapping and modeling, or from field assessments of drainage infrastructure. Regional detention facilities to reduce the peak discharges for downstream reaches were considered for each problem area.

Conceptual solutions were prepared for each identified problem area. Next, GIS shapefiles and a map of the proposed planning area were prepared to show the extents of each conceptual solution along with tabular data describing each CIP project. The conceptual solutions and CIP were presented at Public Meeting #2 on January 24, 2023.

Task 5 – Master Drainage Plan Report

This report has been drafted to document the analysis methods used and conclusions reached regarding potential CIP projects. Preliminary opinions of project costs; other project prioritization factors for each project; and a recommended Capital Improvement Program are included in this report. Two public meetings were conducted with the representatives of the participating political subdivisions above, in an effort to solidify a regional flood protection plan. The Draft Report was presented at Public Meeting #2 on January 24, 2023.

1.3 Study Area Delineation

The entire Coryell Creek – Leon River (1207020109) HUC-10 watershed is shown in **Figure 1-1** below, along with the municipal boundaries of the City of Gatesville, their extra-territorial jurisdiction and the unincorporated areas of Coryell County.

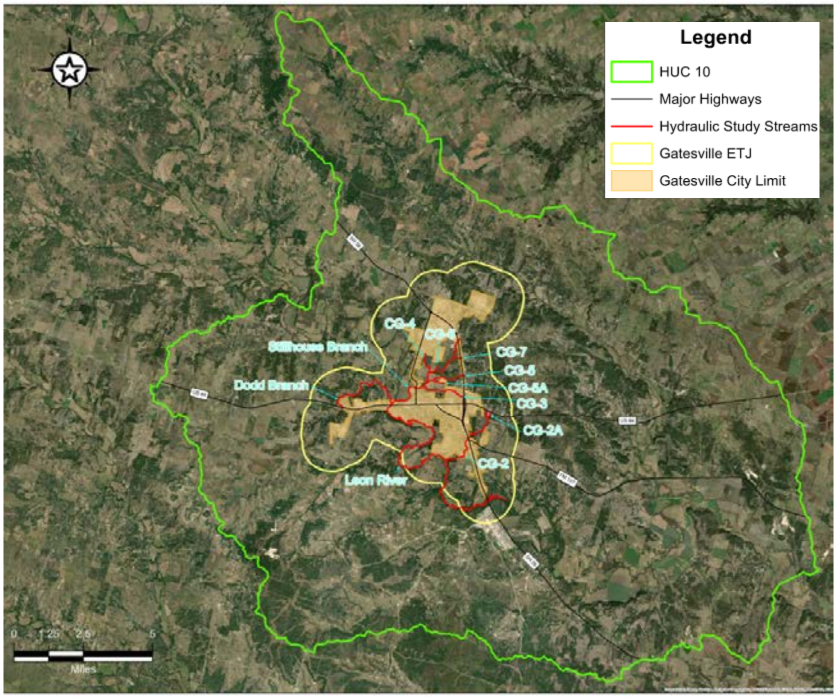


Figure 1-1: Coryell Creek – Leon River (1207020109) HUC-10 Watershed

There are 4 other HUC-10 watersheds upstream of Gatesville below Lake Proctor, shown in **Figure 1-2** below, but due to long travel times it was determined that the most intense storm events would be centered over the Coryell Creek – Leon River HUC-10.

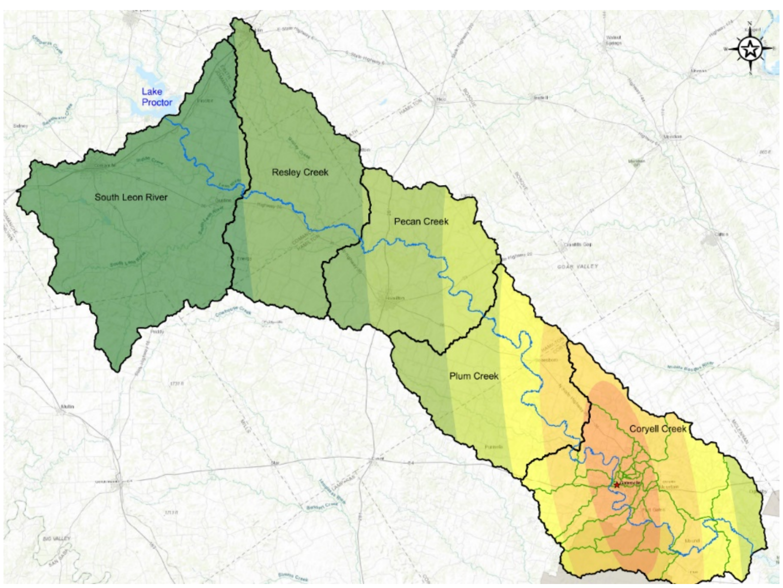


Figure 1-2: HUC-10 Watersheds Downstream of Lake Proctor

2.0 Data Collection

Available existing reports and studies regarding the Coryell Creek – Leon River HUC-10 watershed were gathered and summarized.

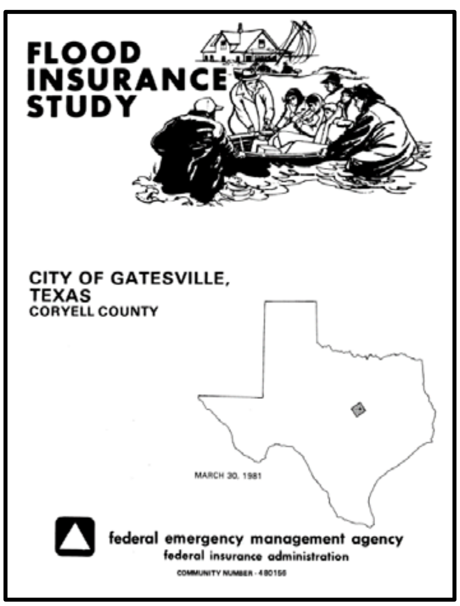
2.1 Previous Studies and Reports

Table 2-1 lists the previous studies / reports that were reviewed as part of our data mining efforts. These sets of data and reports span from 1981 to the present.

Table 2-1: Summary of Previous Studies / Reports.

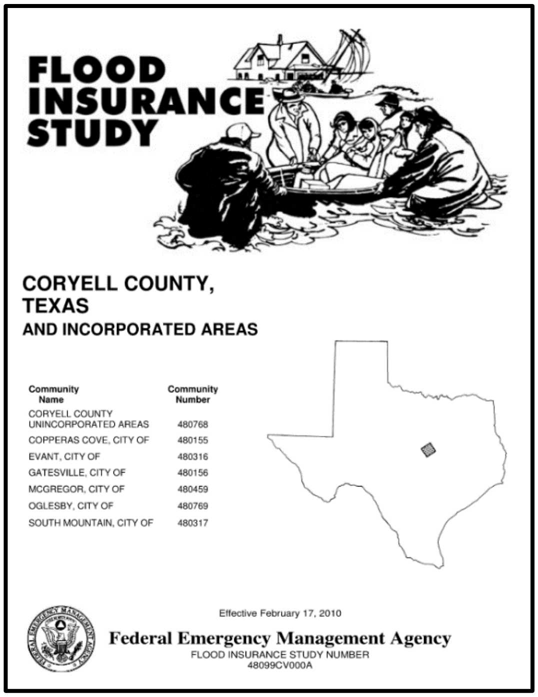
Date	Title	Author
Mar 1981	Flood Insurance Study – City of Gatesville, Coryell County, Texas	Flood Insurance Administration
May 2009	Leon WWTP Slope Protection	LAN
Feb 2010	Flood Insurance Study – Coryell County, Texas	FEMA
Jan 2015	Leon River Watershed Protection Plan	Benchmark Planning
May 2016	Brazos Basin of the Texas Red River FEMA Region 6 LIDAR	USGS
2020	Gatesville Comprehensive Plan	Benchmark Planning
2022	Coryell County Stream Crossing Prioritization	NRS

2.1.1 FEMA Effective Study



March 1981: FEMA *Flood Insurance Study – City of Gatesville, Coryell County, Texas*

The hydrologic and hydraulic analysis for this study represents a revision of the original analyses that were prepared by Albert Halff Associates, Inc. for the Federal Insurance Administration (FIA) under Contract No. H-4648. The hydraulic analysis for the original study was performed with HEC-2 and completed in April 1980.

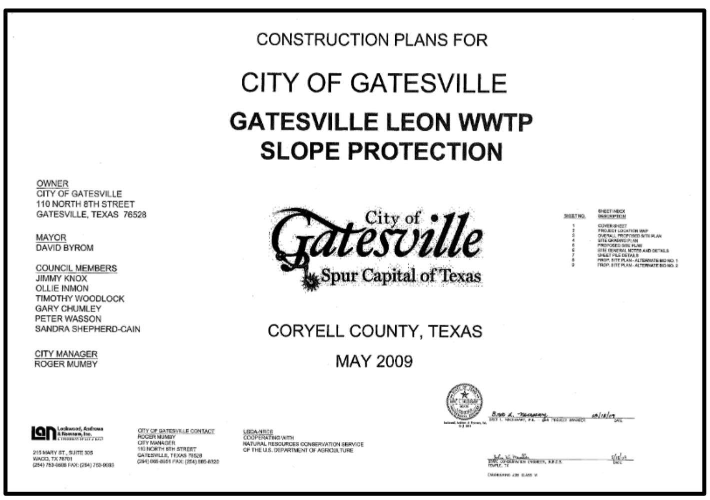


February 2010: FEMA *Flood Insurance Study – Coryell County and Incorporated Areas, Texas*

In 2010 FEMA issued an updated Flood Insurance Study for Coryell County and Incorporated Areas. The effort was largely a modernization of the FIRM maps to a digital countywide format, and the hydrologic and hydraulic analysis for this study remained the same as the original analyses prepared by Albert Halff Associates, Inc. for the FIA under Contract No. H-4648 in April 1980. For streams in Gatesville, the floodplain boundaries of the detailed study and some of the Zone A streams were redelineated onto the latest available topography, which was the USGS 7.5 minute quadrangle series maps from 1957.

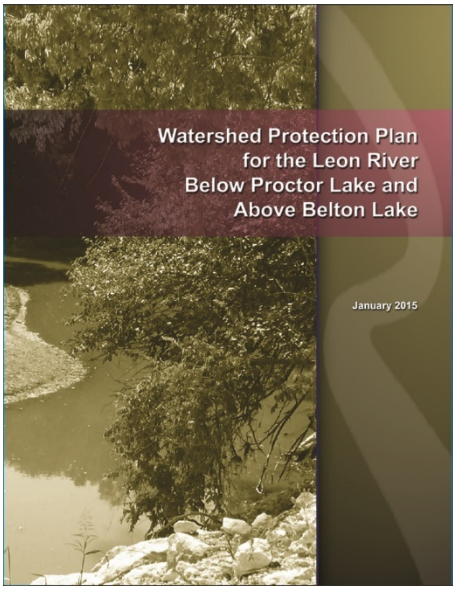
2.1.2 Previous Studies / Reports

The listing of reports below is not considered to be all inclusive, but rather it is a listing of all available reports provided by the City of Gatesville staff.



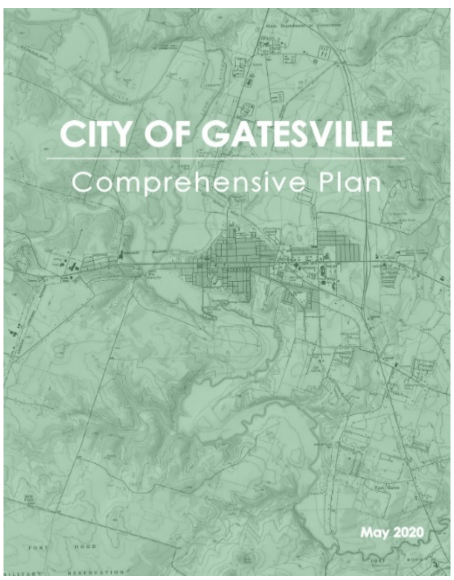
May 2009: Lockwood Andrews and Newnam *Leon WWTP Slope Protection*

In May of 2009 the City of Gatesville received emergency funding from the USDA-NRCS to construct a sheet pile wall to protect the bank of the Leon River from eroding into the Leon Wastewater Treatment Plant.



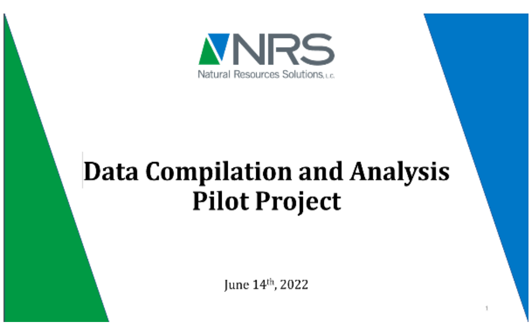
Jan 2015: Parsons Water & Infrastructure *Leon River Watershed Protection Plan*

As part of their Clean Rivers program, the Brazos River Authority (BRA) utilized a federal Clean Water Act §319(h) non-point source grant funding administered through the Texas State Soil Water & Conservation Board (TSSWCB) to develop a watershed protection plan for the Leon River from Lake Proctor downstream to Lake Belton. This was a multi-year effort supported by local stakeholders to reduce levels of bacteria and nutrients in the river and its tributaries. The Leon River was placed on the Texas 303(d) list as impaired for bacteria in 1996. A TMDL process was initiated by the TCEQ in 2002, but they delayed adoption of the final TMDL in 2008 until the WPP was completed.



2020: Benchmark Planning *City of Gatesville - Comprehensive Plan*

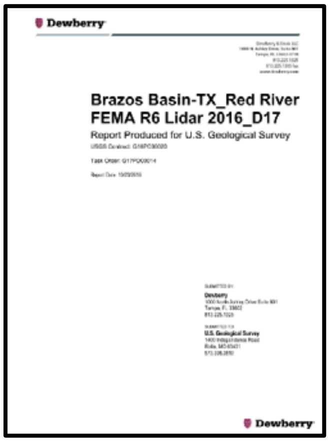
In 2020 the City of Gatesville developed a Comprehensive Plan to establish a cohesive vision for the future growth of the community, to promote sound development and the health, safety and welfare of the community. This vision and policy will help Gatesville preserve desired aspects of the city's character, respond to changing conditions in a coordinated manner and make wise investments with the limited resources available. As stated in Section 4.3, "As evidenced by recent flood events, the hazards associated with flooding, especially the Leon River, can have significant impacts on life and property, and should be strongly considered as plans for development and public infrastructure are developed and implemented.



2022: Natural Resource Solutions *Coryell County – Stream Crossing Prioritization - Data Compilation and Analysis*

In 2022 Coryell County contracted with Natural Resources Solutions to develop a countywide data collection and management system to collect and organize data on county road stream crossings. The initial project mapped and assessed 20 sites. The City of Gatesville is continuing to coordinate with Coryell County on this effort.

2.2 Topographic Data


Dewberry
Brazos Basin-TX_Red River FEMA R6 Lidar 2016_D17
Report Produced for U.S. Geological Survey
Dewberry

In 2016 the U.S. Geological Survey (USGS) acquired Light Detection and Ranging (LiDAR) topographic data for Brazos portion the Texas Red River FEMA Region 6 Project Area which includes the counties of Archer, Baylor, Bell, Bosque, Brown, Callahan, Coleman, Comanche, Coryell, Dickens, Eastland, Erath, Fisher, Hamilton, Jack, Jones, King, Knox, Lampasas, McLennan, Mills, Palo Pinto, Runnels, Shackelford, Stephens, Stonewall, Taylor, Throckmorton, and Young. The Quality Assurance report by Dewberry covers data acquired between November 17, 2016 and May 28, 2018.

Walker Partners reviewed the LiDAR data collected over Coryell County, TX in 2017 by Leading Edge Geomatics. For the Brazos Basin Texas FEMA R6 Lidar Project, the tested RMSEz of the classified lidar data for checkpoints in non-vegetated terrain equaled 9.6 cm compared with the 10 cm specification and the NVA of the classified lidar data computed using RMSEz x 1.9600 was equal to 18.8 cm, compared with the 19.6 cm specification. The LiDAR data was determined to meet industry standards and guidelines to support 1-foot contours in flat open terrain and 2-foot contours in sloped and heavily vegetated areas to the corresponding FEMA standards.

2.3 Field Survey

The study extents for each creek include the limits of the regulatory floodplain on the FEMA FIRM maps (and beyond) from the Leon River to its headwaters. Strategic survey planning sessions determined the optimum locations for the field surveys. A Base Map with aerial photography as a background was created and the FEMA FIS cross-section locations were plotted. New cross-section locations were determined and placed on the Base Map. These sections were intended to supplement the FIS cross-sections and have a maximum spacing of 500 feet. All of the drainage and bridge structures crossing the study reaches were identified and the appropriate number and location for upstream and downstream cross-sections were planned and plotted on the Base Map. The field survey procedures comply with FEMA guidance.

Field survey crews were deployed to gather and collect topographic data at each creek cross-section locations; conduct an "as-built" survey of each bridge and culvert crossing; and locate the aerial pipeline crossings. Ground control was established on NAD 83, Texas State Plane horizontal datum and NAVD 88 vertical datum. Both Global Positioning Systems (GPS) and conventional survey methods were used to collect the cross-section data collected was from top-of-creek bank to top-of-creek bank. All of the overbank portions of the cross-sections were generated from the 2011 LIDAR data. Locations of the survey points collected are shown in **Exhibit A-1** in **Appendix A**.

2.4 Historic Flooding Reports

Information on past flooding events in Gatesville was collected from City staff, as well as from residents during Public Meeting #1 on June 21, 2022.

Table 2-2: Summary of Recent Flood Events.

Date	Title
1995	Numerous businesses along Business SH 36 were forced to close because of flooding.
1996	House on the corner was flooded (1111 S. Lovers Lane).
March 1998	Faunt Le Roy Park flooded causing an event to relocate.
December 2007	The Leon River streambank south of the Leon WWTP eroded to the point of threatening the WWTP.
October 2009	Flooding in both City parks (Faunt Le Roy and Raby).
February 2010	Both City parks (Faunt Le Roy and Raby) closed due to flooding.
October 2015	Heavy flooding impacted the Leon WWTP outfall and caused major road damage in Faunt Le Roy Park.
October 2018	Significant flooding rendered the Faunt Le Roy park road unusable, significant damages to West Leon Street, and washed out approximately 1,000 yards of the walking trail in Raby Park.
2019	Water was close to coming into the house at 1107 S. Lovers Lane and around the edges. Flooding pictures from 2019 were provided.
May 2022	Buildings flooded at Kaylin Siebert Trailers on US 84.
General	Drainage channel parallel to Bridge Street west of Lovers Lane becomes inundated attempting to move more stormwater than it is capable of. A 6-inch water line on Shady Lane where it crosses the ditch has repeatedly been knocked loose, and the crossing is frequently under water.
General	Flooding in the area near 1501 Golf Course Road increased after the development along Highway 36 Loop was constructed.

3.0 Study Methodology

Developing a current understanding of the flood risk in the Coryell Creek – Leon River HUC-10 watershed required updating the hydrology and hydraulic models of the watershed using the current state of the practice techniques, as well as an economic analysis of the benefits and costs of each mitigation alternative, along with an assessment of the potential environmental and cultural impacts. The methodology used for each of these efforts is described in the sections below.

3.1 Hydrology

Peak flow rates were calculated at key discharge points within the Coryell Creek – Leon River HUC-10 watershed using the USACE Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS), Version 4.9. HEC-HMS is a rainfall-runoff model that simulates a watershed's response to precipitation and computes runoff hydrographs, peak discharges, and cumulative runoff volumes for the receiving watershed. Discharge points were established within the Coryell Creek – Leon River HUC-10 watershed at locations where peak runoff calculations were necessary to evaluate flooding hazards for insurable structures, as well as at locations where significant changes in the flow regime occur. This section describes the methods and assumptions used to calculate peak flow rates for each discharge point.

3.1.1 Drainage Area Delineation

Sub-basins describing the area that drains to each discharge point were delineated using the 2011 LiDAR elevation data. The more recent elevation data and higher level of detailed analysis resulted in modifications to the watershed drainage divides, but substantial differences were not observed. The Coryell Creek – Leon River HUC-10 watershed drains a total of 202,105 acres, or 315.7 square miles.

3.1.2 Precipitation

The hydrologic model, HEC-HMS, is a rainfall-runoff model that simulates a watershed's response to precipitation and computes runoff hydrographs, peak discharges, and cumulative runoff volumes for the receiving watershed. In order to develop flood hydrographs for storm events with various return periods, rainfall depths corresponding to the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year recurrence intervals were used.

Time incremental rainfall depths for each recurrence interval were obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14, titled "Precipitation-Frequency Atlas of the United States", Volume 11 Version 2.0 for Texas (NOAA, 2018), and entered into HEC-HMS as rainfall depth-duration, as shown in **Table 3-1** on the next page. Because the majority of the flood hydrograph is generated by the upper 10 square miles of drainage area, no additional areal reduction adjustment was applied to the precipitation.

Table 3-1: Depth-Duration-Frequency Data.

Duration	Rainfall Depth (inches)						
	Storm Return Period						
	2-year	5-year	10-year	25-year	50-year	100-year	500-year
15 Minutes	0.85	1.20	1.45	1.65	1.90	2.20	2.90
1 Hour	1.65	2.15	2.50	2.95	3.35	3.75	4.90
2 Hours	2.05	2.70	3.25	3.95	4.60	5.30	7.10
3 Hours	2.20	3.00	3.60	4.40	5.20	6.00	8.20
6 Hours	2.60	3.55	4.25	5.20	6.20	7.25	10.20
12 Hours	2.95	4.00	4.80	5.85	7.00	8.10	11.90
1 Day	3.40	4.75	5.75	7.25	8.35	9.50	12.90

Reference: "Atlas 14: Precipitation-Frequency Atlas of the United States", Volume 11: Texas, Version 2.0, NOAA, 2018

3.1.3 Soils and Land Use

The Soil Conservation Service (SCS) runoff curve number procedure is an accepted method for computing abstraction for storm rainfall, which reduces the volume of precipitation that falls on a watershed and then becomes runoff. The rainfall in excess of the abstractions that becomes runoff is referred to as the excess rainfall. The SCS runoff curve number method relates soil types, antecedent soil moisture, and land use to precipitation abstractions. Local soils data were downloaded from the SSURGO database through the U.S. Department of Agriculture's (USDA) Web Soil Survey online. The hydrologic soil group classification of a soil, as recorded in the SSURGO database, estimates runoff potential and was used to determine SCS curve numbers.

Land use classifications were determined from a high level of analysis by using the latest aerial imagery in GIS (2014 Aerial NAIP for Coryell County). Undeveloped land was assigned a land use classification of open space, wooded, meadow, brush, or agricultural. Developed areas were assigned a land use classification of open space in anticipation that impervious cover was going to be assigned directly to each sub-basin in HEC-HMS, rather than being accounted for in a general developed land use curve number. Each land use classification was assigned a base curve number, which does not presume an average percent impervious cover, according to guidance in the USDA TR-55, "Urban Hydrology for Small Watersheds" (NRCS,1986).

The National Land Cover Database 2011 (NLCD, 2011) was available in GIS format for Coryell County as feature class polygons, depicting impervious cover percentages for the Coryell Creek - Leon River HUC-10 watershed in 100 foot by 100 foot squares. These impervious cover percentages were reviewed and compared in detail with the latest aerial imagery, and were determined to be acceptable and generally in accordance with the current land uses.

A base curve number for each sub-basin was developed in GIS based on existing open space land use conditions and soil types, and percent impervious cover was applied to represent developed conditions. The runoff volumes were computed in HEC-HMS as a function of the base curve number and impervious cover percentage. For each storm event recurrence interval, average antecedent moisture conditions (AMC-II) were assumed.

3.1.4 Time of Concentration

The unit hydrograph method was used to transform the rainfall excess into a surface runoff hydrograph. The unit hydrograph for a watershed is defined as a direct runoff hydrograph that results from one inch of excess rainfall generated uniformly over the drainage area at a constant rate for an effective duration (Chow, *et al*, 1988).

The SCS unit hydrograph method relates hydrograph characteristics to a physical characteristic of the watershed, the basin time to peak (t_p). The parameter t_p is defined as the time from the beginning of the rainfall event to the time at which the peak runoff rate is observed at the watershed outlet. The time to peak of a basin can be estimated using the following empirical equation:

$$t_p = 0.6\ T_c$$

where:

T_c = Time of concentration for the watershed.

The time of concentration is defined as the time it takes for a drop of rain that falls on the most hydraulically remote point in the watershed to contribute to the flow at the drainage basin outlet. The time of concentration for each sub-basin was computed using 2018 LiDAR elevation data to delineate longest flow-path lines. Each flow-path line was broken into sheet flow, shallow concentrated flow, and channel flow due to the different characteristics of the flow in these regimes. The Kerby-Kirpich method was used to calculate travel time for overland sheet flow, which was limited to 300 linear feet for undeveloped surfaces and 100 linear feet for developed areas. Shallow concentrated flow and channel flow travel time calculations utilized the velocity method as described in the USDA National Engineering Handbook Part 630, Chapter 15.

3.1.5 Hydrologic Channel Routing

Routing simulates the movement of a flood-wave through a stream reach, to account for valley storage and flow resistance within the channel and its floodplain. Routing of flood flows from the outlet of an upstream sub-basin to the next sub-basin outlet downstream was accomplished using the Modified Puls method in HEC-HMS using Normal Depth Storage techniques. The Modified Puls method treats each routing reach as a storage pool with a user-specified storage-discharge relationship, which was obtained from a concurrently developed HEC-RAS model. The average flow velocity from the HEC-RAS model was also used to calculate the number of routing sub-reaches by dividing the length of the routing reach by the average velocity and rounding up to a whole number.

3.2 Hydraulics

The hydraulic analysis incorporates the peak discharge values into a hydraulic model of the channel based on existing geometric conditions. The model output is used to delineate the floodplains for storm events with annual exceedance probabilities (AEP) of 50%, 20%, 10%, 4%, 2%, 1%, and 0.2% (2-, 5, 10-, 25-, 50-, 100-, and 500-yr storm events respectively). This delineation aids in determining the extents and severity of flood prone areas. The Hydrologic Engineering Center-River Analysis System (HEC-RAS Version 6.2) computer program was used to calculate the floodplain extents and other parameters at various locations throughout the studied channels. ESRI's ArcGIS 10.3 was used for mapping and topographic analysis. RASMapper was used to develop various hydraulic parameters (including the cross-sectional geometry) inputs to HEC-RAS. RASMapper is an internal GIS extension which was designed to manage geospatial data for use in HEC-RAS.

There are three main tributaries that comprise the Coryell Creek - Leon River HUC-10 analysis. All reaches and tributaries are labeled in **Exhibit C-2** in **Appendix C**.

3.2.1 Cross Section Development

Ground-based topographic survey data from Walker Partners were used to define the channels geometry (including the thalweg elevation and stream centerline) at key stream locations. These included all the bridge and culvert crossings, significant hydraulic structures and stream cross sections at various locations throughout the study reach limits. In total 234 cross sections and 22 culvert/bridge crossings were surveyed. The topography was tied using surface coordinates (NAD 1983 State Plane Texas Central FIPS 4203 feet). Cross sections extended one channel width past the top of bank (or property line if in close proximity). As a general guideline, spacing between cross sections was set to an average of 500 feet. Surveyed shots included stream invert(s), left and right toe and top of bank among other grade break locations.

The ground survey was complemented with the 2018 USGS LiDAR points (as previously mentioned). Surveyed cross sections were extended as necessary to fully contain the 0.2% AEP (500-year) flows. Additional cross sections were added as necessary at locations where further detail in channel geometry was required (these were strictly based on LiDAR information). The ground survey topo and the LiDAR data were combined using RASMapper. A digital terrain model (DTM) in the form of a triangulated irregular network (TIN) was created with this information (as required by RASMapper). The TIN is a surface representation derived from irregularly spaced points and break-line features. Each sample point of a TIN has an x, y coordinate and a z value (elevation). The cross section data for the hydraulic model is extracted from the TIN surface in order to define the channel and overbank areas. To accomplish this, the user creates a series of line themes including cross section cut lines, stream centerlines, main channel banks, and flow and flow path centerlines which are necessary to develop the required HEC-RAS hydraulic inputs. **Figure 3-2** shows a portion of the TIN surface used to create cross sections for the hydraulic model and for floodplain delineation.

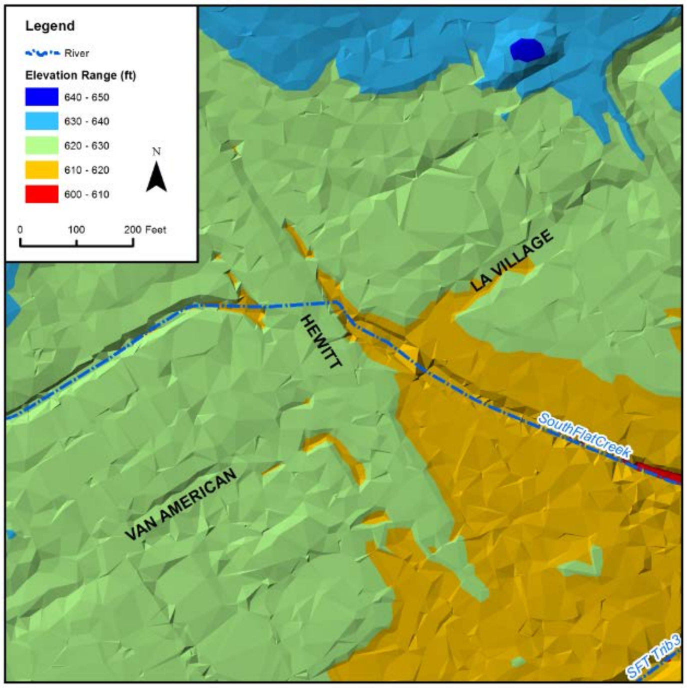


Figure 3-2: TIN used to Cut Cross Sections

The hydraulic work map in **Exhibit C-1** in **Appendix C** reflects the cross section layout for the study reaches as well as the contours and major intersecting structures.

3.2.2 Hydraulic Structures

The hydraulic structures crossing each stream are critical to the flow conveyance and mapping of the floodplain. Each structure can impact the tailwater or headwater condition of a hydraulic model as well as the extents of flooding. Therefore, it was critical that good geometry was used to better represent each structure. Geometry data for bridges and culverts were developed using a combination of on-the-ground survey data, surveyor sketches, and 'as-built' drawings of the structures provided by the City. The 'as-built' drawings were reviewed where available, and the geometry of each structure was verified with the field survey and effective FIS model. Structures included culverts, bridges, natural, and constructed weirs that are large enough to significantly affect the hydraulics of the system. A total of 22 culvert/bridge structures were field surveyed to define the structures dimensions and establish the opening sizes. This also included an upstream and downstream cross section and photographs at each face of structure, the abutment, deck, and piers dimensions and locations of bridges, as well as culvert and headwalls' dimensions. The roadway width and profile were also tied at its highest elevations for at least 200 feet in each direction (from the stream crossing). This was important to identify which structures would be overtopped and by which storm event. The roadway embankment could also be important in defining which properties may be flooded as a result of backwaters. Modelers also field checked the structure crossings (after the field survey) to note any discrepancies with the field survey or record drawings and to better assimilate the actual geometry. The visit noted major debris or blocked obstructions that would impact the hydraulic model. Expansion and contraction coefficients were set to 0.1 and 0.3 for gradual transitions between sections, and 0.3 and 0.5, respectively for bridge sections. The bridge modeling approach used the greater of the energy and momentum solutions at each bridge.

3.2.3 Boundary Conditions

The accuracy of the hydraulic modeling results is dependent on the downstream boundary conditions used in the model. In this study, the downstream limit of the model is located at the Leon River, for which normal depth conditions were used for each flood frequency. A normal depth energy slope of 0.0036 ft/ft was calculated for the downstream most reach. FEMA requires normal depth as the starting condition for the hydraulic models and enforces the 1% AEP water surface elevations of the receiving river on the FIS profile and floodplain mapping only.

3.2.4 Manning's Roughness Coefficients

Cowan's Method (see **Chapter 10** for Reference) was used to determine the Manning's roughness (n) values within the channel areas. Floodplain (overbank) n-values were determined independently using a GIS land use polygon. Data collected during the field investigation, coupled with aerial photographs and contours from 2011, were used for reference in determining n values.

The Cowan's Method specifies the n-values to be based upon the summation of various channel characteristics. These factors are channel irregularity, variation in cross section, obstruction, vegetation, and thalweg meandering. In general, the channel roughness coefficients varied from 0.035 (for heavily mowed and straight channels) to 0.075 (for channel areas with dense vegetation, heavy irregularities in geometry and intense meandering). A land use polygon shapefile was used to determine the left and right overbank n-values (floodplain). RASMapper was used to incorporate the shapefile into the HEC-RAS model. Floodplain values were assigned per general observed land use conditions as noted in **Table 3-2** below. In general, values varied from 0.03 for smooth surfaces to 0.09 for areas heavily wooded or residential areas with fences. Any structures that could be subject to flooding are modeled as either a high n-value of 0.17 or a blocked obstruction in HEC-RAS.

Table 3-2: Overbank Land Use Manning's n-Values.

Land Use	n-value
Pond	0.01
Railroad	0.03
Roadway – paved areas	0.04
Short grass	0.04
Cultivated Fields	0.06
Brush – lightly wooded	0.07
Heavily Wooded	0.09
Residential	0.09
Buildings	0.17
Main Channel	Cowan's Method

Refer to the hydraulic work maps in **Exhibit C-1** through **Exhibit C-17** in **Appendix C** to see the various land-use types assigned for the overbank locations.

3.2.5 Ineffective Flow Areas

Ineffective flow areas (IFA) were added at bridge and culvert sections following a standard contraction ratio of 1 to 1 and expansion ratio of 2 to 1. They are not set to permanent as recommended in the HEC-RAS Technical Manual (see **Chapter 10** for Reference). Ineffective flow areas were also added in off-channel areas that store water where the active conveyance is assumed to be zero and at locations in and around homes or buildings (set as blocked obstructions) where the active conveyance is very limited. These locations are mainly at channel overbanks. The IFA elevations were set to contain flows at the roadway profiles, but also allow effective passage for overflow conditions.

3.3 Economic Analysis

The potential cost effectiveness of proposed flood protection measures was evaluated by calculating the cost of the proposed solutions and comparing it to the expected flood reduction benefits. The flood reduction benefits were estimated by estimating the cost of repair or restoration of property that would be damaged by various levels of flooding. Property damage includes residences, businesses, streets and roadways, crop land and other associated improvements, as well as the "soft costs" such as interruption of businesses. Property values were based on property maps and appraised values from the Coryell County Appraisal District.

4.0 Hydrology

The Coryell Creek - Leon River HUC-10 watershed drains a total of 202,105 acres, or 315.7 square miles.

4.1 Watershed Parameters

Rainfall-runoff responses of the Coryell Creek - Leon River HUC-10 watershed to a range of rainfall depths were calculated using HEC-HMS to determine peak discharges from each sub-basin. The following watershed parameters were used to represent existing watershed conditions in the HEC-HMS hydrologic model.

4.1.1 Drainage Area Delineation

As shown on **Exhibit B-1A** and **Exhibit B-1B** in **Appendix B**, the Coryell Creek - Leon River HUC-10 drainage area was subdivided into 28 new sub-basins to calculate peak discharge rates at points of interest along the Leon River and its tributaries. Sub-basin delineation was done by using the 2018 USGS LiDAR elevation data. Points of interest were evenly spaced throughout the drainage area in attempt to maintain a consistent sub-basin size, resulting in an average sub-basin drainage area of 7,458 acres, with the smallest sub-basin at 25.6 acres and the largest at 29,182 acres.

4.1.2 Soils and Land Use

The USGS SSURGO database was used to obtain the soil classifications and hydrologic soil types for each sub-basin, as illustrated in **Exhibit B-2A** and **Exhibit B-2B** in **Appendix B**. Soil types in the Leon River drainage basin were categorized as predominately hydrologic soil types D and C, with very small pockets of types A and B soils. Land use classifications were assigned based on aerial imagery, as shown on **Exhibit B-3** in **Appendix B**. The upper reaches of the Leon River tributaries were categorized as mostly agricultural lands, while the remaining lower portion of the basin is largely comprised of developed land. Land uses and soil types for each sub-basin were processed in GIS and used to determine a base curve number. Base curve numbers for sub-basins ranged from 61 to 77, with an average value of 72 across the entire drainage area. Base curve numbers were entered into HEC-HMS as part of the sub-basin's initial abstraction parameter.

The other component to the initial abstraction parameter in HEC-HMS is the amount of impervious cover that reduces infiltration. Percent impervious cover for each sub-basin was calculated in GIS with use of the NLCD2011, as shown on **Exhibit B-4A** and **Exhibit B-4B** in **Appendix B**. The average percent impervious cover for sub-basins in Leon River drainage area was 5 percent with the maximum impervious cover being 2 percent for a sub-basin. These values were entered directly into the hydrologic model for each sub-basin.

4.1.3 Time of Concentration

The time of concentration was calculated using the Kerby-Kirpich equations for sheet flow and the velocity method was used for shallow concentrated flow and channel flow calculations. For each sub-basin, the longest flowpath was identified and broken into runoff flow types, as shown on **Exhibit B-1A** and **Exhibit B-1B** in **Appendix B**. The length of overland flow was limited to 300 feet for undeveloped areas and 100 feet for developed areas. The time of concentration calculations are shown in **Exhibit B-5** in **Appendix B**.

4.1.4 Hydrologic Channel Routing

The initial HEC-RAS model was used to develop flow and volume relationships for each routing reach. These tables were entered into HEC-HMS using the Modified Puls routing procedure. The average flow velocity from the HEC-RAS model was used to calculate the number of time steps by dividing the length of the routing reach by the average velocity.

4.2 Peak Flow Rates

Once the peak discharges were calculated, they were input into a hydraulic model to calculate the resulting water surface profiles. **Exhibit B-6** in **Appendix B** contains peak discharges entered into the hydraulic model for a steady state flooding evaluation. The resulting peak discharges along the Leon River are shown in **Table 4-1** below as the Master Drainage Plan (MDP) discharges, along with a comparison to the FEMA FIS effective peak discharges where available.

Table 4-1: FIS Peak Discharge Comparison – Leon River.

Description	Drainage Area (SM)		Discharge (cfs)	
	MDP	FEMA FIS	MDP	FEMA FIS
At Downstream Boundary of HUC-10	1,339.4	N/A	140,012	N/A
Downstream of Coryell Creek	1,302.0	N/A	125,434	N/A
Downstream of Stream CG-1	1,143.2	N/A	88,621	N/A
Downstream of Stream CG-2	1,119.0	N/A	81,349	N/A
At USGS gaging station 08100500 labeled "Leon River at Gatesville"	1,098.2	2,390	73,988	60,400
At Upstream Boundary of HUC-10	1,023.7	N/A	68,970	N/A

Lake Proctor controls runoff from the upper half of the Leon River watershed, with a published drainage area of 1,265 square miles. Combining Lake Proctor's watershed with the current drainage area of 1,098.2 square miles at the USGS Gatesville gage results in 2,363.2 square miles, which is reasonably close to FEMA's FIS drainage area of 2,390 square miles.

The resulting peak discharges for Stillhouse Branch are shown in **Table 4-2** and peak discharges for the other reaches studied in detail are shown in **Table 4-3** below, along with a comparison to the FEMA FIS effective peak discharges where available. **Exhibit B-6** in **Appendix B** contains a listing of all of the peak discharges entered into the hydraulic models.

Table 4-2: FIS Peak Discharge Comparison – Stillhouse Branch.

Description	Drainage Area (SM)		Discharge (cfs)	
	MDP	FEMA FIS	MDP	FEMA FIS
At confluence with Leon River	9.11	9.0	20,678	13,830
Downstream of Stream CG-3 confluence	8.32	8.1	19,660	13,830
Upstream of Stream CG-3 confluence	6.45	6.6	15,515	13,630
Downstream of Stream CG-4 confluence	5.73	6.0	13,947	13,640
Downstream of Stream CG-7 confluence	2.60	N/A	6,933	N/A
Downstream of SH-36	1.45	N/A	3,715	N/A

Table 4-3: FIS Peak Discharge Comparison – Other Study Streams.

Tributary	Description	Drainage Area (SM)		Discharge (cfs)	
		MDP	FEMA FIS	MDP	FEMA FIS
Stream CG-3	At Stillhouse Branch confluence	1.58	N/A	4,426	N/A
Stream CG-5	At Stillhouse Branch confluence	0.68	N/A	1,840	N/A
Stream CG-5	Just downstream Stream CG-5A	0.60	N/A	1,707	N/A
Stream CG-5	Just downstream of SH 36	0.54	N/A	1,577	N/A
Stream CG-5A	At Stream CG-5 confluence	0.06	N/A	136	N/A
Stream CG-4	At Stillhouse Branch confluence	2.53	2.2	7,212	7,690
Stream CG-4	At limit of detailed study	1.9	1.9	7,150	7,360
Stream CG-7	At Stillhouse Branch confluence	1.15	N/A	3,353	N/A
Dodd Branch	At confluence with Leon River	23.1	N/A	33,900	N/A
Dodd Branch	Downstream of US 84	18.6	N/A	30,472	N/A
Stream CG-2	At confluence with Leon River	4.33	4.2	8,324	10,290
Stream CG-2	Downstream of Straws Mill Road	2.67	4.0	6,670	10,130
Stream CG-2	Downstream of US 84	2.16	3.7	5,331	10,040

Table 4-4: FIS Peak Discharge Comparison – Other Watersheds in HUC-10.

Tributary	Description	Drainage Area (SM)		Discharge (cfs)	
		MDP	FEMA FIS	MDP	FEMA FIS
Blue Branch	At Leon River confluence	16.7	N/A	21,420	N/A
Four Mile Branch	At Leon River confluence	25.6	N/A	28,947	N/A
Cottonwood Creek	At Leon River confluence	16.5	N/A	25,886	N/A
Shoal Creek	At Leon River confluence	11.5	N/A	16,421	N/A
Stream CG-1	At Leon River confluence	N/A	3.2	N/A	9,120
Turnover Creek	At Leon River confluence	12.7	N/A	22,551	N/A
Henson Creek	At Leon River confluence	23.6	N/A	32,437	N/A
Flat Creek	At Leon River confluence	31.0	N/A	43,412	N/A
Coryell Creek	At Leon River confluence	85.0	N/A	59,721	N/A
Coryell Creek	Just downstream of FM 929	39.4	N/A	31,357	N/A
Pew Branch	At Leon River confluence	37.4	N/A	37,599	N/A

5.0 Hydraulics and Floodplain Mapping

A HEC-RAS model of existing conditions was used to simulate the various storm events with the hydraulic parameters and floodplain geometry as discussed in **Chapter 3**, **Section 3.3**.

5.1 Hydraulic Model Results

The hydraulic work maps in **Exhibits C-1, C-12, C-13** and **C-14** in **Appendix C** show the reach name, cross section layout, roadway crossings, contours, bank stations, and the land use types used to select the overbank Manning's n-values along the Leon River. **Table 5-1** compares the MDP results with the FEMA FIS along the Leon River.

Table 5-1: FIS Comparison – Leon River.

Study Cross Section	FIS Lettered Section Location	Description	Discharge (cfs)		WSEL (feet)	
			MDP	FEMA FIS**	MDP	FEMA FIS
147388	A (100)	8,500 ft DS of SH 36	88,621	N/A	721.60	715.3
163180	B (12170)	At Fowler Street	81,349	N/A	728.80	723.8
175060	C (22510)	Upstream of Shoal Creek	81,349	N/A	736.65	732.3
182826	D (30450)	At Surrey Lane	73,988	N/A	742.14	738.0
204527	E (52000)	At Riverbend Lane	73,988	N/A	752.91	750.6
210722	F (62620)	At Leon WWTP	73,988	N/A	756.61	756.0
222744	G (68450)	Upstream of Dodd Branch	73,988	60,400	762.12	760.9

*Section was approximated to FIS Lettered Section, but not at exact location.
**Approximated per FIS Table 3 Discharge Location.

Overall, the MDP peak discharges are greater than the FIS peak discharges due to the urbanized conditions in the upper areas of the watershed. With higher peak discharges, the calculated base flood elevations are higher than the FEMA effective FIS throughout Gatesville, ranging from 0.6 feet higher at the Leon WWTP to 6.3 feet higher downstream of State Highway 36.

The hydraulic work maps in **Exhibits C-5, C-6** and **C-18** in **Appendix C** show the reach names and land use types used to select the overbank Manning's n-values along the Stillhouse Branch. **Table 5-2** compares the MDP results with the FEMA FIS along Stillhouse Branch.

Table 5-2: FIS Comparison – Stillhouse Branch.

Study Cross Section	FIS Lettered Section Location	Description	Discharge (cfs)		WSEL (feet)	
			MDP	FEMA FIS**	MDP	FEMA FIS
7294	A (5690)	At Stillhouse WWTF	19,660	13,830	765.48	763.7
10128	B (8620)	Upstream of Stream CG-3	15,515	13,630	780.90	778.6
12282	C (10550)	Upstream of Stream CG-5	13,947	13,640	782.87	783.7

*Section was approximated to FIS Lettered Section, but not at exact location.
**Approximated per FIS Table 3 Discharge Location.

Overall, the MDP peak discharges are greater than the FIS peak discharges downstream of Stream CG-5 since many of the runoff hydrographs from each subbasin have similar peak times. The peak discharge values in the FIS increase by less than 200 cfs for an increase in drainage area of 3.38 square miles (9.11 to 5.73 square miles). The MDP and FIS discharges match well upstream of Stream CG-5. The MDP discharges are more reasonable, resulting in higher water surface elevations downstream of Stream CG-5.

The hydraulic work maps in **Exhibits C-7, C-15, C-16** and **C-17** in **Appendix C** show the reach names and land use types used to select the overbank Manning's n-values along the Stream CG-4 and Stream CG-2. **Table 5-3** provides a comparison of the MDP results with the FEMA FIS along Stream CG-2 and Stream CG-4.

Table 5-3: FIS Comparison – Stream CG-2 and Stream CG-4.

Study Cross Section	FIS Lettered Section Location	Description	Discharge (cfs)		WSEL (feet)	
			MDP	FEMA FIS**	MDP	FEMA FIS
1987	CG-2 A (1900)	DS Straws Mill Road	8,324	10,130	741.87	741.9
9015	CG-2 LOS (8000)	Upstream of SH 36	6,670	10,040	810.49	810.0
1986	CG-4 A (1720)	At Powell Farm Road	7,212	7,690	796.30	794.3
4485	CG-4 LOS (3850)	Upstream of FM 929	7,212	7,360	811.58	811.5

*Section was approximated to FIS Lettered Section, but not at exact location.
**Approximated per FIS Table 3 Discharge Location.

Although the MDP peak discharges are lower than the FIS peak discharges for Stream CG-4, the resulting water surface elevations are very close. For Stream CG-4 both the peak discharges and water surface elevations are reasonably close.

5.2 Floodplain Mapping

As explained in **Chapter 3 Section 3.3.1**, model cross sections were created within RASMapper from a TIN file derived from a combination of surveyed spot elevations and 2018 USGS LiDAR data. This TIN file was also used for the delineation of existing and fully developed floodplains. RASMapper was used to create a water surface elevation TIN from the HEC-RAS model results and compare that TIN to the ground surface TIN to delineate the floodplain. The resulting floodplain was reviewed and manually revised and polished within the GIS platform where necessary.

The mapped 1% AEP floodplain from this study is referred to as the "MDP Floodplain". A comparison of the MDP Floodplain and FEMA effective 1% ACE (100-year) floodplains is shown in **Exhibits C-19** through **C-36** in **Appendix C**. In these exhibits the MDP Floodplain in purple is reasonably close to the FEMA effective floodplain in green and the MDP Floodplain is extended further upstream for several of the streams where only Zone A approximate floodplains are shown on the effective FIRM maps.

6.0 Problem Area Evaluation

Once the inundation mapping for existing conditions was finalized, it was used to identify areas of potential flooding during the 1% ACE event.

6.1 Problem Area Identification

The primary category of flood damages considered was inundation of residential and commercial insurable structures. In some areas, the new inundation limits are wider than the FEMA's current effective floodplain. Due to the potential for loss of life when cars are washed off a low water crossing, overtopping of roadways is also a primary category. Both the depth of overtopping and the flow velocity are available at these locations from the hydraulic models.

Evaluations of problem areas to identify potential flood risk reduction and flood mitigation projects are consistent with "Technical Guidelines for Regional Flood Planning," Exhibit C to Regional Flood Planning Grant Contracts. Each feasible flood mitigation alternative evaluated must identify and compare cost and benefits of the project. Quantification of cost includes engineering, permitting, easement and/or property acquisition, capital cost, operation and maintenance, and other applicable costs. Quantification of benefit of the project includes the following items, as applicable:

1. Number of structures with reduced 100-year flood risk.*
2. Number of structures removed from 100-year flood risk.*
3. Number of structures removed from 500-year flood risk.*
4. Residential structures removed from 100-year flood risk.*
5. Estimated Population removed from 100-year flood risk.*
6. Critical facilities removed from 100-year flood risk.*
7. Number of low water crossings removed from 100-year flood risk.*
8. Estimated reduction in road closure occurrences.
9. Estimated length of roads removed from 100-year flood risk (miles).
10. Estimated farm & ranch land removed from 100-year flood risk (acres).
11. Estimated reduction in fatalities (if available).
12. Estimated reduction in injuries (if available).
13. Pre-Project Level-of-Service
14. Post-Project Level-of-Service
15. Cost/ Structure removed
16. Percent Nature-based Solution (by cost)*
17. Negative Impact (Y/N)*
18. Negative Impact Mitigation (Y/N)*
19. Social Vulnerability Index (SVI)*
20. Water Supply Benefit (Y/N)*
21. Traffic Count for Low Water Crossings

The recommended solutions must be permittable, constructable and implementable. Per TWDB guidance in April 2023, an abridged set of data was provided for flood mitigation projects that are not proposed to be funded by the Flood Infrastructure Fund, as indicated by the asterisks above.

The recommended flood risk reduction solutions must have no negative effect on neighboring areas in accordance with statutory requirements for regional flood plans codified in Texas Water Code §16.062(i) and (j)(2).

6.2 Dodd Branch Problem Areas

Flooding problems were identified in 3 areas of the Dodd Branch watershed.

6.2.1 01 Kalyn Siebert Trailers on US 84

The manager of Kalyn Siebert contacted City staff to discuss runoff from an adjacent area that was flowing up against and into several of the shop and warehouse facilities. As shown in **Figure 6-1** below, the source of the flooding issue at this location is not riverine flooding from Dodd Branch, but localized flooding from adjacent properties.

Figure 6-1: Kalyn Siebert Trailers on US 84

6.2.1.1 Structures At Risk

Within the problem area boundaries on **Figure 6-1**, no residential or commercial properties are inundated by the MDP Floodplain in blue.

6.2.1.2 Inundated Roadways

Within the problem area boundaries in **Figure 6-1**, no roadways are inundated.

6.2.1.3 Potential Mitigation

This location will be evaluated with the HEC-RAS 2D model in Phase 2 of the Master Drainage Plan.

6.2.2 02 FM 2412 Crossing

FM 2412 crosses the Dodd Branch through a bridge structure that is approximately 185 feet wide. As shown in **Figure 6-2** below, the MDP floodplain inundates roughly 950 feet of FM 2412. This problem area is located outside of the corporate limits of Gatesville, in the ETJ with Coryell County.

Figure 6-2: FM 2412 at Dodd Branch

6.2.2.1 Structures At Risk

Within the problem area boundaries on **Figure 6-2**, there are 2 residential buildings that are close to being inundated by the MDP Floodplain in blue.

6.2.2.2 Inundated Roadways

The FM 2412 bridge over Dodd Branch passes the 10-year (10% AEP) storm event. During the 100-year (1% AEP) storm event, FM 2412 will be overtopped by 0.5 feet flowing at a velocity of 5 fps. The TXDOT 2022 Traffic Count for Golf Course Road is an Annual Average Daily Traffic of 1,294 vehicles.

6.2.2.3 Potential Mitigation

This location will be evaluated with the HEC-RAS 2D model in Phase 2 of the Master Drainage Plan.

6.2.3 03 Moccasin Bend Road Crossing

Moccasin Bend Road crosses the Dodd Branch through a bridge structure that is about 170 feet wide. As shown in **Figure 6-2** below, the 1% ACE event inundates roughly 1,300 feet of Moccasin Bend Road. This problem area is located outside of the corporate limits of Gatesville, in the ETJ with Coryell County.

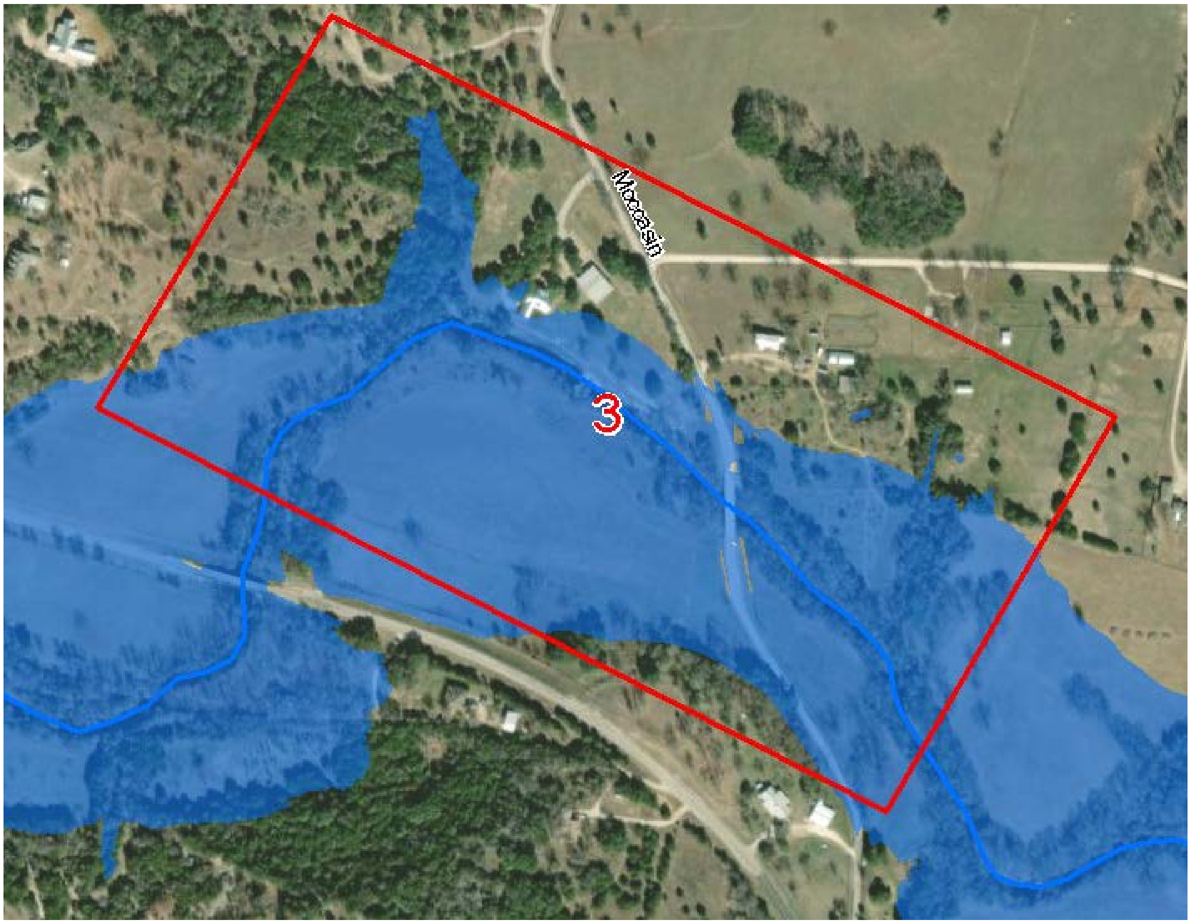


Figure 6-3: Moccasin Bend Road at Dodd Branch

6.2.3.1 Structures At Risk

Within the problem area boundaries on **Figure 6-2**, there are 2 residential buildings that are close to being inundated by the MDP Floodplain in blue.

6.2.3.2 Inundated Roadways

The Moccasin Bend Road bridge over Dodd Branch passes the 10-year (10% AEP) storm event. During the 100-year (1% AEP) storm event, Moccasin Bend Road will be overtopped by 0.5 feet flowing at a velocity of 6 fps. The TXDOT 2022 Traffic Count for Moccasin Bend Road is an Annual Average Daily Traffic of 216 vehicles.

6.2.3.3 Potential Mitigation

This location will be evaluated with the HEC-RAS 2D model in Phase 2 of the Master Drainage Plan.

6.3 Leon River Problem Areas

Flooding problems were identified at 6 areas along the Leon River.

6.3.1 04 East Leon Street

Downstream of the bridge at US 84, the Leon River turns towards the west but flows in its overbanks continue south and spread out towards the east. As shown in **Figure 6-4** below, the source of the flooding issue at this location is riverine flooding from the Leon River.

Figure 6-4: East Leon Street at Leon River

6.3.1.1 Structures At Risk

Within the problem area boundaries shown on **Figure 6-4**, there are 10 residences within the MDP Floodplain in blue.

6.3.1.2 Inundated Roadways

Within the problem area boundaries in **Figure 6-4**, the 1% ACE event inundates roughly 1,800 feet of East Leon Street. The TXDOT 2022 Traffic Count for East Leon Street is an Annual Average Daily Traffic of 122 vehicles.

6.3.1.3 Potential Mitigation

This location can be mitigated with either an earthen levee system to protect the neighborhood or by property acquisitions, as described in **CIP Project 01A** and **CIP Project 01B** in **Section 7.2.1**.

6.3.2 05 Faunt Le Roy Park

South of downtown Gatesville, the Leon River makes a sharp 'S' turn. Since it is a scenic location during normal flows, Faunt Le Roy Park was developed on the peninsula created by the turn in the river. As shown in **Figure 6-5** below, the source of the flooding issue at this location is riverine flooding from the Leon River.

Figure 6-5: Faunt Le Roy Park at Leon River

6.3.2.1 Structures At Risk

Within the problem area boundaries shown on **Figure 6-5**, there are no residences within the MDP Floodplain in blue.

6.3.2.2 Inundated Roadways

Within the problem area boundaries in **Figure 6-5**, the 1% ACE event inundates roughly 1,600 feet of the park road within Faunt Le Roy Park in blue.

6.3.2.3 Potential Mitigation

The City is already working on a FEMA grant to stabilize the river banks at this location. With a budget of $1.3 million, the City has decided it would be more prudent to build a new park by the Fitness Center instead of stabilizing the banks.

6.3.3 06 Leon Wastewater Treatment Plant

Located south of downtown Gatesville, the Leon Wastewater Treatment Plant treats much of the City's sewage. As shown in **Figure 6-6** below, the existing embankment that protects the WWTP is overtopped by the MDP Floodplain of the Leon River.

Figure 6-6: Leon Wastewater Treatment Plant at Leon River

6.3.3.1 Structures At Risk

Within the problem area boundaries shown on **Figure 6-6**, there are no residences within the MDP Floodplain in blue.

6.3.3.2 Inundated Roadways

Within the problem area boundaries in **Figure 6-6**, the 1% ACE event inundates roughly 2.98 acres of the Leon Wastewater Treatment Plant in blue.

6.3.3.3 Potential Mitigation

The flooding at this location can be mitigated by raising the top of the embankment by two feet, with stop log structures at each access point that is not able to be raised, as described in **CIP Project 02** in **Section 7.2.2**.

6.3.4 07 Raby Park

South of downtown Gatesville, the Leon River makes a sharp S turn. Raby Park was developed by the Works Progress Administration. As shown in **Figure 6-7** below, the source of the flooding issue at this location is not riverine flooding from the Leon River, but localized flooding from adjacent properties.

Figure 6-7: Raby Park

6.3.4.1 Structures At Risk

Within the problem area boundaries shown on **Figure 6-7**, there are no residences within the MDP Floodplain in blue.

6.3.4.2 Inundated Roadways

Within the problem area boundaries in **Figure 6-7**, the 1% ACE event does not inundate any of the park road within Raby Park in blue.

6.3.4.3 Potential Mitigation

This location will be evaluated with the HEC-RAS 2D model in Phase 2 of the Master Drainage Plan.

6.3.5 08 Shady Lane Channel

Recent development upstream of Business 84 has increased flows significantly in a channel that drains towards the west before flowing into the Leon River. Flooding along this channel was the original concern that led the City of Gatesville to pursue this Master Drainage Plan. As shown in **Figure 6-8** below, the source of the flooding issue at this location is not riverine flooding from the Leon River, but localized flooding along the undersized channel from upstream properties.

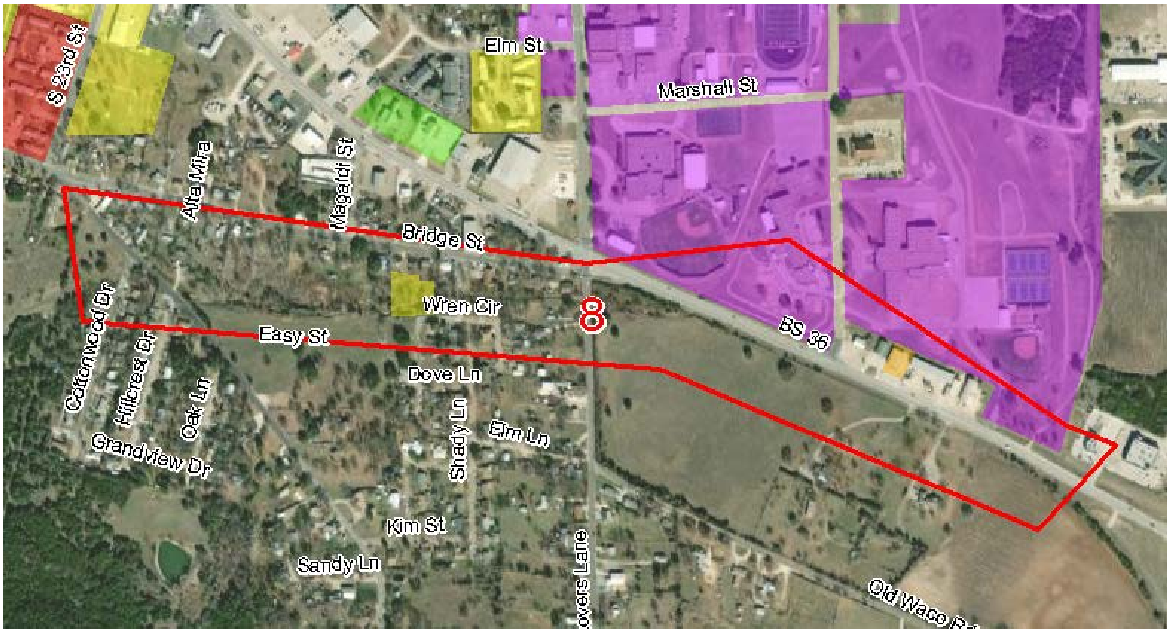


Figure 6-8: Shady Lane Channel

6.3.5.1 Structures At Risk

Within the problem area boundaries shown on **Figure 6-8**, there are no residences within the MDP Floodplain in blue because there is no mapped floodplain along this flooding source.

6.3.5.2 Inundated Roadways

Within the problem area boundaries in **Figure 6-8**, since this channel has not been studied in detail, the 1% ACE event does not inundate any of the adjacent roads within Shady Lane Channel. The TXDOT 2022 Traffic Count for the Ludderloh Avenue crossing is an Annual Average Daily Traffic of 1,201 vehicles.

6.3.5.3 Potential Mitigation

This location will be evaluated with the HEC-RAS 2D model in Phase 2 of the Master Drainage Plan.

6.3.6 09 Golf Course Road and Lovers Lane

The primary flooding concern the City received during Public Meeting #1 was flooding along Golf Course Road and Lovers Lane. As shown in **Figure 6-9** below, the source of the flooding issue at this location is not riverine flooding, but localized flooding from upstream properties.

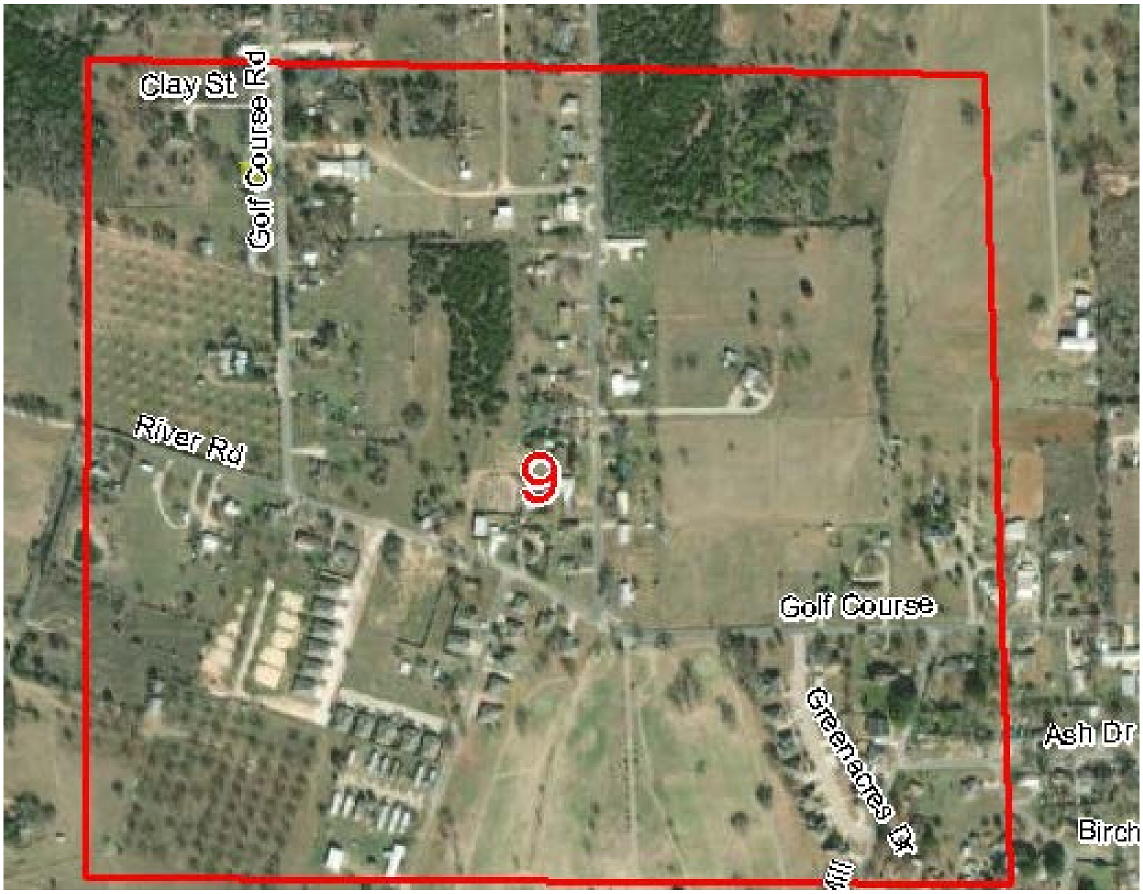


Figure 6-9: Golf Course Road and Lovers Lane

6.3.6.1 Structures At Risk

Within the problem area boundaries shown on **Figure 6-9**, there are no residences within the MDP Floodplain in blue because there is no mapped floodplain along this flooding source.

6.3.6.2 Inundated Roadways

Within the problem area boundaries in **Figure 6-9**, no roadways within Golf Course Road and Lovers Lane are inundated by the MDP Floodplain in blue. The TXDOT 2022 Traffic Count for Golf Course Road is an Annual Average Daily Traffic of 2,117 vehicles.

6.3.6.3 Potential Mitigation

This location will be evaluated with the HEC-RAS 2D model in Phase 2 of the Master Drainage Plan.

6.4 Stream CG-2 Problem Areas

Flooding problems were identified at 3 areas along Stream CG-2.

6.4.1 10 Straws Mill Road Low Water Crossing

Straws Mill Road crosses Stream CG-2 roughly 2,900 feet upstream of its confluence with the Leon River. As shown in **Figure 6-10** below, the source of the flooding issue at this location is riverine flooding from Stream CG-2.

Figure 6-10: Straws Mill Road Low Water Crossing

6.4.1.1 Structures At Risk

Within the problem area boundaries shown on **Figure 6-10**, there are no residences within the MDP Floodplain in blue.

6.4.1.2 Inundated Roadways

Within the problem area boundaries in **Figure 6-10**, the 1% ACE event inundates roughly 100 feet of Straws Mill Road. During the 100-year (1% AEP) storm event, Straws Mill Road will be overtopped by 7.6 feet flowing at a velocity of 7.2 fps. The TXDOT 2022 Traffic Count for Straws Mill Road is an Annual Average Daily Traffic of 555 vehicles, and it is a heavily travelled shortcut to the Gatesville ISD facilities.

6.4.1.3 Potential Mitigation

The flood risk at this location can be mitigated by raising the roadway and constructing a larger culvert, as described in **CIP Project 03** in **Section 7.2.3**.

6.4.2 11 SH 36 and Arrowood Crossing

Upstream of SH 36 flow from Stream CG-2 overflows the banks and spreads along the SH-36 right-of-way. Stream CG-2 overtops the Arrowood crossing and has washed it out several times in recent years. As shown in **Figure 6-11** below, the source of the flooding issue at this location is riverine flooding from Stream CG-2.

Figure 6-11: SH 36 and Arrowood Crossing

6.4.2.1 Structures At Risk

Within the problem area boundaries shown on **Figure 6-11**, there are 4 commercial buildings and 2 residences within the MDP Floodplain in blue.

6.4.2.2 Inundated Roadways

Within the problem area boundaries in **Figure 6-11**, the 1% ACE event inundates roughly 1,950 feet of Arrowood Lane. TXDOT does not have a traffic count for Arrowood Lane.

6.4.2.3 Potential Mitigation

Coryell County already has a project underway to replace the Arrowood Lane bridge using CDBG-DR mitigation funds, as described in **CIP Project 04** in **Section 7.2.4**. The area upstream of SH 36 will be evaluated with the HEC-RAS 2D model in Phase 2 of the Master Drainage Plan.

6.4.3 12 At US 84 Crossing

Downstream of the bridge at US 84, Stream CG-2 turns towards the west but flow in its overbanks continues south and spreads out towards the east. As shown in **Figure 6-12** below, the source of flooding at this location is riverine flooding from Stream CG-2.

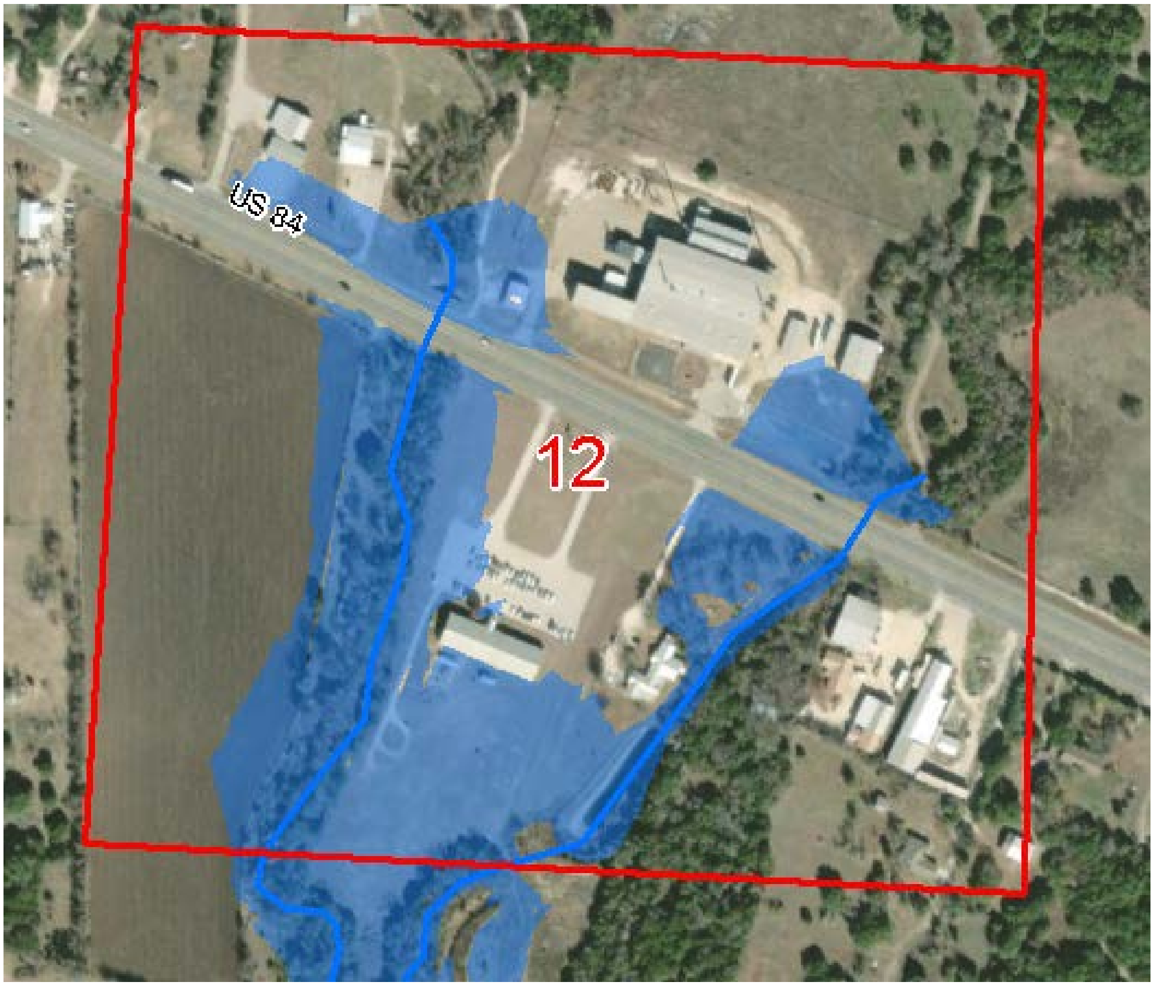


Figure 6-12: At US 84 Crossing

6.4.3.1 Structures At Risk

Within the problem area boundaries shown on **Figure 6-12**, there are no residences within the MDP Floodplain in blue.

6.4.3.2 Inundated Roadways

Within the problem area boundaries in **Figure 6-12**, none of the US 84 Crossing is inundated by the 1% ACE event floodplain in blue.

6.4.3.3 Potential Mitigation

Although there is some inundation at this location, it does not appear to threaten any insurable structures or overtop the roadways.

6.5 Stillhouse Branch Problem Areas

Flooding problems were identified at 4 areas along Stillhouse Branch and its tributaries.

6.5.1 13 Mears Drive and 28th Street

As it flows westward downstream of SH 36, Stream CG-3 cuts across the intersection of Mears Drive and 28th Street. As shown in **Figure 6-13** below, the flooding issue at this location is riverine flooding from Stream CG-3.

Figure 6-13: Mears Drive and 28th Street

6.5.1.1 Structures At Risk

Within the problem area boundaries shown on **Figure 6-13**, there is 1 residence within the MDP Floodplain in blue.

6.5.1.2 Inundated Roadways

Within the problem area boundaries in **Figure 6-13**, the 1% ACE event inundates roughly 260 feet of the roadway at Mears Drive and 28th Street. TXDOT does not have a traffic count at this location.

6.5.1.3 Potential Mitigation

The flood risk at this location can be mitigated by constructing the remainder of the roadway at the intersection at an elevated level, with storm drains to drain interior areas.

6.5.2 14 FM 929 Crossing

As it flows to the south at FM 929, Stream CG-4 overtops the roadway and spreads out across several blocks downstream until flow becomes collected again in the channel. As shown in **Figure 6-14** below, the source of the flooding issue at this location is riverine flooding from Stream CG-4.

Figure 6-14: FM 929 Crossing

6.5.2.1 Structures At Risk

Within the problem area boundaries shown on **Figure 6-14**, there are 19 residences within the MDP Floodplain in blue.

6.5.2.2 Inundated Roadways

Within the problem area boundaries in **Figure 6-14**, the 1% ACE event inundates roughly 1,500 feet of the roadway of FM 929. The TXDOT 2022 Traffic Count for FM 929 is an Annual Average Daily Traffic of 1,469 vehicles.

6.5.2.3 Potential Mitigation

This flood risk can be mitigated by increasing the number of box culverts under FM 929 to prevent overtopping of the roadway, along with downstream channel improvements. This solution is described as **CIP Project 05** in **Section 7.2.5**.

6.5.3 15 Stillhouse Wastewater Treatment Plant

Located northwest of downtown Gatesville, the Stillhouse Wastewater Treatment Plant treats much of the sewage from the correctional facilities and surrounding neighborhoods. As shown in **Figure 6-15** below, the effective FEMA FIRM shows the southern half of the WWTP to be inundated by the Leon River floodplain.

Figure 6-15: Stillhouse Wastewater Treatment Plant

6.5.3.1 Structures At Risk

Within the problem area boundaries shown on **Figure 6-15**, there are no residences within the MDP Floodplain in blue.

6.5.3.2 Inundated Roadways

Within the problem area boundaries in **Figure 6-15**, the 1% ACE event inundates roughly 1,300 square feet of the Stillhouse Wastewater Treatment Plant in blue.

6.5.3.3 Potential Mitigation

Although the 100-year floodplain shown on the effective FIRM is halfway through the WWTP, the 100-year inundation from the MDP floodplain is along the south ring road, so no further improvements are necessary.

6.5.4 16 Sun Valley Neighborhood

As Stillhouse Branch flows to the south there is a large area on the right overbank upstream of State School Road where the floodplain spreads out over a large oxbow area and inundates several blocks of the Sun Valley neighborhood downstream. As shown in **Figure 6-16** below, the source of the flooding issue at this location is riverine flooding from Stillhouse Branch.

Figure 6-16: Sun Valley Neighborhood

6.5.4.1 Structures At Risk

Within the problem area boundaries shown on **Figure 6-16**, there are 45 residences in the Sun Valley Neighborhood located within the MDP Floodplain in blue.

6.5.4.2 Inundated Roadways

Within the problem area boundaries in **Figure 6-16**, the 1% ACE event inundates roughly 2,300 feet of roadways in the Sun Valley neighborhood. The TXDOT 2022 Traffic Count for Venus Avenue is an Annual Average Daily Traffic of 112 vehicles.

6.5.4.3 Potential Mitigation

The flood risk at this location can be mitigated by improving the State School Road crossing or by constructing an earthen levee to cut off the large ponding area east of Stillhouse Branch, as described in **CIP Project 06** in **Section 7.2.6**.

6.6 Problem Area Evaluation Summary

Evaluation results for the 16 problem areas are summarized in **Table 6-1** below, along with which problem areas were selected for further CIP project development.

Table 6-1: Problem Area Evaluation Summary.

Evaluation Parameter	Problem Area Evaluated	Kaylin Siebert Trailers on US 84	FM 2412 Crossing	Moccasin Bend Road Crossing	East Leon Street	Faunt Le Roy Park	Leon WWTP	Raby Park	Shady Lane Channel	Golf Course Road / Lovers Lane	Straws Mill Road	SH 36 and Arrowood Lane	At US 84 Crossing	Mears Drive and 28th Street	FM 929 Crossing	Stillhouse WWTP	Sun Valley Neighborhood
	Problem Area Number	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
1	Structures with reduced 100-year flood risk	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0
2	Structures removed from 100-year flood risk	0	0	0	11	0	1	0	20*	20*	0	3	0	1	19	0	45
3	Structures removed from 500-year flood risk	0	2	2	11	0	0	0	0	0	0	3	0	1	0	0	45
4	Residential structures removed from 100-year	0	0	0	11	0	0	0	20*	20*	0	3	0	1	19	0	45
5	Population removed from 100-year flood risk	0	0	0	33	0	0	0	60*	60*	0	9	0	3	57	0	135
6	Critical facilities removed from 100-year flood risk	0	0	0	0	0	1	0	0	0	1	1	0	0	0	1	0
7	Low water crossings removed from 100-year	0*	1	1	0	0	0	0*	4*	1*	1	1	0	0	1	0	0
8	Reduction in road closure occurrences	0	N/A	N/A	N/A	0	0	0	N/A	N/A	10	N/A	0	0	N/A	0	N/A
9	Length of roads removed from 100-year flood risk	0	950	1300	1800	0	0	0	N/A	N/A	100	1950	0	260	1500	0	2300
10	Farm & ranch land removed from 100-year	0	0	0	0	0	0	0	0	0	0	0	0	0	Y	0	Y
11	Reduction in fatalities (if available)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12	Reduction in injuries (if available)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	Pre-Project Level-of-Service	2	10	10	10	2	50	10	5	2	2	5	100	10	10	50	10
14	Post-Project Level-of-Service	10	100	100	500	10	100	100	100	100	100	100	100	100	100	100	500
15	Cost / Structure removed (Low/Medium/High)	N/A	0	0	Med	N/A	N/A	N/A	Med	High	N/A	High	N/A	High	Med	N/A	Low
16	Percent Nature-based Solution (by cost)	0	0	0	0	0	0	0	25	0	0	10	0	0	10	0	10
17	Negative Impact (Y/N)	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
18	Negative Impact Mitigation (Y/N)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	Social Vulnerability Index (SVI)	0.60	0.61	0.43	0.60	0.60	0.51	0.51	0.60	0.51	0.51	0.70	0.70	0.70	0.52	0.60	0.70
20	Water Supply Benefit (Y/N)	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
21	Traffic Count for Low Water Crossings	N/A	1294	216	122	N/A	N/A	N/A	1201	2117	555	N/A	N/A	N/A	1469	N/A	112
	Flood Mitigation Project Number				01		02				03	04			05		06

* Localized flood risk not studied

7.0 Mitigation Solutions

This plan offers a unique opportunity to examine and plan for regional projects to address flooding problems on a watershed-wide basis in a systematic approach, rather than each city constructing its own "isolated" project.

7.1 Mitigation Strategies

Three structural and three non-structural mitigation strategies were considered. Structural mitigation strategies included regional detention to reduce the peak flow rates, channel improvements to pass existing flows at a lower water surface elevation, and bridge or culvert improvements at locations where upstream flooding is the result of undersized roadway crossings. Non-structural strategies included property acquisitions, flood warning systems and strengthening regional drainage criteria.

7.1.1 Regional Detention

The first structural strategy considered at each problem area was regional detention, to store the incoming flows and release them at a safer rate. To evaluate the potential for regional detention, a non-damaging flow was determined, such as the 2-year, 5-year or 10-year event – and the percent flow reduction was calculated to establish the required storage volume. This volume was then divided by the available height (embankment tie-in minus flowline) to calculate the required open area. This was used to establish the area of open space required for detention.

7.1.2 Channel Improvements

The second strategy considered at each problem area was channel improvements to increase the conveyance capacity to reduce the water surfaces during peak flows. A non-damaging elevation was identified – below which all of the flow is able to pass – and the additional flow area required was calculated, along with a percent increase and/or top width required. If feasible, the conceptual solution design was modeled with the channel improvement tool in RAS. For a given flow depth, a trapezoidal section was applied to estimate top width, and the easement required to determine if the channel improvements were feasible.

7.1.3 Bridge and Culvert Improvements

The third strategy considered at each problem area was bridge or culvert improvements to increase the capacity of the crossing. In some areas, flooding is caused by undersized roadway crossings, which cause flow to back up into structures upstream. The best solution that could be achieved would be no head loss across the crossing – although the downstream impacts of the additional flow must be evaluated as well. The difference between headwater and tailwater was calculated and if the difference was not large enough to solve the problem this strategy was not viable. If this strategy was selected, the solution configuration would be modeled in HEC-RAS to verify the reduction in the upstream WSEL.

7.1.4 Property Acquisitions

The first non-structural strategy considered for each problem area was property acquisition, in which the local jurisdiction purchases residential or commercial structures and demolishes the buildings to return the property to an open space use that is more consistent with the floodplain. Often property acquisitions with multiple flood insurance damage claims are accomplished with federal or state grants, typically at a 75% federal / 25% local cost share.

7.1.5 Flood Warning Systems

The second non-structural strategy considered for each problem area where bridge and culvert improvements were not feasible and overtopping of the roadway will continue to occur was installation of a flood warning system, which is typically a pair of flashing light warning signs that are activated by a pressure transducer sensor upstream of the roadway.

7.2 Conceptual Mitigation Solutions

Conceptual mitigation solutions were developed in multiple jurisdictions for 6 of the 16 problem areas. Each area was investigated to determine which mitigation strategy should be pursued to produce the greatest benefit at the most economical cost. The alternatives were analyzed to determine the effectiveness of each solution. Since the Sun Valley Neighborhood Levee and Straws Mill Road Low Water Crossing projects are proposed to be funded by the TWDB's Flood Infrastructure Fund, data for all 21 categories listed in **Section 6.1** above.

7.2.1 01 East Leon Street

This problem area experiences riverine flooding from the Leon River, which has a very large drainage area upstream of Gatesville. As such, no detention pond would be able to produce a significant reduction in flows other than construction of a new flood control reservoir immediately upstream of Gatesville.

The first mitigation option considered for this problem area was construction of an earthen levee to protect the 10 residential properties along East Leon Street. A 150-foot long, 2-foot high concrete floodwall is constructed along the sidewalk of US 84 with a crest at elevation 764. The earthen levee ties into the floodwall at elevation 762 and wraps around the neighborhood for 1,700 feet until it ties back into the bluff behind 302 E. Leon Street. This alternative also requires raising the roadway by 8 feet at East Leon Street, which includes reconstruction of 500 feet of the street. Construction of a closure system for the 32-foot wide by 8-foot high roadway opening is an alternative to raising the roadway, but the structure would be cost prohibitive. The interior sump area is drained by 24" RCP pipe that runs down to E. Leon Street, and along E. Leon Street to an existing outfall channel where it discharges through a 24" flap gate into the Leon River, as shown in **Figure 7-1** below. The HEC-RAS geometry for the Leon River was updated to reflect the proposed levee and roadway improvements (Plan P02), resulting in the proposed floodplain in purple in **Figure 7-1**. A comparison of the proposed and existing water surfaces demonstrates no negative effect, as described in Exhibit C Section 3.6 of TWDB's state flood planning guidance.

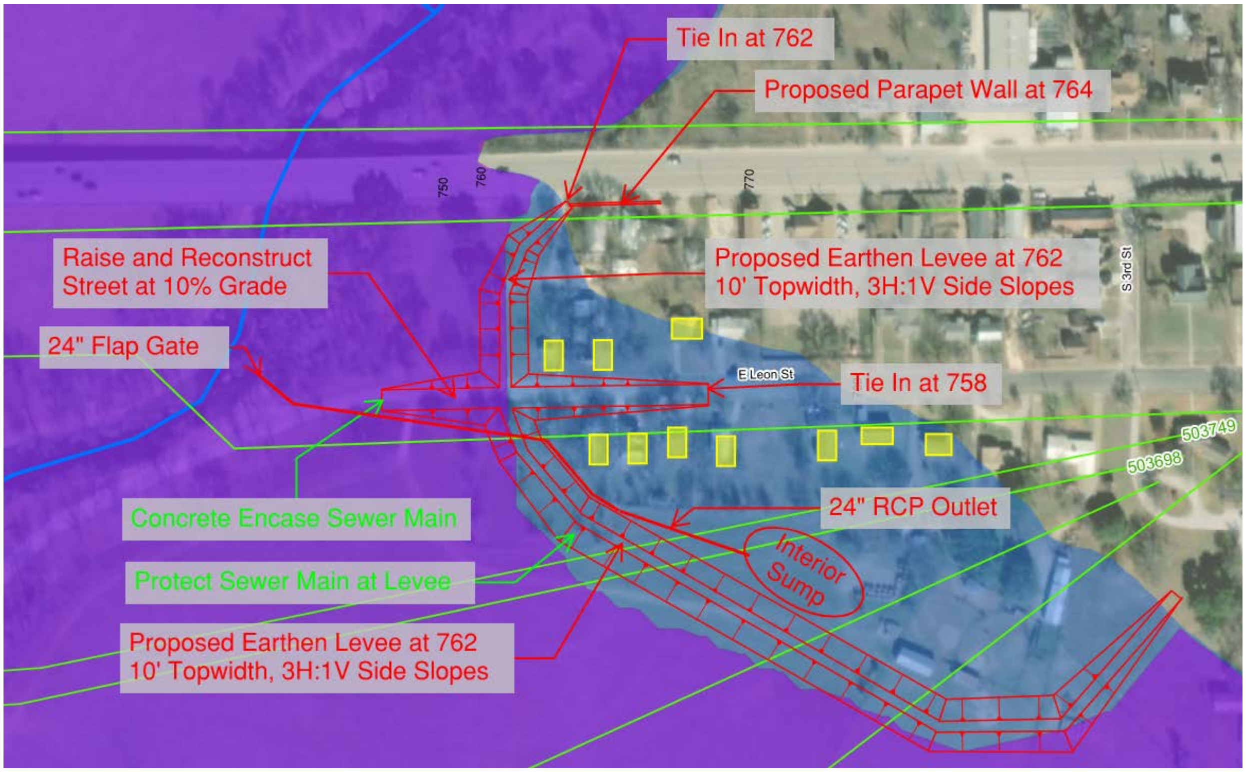


Figure 7-1: East Leon Street Levee Alternative

As shown in **Exhibit D-1A** in **Appendix D**, the total estimated project cost is $2,360,877, or $236,088 per protected structure. Although the earthen levee is permittable, constructible and implementable, after preparing the cost analysis to implement the earthen levee improvements, it was determined to be cost prohibitive and not economically feasible.

The second option considered was property acquisition. As shown in **Exhibit D-1B** in **Appendix D**, the total estimated project cost to acquire the 10 properties is $1,425,405, or $142,541 per acquired structure.

After considering both strategies, it was determined that the most feasible and economical option would be for the City to assist each homeowner in obtaining a grant to raise the finished floor elevation of their structure above the MDP 1% water surface elevation. This could be accomplished by either leaving the houses in their current location to utilize the existing foundation or by shifting the houses to a new location on the property and incorporating a new foundation. However raising the houses would be improvements on private property, which are not allowed to be paid for by public funds. As a flood mitigation strategy, the City could help each property owner obtain a mitigation grant to elevate their structure.

7.2.2 02 Leon Wastewater Treatment Plant

Located south of downtown Gatesville, the Leon Wastewater Treatment Plant (WWTP) treats much of the City's sewage. This WWTP is protected from riverine flooding by an earthen embankment which completely encircles the plant that has a crest elevation at elevation 757. The 100-year base flood elevation on the effective FIRM map is 757.09, so the WTTP is shown on the FIRM as outside of the floodplain. However, the 1% ACE peak discharge at the USGS stream gage at the US 84 bridge is 60,400 cfs and the new 1% ACE peak discharge calculated in the current study is 73,988 cfs. Placing the higher discharge into the USACE's HEC-RAS model resulted in a 100-year water surface elevation of 757.33 feet, and FEMA currently requires an additional 2 feet of freeboard to show protection from the 1% ACE on a FIRM map.

There are two practical ways to increase the height of the embankment – either additional earthfill or a parapet wall. Adding earthfill requires additional area along both the river side and inside toe which is not available. Additional earthfill also increases the earth pressures on the sheet pile wall that protects the riverside toe, and along the landside toe it reduces the working area of the WWTP resulting in several conflicts with existing structures. As such, the most practical means is to add a concrete parapet wall along the top of the embankment, as an inverted T-section with stop log structures at the driveway into the plant and the walkway to the outfall on the river side, as shown in **Figure 7-2** below. The HEC-RAS geometry for the Leon River was updated to reflect the roadway and culvert improvements (Plan P03), resulting in the proposed floodplain in purple in **Figure 7-2**. A comparison of the proposed and existing water surfaces demonstrates no negative effect, as described in Exhibit C Section 3.6 of TWDB's state flood planning guidance.

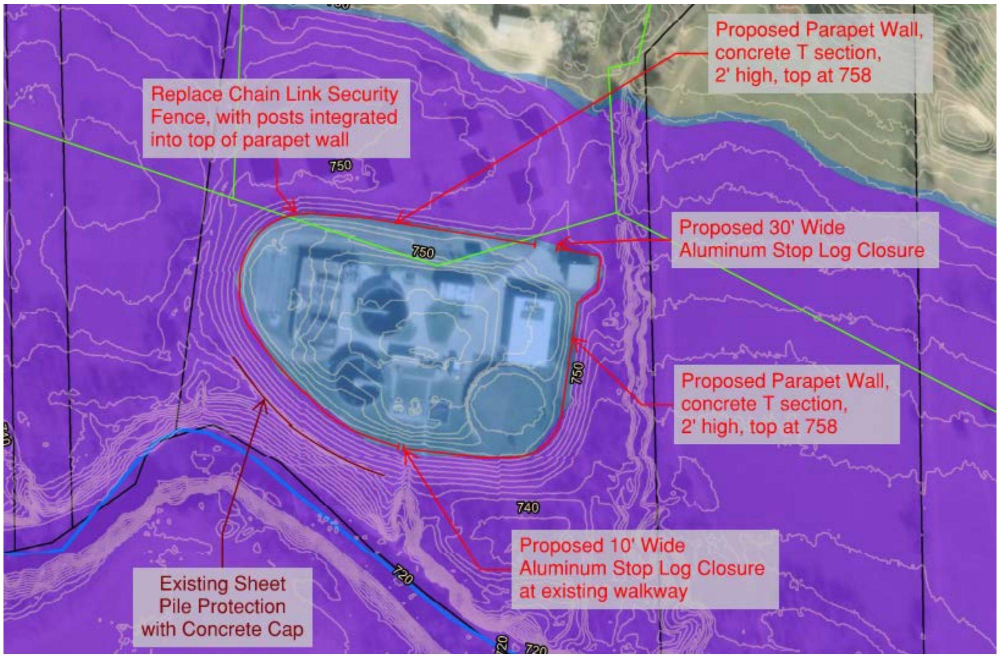


Figure 7-2: Leon WWTP Parapet Wall

As shown in **Exhibit D-2** in **Appendix D**, the total estimated project cost is $642,100 for the concrete parapet wall and stop log structures. The recommended parapet wall and closure structures are permittable, constructible and implementable.

7.2.3 03 Straws Mill Road Low Water Crossing

The current crossing of Straws Mill Road at Stream CG-2 is a classic low water crossing configuration, with steep roadway approaches in both directions and a small 24" CMP culvert to pass low flow amounts. This problem area is located near the downstream end of the Stream CG-2 watershed, which has a relatively large drainage area upstream. As such, no detention pond would be able to produce a significant reduction in peak flows at this location.

The elevation of adjacent driveways usually constrains how much the roadway can be elevated. At this location, no driveways are within the 1% ACE floodplain, but the City's wastewater lift station is roughly 7 feet above the existing low water crossing at elevation 748. As such, the recommended improvement is to raise the roadway by 10 feet up to elevation 751, and construct four 10-foot wide by 10-foot high box culverts to safely pass the 2% ACE peak flow without overtopping the roadway, as shown in **Figure 7-3** below. The HEC-RAS geometry for Stream CG-2 was updated to reflect the roadway and culvert improvements (Plan P02), resulting in the proposed floodplain in purple in **Figure 7-3**. Minor channel grading is also required to increase the channel bottom width to accommodate the culverts. A comparison of the proposed and existing water surfaces demonstrates no negative effect, as described in Exhibit C Section 3.6 of TWDB's state flood planning guidance.

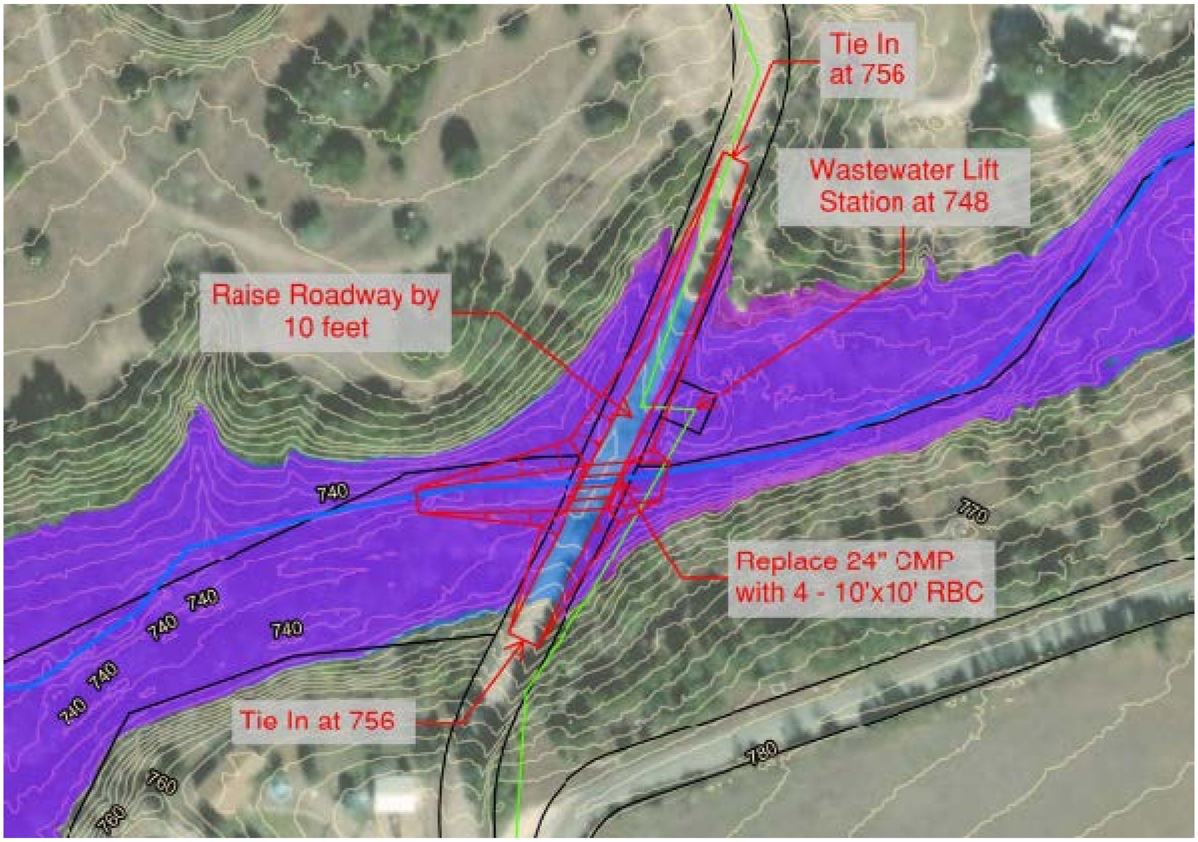


Figure 7-3: Straws Mill Road Low Water Crossing

As shown in **Exhibit D-2** in **Appendix D**, the total estimated project cost is $1,021,710 for the raised roadway and box culvert structures. The recommended roadway and culvert improvements are permittable, constructible and implementable.

The following assumptions were made in the Benefit Cost Analysis:

- *Project Useful Life:* The project useful life was 30 years, which is consistent with the standard design life for a municipal roadway.
- *Initial Project Cost:* As described above, the total estimated project cost is $1,021,710.
- *Annual Maintenance Cost:* Maintenance of the roadway embankments and box culverts was estimated to be $5,000 per year.
- *Total Mitigation Project Cost:* The initial project cost and present value of 30 years of annual maintenance costs results in a total mitigation project cost of $1,083,755.
- *Flood Hazard Data:* The 25-year, 50-year and 100-year water surface elevations were taken from the RASMapper inundation results at the center of the roadway over the culvert. Although the existing low water crossing actually overtops by 4.23 feet (51 inches) in the 5-year, 5.43 feet (65 inches) in the 10-year and 7.64 feet (92 inches) in the 100-year, the current TWDB BCA Input spreadsheet only allows a maximum overtopping depth of 48 inches. Per TWDB direction, 48 inches was used for all 3 events, with a duration of 4 hours for the 5-year, 6 hours for the 10-year and 8 hours for the 100-year events.
- *Daily Traffic:* The TXDOT 2022 Traffic Count for Straws Mill Road is an Annual Average Daily Traffic of 555 vehicles, and it is a heavily travelled shortcut to the Gatesville ISD facilities.
- *Length of Detour:* When the crossing is closed traffic must detour around to SH 36, a distance of 2.69 miles that takes roughly 15 minutes.
- *Utility Outage Reduction:* The wastewater lift station serves roughly 2,000 customers, and would be out 2 days, 4 days and 4 days due to the 5-, 10- and 100-year events.
- *Before-Mitigation Damage:* TWDB's BCA Input spreadsheet was used to calculate event damages of $324,185 for the 5-year event, $592,101 for the 10-year event and $648,370 for the 100-year event. FEMA's BCA Tool Version 6.0 was used to include traffic and detour costs to calculate a total Before-Mitigation Damage of $735,266 from the 5-year event, $809,387 from the 10-year event and $671,860 from the 100-year event.
- *After-Mitigation Damage:* The improved crossing can safely pass the 5-year, 10-year and 50-year events without overtopping, with $235,137 from the 100-year event, so total After-Mitigation Damages are $235,137.
- *Total Standard Mitigation Benefits:* FEMA's BCA Tool Version 6.0 was used to calculate a total Standard Mitigation Benefit of $1,956,732.
- *Standard Benefit Cost Ratio:* 1.81 (actual BC Ratio is higher due to overtopping depth)
- *Social Benefits:* With no affected residential or commercial structures there are no additional social benefits.
- *Standard + Social Benefit Cost Ratio:* 1.81

7.2.4 04 SH 36 and Arrowood Crossing

The drainage area of the Stream CG-2 watershed upstream of this location is too large for an online detention pond to effectively reduce peak flows. Currently Arrowood Lane crosses Stream CG-2 with a timber bridge, which Coryell County reports has washed out several times in the past 10 years. It is the only access for 6 properties. To prevent future washouts, the timber bridge is replaced with a 24-foot wide, 6-foot high ConSpan precast concrete arch culvert. The existing timber bridge will remain open during construction to provide residents access to their homes. The HEC-RAS geometry for Stream CG-2 was updated to reflect the bridge replacement and channel improvements (Plan P03), resulting in the proposed floodplain in purple in **Figure 7-4A**. Although the raised roadway results in localized increases in the 1% ACE WSEL roughly 200 feet upstream of the roadway, these increases do not affect any insurable property. Arrowood Lane runs alongside the channel a good distance in both directions, and it is not possible to remove it from the 1% ACE floodplain without elevating the entire length of the roadway. However the 24'x6' arch culvert can pass the 10% ACE peak flow if channel improvements are made downstream to the SH 36 culverts. The side slope of portions of the channel improvements are armored to protect the roadway from future scour and erosion. A comparison of the proposed and existing water surfaces demonstrates no negative effect, as described in Exhibit C Section 3.6 of TWDB's state flood planning guidance.

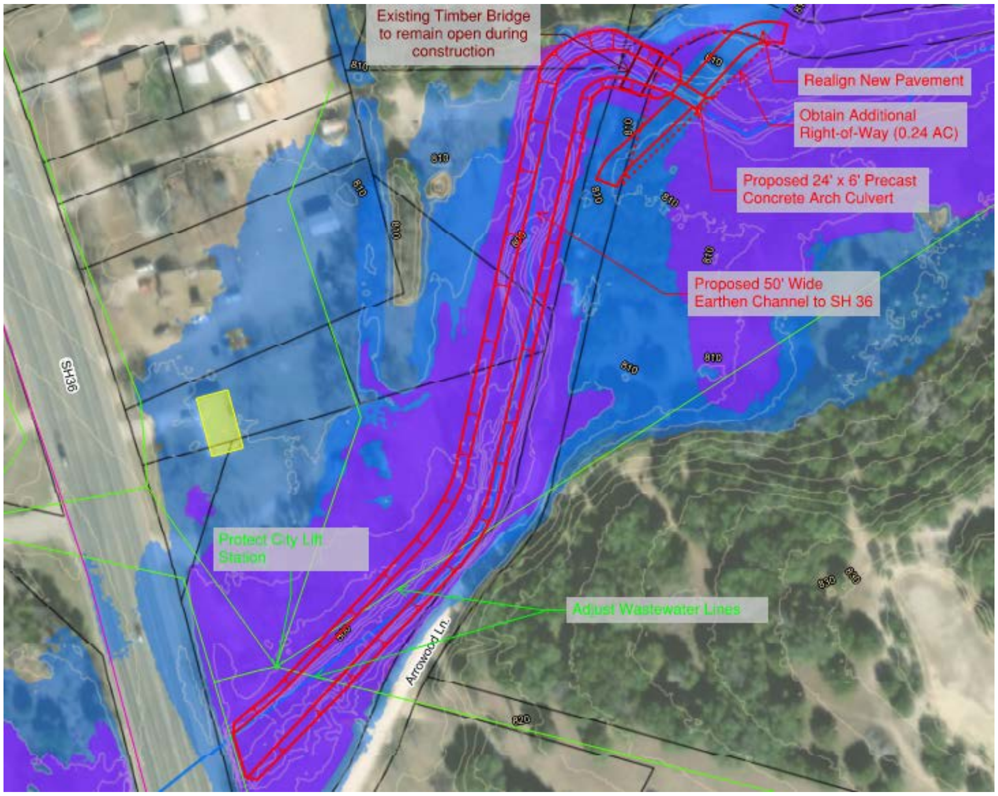


Figure 7-4A: Arrowood Lane Culvert and Channel – 10% ACE

As shown in **Exhibit D-4A** in **Appendix D**, the total estimated project cost is $982,192 for the raised roadway and box culvert structures. This project is currently being funded by a CDBG-DR mitigation grant through Coryell County. The recommended bridge replacement and channel improvements are permittable, constructible and implementable.

The second location is the flooding of 2 residential properties along the SH 36 frontage. At the crossing of SH 36 and Stream CG-2, the existing 4 - 9'x8' box culverts have sufficient capacity to pass the 100-year flows, but flow accumulates on the upstream side that floods these residential structures. The upstream WSEL can be lowered by adding 2 additional 8'x8' box culverts under SH 36, removing one of the two structures from the 100-year floodplain. The HEC-RAS geometry for Stream CG-2 was updated to reflect additional box culverts (Plan P04), resulting in the proposed floodplain in purple in **Figure 7-4B**. A comparison of the proposed and existing water surfaces demonstrates no negative effect, as described in Exhibit C Section 3.6 of TWDB's state flood planning guidance.

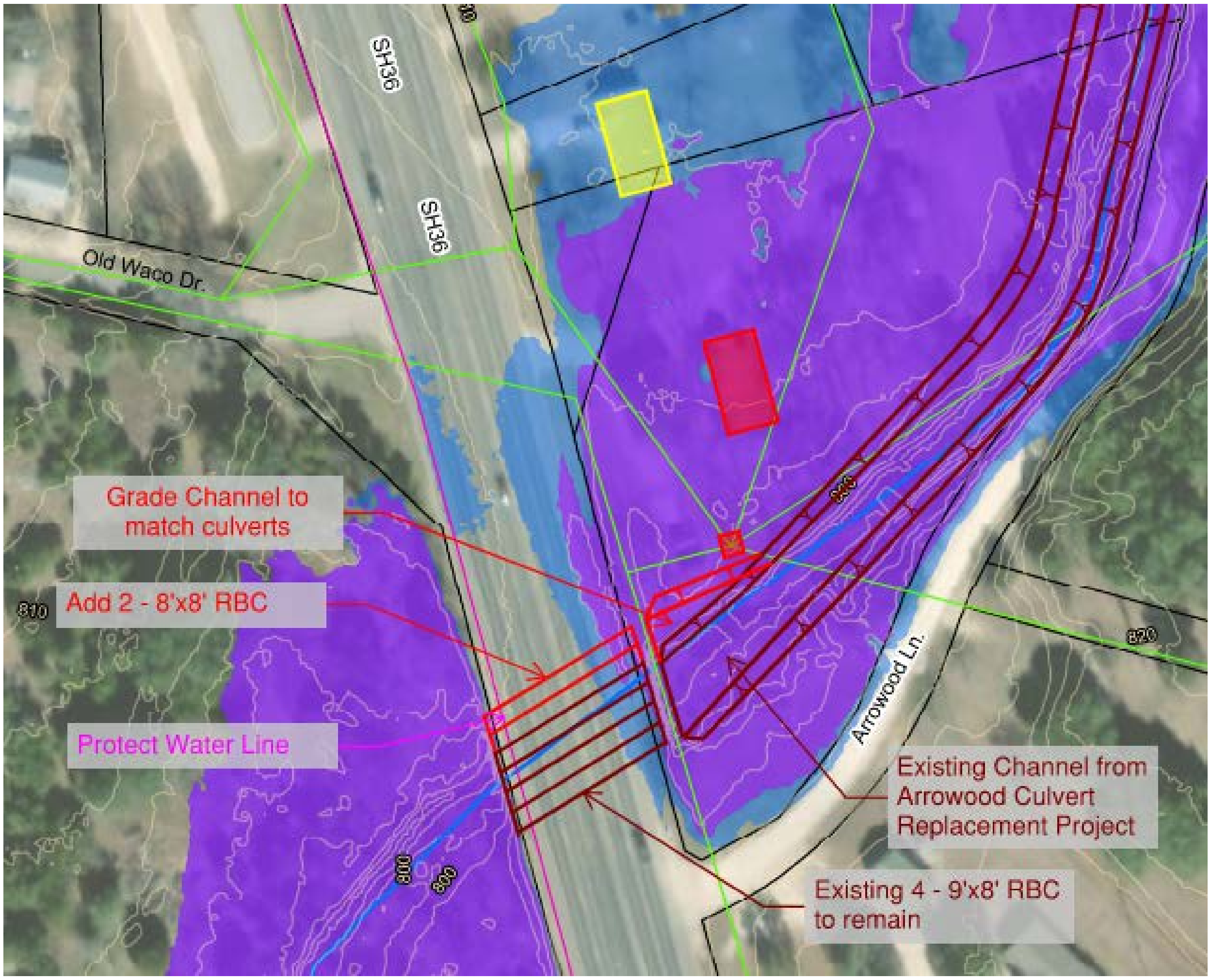


Figure 7-4B: SH 36 Culverts – 1% ACE

As shown in **Exhibit D-4B** in **Appendix D**, the total estimated project cost is $328,140 for the raised roadway and box culvert structures. These culvert improvements must be coordinated with TXDOT, who might require the culverts to be jacked and bored under the highway at a higher construction cost. According to the Coryell County Appraisal District, the current market value of the removed house in yellow is $131,650. The recommended additional culverts are permittable, constructible and implementable.

7.2.5 05 FM 929 Crossing

At the crossing of FM 929 and Stream CG-4, the existing 4 - 8'x4' box culverts do not have sufficient capacity to pass the 100-year flows. The roadway is very flat, and it acts like a flow spreader distributing the overflows across 3 blocks downstream flooding 19 insurable structures before flow can make its way back to the Stream CG-4 channel.

The FM 929 Culvert and Channel Improvements project includes replacing the existing culverts with 4-8'x6' box culverts and the addition of 4-8'x6' box culverts under the roadway to provide capacity to pass the 100-year event without overtopping, along with channel improvements with a bottom width of 120 feet extending 1,300 feet downstream to lower the channel flowline by 2 feet at FM 929, increase channel capacity and lower the tailwater, as shown in **Figure 7-5** below. A linear embankment along the left channel bank prevents flow from inundating a row of 7 houses along the east side of the floodplain, and since it is not hydraulically connected it was mapped at a backwater elevation from its hydraulic connected area 800 feet downstream. The HEC-RAS geometry for Stream CG-4 was updated to reflect the levee improvements (Plan P02), resulting in the proposed floodplain in purple in **Figure 7-5**. A comparison of the proposed and existing water surfaces demonstrates no negative effect, as described in Exhibit C Section 3.6 of TWDB's state flood planning guidance.

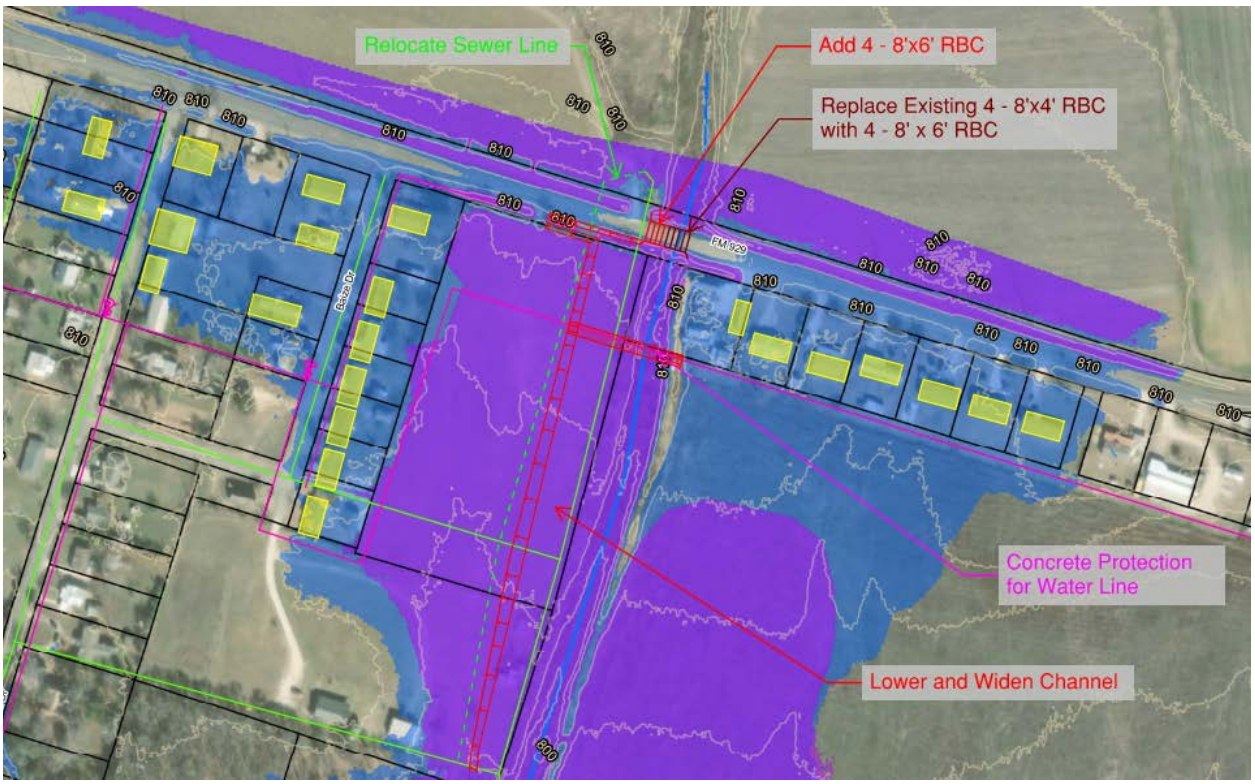


Figure 7-5: FM 929 Culverts and Channel – 1% ACE

As shown in **Exhibit D-5** in **Appendix D**, the total estimated project cost is $1,535,250 for the box culvert structures and channel excavation. These culvert improvements must be coordinated with TXDOT. The recommended culvert replacement and overbank improvements are permittable, constructible and implementable.

7.2.6 06 Sun Valley Neighborhood

Upstream of the State School Road bridge, flow in the right overbank of Stillhouse Branch spreads out over a large agricultural area and inundates 3 blocks of houses in the Sun Valley neighborhood, as well as several houses along State School Road. This is backwater riverine flooding from Stillhouse Branch, which has a large drainage area upstream of Gatesville. As such, no online detention pond would be able to produce a significant reduction in flows.

The first mitigation option considered for this problem area was construction of an earthen levee to protect the 45 residential properties along Sun Valley Avenue, Venus Avenue and State School Road. The west end of the earthen levee ties into natural ground at elevation 780 and it wraps around the neighborhood for 4,000 feet to tie back into high ground at elevation 786 behind 410 State School Road. The interior sump area is drained by 24" RCP pipe that runs over to an existing drainage ditch and underneath the levee to an existing outfall channel where it discharges through a 24" flap gate into Stillhouse Branch, as shown in **Figure 7-6**, below.

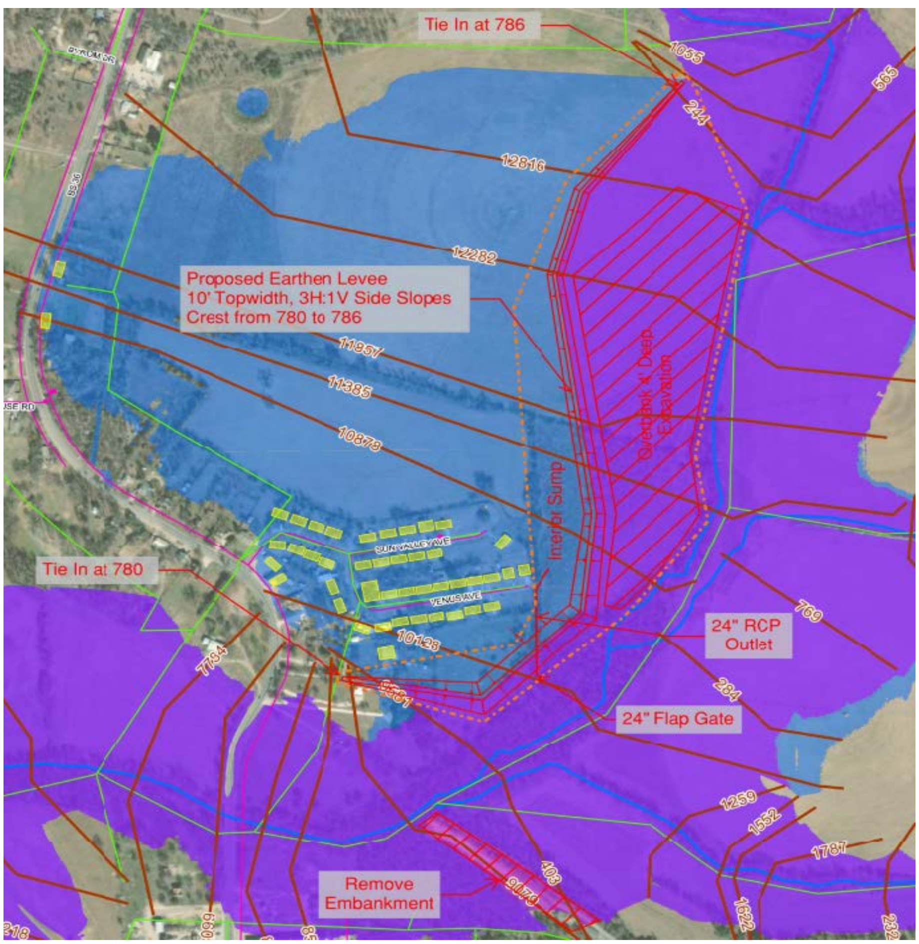


Figure 7-6: Sun Valley Neighborhood Levee Alternative

As shown in **Exhibit D-6A** in **Appendix D**, the total estimated project cost is $1,594,294, or $35,429 per structure. The HEC-RAS geometry for Stillhouse Branch was updated to reflect the levee improvements (Plan P02), resulting in the proposed floodplain in purple in **Figure 7-6**.

A comparison of the proposed and existing HEC-RAS water surfaces demonstrates no negative effect, as described in Exhibit C Section 3.6 of TWDB's state flood planning guidance. The recommended levee alternative is permittable, constructible and implementable.

The following assumptions were made to prepare the detailed Benefit Cost Analysis:

- *Project Useful Life:* The project useful life was 50 years, which is consistent with the FEMA standard design life for the project.
- *Initial Project Cost:* As described above, the total estimated project cost is $1,594,294.
- *Annual Maintenance Cost:* Based on standard NRCS budgets for similar earthen embankments the annual maintenance cost was estimated to be $20,000 per year.
- *Total Mitigation Project Cost:* The initial project cost and present value of 50 years of annual maintenance costs results in a total mitigation project cost of $1,870,309.
- *Lowest Floor Elevations:* The ground elevation was determined from the LIDAR at all 4 corners of each structure, and the highest ground elevation was assumed to be the Lowest Floor Elevation for that structure.
- *Flood Hazard Data:* The 25-year, 50-year and 100-year water surface elevations were taken from the RASMapper inundation results at the highest corner of each structure.
- *Building Information:* The building sizes and types were obtained from the Coryell County Appraisal District database. An average year of construction for the subdivision is 1980. The default analysis duration and building replacement values were applied.
- *Building Occupancy:* Per TWDB guidance, each building was assumed to have 3 occupants, of which 2 were full-time workers.
- *Before-Mitigation Damage:* FEMA's BCA Tool Version 6.0 was used to calculate a total Before-Mitigation Damage of $392,039 from the 25-year event, $2,564,615 from the 50-year event and $5,324,919 from the 100-year event.
- *After-Mitigation Damage:* Since the levee protects the structures from damage during 25-year, 50-year and 100-year events, the total After-Mitigation Damages were $0.
- *Number of Residents:* Assuming 3 residents per structure, a total of 129 residents.
- *Number of Employed Residents:* Assuming 2 of 3 residents works, a total of 86 residents.
- *Social Benefits:* FEMA's BCA Tool Version 6.0 was used to calculate a total Expected Annual Social Benefit of $1,066,443.
- *Standard Benefit Cost Ratio:* 0.81
- *Standard + Social Benefit Cost Ratio:* 1.38

The second option considered was property acquisition of 45 residential properties along Sun Valley Avenue, Venus Avenue and State School Road. As shown in **Exhibit D-6B** in **Appendix D**, the total estimated project cost to acquire these 45 properties is $11,134,005, or an average of $247,422 per acquired structure. The levee is the most cost-effective solution.

8.0 Conclusions and Recommendations

The Gatesville Master Drainage Plan is a set of structural and non-structural flood protection measures to reduce the flooding losses in the watershed, based on updated hydrologic and hydraulic models.

8.1 Public Meetings and Workshops

The jurisdictions in the watershed and the general public were involved throughout the planning process. Several public meetings were held as the Gatesville Master Drainage Plan was developed, a list of which is shown in **Table 8-1** below.

Table 8-1: List of Public Meetings.

Meeting	Date	Description
Workshop and Public Meeting #1	June 21, 2022	Presented scope of study and collected drainage concerns
Workshop and Public Meeting #2	January 24, 2023	Present the results of the updated hydrology and hydraulics, each of the 16 problem areas and the 6 conceptual mitigation solutions

8.2 Ranking of Solutions

Since the flood mitigation solutions are to be implemented by different funding methods and cooperation with Coryell County and TXDOT, a formal ranking process to develop a prioritized order in which they should be implemented is not applicable.

8.3 Recommendations

The recommended flood mitigation solutions are summarized in **Table 8-2** below.

Table 8-2: Summary of Mitigation Solutions.

Flood-Prone Area	Recommended Solution	Estimated Cost	Responsible Entity	BC Ratio	Funding Source
East Leon Street	Acquire or raise 10 houses	$1,425,405	City of Gatesville	N/A	FEMA Hazard Mitigation or Increased Cost of Compliance
Leon Wastewater Treatment Plant	Construct a parapet wall to add 2 feet to the ring embankment	$642,100	City of Gatesville	N/A	CWSRL grant
Straws Mill Road Low Water Crossing	Raise roadway by 10 feet and enlarge culverts	$1,021,710	City of Gatesville; Coryell County	1.81	FIF Project grant
Arrowood Lane **SH 36**	Replace the bridge crossing Add 2 8’x8’ culverts	$982,192 $328,140	Coryell County, City of Gatesville	N/A N/A	CDBG-DR grant TXDOT
FM 929 crossing	Replace and add culverts, widen downstream channel	$1,535,250	TXDOT and City of Gatesville	N/A	General TXDOT
Sun Valley Neighborhood	Construct an earthen levee	$1,594,294	City of Gatesville	1.38	FIF Project grant
Total Proposed	**Mitigation Cost**	$7,529,091			

The locations of the recommended CIP solutions are also shown on **Figure 8-1** on the following page.

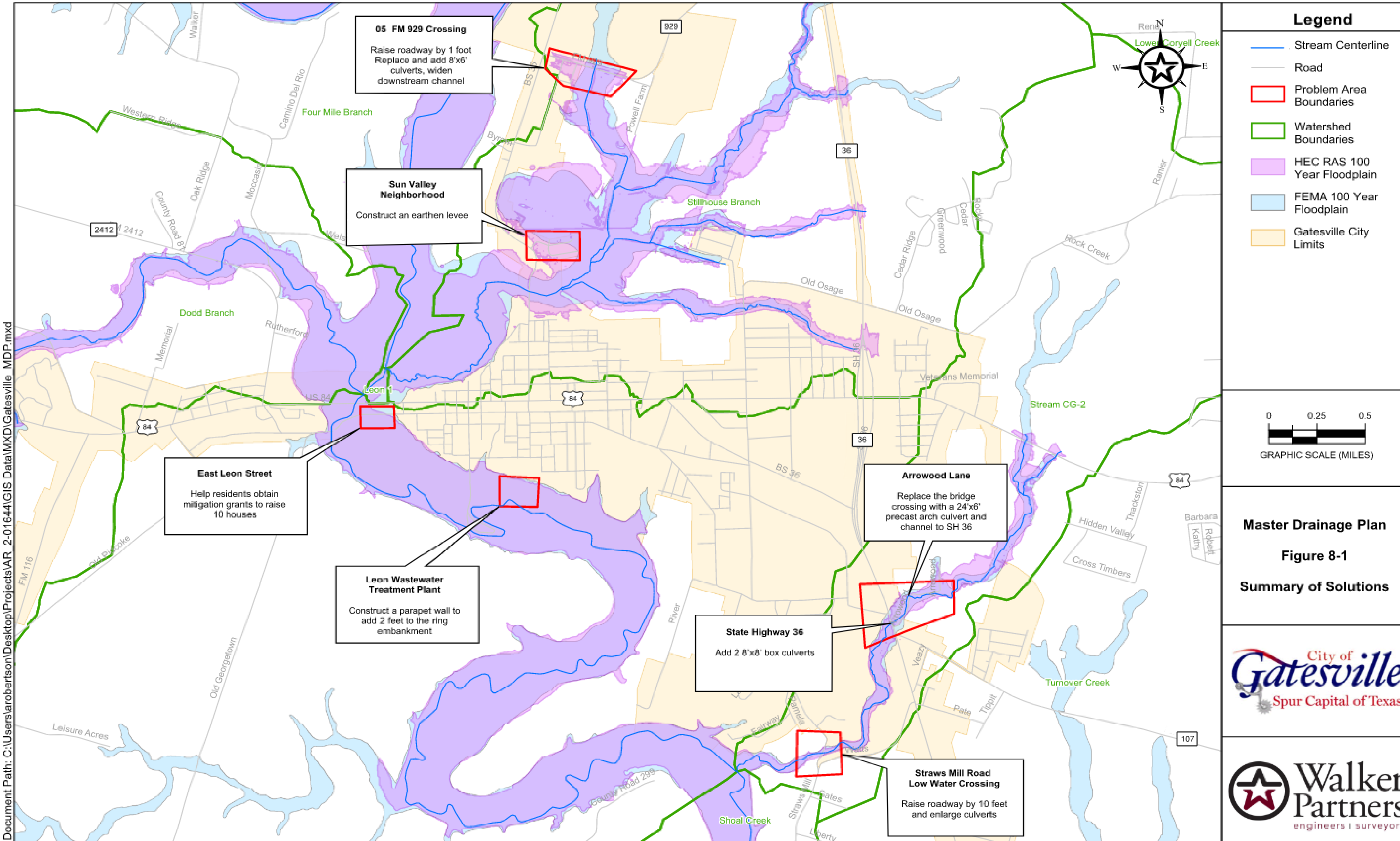


Figure 8-1: Summary of Recommended CIP Solutions

9.0 Acknowledgements

We would like to thank the Staff of the City of Gatesville for their leadership and effort put forth to make this study possible. Likewise, we would like to thank staff from Coryell County for coordinating with the City to collect and evaluate information on low water crossings in the ETJ.

In addition, we appreciate Chris Ryon and the entire Team at the Texas Water Development Board for providing this Flood Infrastructure Fund Grant to the City of Gatesville.

Finally, we would also like to thank the Fort Worth District of the U.S. Army Corps of Engineers for their cooperation and support throughout this study.

10.0 References

Benchmark Planning, “City of Gatesville – Comprehensive Plan”, prepared for the City of Gatesville, May 26, 2020.

Dewberry & Davis, LLC, Independent Quality Control Report, “Brazos Basin-TX Red River FEMA R6 Lidar 2016 D17”, prepared for the U.S. Geological Survey, Task Order G17PD00014, October 23, 2018.

Federal Emergency Management Agency (FEMA). Flood Insurance Study #48099CV000A, Coryell County, Texas and Incorporated Areas, Washington, D.C., February 17, 2010.

Hydrologic Engineering Center, U.S. Army Corps of Engineers. Hydrologic Modeling System, Version 4.1, July 2022.

Hydrologic Engineering Center, U.S. Army Corps of Engineers. River Analysis System, Version 6.2, March 2022.

Hydrologic Engineering Center, U.S. Army Corps of Engineers. HEC-RAS Hydraulic Reference Manual, Version 6.2, March 2022.

Lockwood, Andrews & Newnam, Inc., “Construction Plans for Leon WWTP Slope Protection”, prepared for City of Gatesville, May 2009.

Natural Resources Conservation Service, United States Department of Agriculture. “Urban Hydrology for Small Watersheds”, Technical Release No. 55 (TR-55), 1986.

Parsons Water Infrastructure and the Brazos River Authority “Watershed Protection Plan for the Leon River Below Proctor Lake and Above Belton Lake,” Texas State Soil & Water Conservation Board, January 2015.

Perica, Sanja, Pavlovic, Sandra, “NOAA Atlas 14: Precipitation-Frequency Atlas of the United States”, Volume 11: Texas, Version 2.0, National Oceanic and Atmospheric Administration, Silver Spring, Maryland, 2018.

United States Department of Agriculture, Web Soil Survey, Accessed in April 2022, https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

United States Department of Agriculture. Part 630 Hydrology National Engineering Handbook, Ch. 15, Time of Concentration, 210-VI-NEH, 2010.

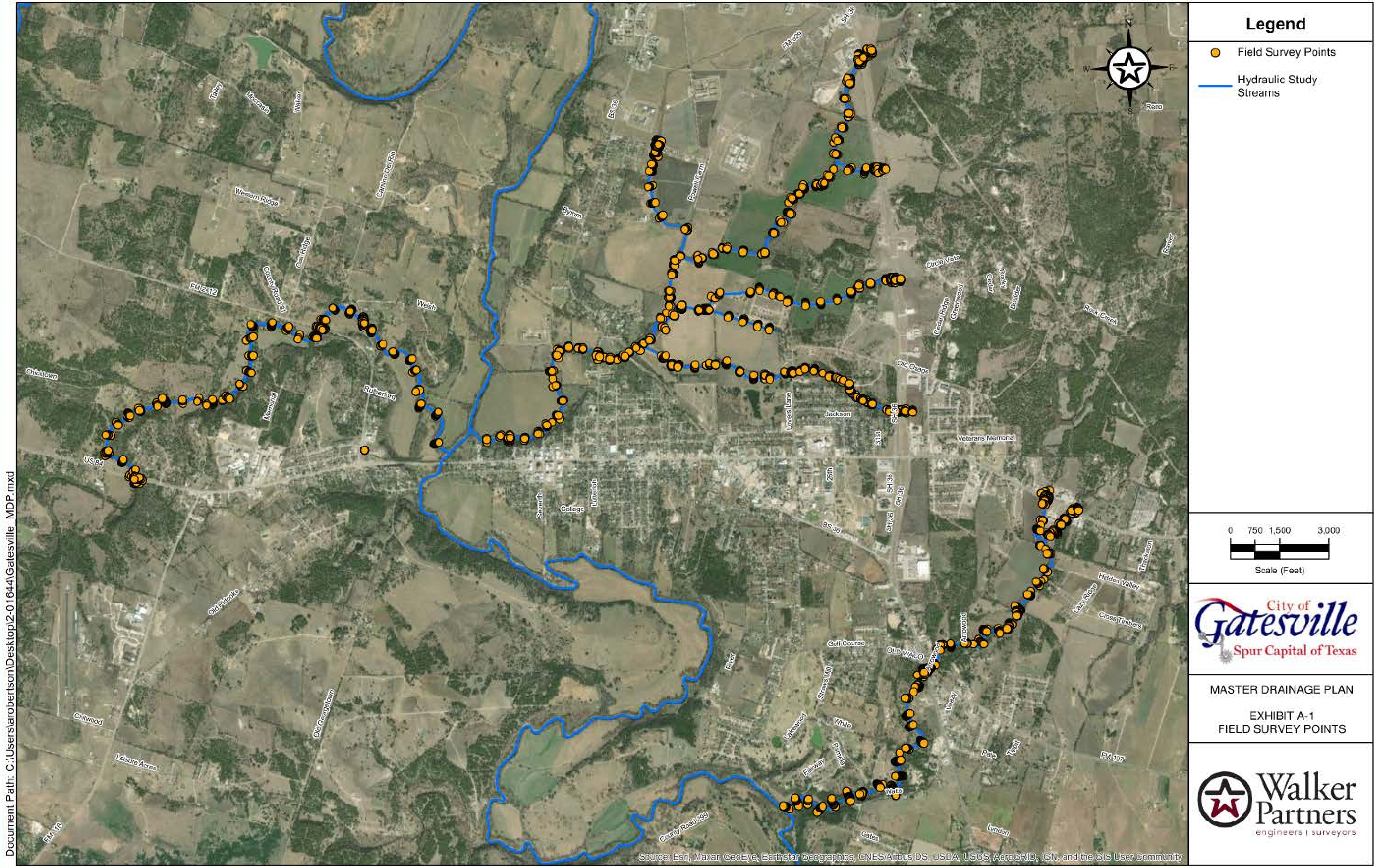
Texas Department of Transportation (TxDOT) Hydraulic Design Manual. Chapter 4 – Hydrology, Revised September 2019.

United States Geological Survey (USGS). “Guide for Selecting Manning’s Roughness Coefficients for Natural Channels and Flood Plains –Cowan’s Method 1956” – Water-Supply Paper 2339, 1992.

Walker Partners, LLC, “Gatesville Drainage Criteria Manual”, prepared for City of Gatesville, August 2018.

Appendix A – Data Collection

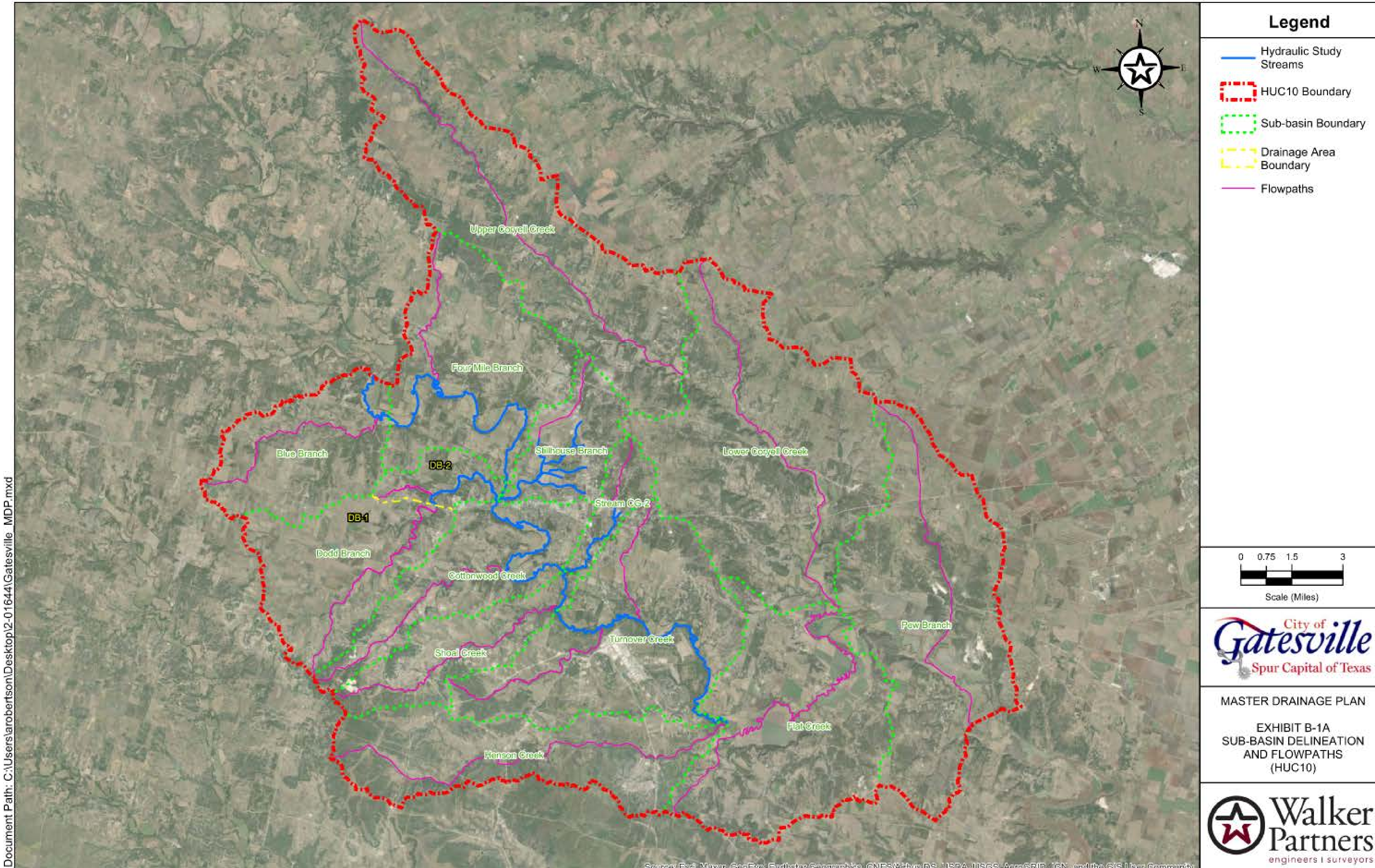
Exhibit A-1 Field Survey Points


Legend
Field Survey Points
Hydraulic Study Streams
0 750 1,500 3,000
Scale (Feet)
City of Gatesville
Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT A-1
FIELD SURVEY POINTS
Walker Partners
engineers | surveyors
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Document Path: C:\Users\arobertson\Desktop\2-01644\Gatesville_MDP.mxd

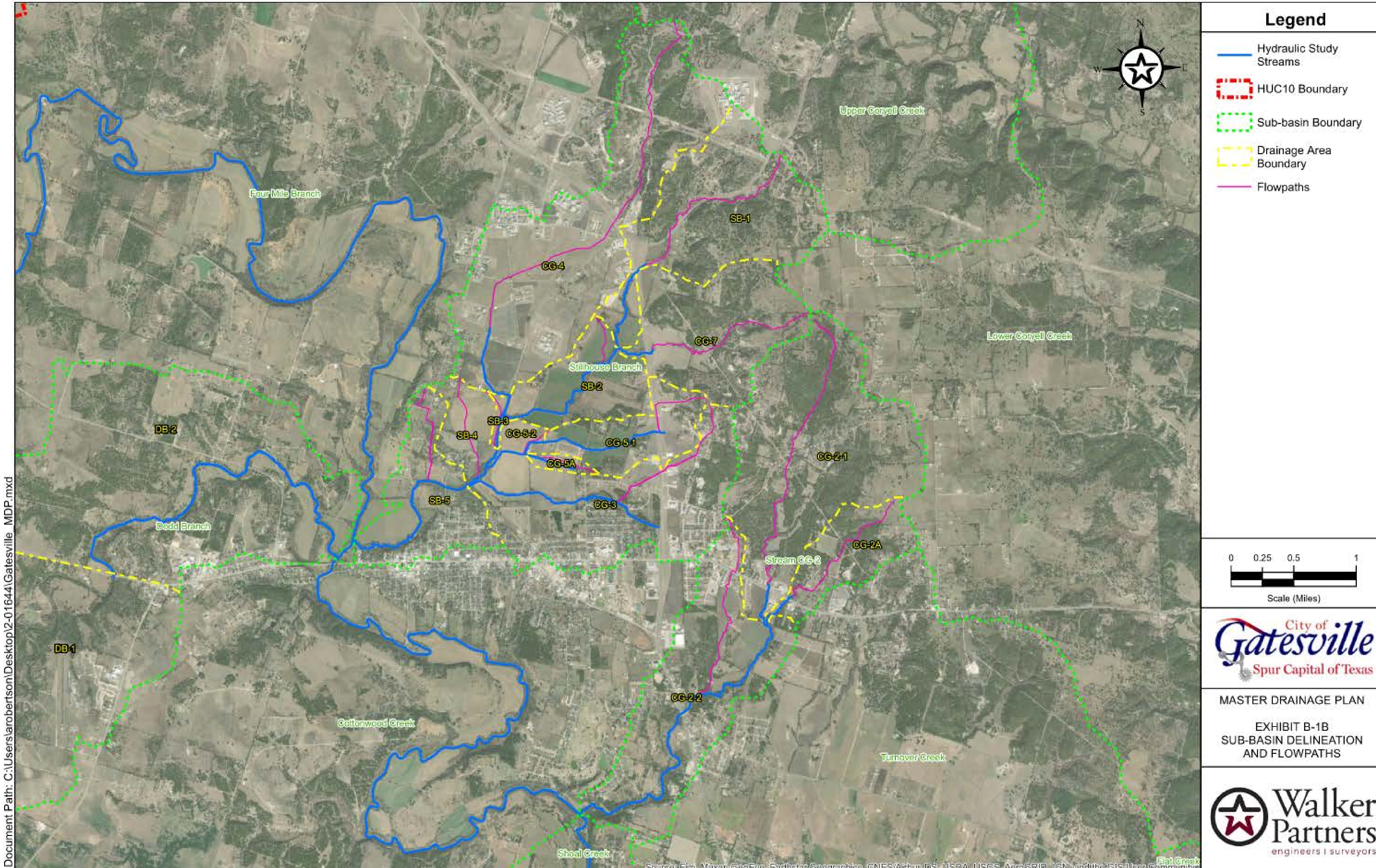
Appendix B – Hydrology

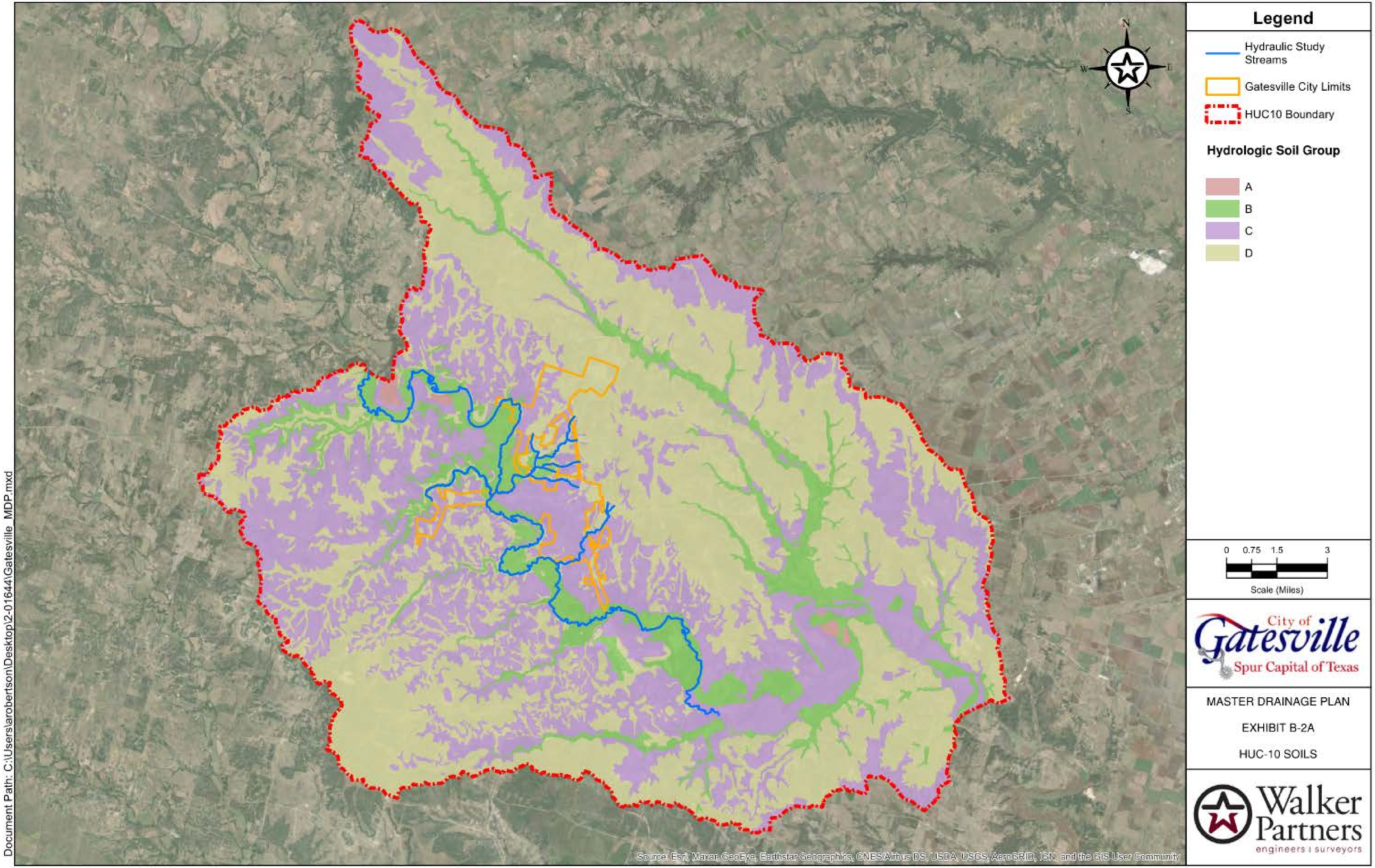
Exhibit B-1A	**Sub-basin Delineation and Flow Paths (HUC-10)**
Exhibit B-1B	**Sub-basin Delineation and Flow Paths (Citywide)**
Exhibit B-2A	**Soils (HUC 10)**
Exhibit B-2B	**Soils (Citywide)**
Exhibit B-3	**Land Use**
Exhibit B-4A	**Impervious Cover Percentage (HUC 10)**
Exhibit B-4B	**Impervious Cover Percentage (Citywide)**
Exhibit B-5	**Time of Concentration Calculations**
Exhibit B-6	**Sub-basin Peak Discharge**

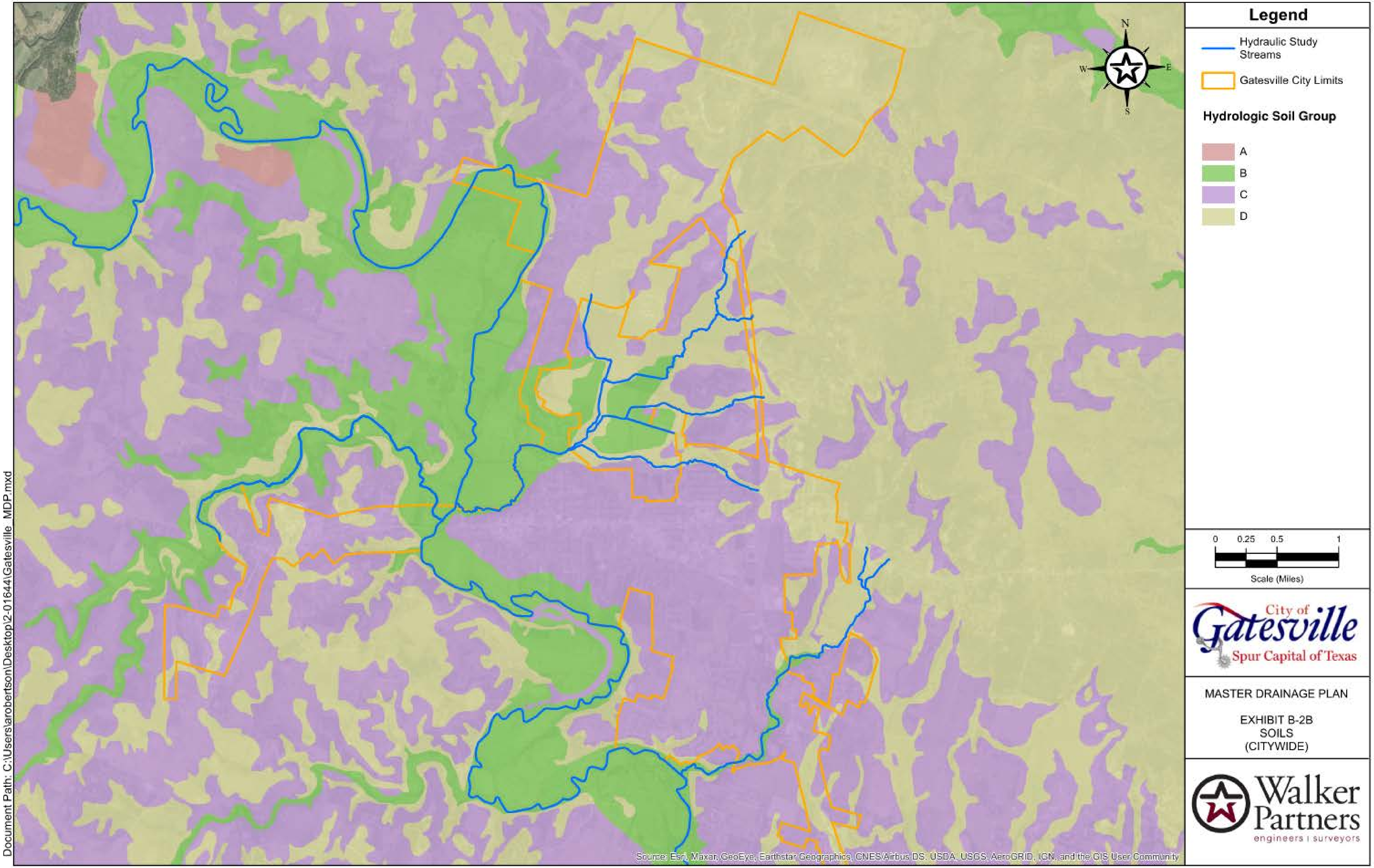
Document Path: C:\Users\arobertson\Desktop\2-01644\Gatesville_MDP.mxd

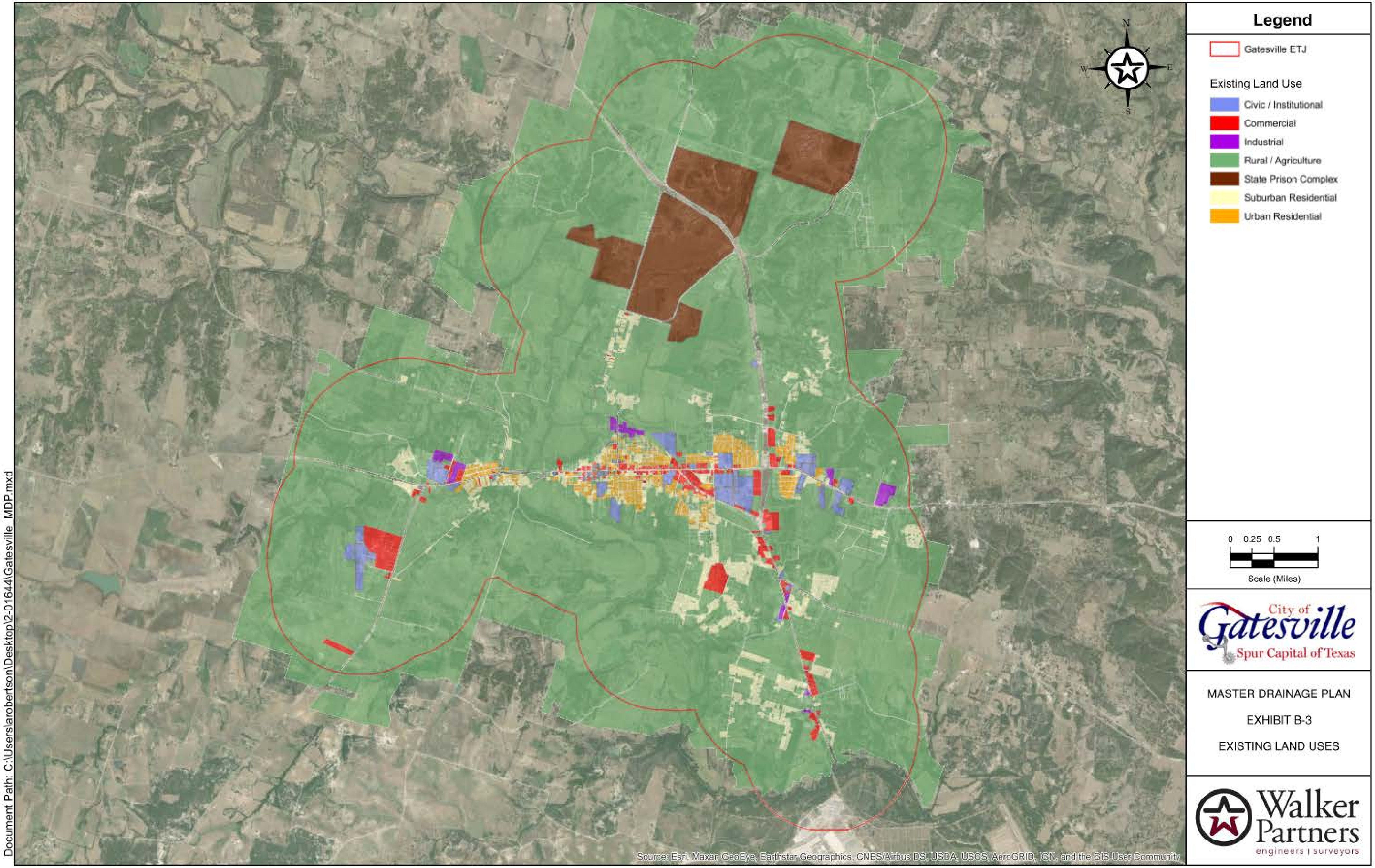


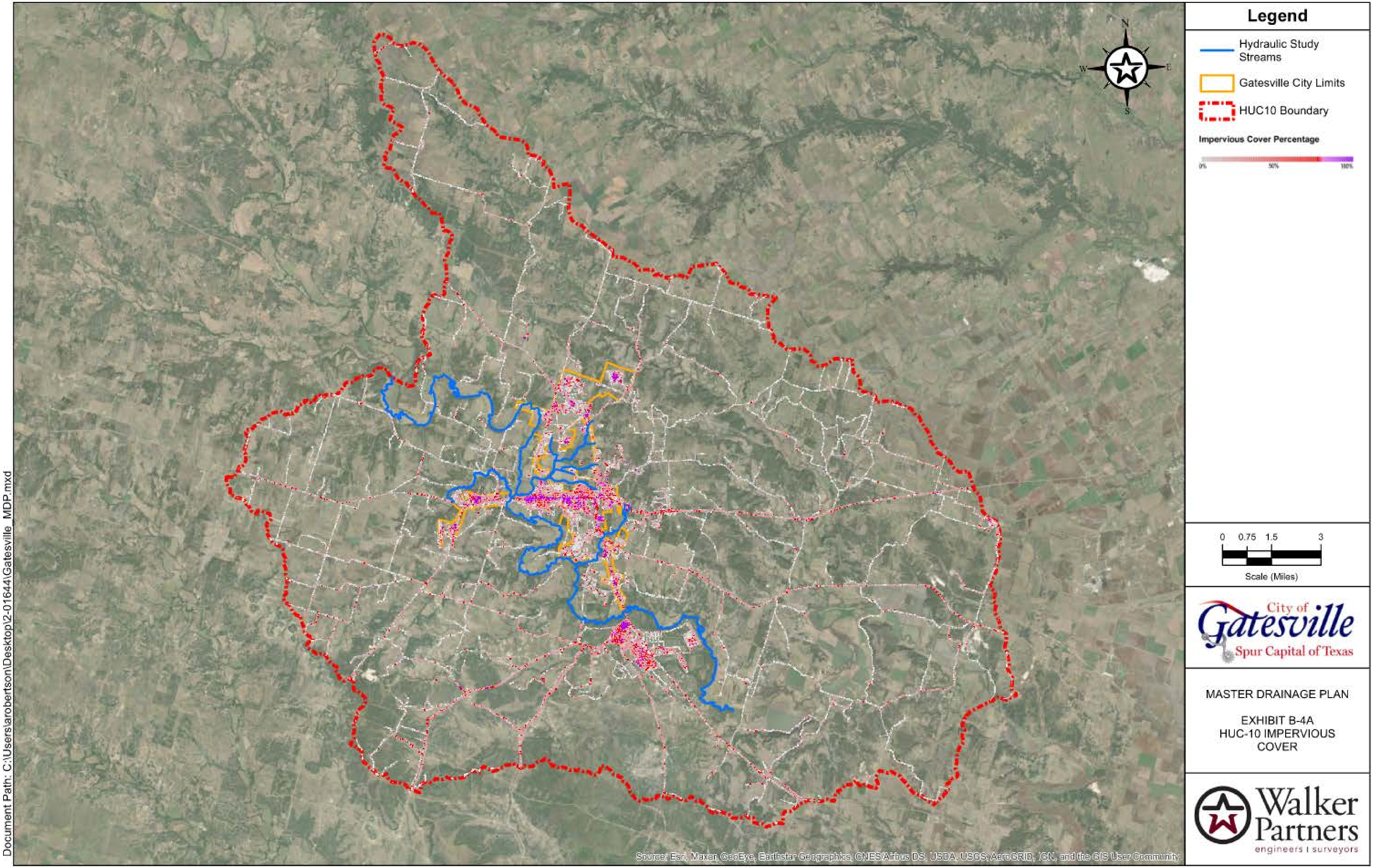
Document Path: C:\Users\arobertson\Desktop\2-01644\Gatesville_MDP.mxd

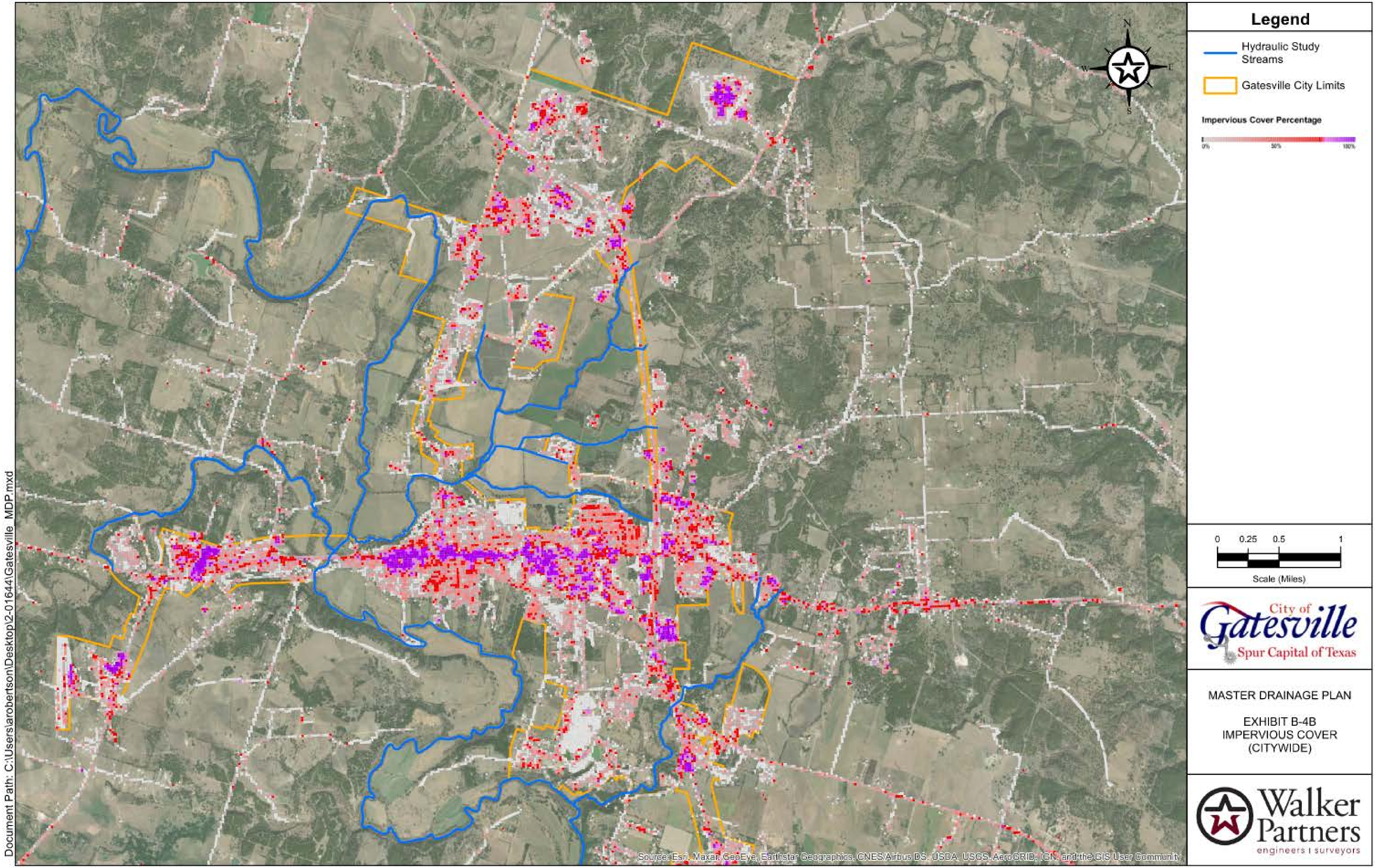



Legend
Hydraulic Study Streams
Gatesville City Limits
HUC10 Boundary
Hydrologic Soil Group
A
B
C
D
0 0.75 1.5 3
Scale (Miles)
City of Gatesville
Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT B-2A
HUC-10 SOILS
Walker Partners
engineers | surveyors
Document Path: C:\Users\arobertson\Desktop\2-01644\Gatesville_MDP.mxd
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


Legend
Hydraulic Study Streams
Gatesville City Limits
Hydrologic Soil Group
A
B
C
D
N
S
E
W
0
0.25
0.5
1
Scale (Miles)
City of Gatesville
Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT B-2B
SOILS
(CITYWIDE)
Walker Partners
engineers | surveyors
Document Path: C:\Users\arobertson\Desktop\2-01644\Gatesville_MDP.mxd
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


Legend
Gatesville ETJ
Existing Land Use
Civic / Institutional
Commercial
Industrial
Rural / Agriculture
State Prison Complex
Suburban Residential
Urban Residential
N
S
E
W
0 0.25 0.5 1
Scale (Miles)
City of Gatesville
Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT B-3
EXISTING LAND USES
Walker Partners
engineers | surveyors
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Document Path: C:\Users\arobertson\Desktop\2-01644\Gatesville_MDP.mxd


Legend
Hydraulic Study Streams
Gatesville City Limits
HUC10 Boundary
Impervious Cover Percentage
0%
50%
100%
N
S
E
W
0 0.75 1.5 3
Scale (Miles)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT B-4A
HUC-10 IMPERVIOUS COVER
Walker Partners engineers | surveyors
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Document Path: C:\Users\arobertson\Desktop\2-01644\Gatesville_MDP.mxd


Legend
Hydraulic Study Streams
Gatesville City Limits
Impervious Cover Percentage
0 0.25 0.5 1
Scale (Miles)
City of Gatesville
Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT B-4B
IMPERVIOUS COVER
(CITYWIDE)
Walker Partners
engineers | surveyors
Document Path: C:\Users\arobertson\Desktop\2-01644\Gatesville_MDP.mxd
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

DRAINAGE AREA ID	OVERLAND SHEET FLOW ($t_{c,sheet}$)				SHALLOW CONCENTRATED FLOW ($t_{c,shallow}$)					CHANNELIZED FLOW ($t_{c,channel}$)			T_c	
	N	L	S	t_t	L	S	Surface	V	t_t	L	V	t_t	ΔTc	∑Tc
		(FT)	(FT/FT)	(MIN)	(FT)	(FT/FT)	(P or U)	(FT/S)	(MIN)	(FT)	(FT/S)	(MIN)	(MIN)	(MIN)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

DRAINAGE AREA ID	L	V	t_t
	(FT)	(FT/S)	(MIN)
Reach - 1	62992.26	8.0	131.2
Reach - 6	18826.47	8.0	39.2
Reach - 2	998.55	8.0	2.1
Reach - 3	41857.57	8.0	87.2
Reach - 4	7821.85	8.0	16.3
Reach - 5	20193.18	8.0	42.1
CG2 Branch -- Reach - 7	13140.00	8.0	27.4
SHB - A-B	7279.41	8.0	15.2
SHB - B-D	2379.97	8.0	5.0
SHB - D-E	1227.84	8.0	2.6
SHB - E-F	8361.90	8.0	17.4

City of Gatesville Spur Capital of Texas

EXHIBIT B-5

TIME OF CONCENTRATION CALCULATIONS

Walker Partners engineers | surveyors

Hydrologic Element	Peak Discharge (CFS)
SB1	3715.2
CG-7	3353
CG-4	7212.2
SB2	1737.2
CG5-1	1576.9
CG5-A	135.9
CG5-2	140.4
SB3	104.3
CG3	4425.9
SB4	634.1
SB5	1762.1
Blue Branch	21420.1
Fourmile Branch	28947.5
DB1	30471.7
DB2	7697.9
Leon River 1	54.6
Cottonwood Creek	25886.2
CG2-1	5330.8
CG-2A	1556.3
CG2-2	4633.7
Shoal Creek	16421.2
Turnover Creek	22551.3
Henson	32436.7
Turnover Creek 2	31028.9
Coryell - Upper	31357.3
Coryell - Lower	56826.2
Flat Creek	43412
Pew Branch	37599

EXHIBIT B-6

SUB-BASIN
PEAK DISCHARGES

Appendix C – Hydraulics and Floodplain Mapping

Exhibit C-1 Hydraulic Work Map – Leon River A

Exhibit C-2 Hydraulic Work Map – Dodd Branch A

Exhibit C-3 Hydraulic Work Map – Dodd Branch B

Exhibit C-4 Hydraulic Work Map – Dodd Branch C

Exhibit C-5 Hydraulic Work Map – Stillhouse Branch A

Exhibit C-6 Hydraulic Work Map – Stillhouse Branch B

Exhibit C-7 Hydraulic Work Map – Stillhouse Branch C

Exhibit C-8 Hydraulic Work Map – Stream CG-4

Exhibit C-9 Hydraulic Work Map – Stream CG-5 A

Exhibit C-10 Hydraulic Work Map – Stream CG-5 B

Exhibit C-11 Hydraulic Work Map – Stream CG-3 A

Exhibit C-12 Hydraulic Work Map – Stream CG-3 B

Exhibit C-13 Hydraulic Work Map – Leon River B

Exhibit C-14 Hydraulic Work Map – Leon River C

Exhibit C-15 Hydraulic Work Map – Leon River D

Exhibit C-16 Hydraulic Work Map – Stream CG-2 A

Exhibit C-17 Hydraulic Work Map – Stream CG-2 B

Exhibit C-18 Hydraulic Work Map – Stream CG-2 C

Exhibit C-19 MDP vs. FEMA 1% Floodplain – Leon River A

Exhibit C-20 MDP vs. FEMA 1% Floodplain – Dodd Branch A

Exhibit C-21 MDP vs. FEMA 1% Floodplain – Dodd Branch B

Exhibit C-22 MDP vs. FEMA 1% Floodplain – Dodd Branch C

Exhibit C-23 MDP vs. FEMA 1% Floodplain – Stillhouse Branch A

Exhibit C-24 MDP vs. FEMA 1% Floodplain – Stillhouse Branch B

Exhibit C-25 MDP vs. FEMA 1% Floodplain – Stillhouse Branch C

Exhibit C-26 MDP vs. FEMA 1% Floodplain – Stream CG-4

Exhibit C-27 MDP vs. FEMA 1% Floodplain – Stream CG-5 A

Exhibit C-28 MDP vs. FEMA 1% Floodplain – Stream CG-5 B

Exhibit C-29 MDP vs. FEMA 1% Floodplain – Stream CG-3 A

Exhibit C-30 MDP vs. FEMA 1% Floodplain – Stream CG-3 B

Exhibit C-31 MDP vs. FEMA 1% Floodplain – Leon River B

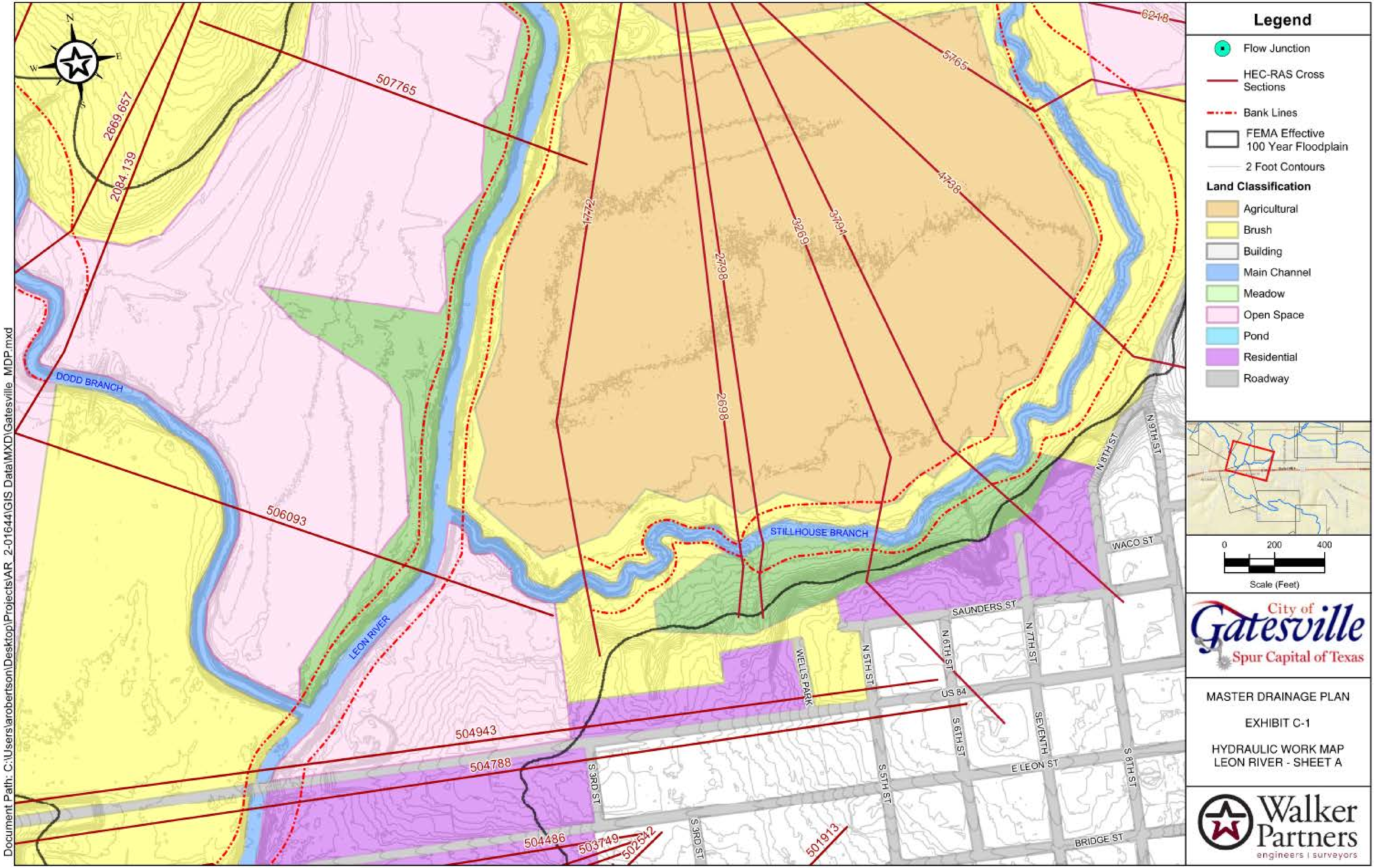
Exhibit C-32 MDP vs. FEMA 1% Floodplain – Leon River C

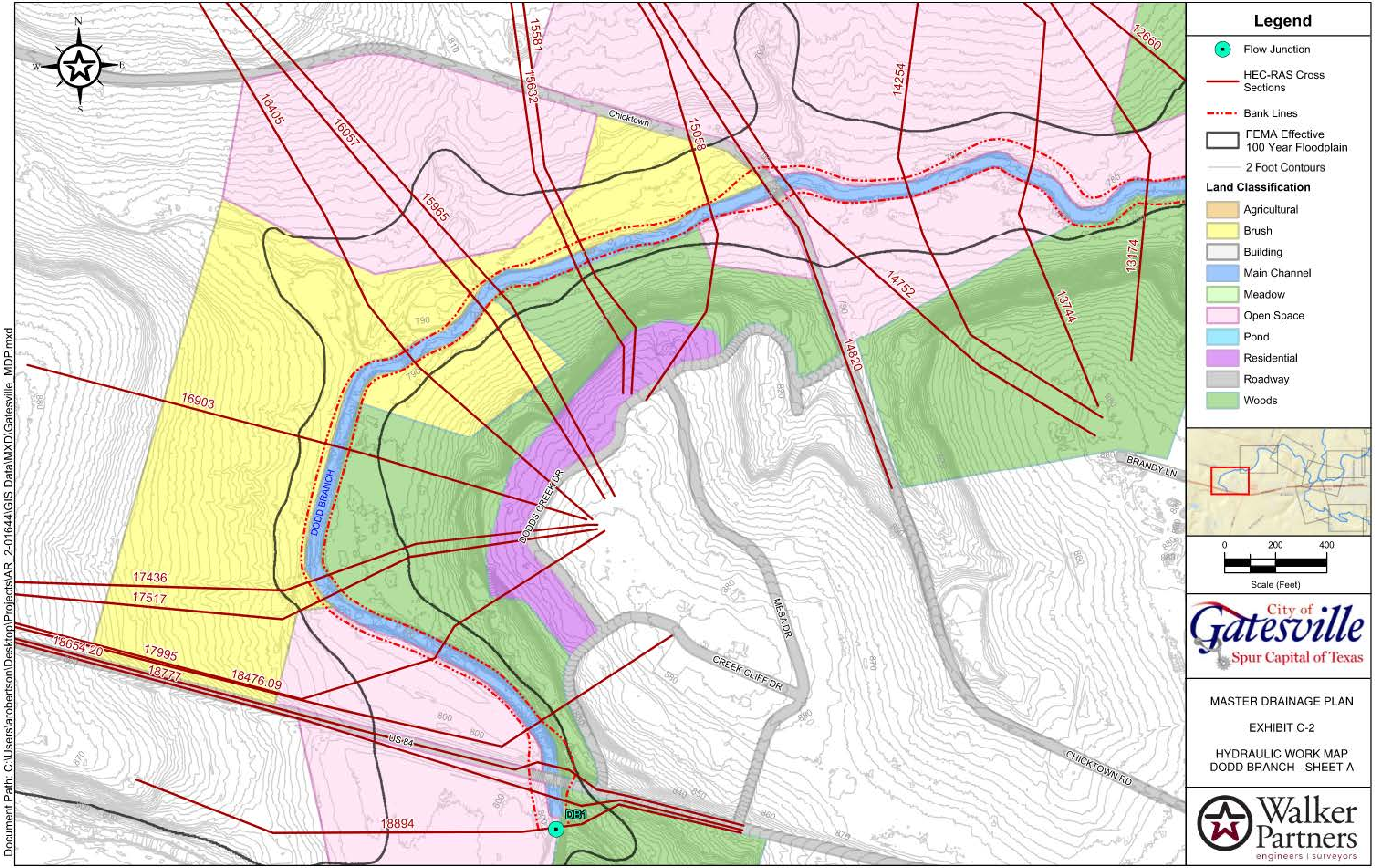
Exhibit C-33 MDP vs. FEMA 1% Floodplain – Leon River D

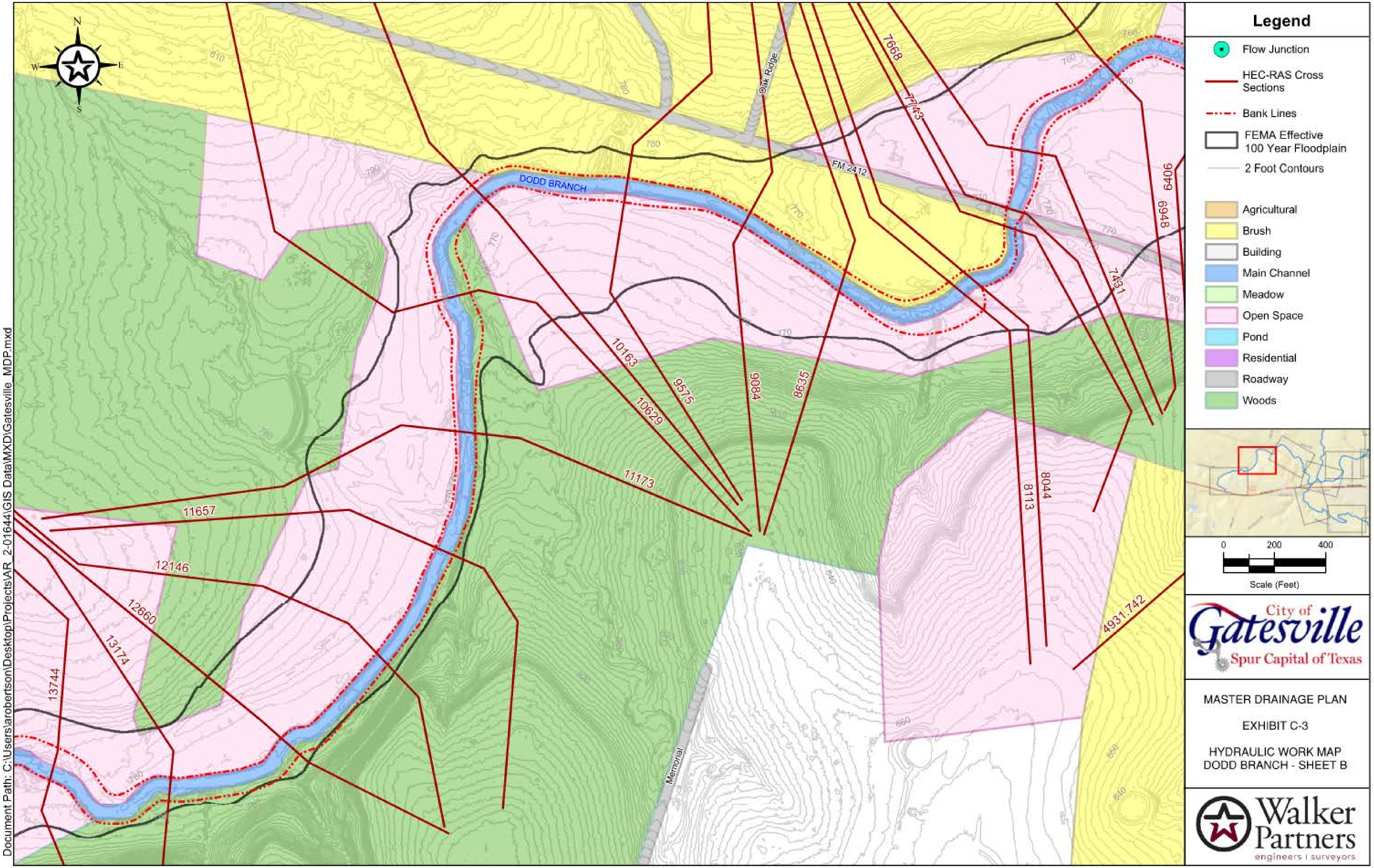
Exhibit C-34 MDP vs. FEMA 1% Floodplain – Stream CG-2 A

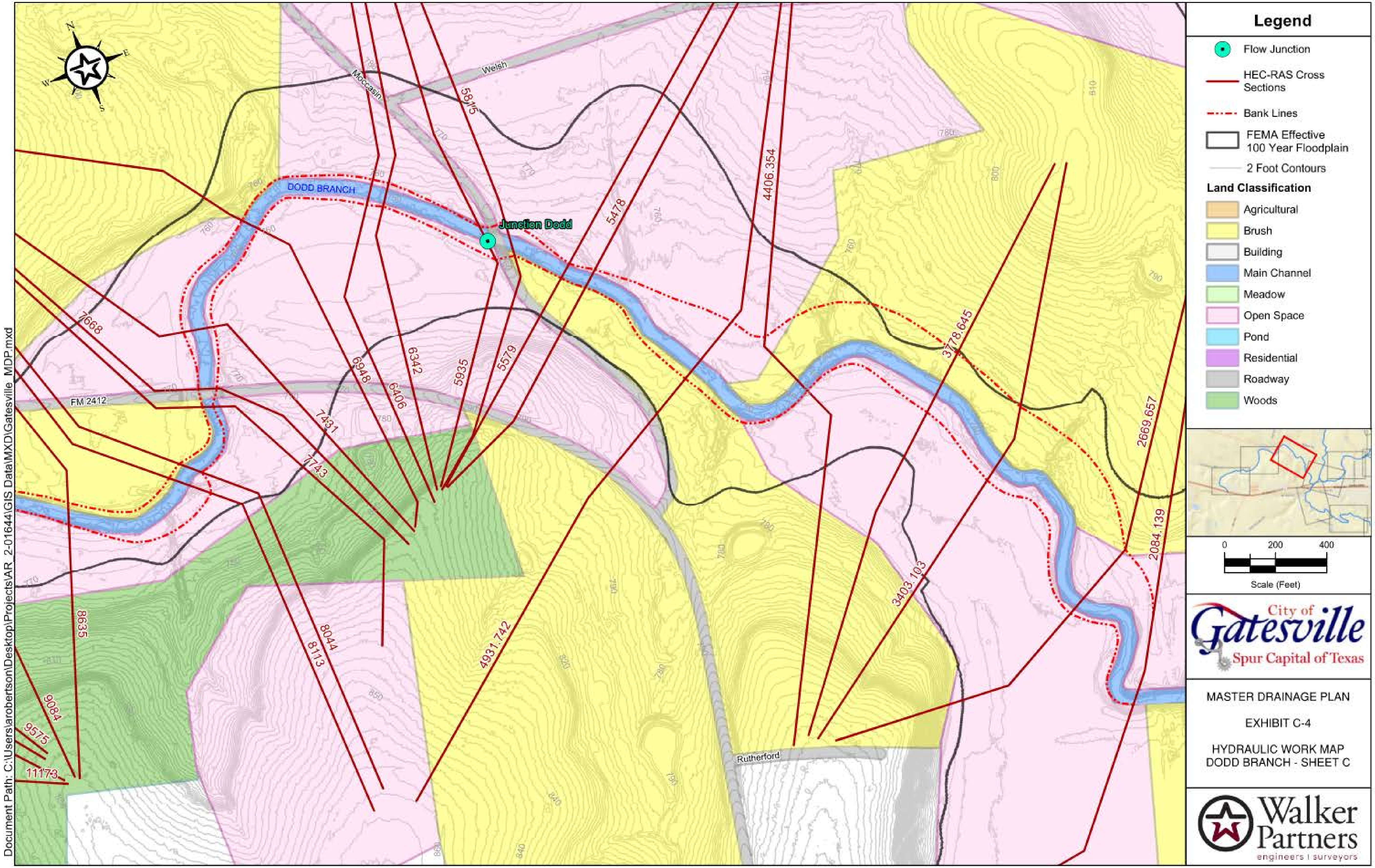
Exhibit C-35 MDP vs. FEMA 1% Floodplain – Stream CG-2 B

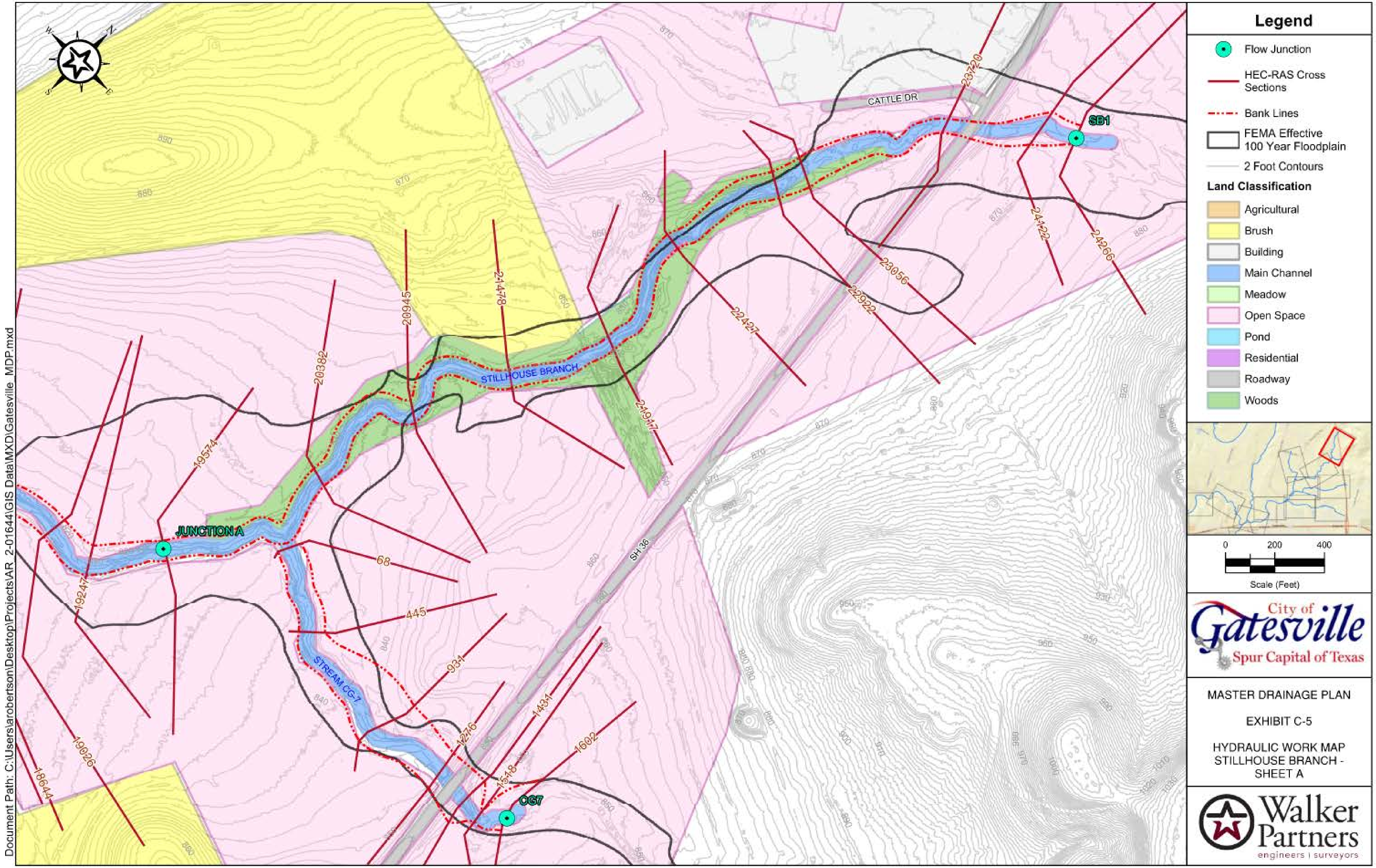
Exhibit C-36 MDP vs. FEMA 1% Floodplain – Stream CG-2 C

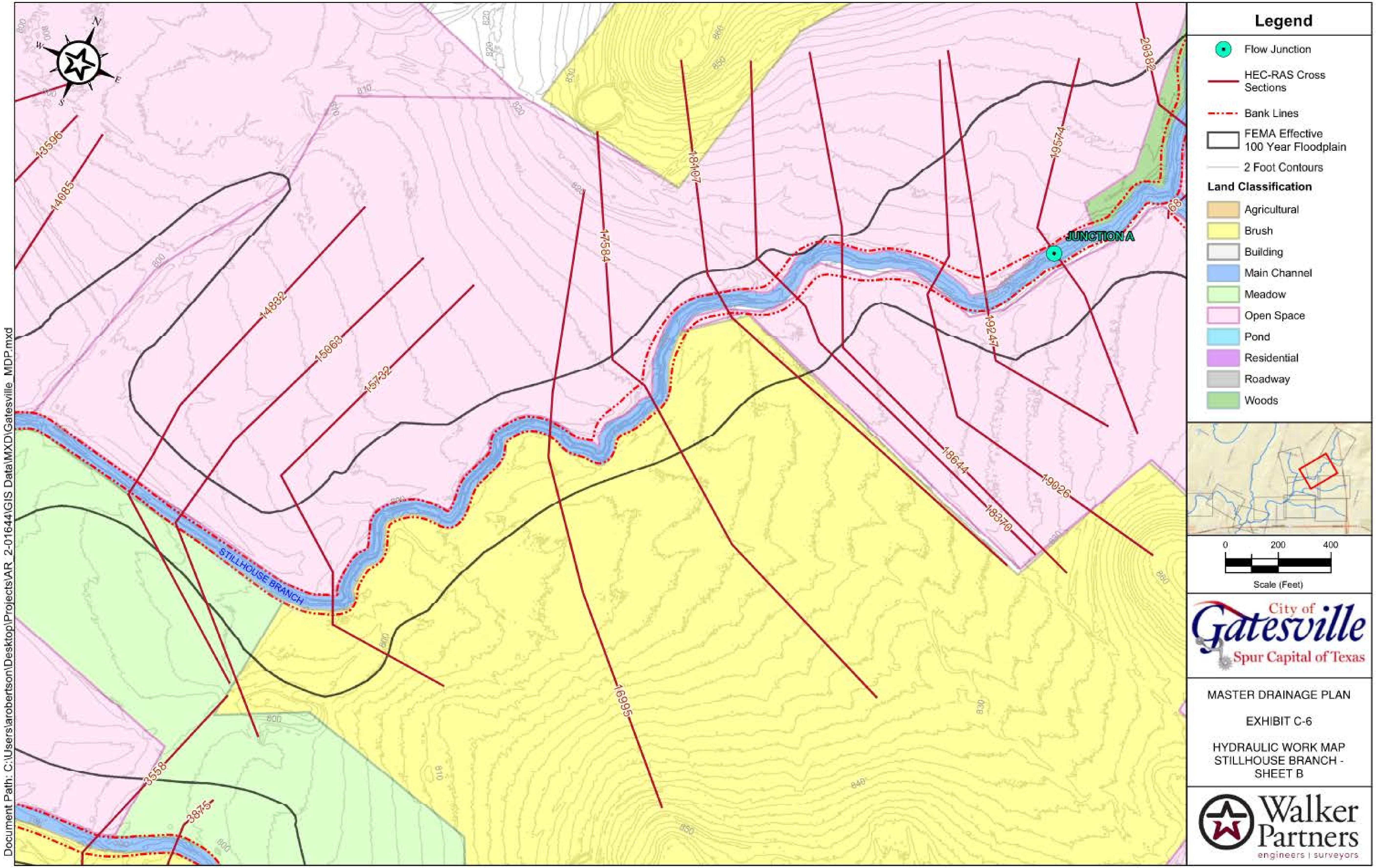

Legend
Flow Junction
HEC-RAS Cross Sections
Bank Lines
FEMA Effective 100 Year Floodplain
2 Foot Contours
Land Classification
Agricultural
Brush
Building
Main Channel
Meadow
Open Space
Pond
Residential
Roadway
0 200 400
Scale (Feet)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-1
HYDRAULIC WORK MAP
LEON RIVER - SHEET A
Walker Partners engineers | surveyors
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd
DODD BRANCH
LEON RIVER
STILLHOUSE BRANCH
507765
506093
504943
504788
504486
503749
502542
501913
2669.657
2084.139
1772
2798
2698
3269
3794
4738
5765
6218
SAUNDERS ST
WACO ST
US 84
E LEON ST
BRIDGE ST
WELLS PARK
N 5TH ST
N 6TH ST
N 7TH ST
N 8TH ST
N 9TH ST
S 3RD ST
S 5TH ST
S 6TH ST
SEVENTH
S 8TH ST

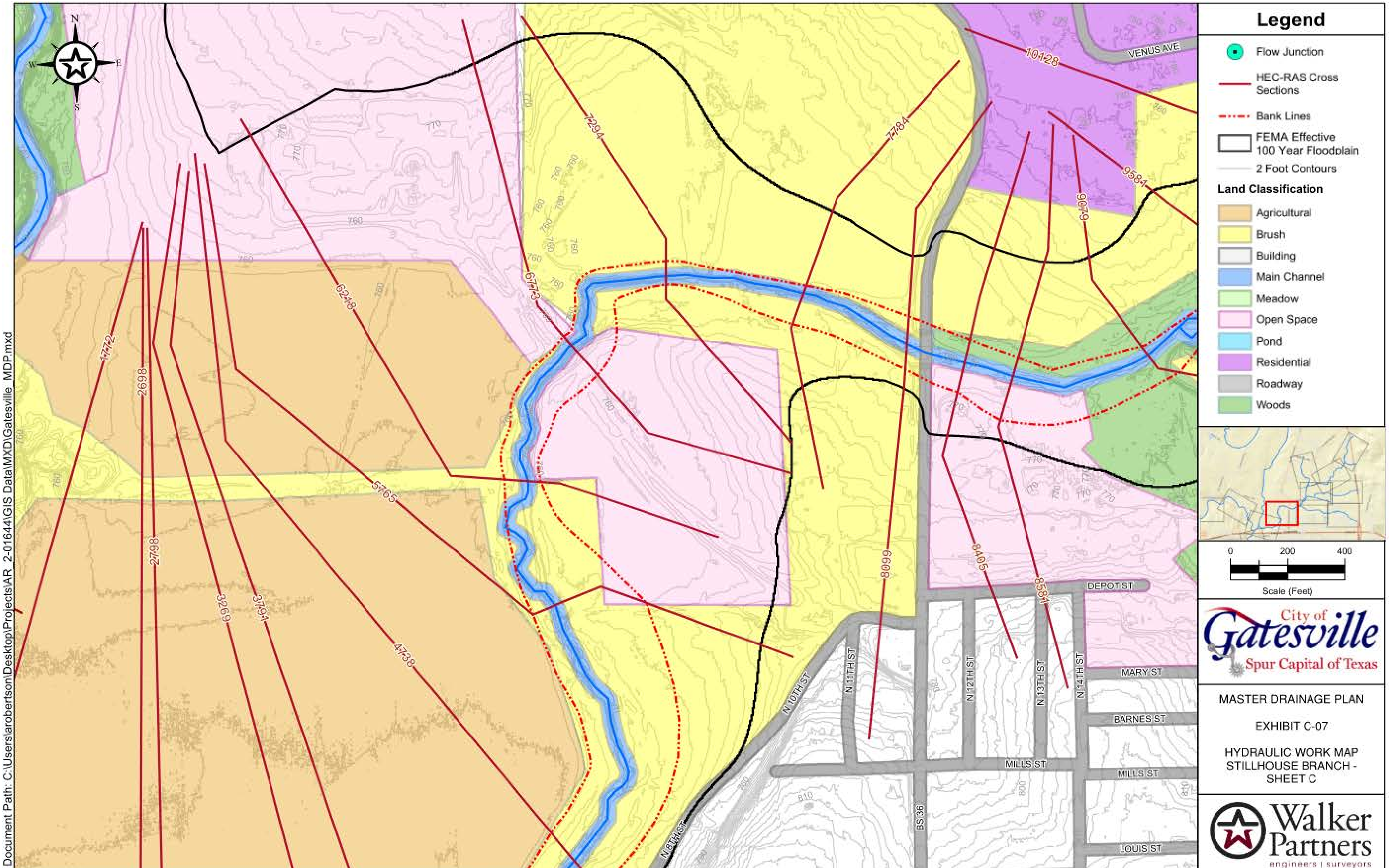

Legend
Flow Junction
HEC-RAS Cross Sections
Bank Lines
FEMA Effective 100 Year Floodplain
2 Foot Contours
Land Classification
Agricultural
Brush
Building
Main Channel
Meadow
Open Space
Pond
Residential
Roadway
Woods
0
200
400
Scale (Feet)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-2
HYDRAULIC WORK MAP
DODD BRANCH - SHEET A
Walker Partners
engineers | surveyors
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd
Chicktown
DODD BRANCH
DODDS CREEK DR
MESA DR
CREEK CLIFF DR
BRANDY LN
CHICKTOWN RD
US-84
DB1
16405
16057
15965
15581
15632
15058
14254
14752
14820
13744
13174
12660
16903
17436
17517
17995
18654.20
18777
18476.09
18894

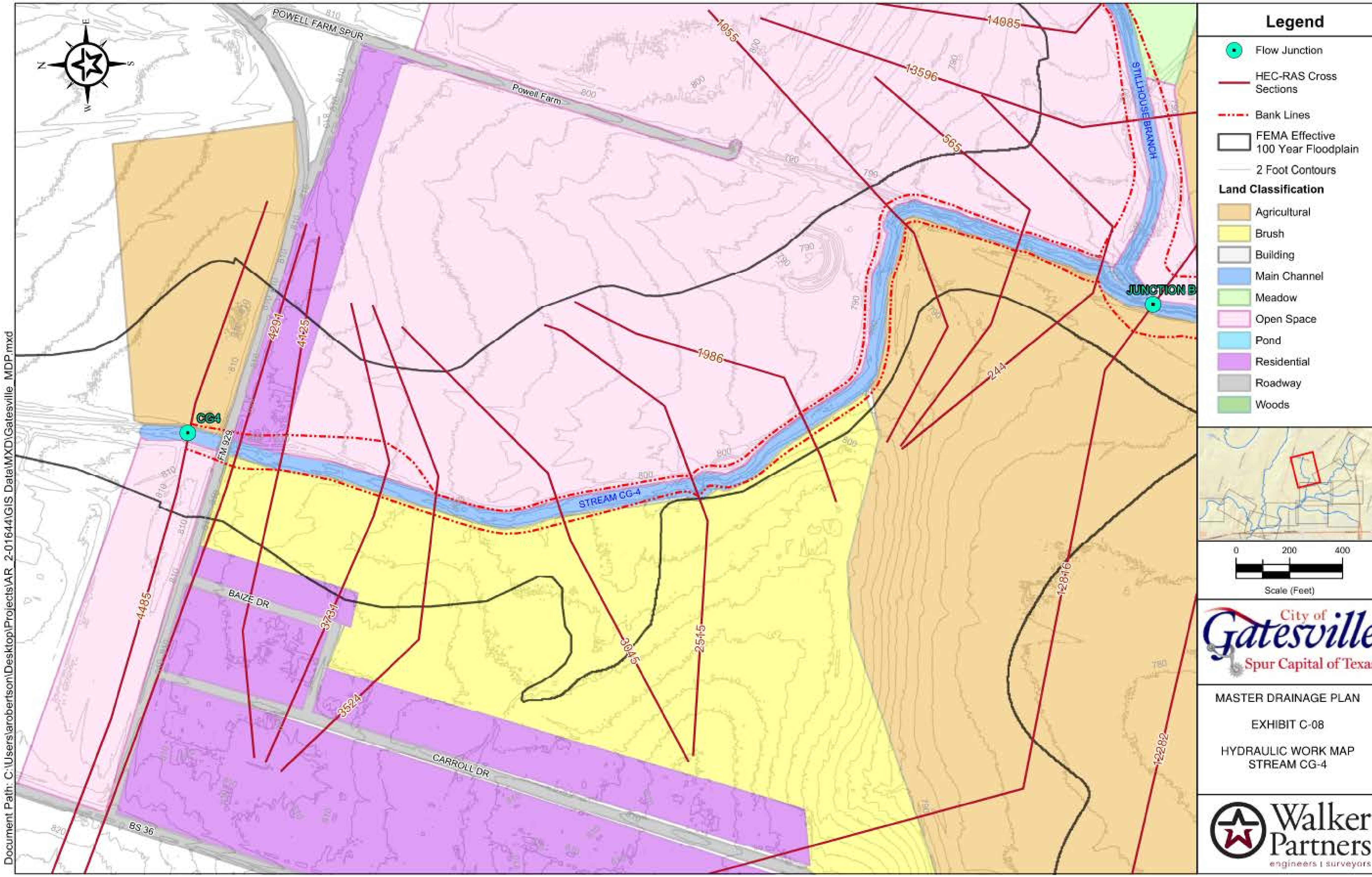

Legend
Flow Junction
HEC-RAS Cross Sections
Bank Lines
FEMA Effective 100 Year Floodplain
2 Foot Contours
Agricultural
Brush
Building
Main Channel
Meadow
Open Space
Pond
Residential
Roadway
Woods
0 200 400
Scale (Feet)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-3
HYDRAULIC WORK MAP
DODD BRANCH - SHEET B
Walker Partners engineers | surveyors
DODD BRANCH
FM 2412
Oak Ridge
Memorial
7668
7743
6406
6948
7431
10163
10629
9575
9084
8635
11173
11657
12146
12660
13174
13744
8113
8044
4931.742
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd

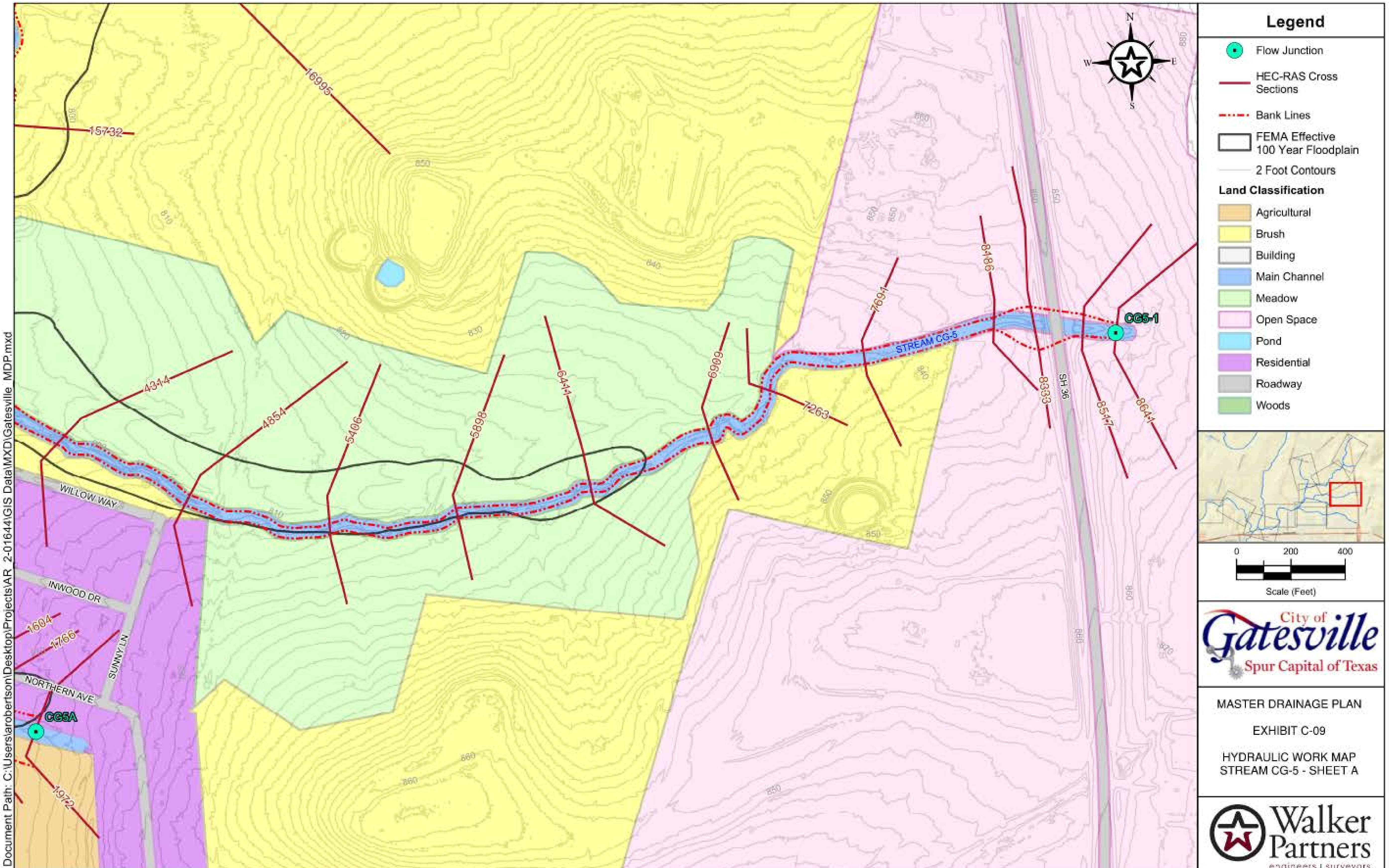

Legend
Flow Junction
HEC-RAS Cross Sections
Bank Lines
FEMA Effective 100 Year Floodplain
2 Foot Contours
Land Classification
Agricultural
Brush
Building
Main Channel
Meadow
Open Space
Pond
Residential
Roadway
Woods
0 200 400
Scale (Feet)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-4
HYDRAULIC WORK MAP
DODD BRANCH - SHEET C
Walker Partners engineers | surveyors
DODD BRANCH
Junction Dodd
Welsh
Moccasin
FM 2412
Rutherford
5845
5478
4406.354
3778.645
2669.657
2084.139
3403.103
4931.742
5579
5935
6342
6406
6948
7431
7743
7668
8044
8113
8635
9084
9575
11173
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd

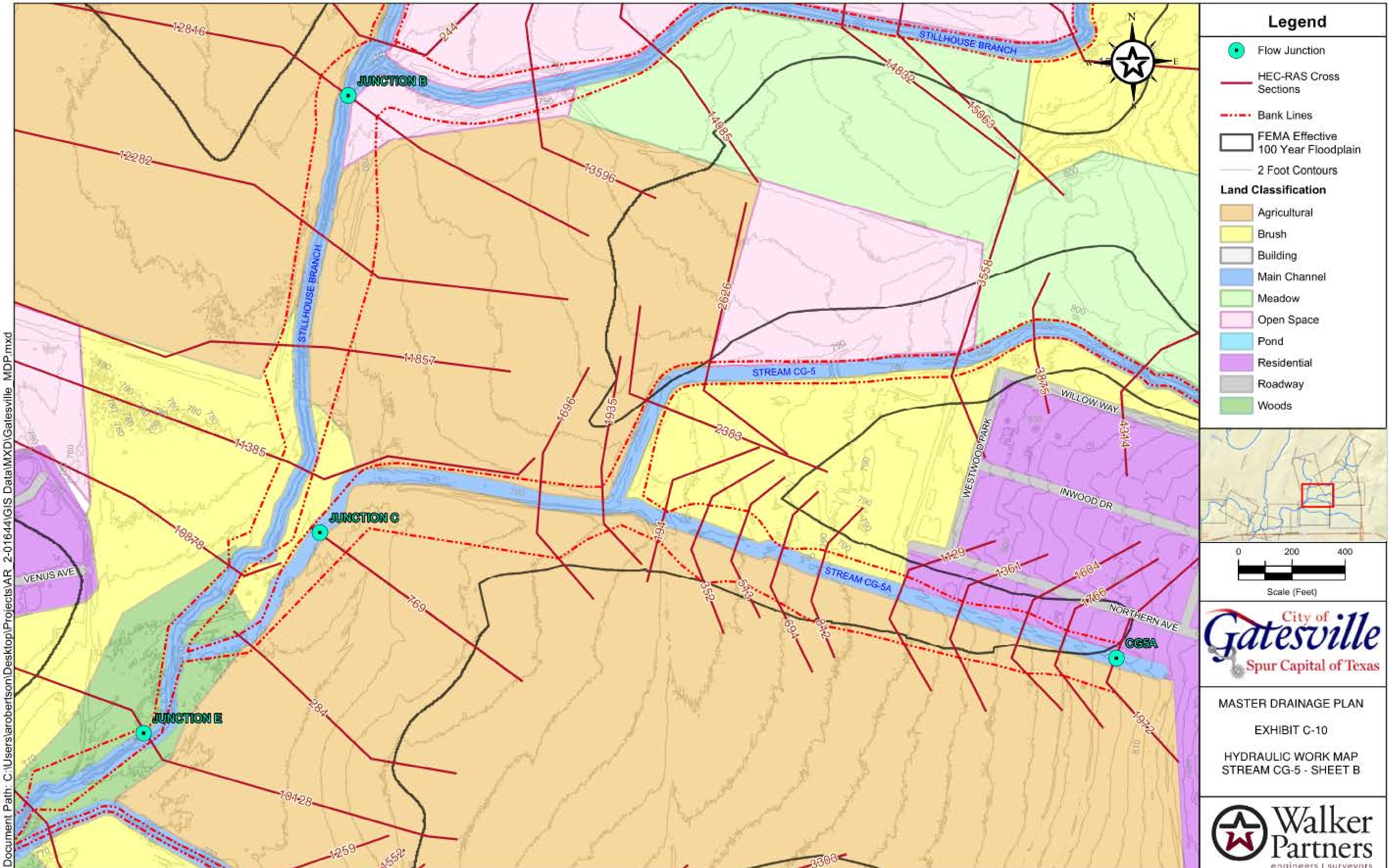

Legend
Flow Junction
HEC-RAS Cross Sections
Bank Lines
FEMA Effective 100 Year Floodplain
2 Foot Contours
Land Classification
Agricultural
Brush
Building
Main Channel
Meadow
Open Space
Pond
Residential
Roadway
Woods
0
200
400
Scale (Feet)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-5
HYDRAULIC WORK MAP
STILLHOUSE BRANCH -
SHEET A
Walker Partners
engineers | surveyors
STILLHOUSE BRANCH
STREAM CG-7
JUNCTION A
SB1
CG7
CATTLE DR
SH 36
23720
24422
24266
23056
22922
22427
21917
21478
20945
20382
19574
19247
19026
18644
68
445
931
1276
1431
1518
1602
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd

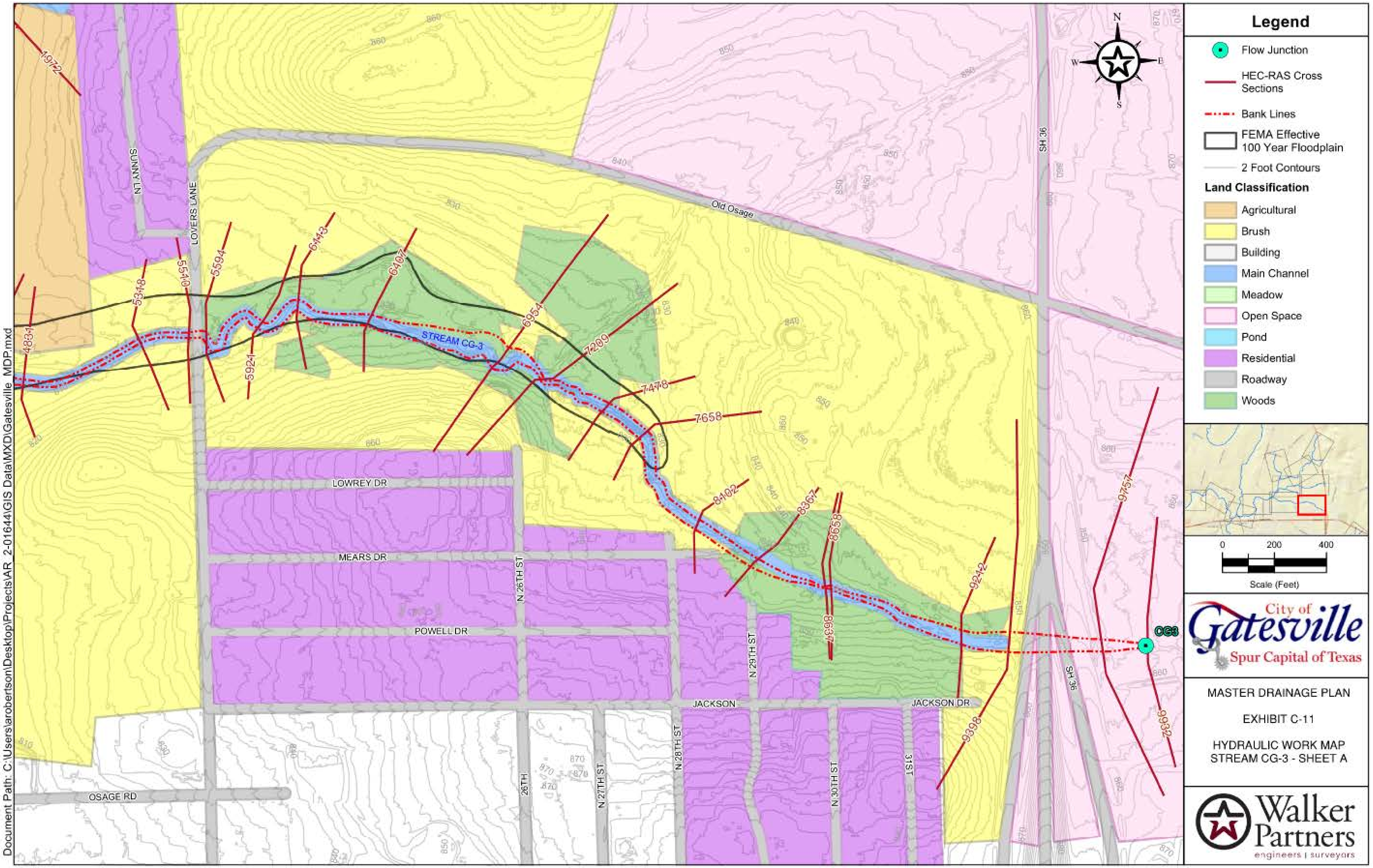

Legend
Flow Junction
HEC-RAS Cross Sections
Bank Lines
FEMA Effective 100 Year Floodplain
2 Foot Contours
Land Classification
Agricultural
Brush
Building
Main Channel
Meadow
Open Space
Pond
Residential
Roadway
Woods
0
200
400
Scale (Feet)
City of Gatesville
Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-6
HYDRAULIC WORK MAP
STILLHOUSE BRANCH -
SHEET B
Walker Partners
engineers | surveyors
JUNCTION A
STILLHOUSE BRANCH
13596
14685
14832
15063
15732
16995
17584
18107
18370
18644
19026
19247
19574
20382
3558
3875
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd

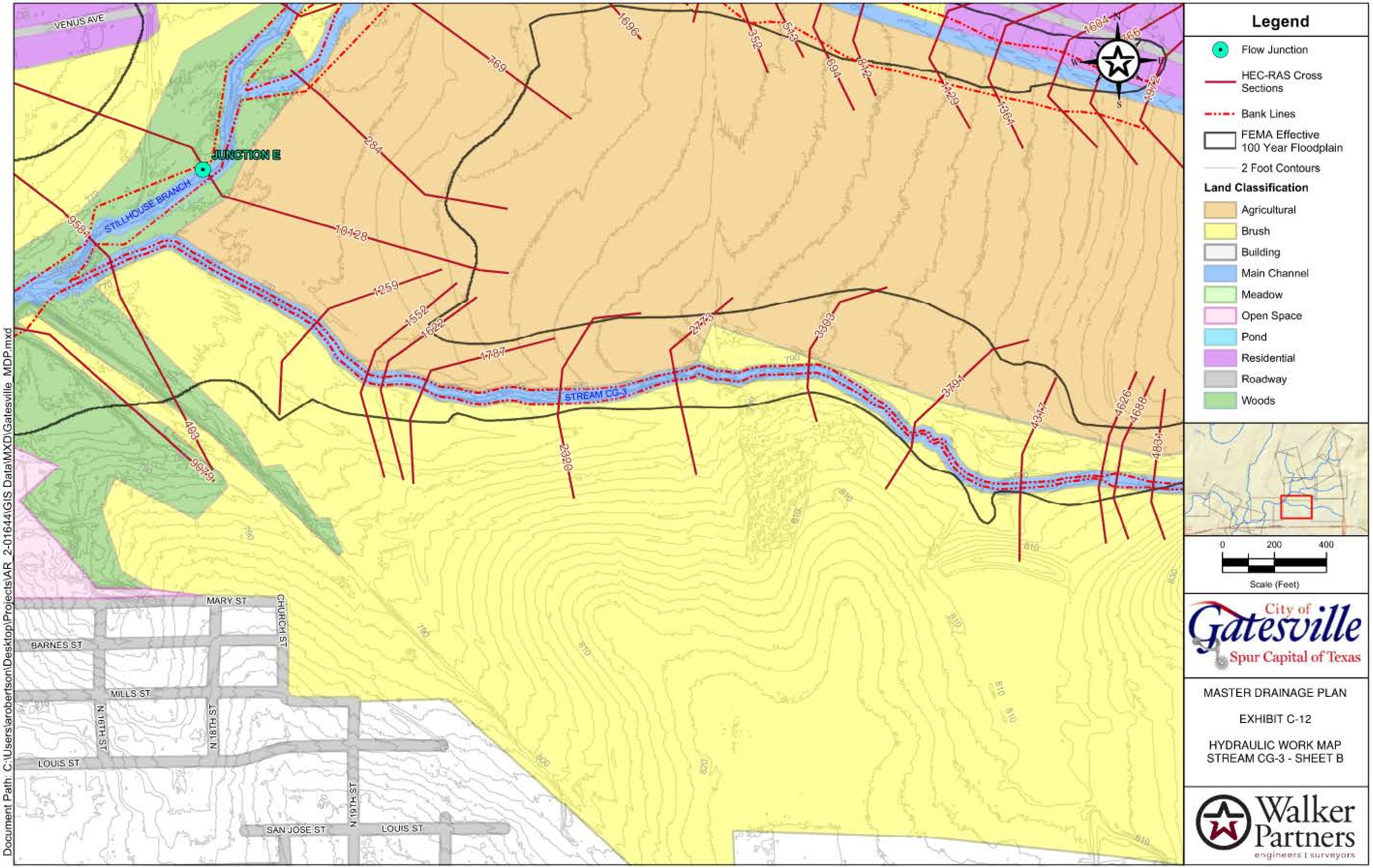

Legend
Flow Junction
HEC-RAS Cross Sections
Bank Lines
FEMA Effective 100 Year Floodplain
2 Foot Contours
Land Classification
Agricultural
Brush
Building
Main Channel
Meadow
Open Space
Pond
Residential
Roadway
Woods
0 200 400
Scale (Feet)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-07
HYDRAULIC WORK MAP STILLHOUSE BRANCH - SHEET C
Walker Partners engineers | surveyors
VENUS AVE
DEPOT ST
MARY ST
BARNES ST
MILLS ST
LOUIS ST
N 10TH ST
N 11TH ST
N 12TH ST
N 13TH ST
N 14TH ST
N 8TH ST
BS 36
10128
9581
9406
8581
8405
8099
7784
7294
6773
6248
5765
4738
3791
3269
2798
2698
1772
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd

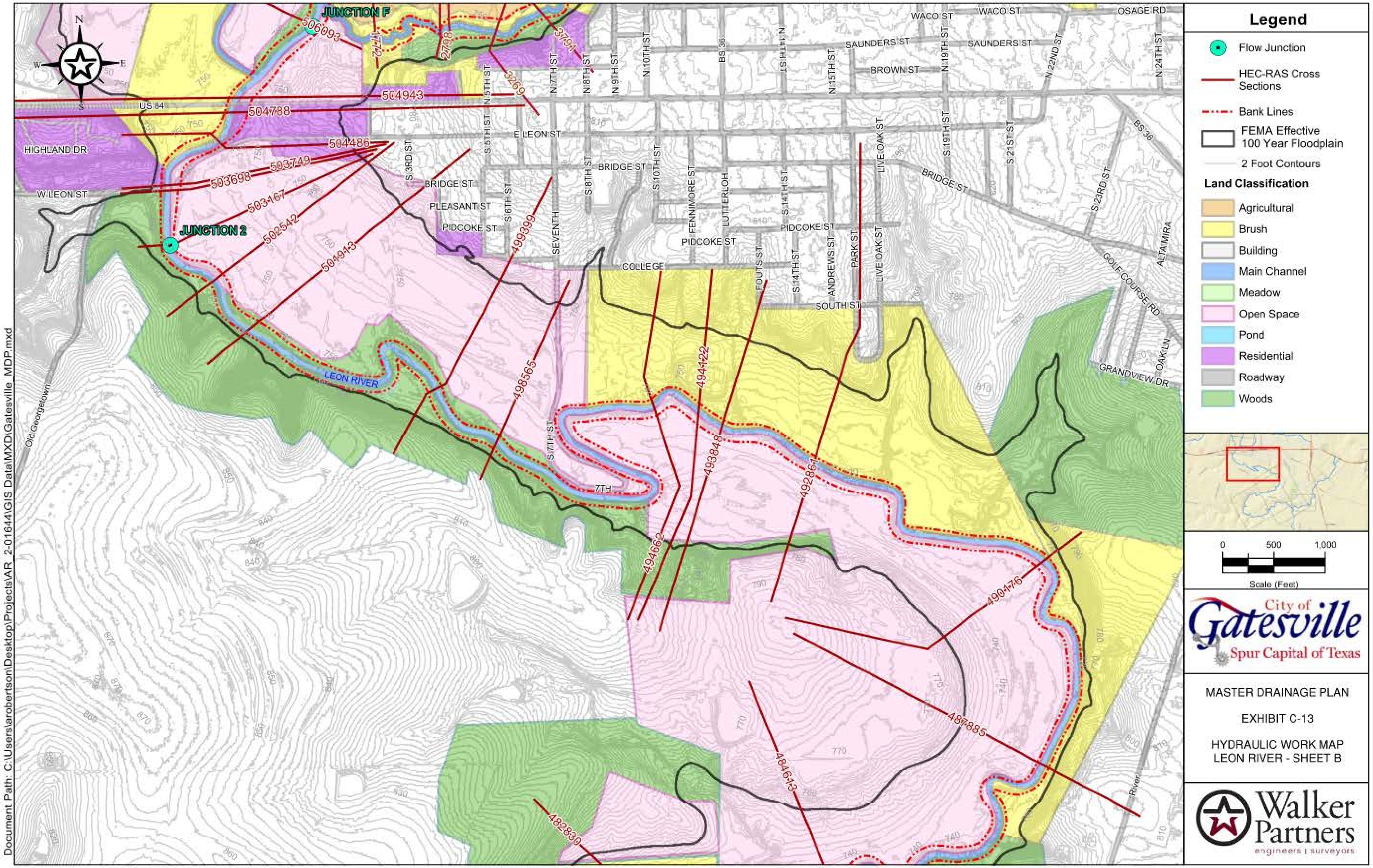

Legend
Flow Junction
HEC-RAS Cross Sections
Bank Lines
FEMA Effective 100 Year Floodplain
2 Foot Contours
Land Classification
Agricultural
Brush
Building
Main Channel
Meadow
Open Space
Pond
Residential
Roadway
Woods
0
200
400
Scale (Feet)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-08
HYDRAULIC WORK MAP STREAM CG-4
Walker Partners engineers | surveyors
POWELL FARM SPUR
Powell Farm
FM 929
BAIZE DR
CARROLL DR
BS 36
STREAM CG-4
STILLHOUSE BRANCH
CG4
JUNCTION B
14085
13596
1055
565
1986
244
4291
4125
4485
3731
3524
3045
2515
12816
12282
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd

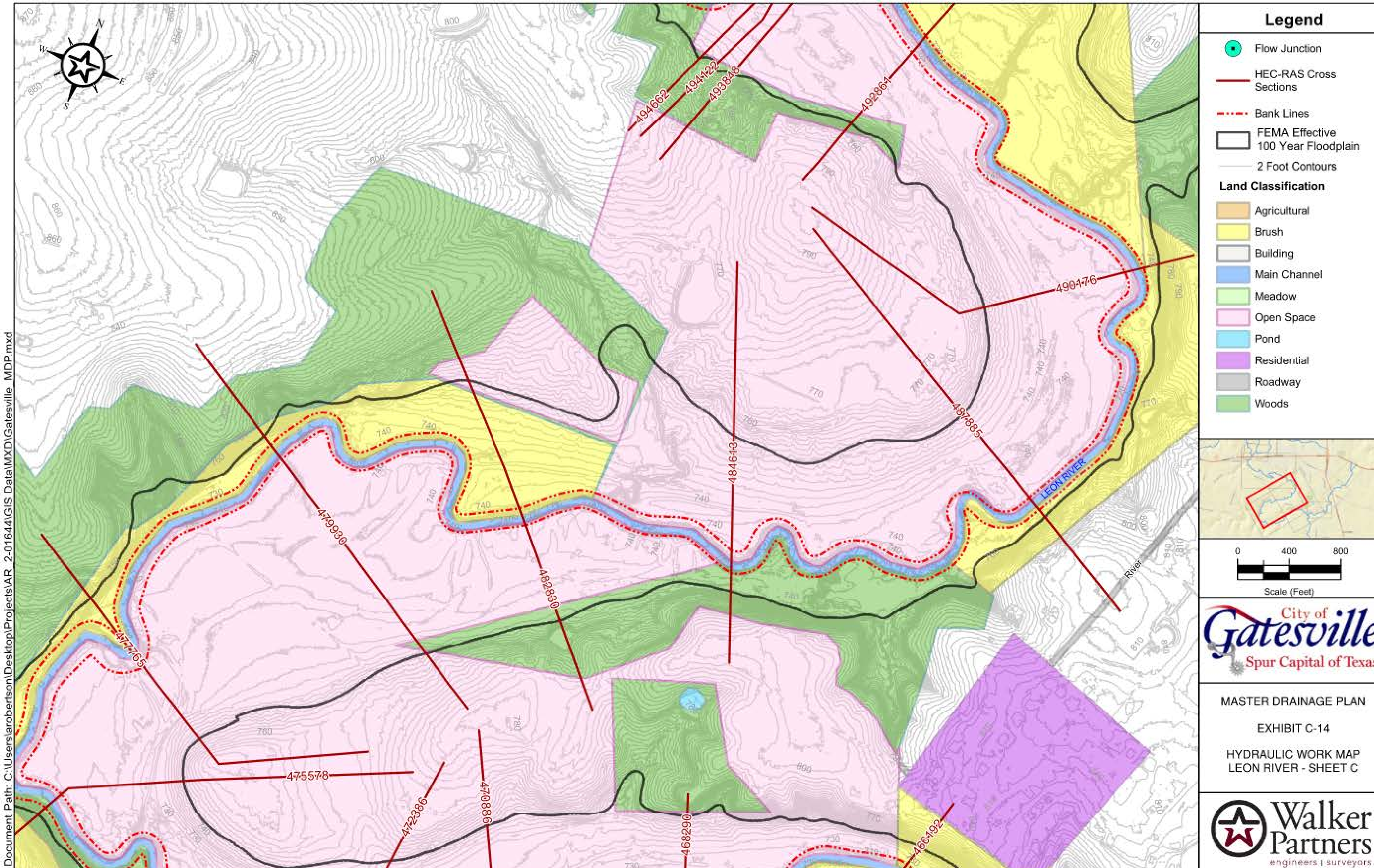

Legend
Flow Junction
HEC-RAS Cross Sections
Bank Lines
FEMA Effective 100 Year Floodplain
2 Foot Contours
Land Classification
Agricultural
Brush
Building
Main Channel
Meadow
Open Space
Pond
Residential
Roadway
Woods
0 200 400
Scale (Feet)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-09
HYDRAULIC WORK MAP
STREAM CG-5 - SHEET A
Walker Partners engineers | surveyors
STREAM CG-5
CG5-1
CG5A
SH 36
WILLOW WAY
INWOOD DR
NORTHERN AVE
SUNNY LN
16995
15732
4344
4854
5406
5898
6441
6909
7263
7691
8186
8333
8517
8641
1604
1766
1972
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd

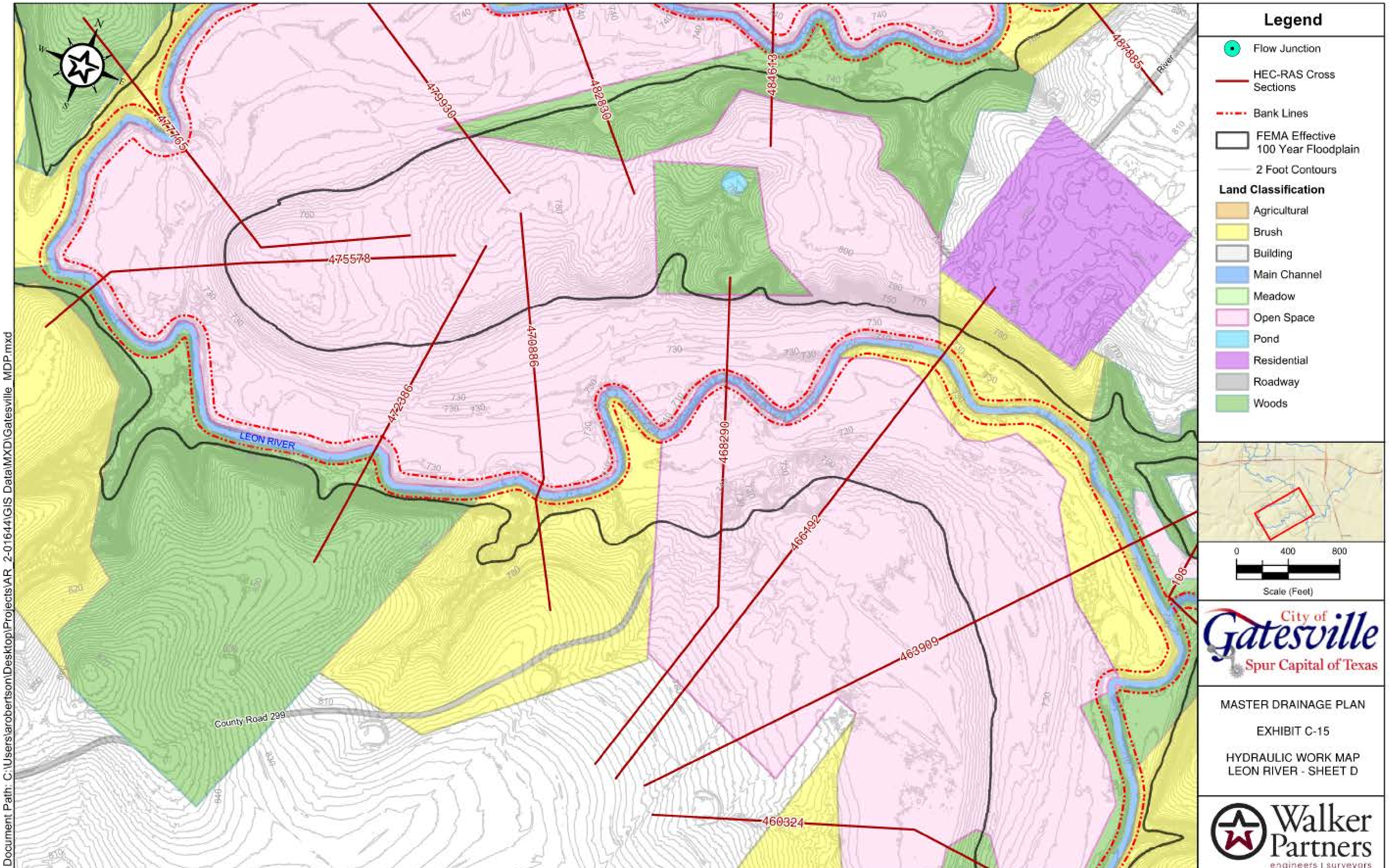

Legend
Flow Junction
HEC-RAS Cross Sections
Bank Lines
FEMA Effective 100 Year Floodplain
2 Foot Contours
Land Classification
Agricultural
Brush
Building
Main Channel
Meadow
Open Space
Pond
Residential
Roadway
Woods
0 200 400
Scale (Feet)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-10
HYDRAULIC WORK MAP
STREAM CG-5 - SHEET B
Walker Partners
engineers | surveyors
JUNCTION B
JUNCTION C
JUNCTION E
CG5A
STILLHOUSE BRANCH
STREAM CG-5
STREAM CG-5A
WILLOW WAY
INWOOD DR
NORTHERN AVE
WESTWOOD PARK
VENUS AVE
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd

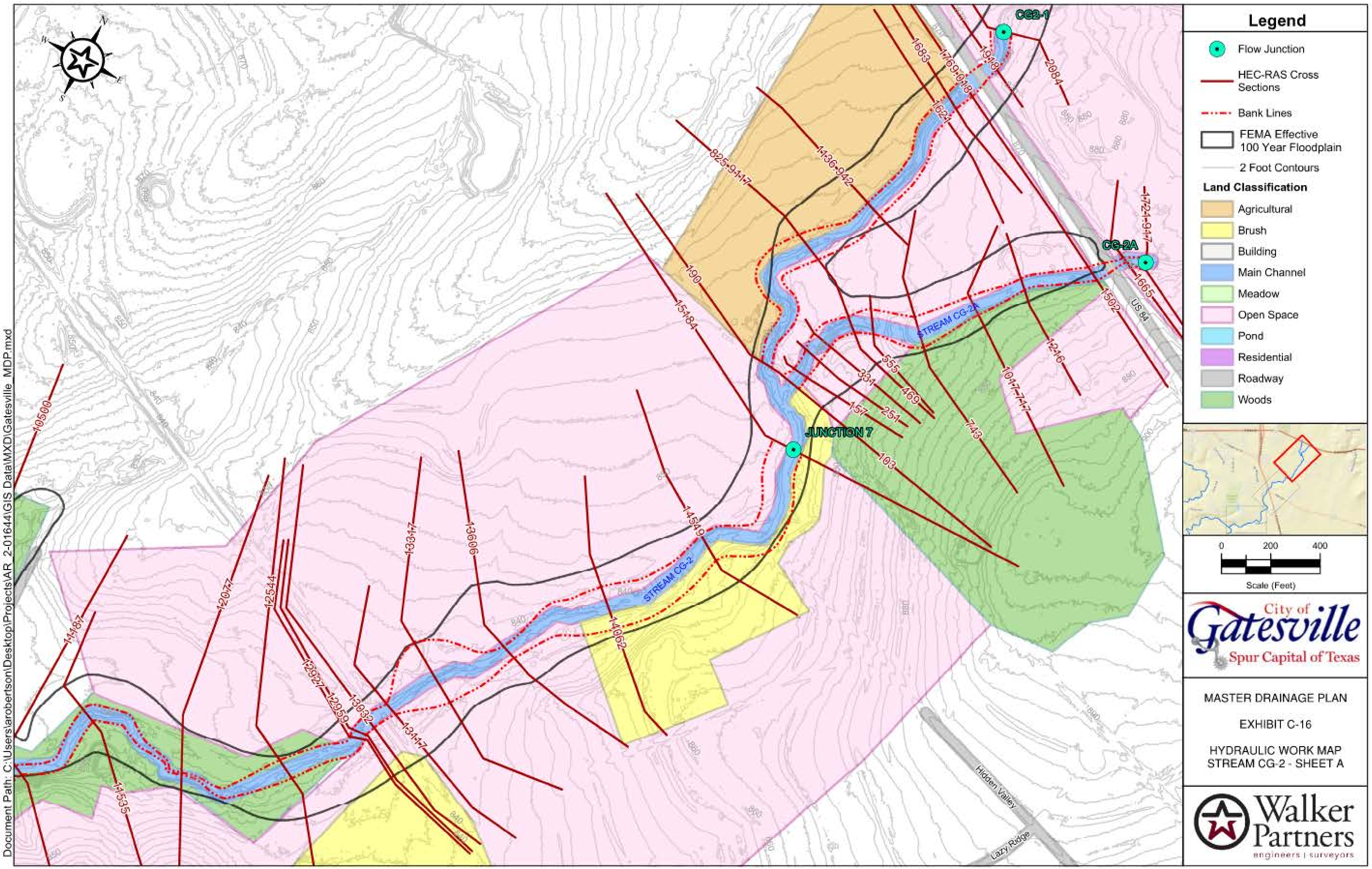

Legend
Flow Junction
HEC-RAS Cross Sections
Bank Lines
FEMA Effective 100 Year Floodplain
2 Foot Contours
Land Classification
Agricultural
Brush
Building
Main Channel
Meadow
Open Space
Pond
Residential
Roadway
Woods
0 200 400
Scale (Feet)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-11
HYDRAULIC WORK MAP
STREAM CG-3 - SHEET A
Walker Partners engineers | surveyors
STREAM CG-3
CG3
Old Osage
LOVERS LANE
SUNNY LN
LOWREY DR
MEARS DR
POWELL DR
JACKSON
JACKSON DR
OSAGE RD
SH 36
N 26TH ST
N 27TH ST
N 28TH ST
N 29TH ST
N 30TH ST
31ST
26TH
1972
4834
5348
5510
5594
5921
6443
6407
6954
7209
7478
7658
8102
8367
8658
8634
9242
9398
9757
9932
Document Path: C:\Users\arobertson\Desktop\Projects\AR 2-01644\GIS Data\MXD\Gatesville_MDP.mxd

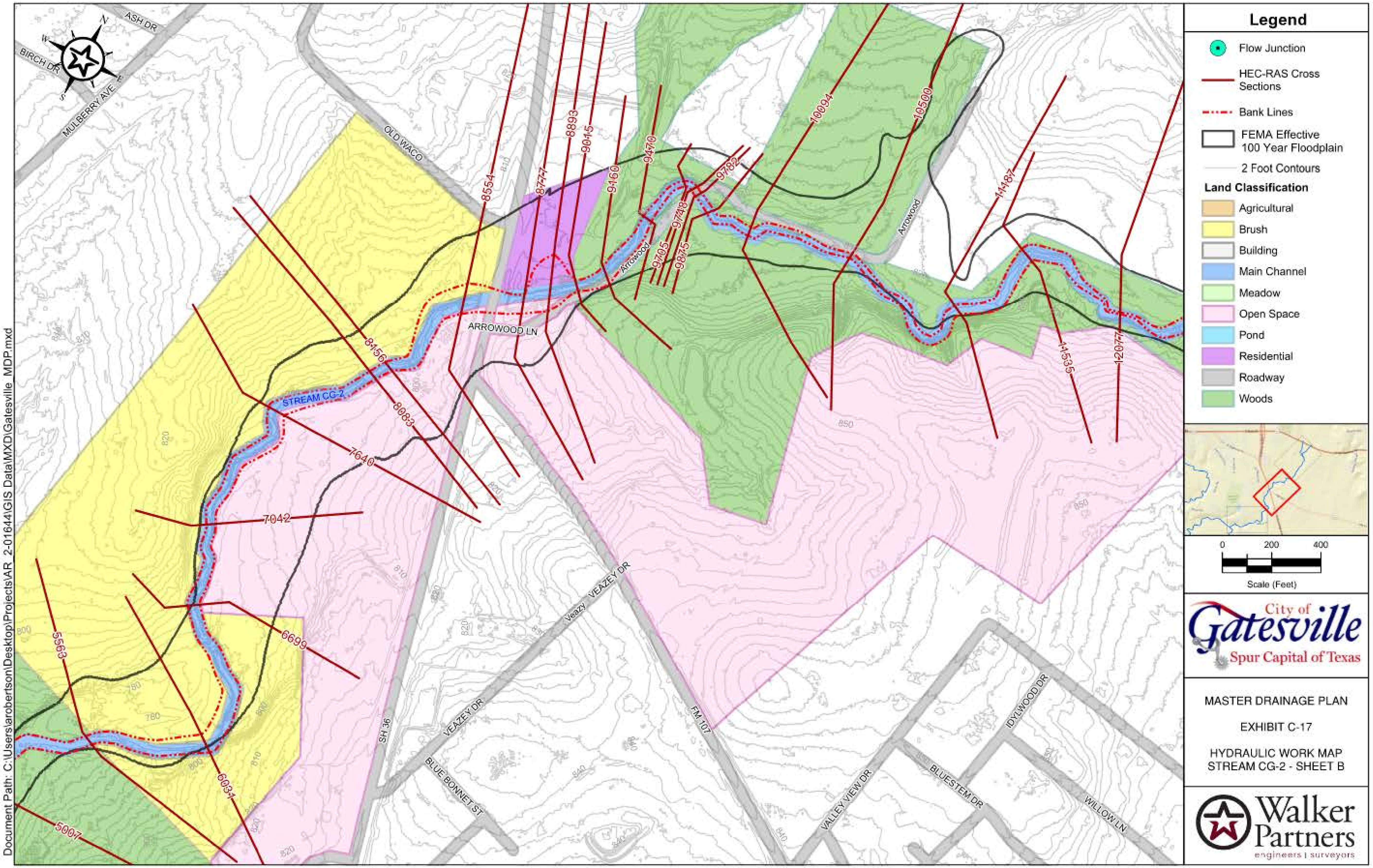

Legend
Flow Junction
HEC-RAS Cross Sections
Bank Lines
FEMA Effective 100 Year Floodplain
2 Foot Contours
Land Classification
Agricultural
Brush
Building
Main Channel
Meadow
Open Space
Pond
Residential
Roadway
Woods
0
200
400
Scale (Feet)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-12
HYDRAULIC WORK MAP
STREAM CG-3 - SHEET B
Walker Partners
engineers | surveyors
JUNCTION E
STILLHOUSE BRANCH
STREAM CG-3
VENUS AVE
MARY ST
CHURCH ST
BARNES ST
MILLS ST
N 16TH ST
N 18TH ST
LOUIS ST
SAN JOSE ST
N 19TH ST
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd

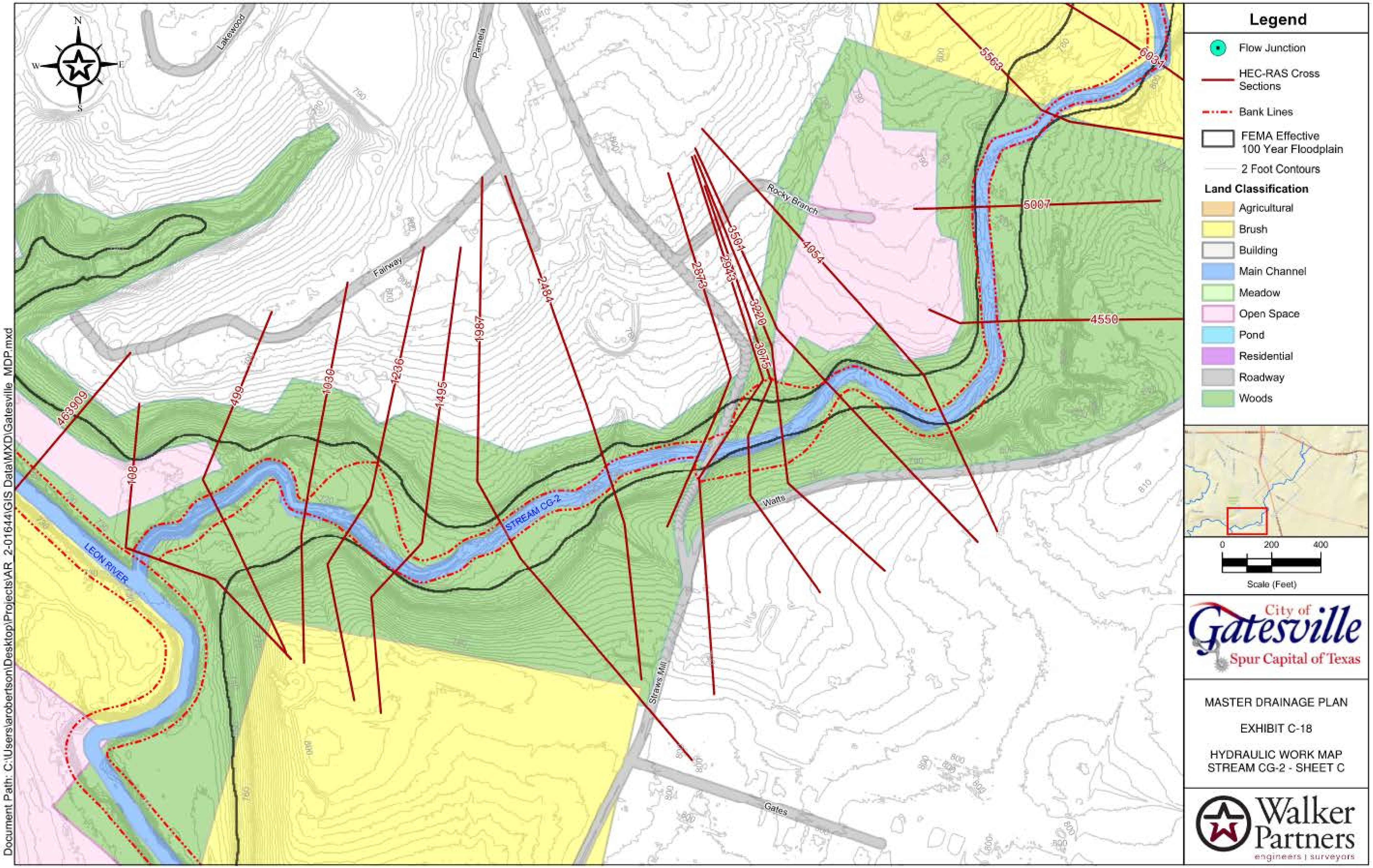

Legend
Flow Junction
HEC-RAS Cross Sections
Bank Lines
FEMA Effective 100 Year Floodplain
2 Foot Contours
Land Classification
Agricultural
Brush
Building
Main Channel
Meadow
Open Space
Pond
Residential
Roadway
Woods
0 500 1,000
Scale (Feet)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-13
HYDRAULIC WORK MAP
LEON RIVER - SHEET B
Walker Partners engineers | surveyors
JUNCTION F
JUNCTION 2
LEON RIVER
506093
504943
504788
504486
503749
503698
503167
502542
501913
499399
498565
494122
493848
494662
492861
490176
487885
484613
482830
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd

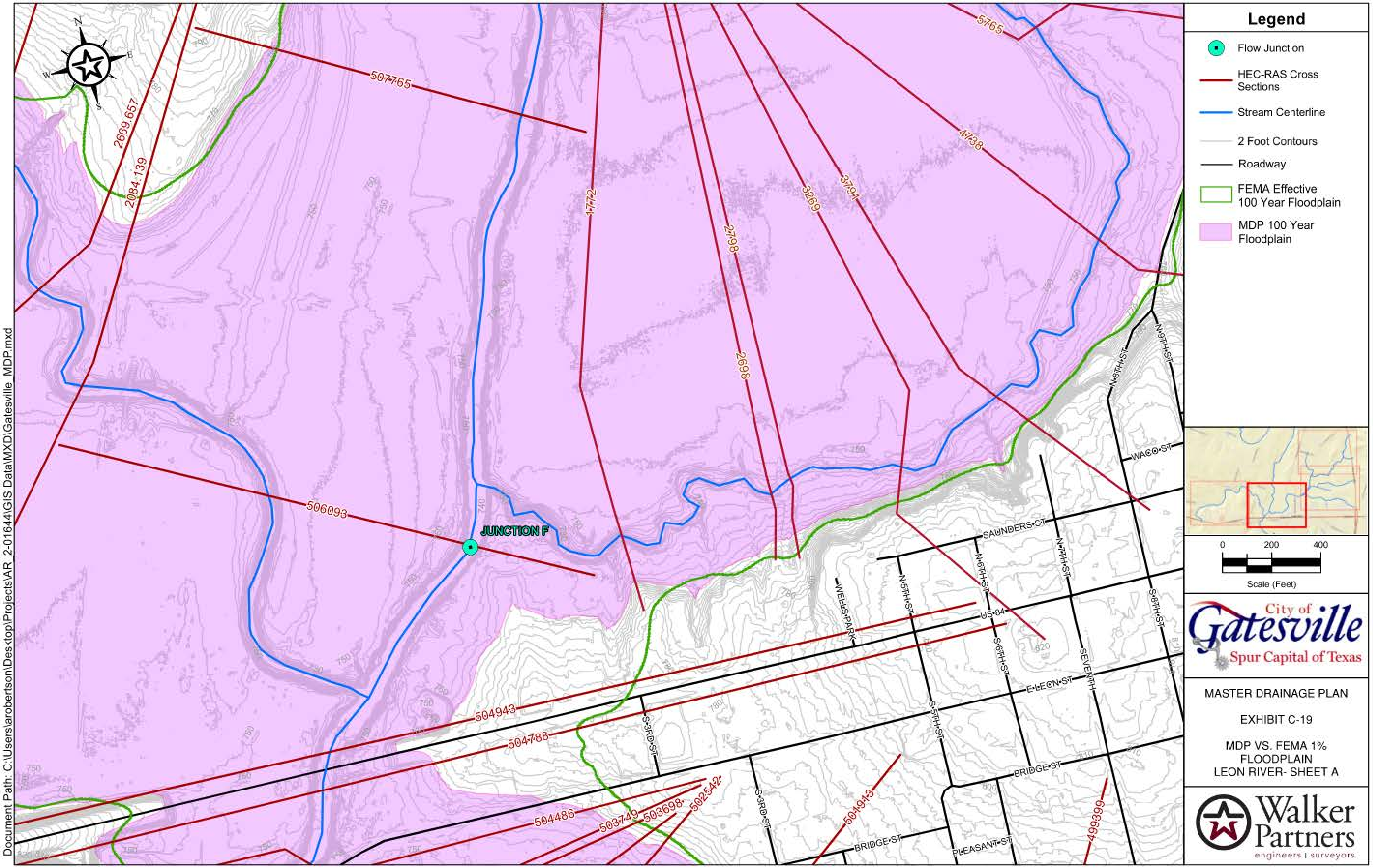

Legend
Flow Junction
HEC-RAS Cross Sections
Bank Lines
FEMA Effective 100 Year Floodplain
2 Foot Contours
Land Classification
Agricultural
Brush
Building
Main Channel
Meadow
Open Space
Pond
Residential
Roadway
Woods
0
400
800
Scale (Feet)
City of Gatesville
Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-14
HYDRAULIC WORK MAP
LEON RIVER - SHEET C
Walker Partners
engineers | surveyors
LEON RIVER
494662
494122
493848
492861
490476
487885
484613
482830
479930
477765
475578
472386
470886
468290
466192
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd

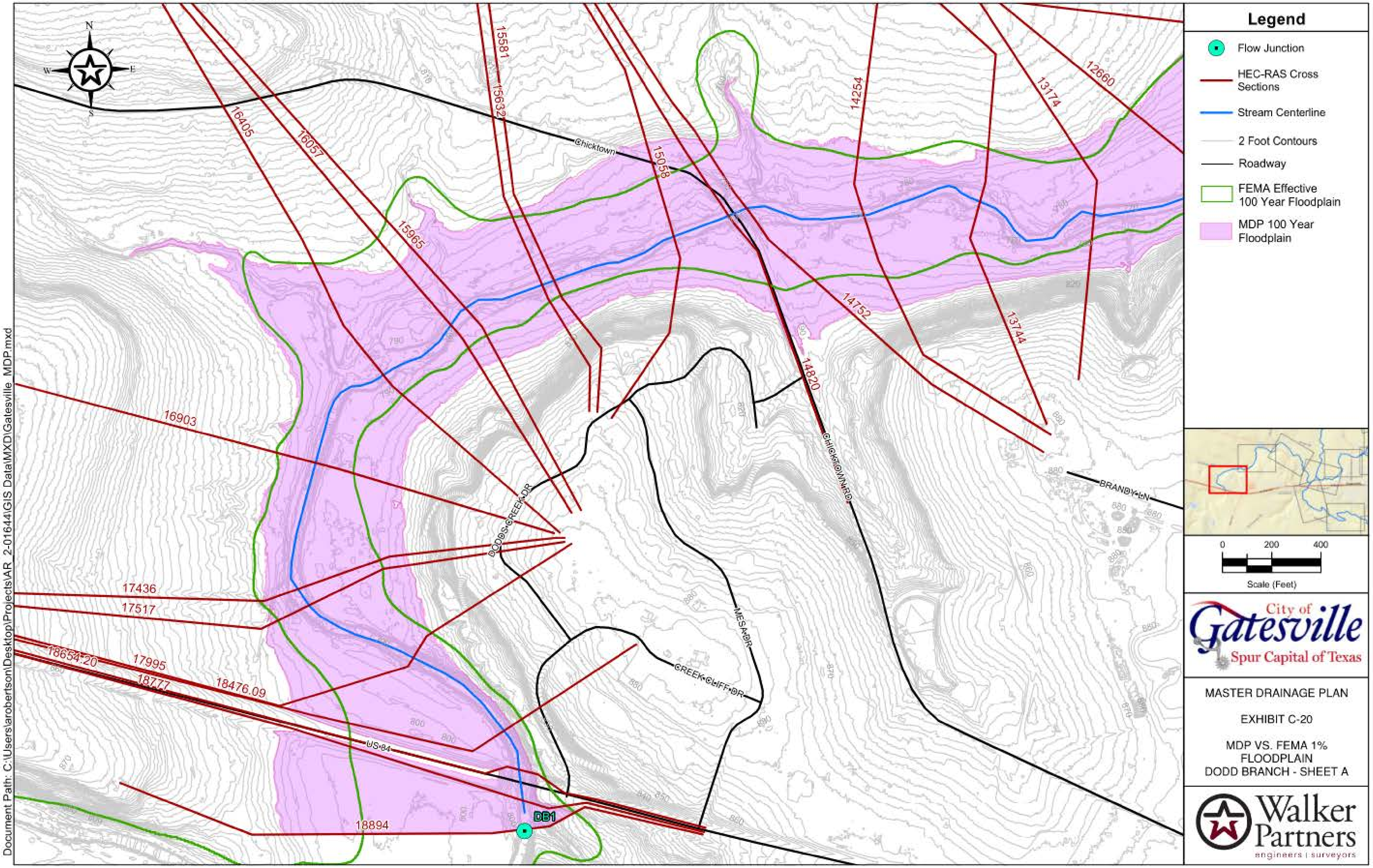

Legend
Flow Junction
HEC-RAS Cross Sections
Bank Lines
FEMA Effective 100 Year Floodplain
2 Foot Contours
Land Classification
Agricultural
Brush
Building
Main Channel
Meadow
Open Space
Pond
Residential
Roadway
Woods
0
400
800
Scale (Feet)
City of Gatesville
Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-15
HYDRAULIC WORK MAP
LEON RIVER - SHEET D
Walker Partners
engineers | surveyors
LEON RIVER
County Road 299
477765
475578
479930
482830
484613
487885
472386
470886
468290
466192
463909
460324
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd

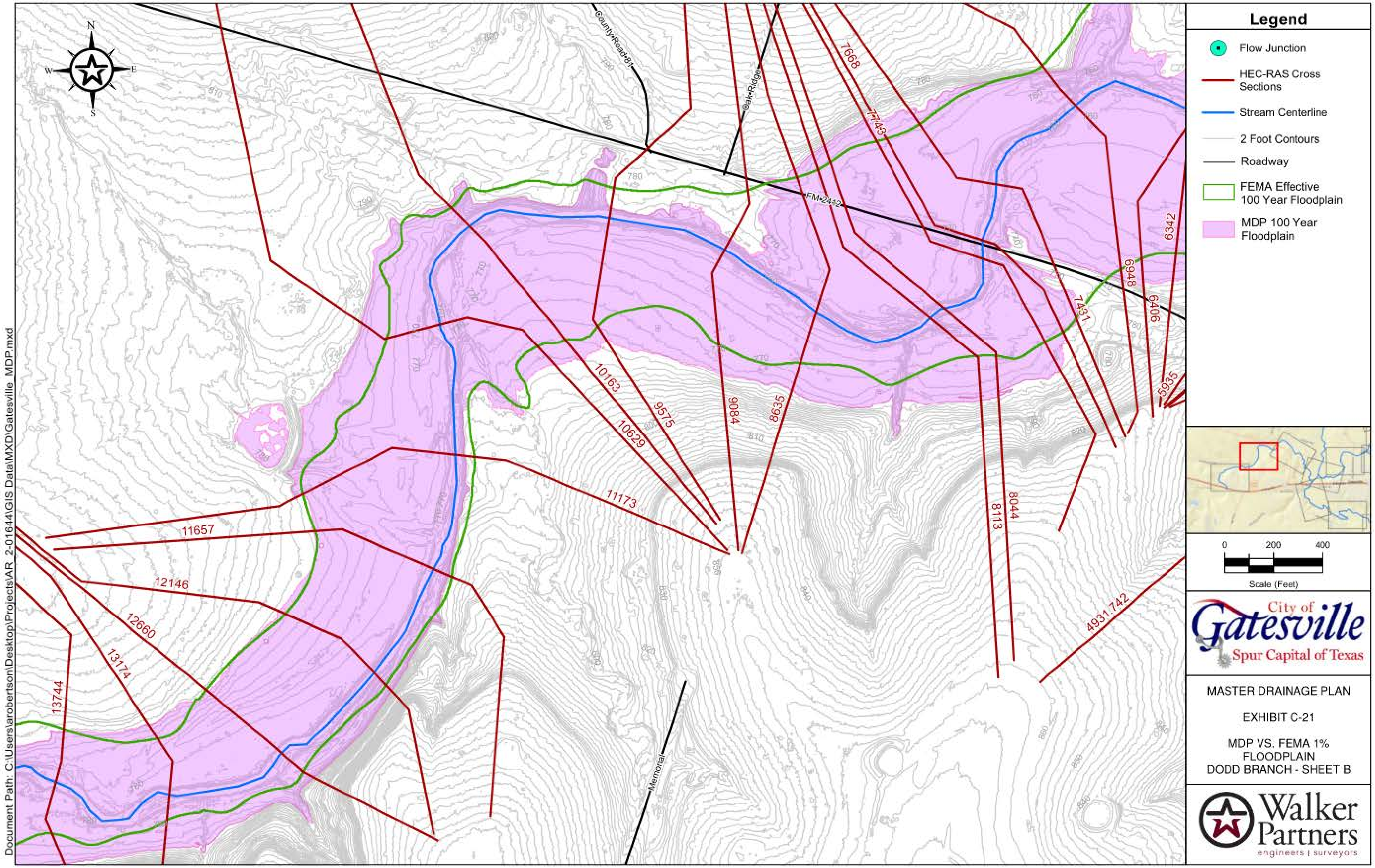

Legend
Flow Junction
HEC-RAS Cross Sections
Bank Lines
FEMA Effective 100 Year Floodplain
2 Foot Contours
Land Classification
Agricultural
Brush
Building
Main Channel
Meadow
Open Space
Pond
Residential
Roadway
Woods
0
200
400
Scale (Feet)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-16
HYDRAULIC WORK MAP
STREAM CG-2 - SHEET A
Walker Partners engineers | surveyors
CG2-1
CG-2A
JUNCTION 7
STREAM CG-2
STREAM CG-2A
US 84
Hidden Valley
Lazy Ridge
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd

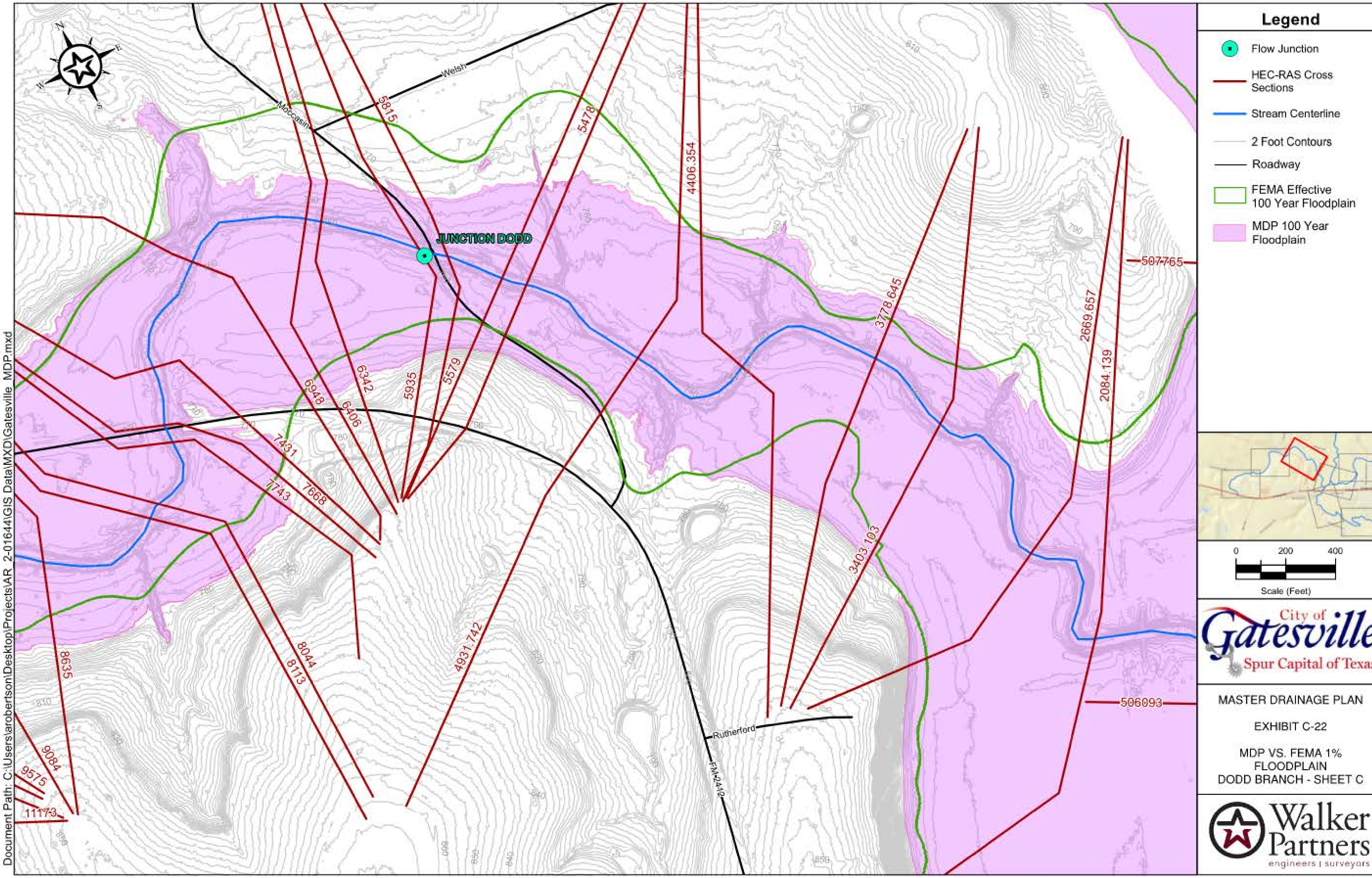

Legend
Flow Junction
HEC-RAS Cross Sections
Bank Lines
FEMA Effective 100 Year Floodplain
2 Foot Contours
Land Classification
Agricultural
Brush
Building
Main Channel
Meadow
Open Space
Pond
Residential
Roadway
Woods
0
200
400
Scale (Feet)
City of Gatesville
Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-17
HYDRAULIC WORK MAP
STREAM CG-2 - SHEET B
Walker Partners
engineers | surveyors
STREAM CG-2
ARROWOOD LN
OLD WACO
ASH DR
BIRCH DR
MULBERRY AVE
SH 36
FM 107
VEAZEY DR
BLUE BONNET ST
VALLEY VIEW DR
BLUESTEM DR
IDYLWOOD DR
WILLOW LN
Arrowood
5007
5563
6031
6699
7042
7640
8083
8156
8554
8777
8893
9015
9160
9470
9705
9748
9782
9875
10094
10500
11487
11535
12077
Document Path: C:\Users\arobertson\Desktop\Projects\AR 2-01644\GIS Data\MXD\Gatesville_MDP.mxd

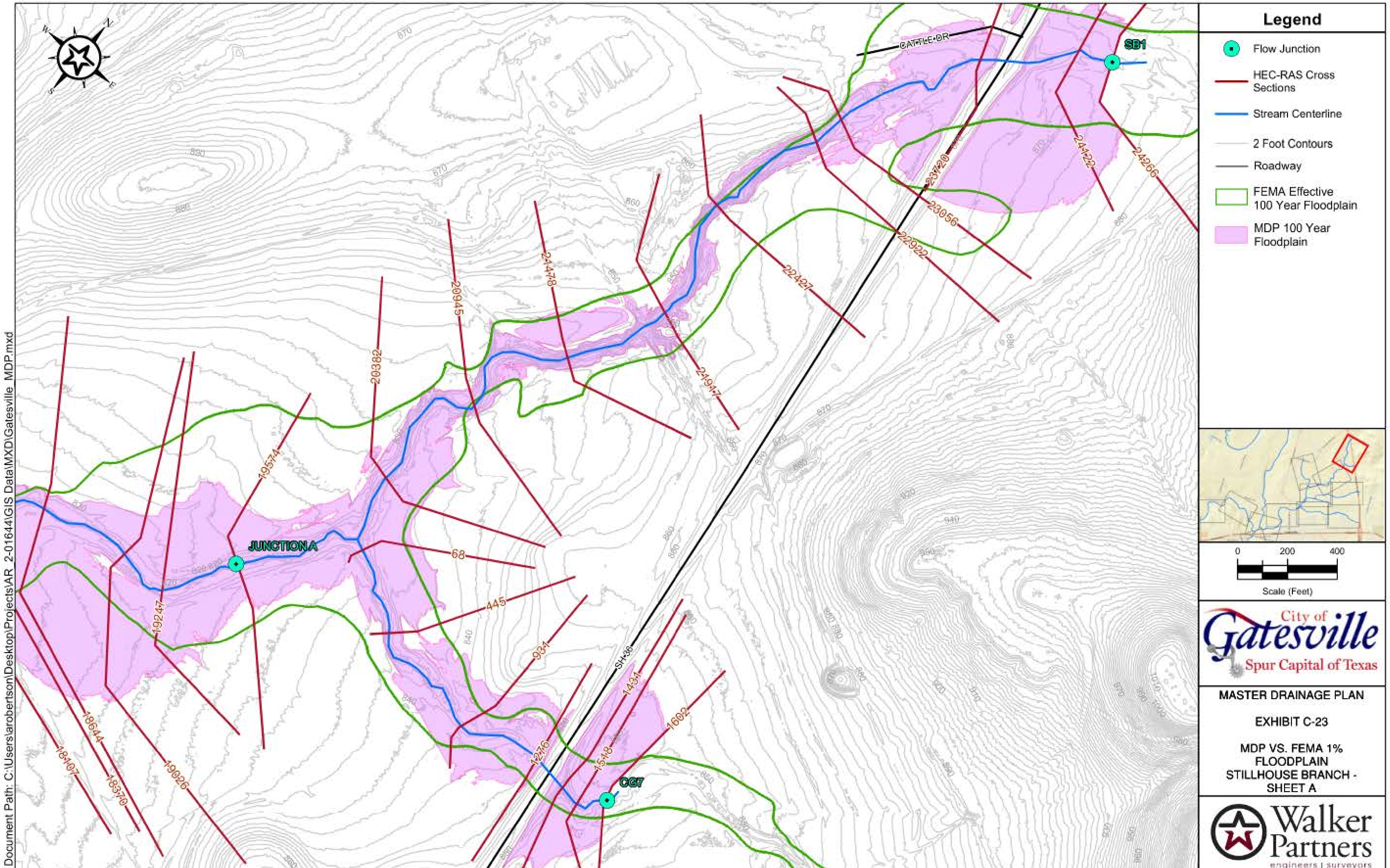

Legend
Flow Junction
HEC-RAS Cross Sections
Bank Lines
FEMA Effective 100 Year Floodplain
2 Foot Contours
Land Classification
Agricultural
Brush
Building
Main Channel
Meadow
Open Space
Pond
Residential
Roadway
Woods
0
200
400
Scale (Feet)
City of Gatesville
Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-18
HYDRAULIC WORK MAP
STREAM CG-2 - SHEET C
Walker Partners
engineers | surveyors
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd
STREAM CG-2
LEON RIVER
Lakewood
Pamela
Fairway
Rocky Branch
Watts
Straws Mill
Gates
463909
108
499
1030
1236
1495
1987
2484
2873
2943
3501
3220
3075
4054
4550
5007
5563
6031


Legend
Flow Junction
HEC-RAS Cross Sections
Stream Centerline
2 Foot Contours
Roadway
FEMA Effective 100 Year Floodplain
MDP 100 Year Floodplain
0
200
400
Scale (Feet)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-19
MDP VS. FEMA 1% FLOODPLAIN
LEON RIVER- SHEET A
Walker Partners
engineers | surveyors
JUNCTION F
507765
506093
2669.657
2084.139
1772
2798
2698
3269
3791
4738
5765
504943
504788
504486
503749
503698
502542
504943
499399
SAUNDERS ST
WACO ST
US 84
E LEON ST
BRIDGE ST
PLEASANT ST
N 9TH ST
N 8TH ST
N 7TH ST
N 6TH ST
N 5TH ST
S 5TH ST
S 6TH ST
S 8TH ST
S 3RD ST
SEVENTH
WELLS PARK
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd

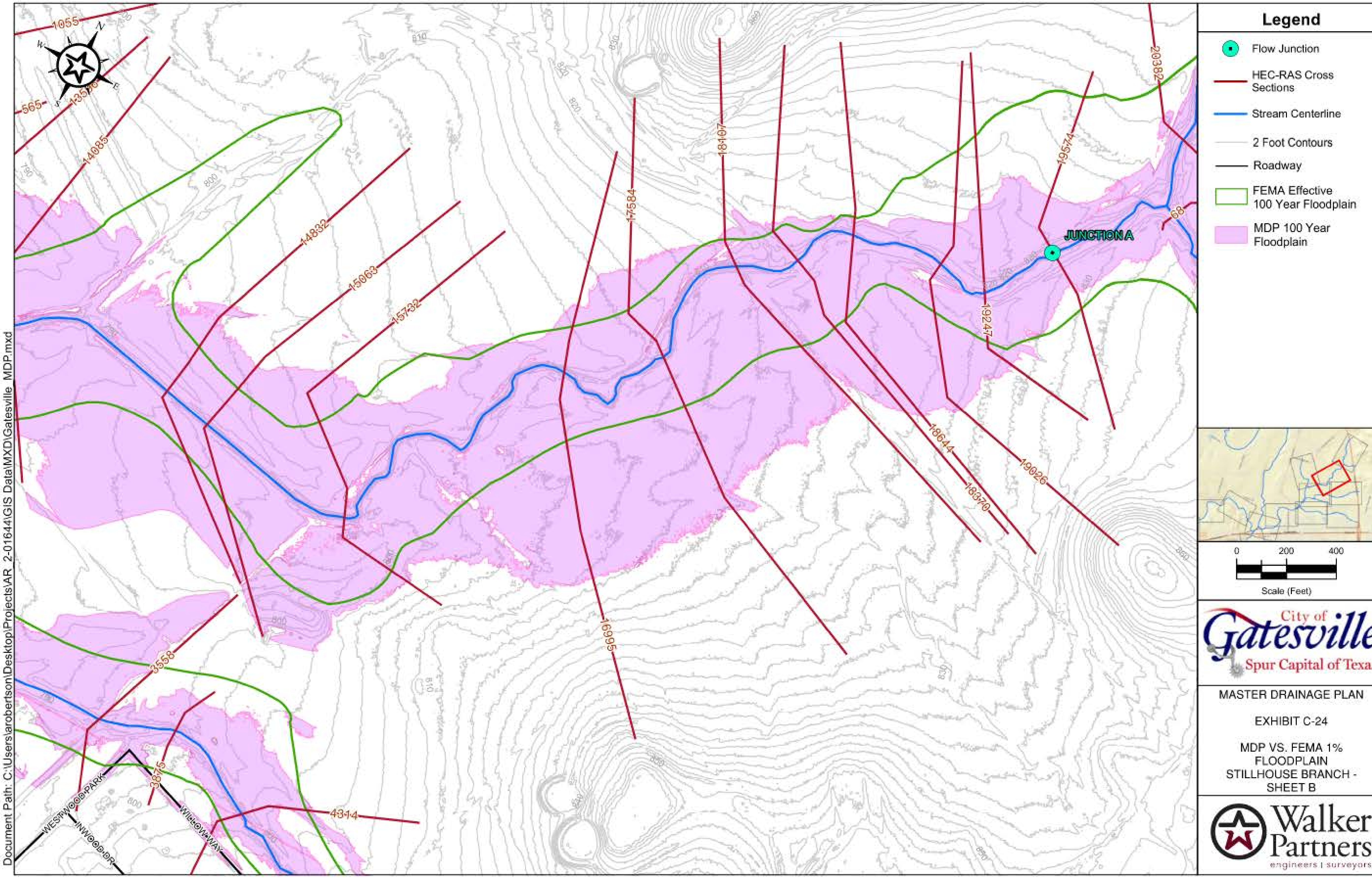

Legend
Flow Junction
HEC-RAS Cross Sections
Stream Centerline
2 Foot Contours
Roadway
FEMA Effective 100 Year Floodplain
MDP 100 Year Floodplain
0 200 400
Scale (Feet)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-20
MDP VS. FEMA 1% FLOODPLAIN DODD BRANCH - SHEET A
Walker Partners engineers | surveyors
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd
DB1
Chicktown
CHICKTOWN RD
DODDS CREEK DR
MESA DR
CREEK CLIFF DR
BRANDY LN
US 84
15581
15632
16405
16057
15965
15058
14254
13174
12660
14752
13744
14820
16903
17436
17517
18654.20
17995
18777
18476.09
18894

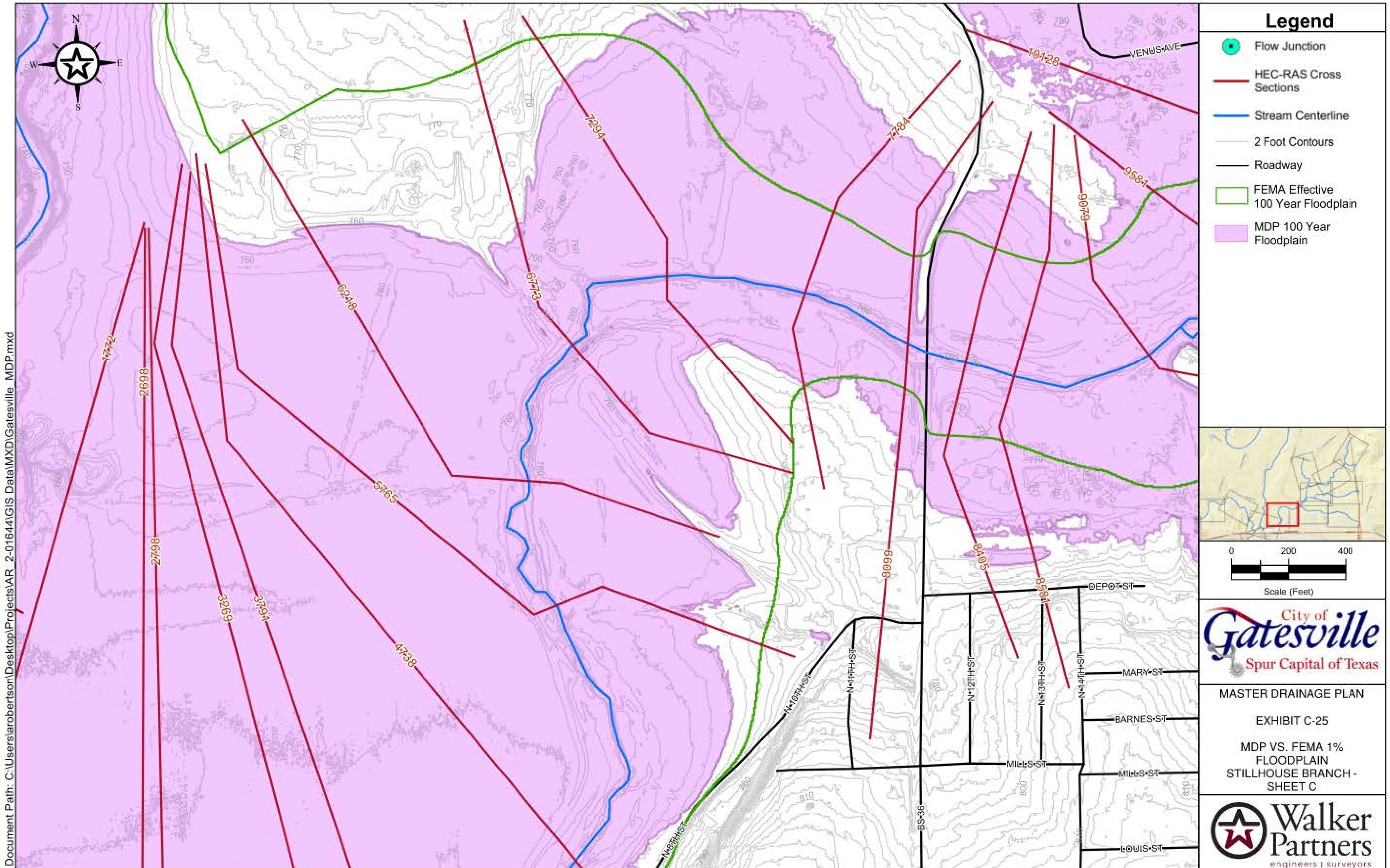

Legend
Flow Junction
HEC-RAS Cross Sections
Stream Centerline
2 Foot Contours
Roadway
FEMA Effective 100 Year Floodplain
MDP 100 Year Floodplain
0 200 400
Scale (Feet)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-21
MDP VS. FEMA 1% FLOODPLAIN
DODD BRANCH - SHEET B
Walker Partners engineers | surveyors
County Road 81
Oak Ridge
FM 2412
Memorial
7668
7743
7431
6948
6406
6342
5935
4931.742
8044
8113
8635
9084
9575
10163
10629
11173
11657
12146
12660
13174
13744
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd

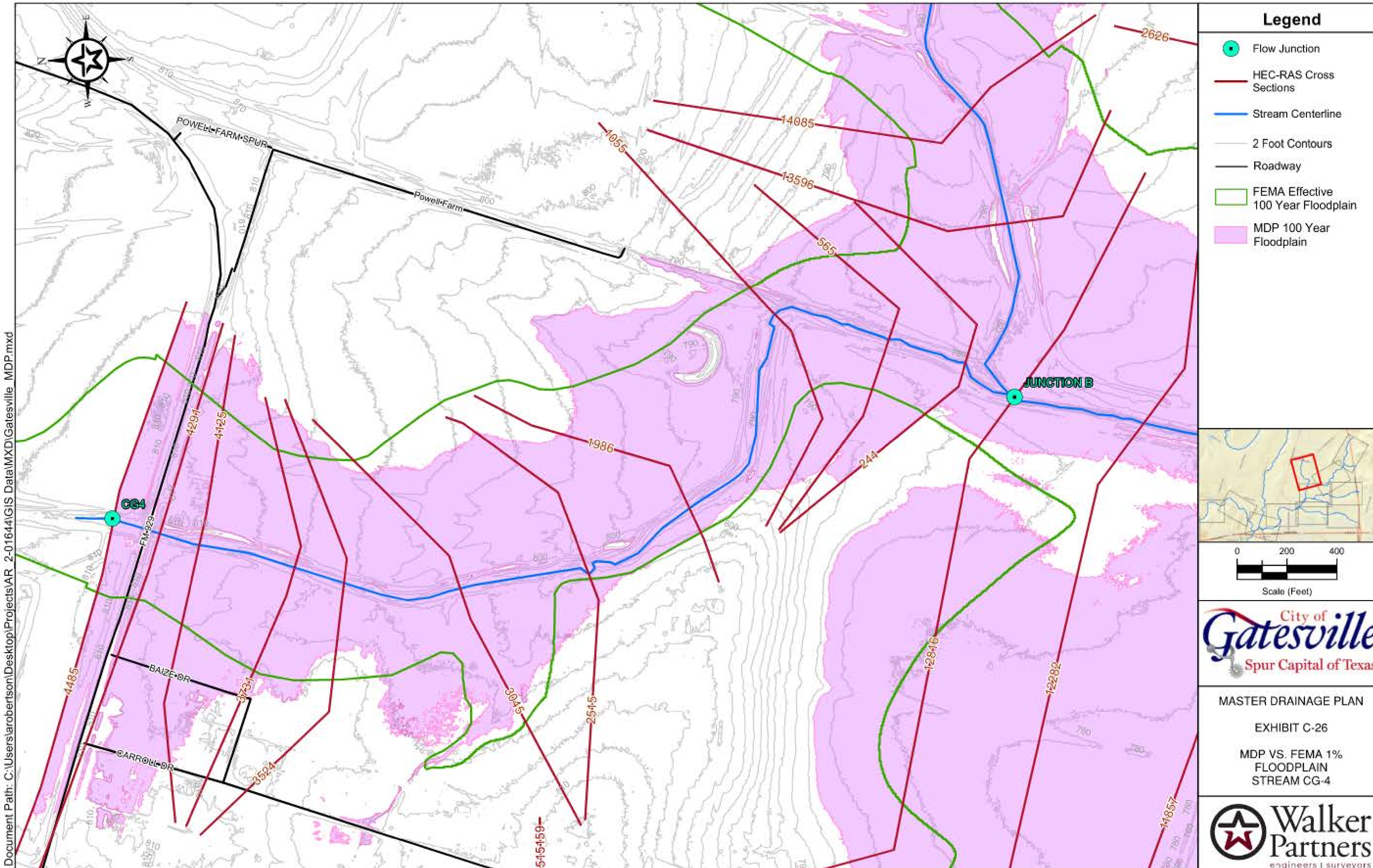

Legend
Flow Junction
HEC-RAS Cross Sections
Stream Centerline
2 Foot Contours
Roadway
FEMA Effective 100 Year Floodplain
MDP 100 Year Floodplain
JUNCTION DODD
Welsh
Moccasin
Rutherford
FM-2412
507765
506093
5815
5478
4406.354
3778.645
2669.657
2084.139
3403.103
4931.742
6948
6342
6406
5935
5579
7431
7668
7743
8044
8113
8635
9084
9575
11173
0
200
400
Scale (Feet)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-22
MDP VS. FEMA 1% FLOODPLAIN
DODD BRANCH - SHEET C
Walker Partners
engineers | surveyors
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd


Legend
Flow Junction
HEC-RAS Cross Sections
Stream Centerline
2 Foot Contours
Roadway
FEMA Effective 100 Year Floodplain
MDP 100 Year Floodplain
0 200 400
Scale (Feet)
City of Gatesville
Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-23
MDP VS. FEMA 1% FLOODPLAIN STILLHOUSE BRANCH - SHEET A
Walker Partners
engineers | surveyors
JUNCTION A
SB1
CG7
CATTLE DR
SH 36
Document Path: C:\Users\arobertson\Desktop\Projects\AR 2-01644\GIS Data\MXD\Gatesville_MDP.mxd

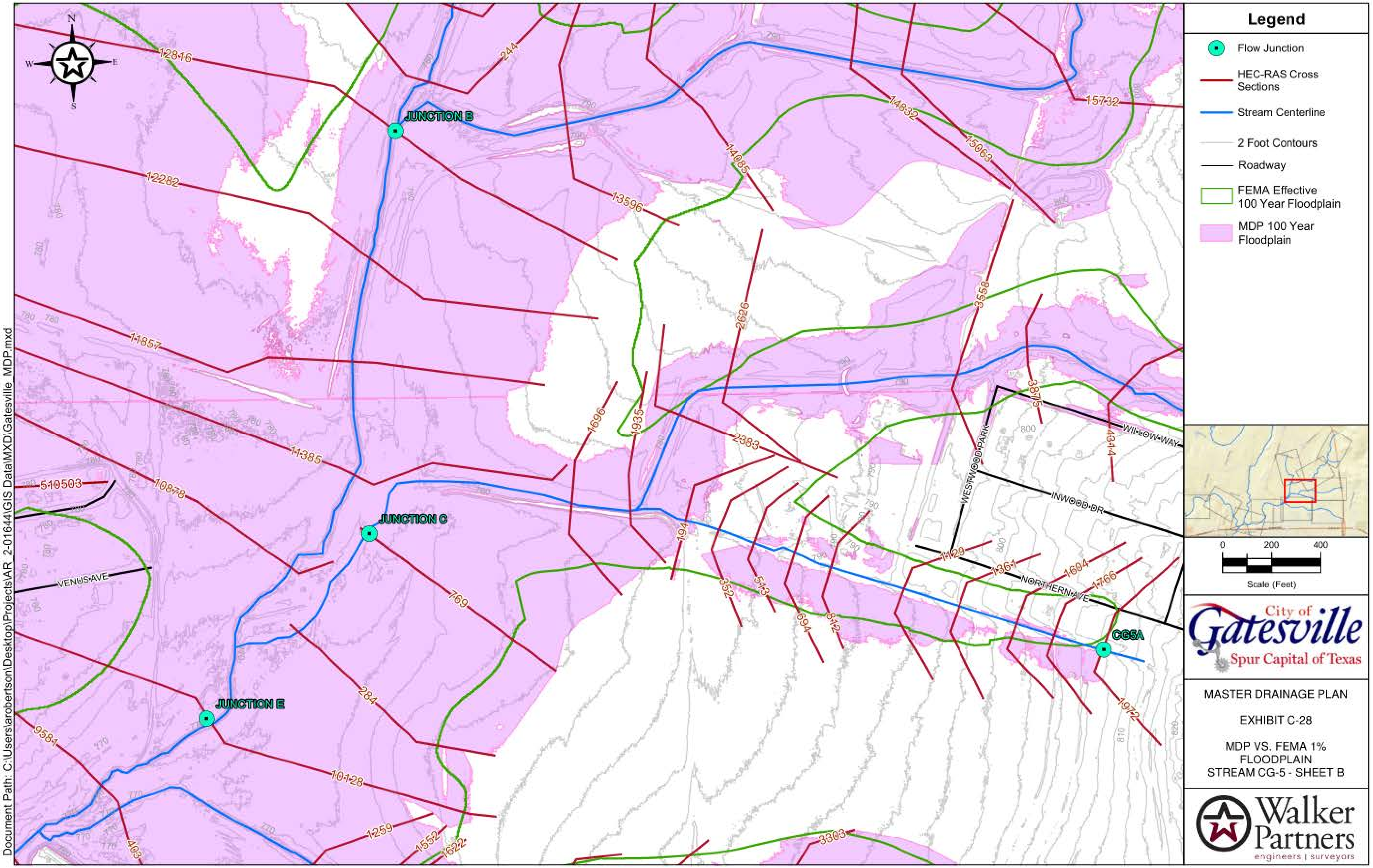
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd

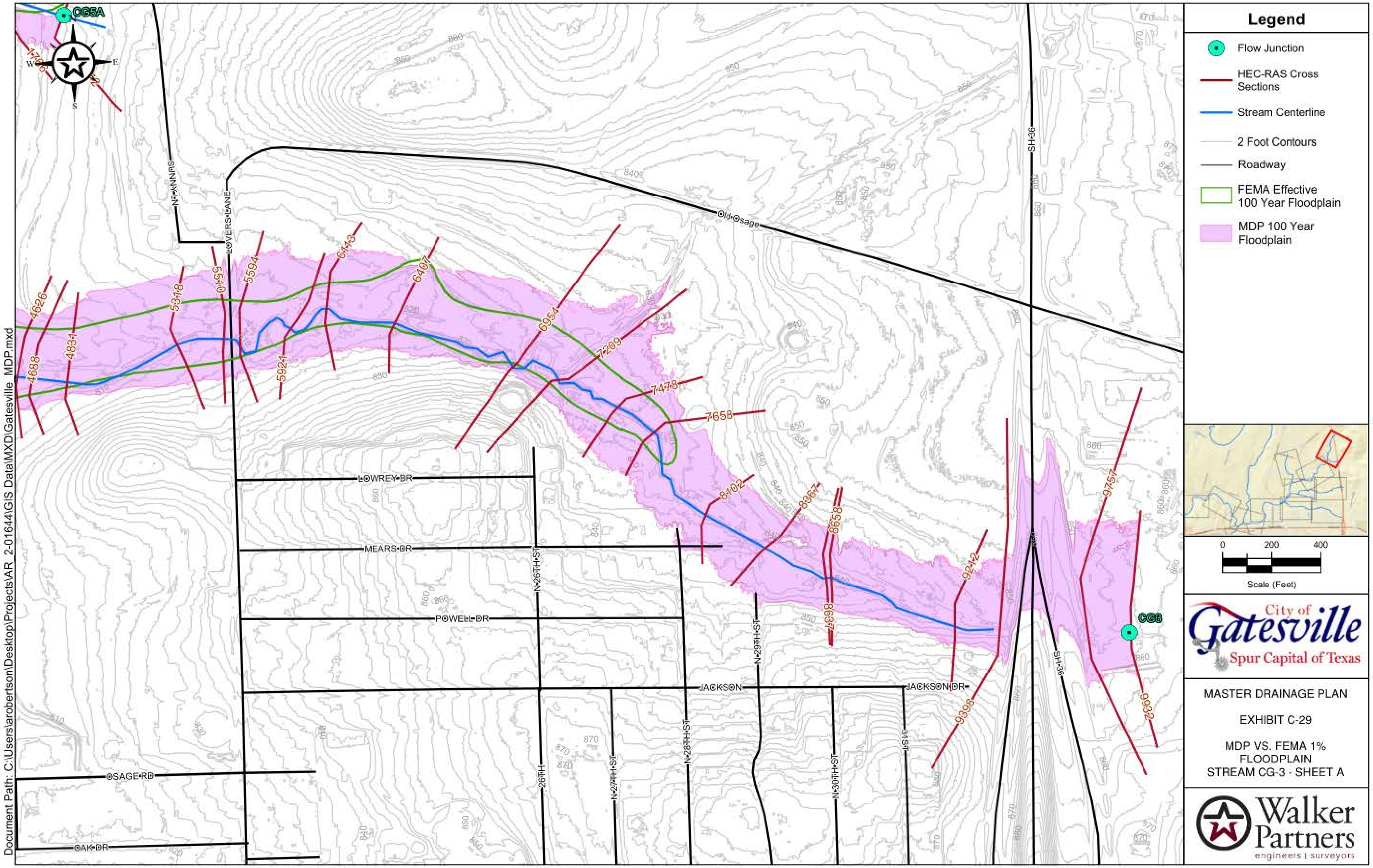


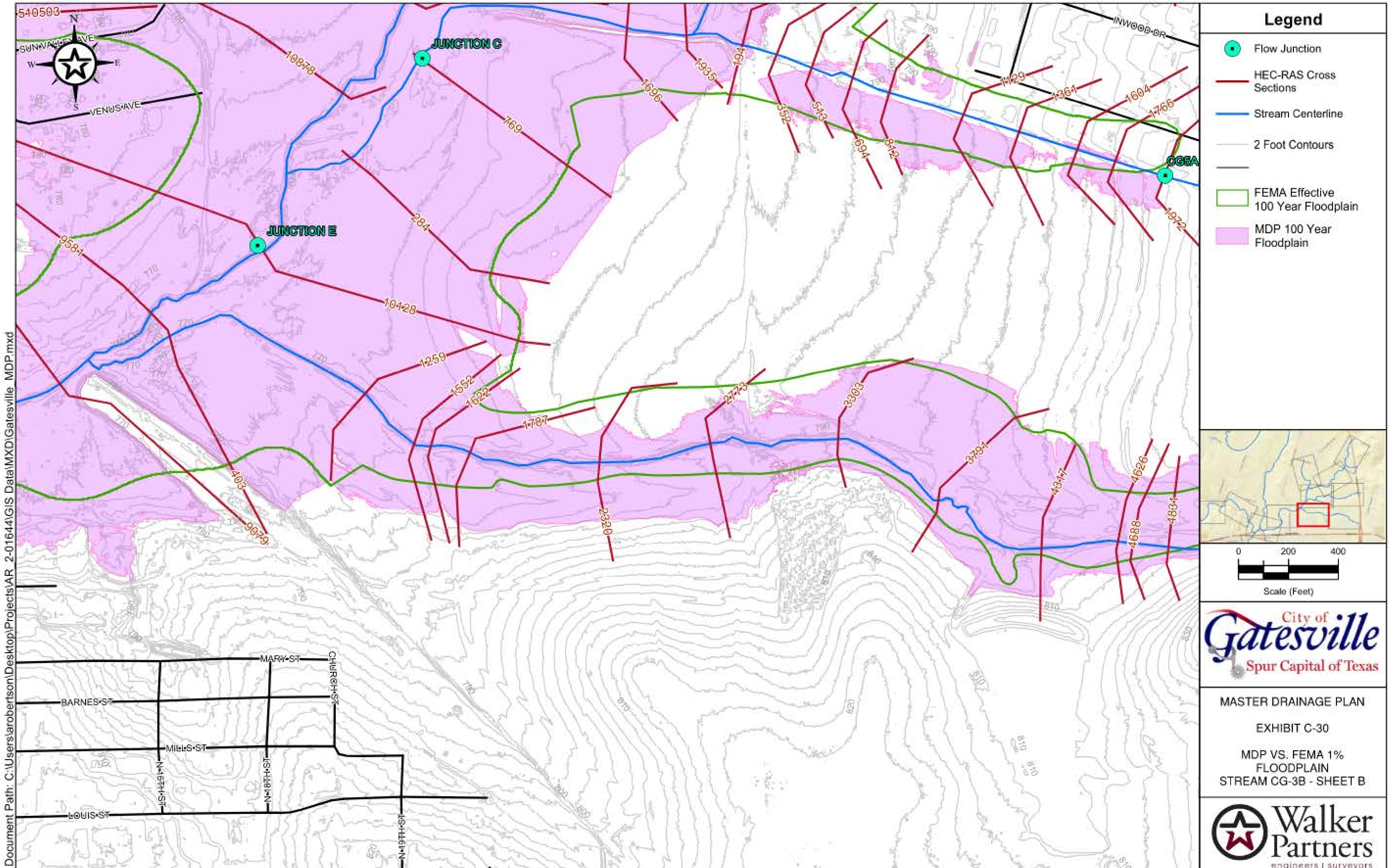

Legend
Flow Junction
HEC-RAS Cross Sections
Stream Centerline
2 Foot Contours
Roadway
FEMA Effective 100 Year Floodplain
MDP 100 Year Floodplain
0
200
400
Scale (Feet)
City of Gatesville
Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-25
MDP VS. FEMA 1% FLOODPLAIN
STILLHOUSE BRANCH - SHEET C
Walker Partners
engineers | surveyors
VENUS AVE
DEPOT ST
MARY ST
BARNES ST
MILLS ST
LOUIS ST
N 10TH ST
N 11TH ST
N 12TH ST
N 13TH ST
N 14TH ST
BS 36
10128
9584
9049
7784
7294
6773
6248
5765
4738
3791
3269
2798
2698
1772
8405
8099
8584
Document Path: C:\Users\arobertson\Desktop\Projects\AR 2-01644\GIS Data\MXD\Gatesville_MDP.mxd

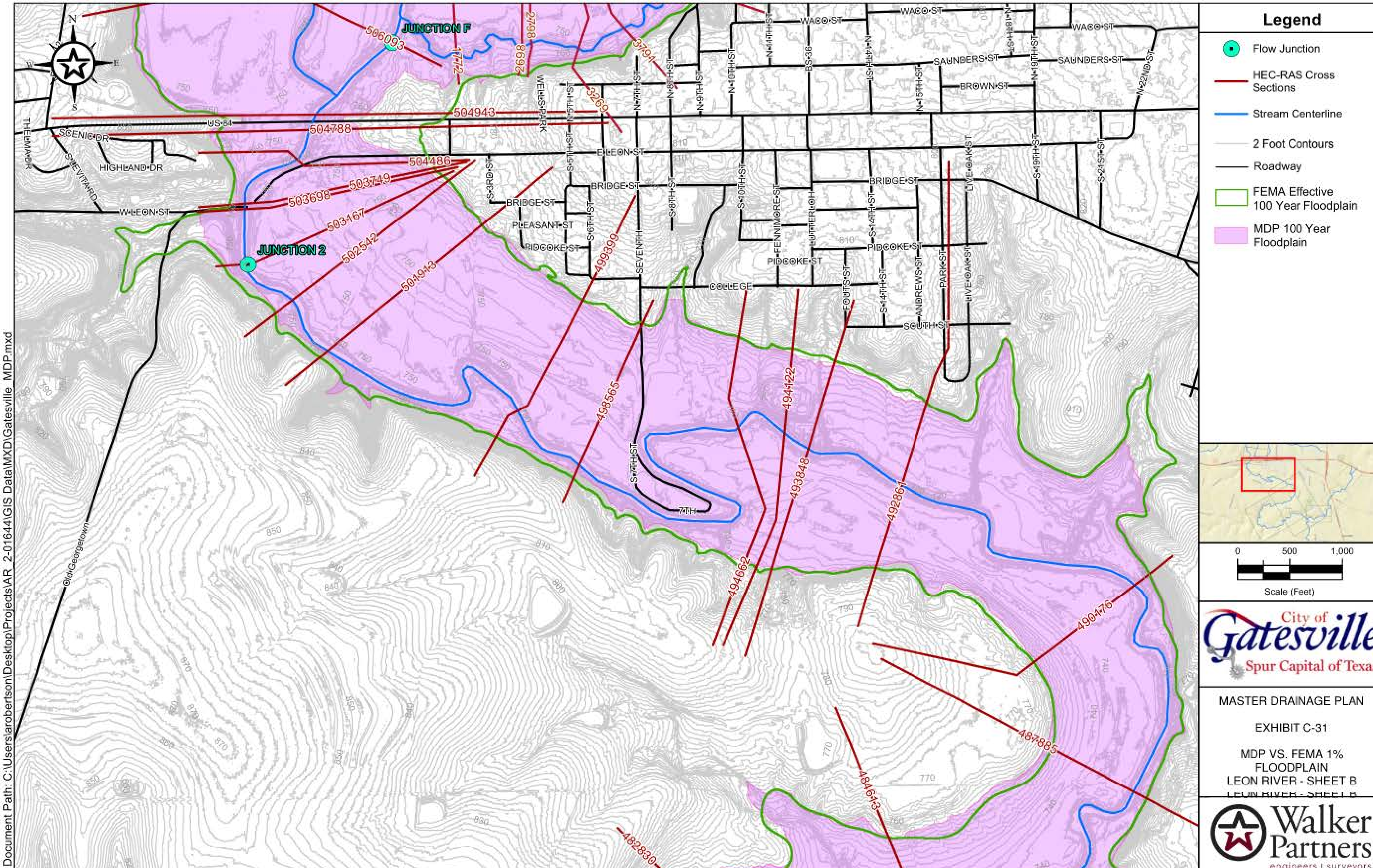

Legend
Flow Junction
HEC-RAS Cross Sections
Stream Centerline
2 Foot Contours
Roadway
FEMA Effective 100 Year Floodplain
MDP 100 Year Floodplain
0 200 400
Scale (Feet)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-26
MDP VS. FEMA 1% FLOODPLAIN STREAM CG-4
Walker Partners engineers | surveyors
JUNCTION B
CG4
POWELL FARM SPUR
Powell Farm
BAIZE DR
CARROLL DR
FM 929
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd


Legend
Flow Junction
HEC-RAS Cross Sections
Stream Centerline
2 Foot Contours
Roadway
FEMA Effective 100 Year Floodplain
MDP 100 Year Floodplain
0
200
400
Scale (Feet)
City of Gatesville
Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-27
MDP VS. FEMA 1% FLOODPLAIN
STREAM CG-5 - SHEET A
Walker Partners
engineers | surveyors
CG5-1
CG5A
16995
15732
15063
4314
4854
5406
5898
6441
6909
7263
7691
8186
8333
8517
8641
3875
1604
1766
1972
WILLOW WAY
INWOOD DR
NORTHERN AVE
SUNNY LN
SH 36
Old Osage
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd

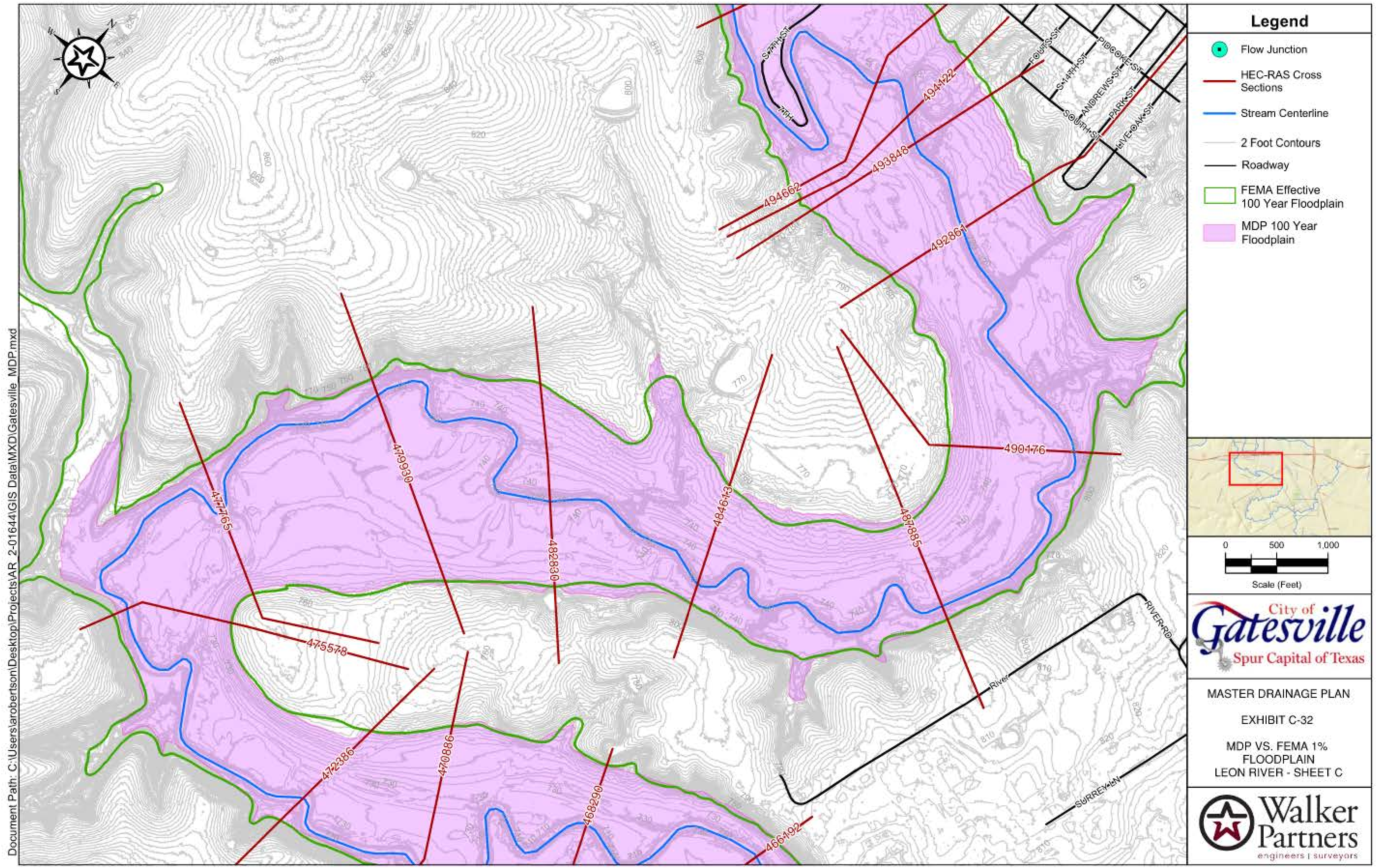

Legend
Flow Junction
HEC-RAS Cross Sections
Stream Centerline
2 Foot Contours
Roadway
FEMA Effective 100 Year Floodplain
MDP 100 Year Floodplain
0 200 400
Scale (Feet)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-28
MDP VS. FEMA 1% FLOODPLAIN
STREAM CG-5 - SHEET B
Walker Partners engineers | surveyors
JUNCTION B
JUNCTION C
JUNCTION E
CG5A
WILLOW WAY
INWOOD DR
NORTHERN AVE
WESTWOOD PARK
VENUS AVE
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd

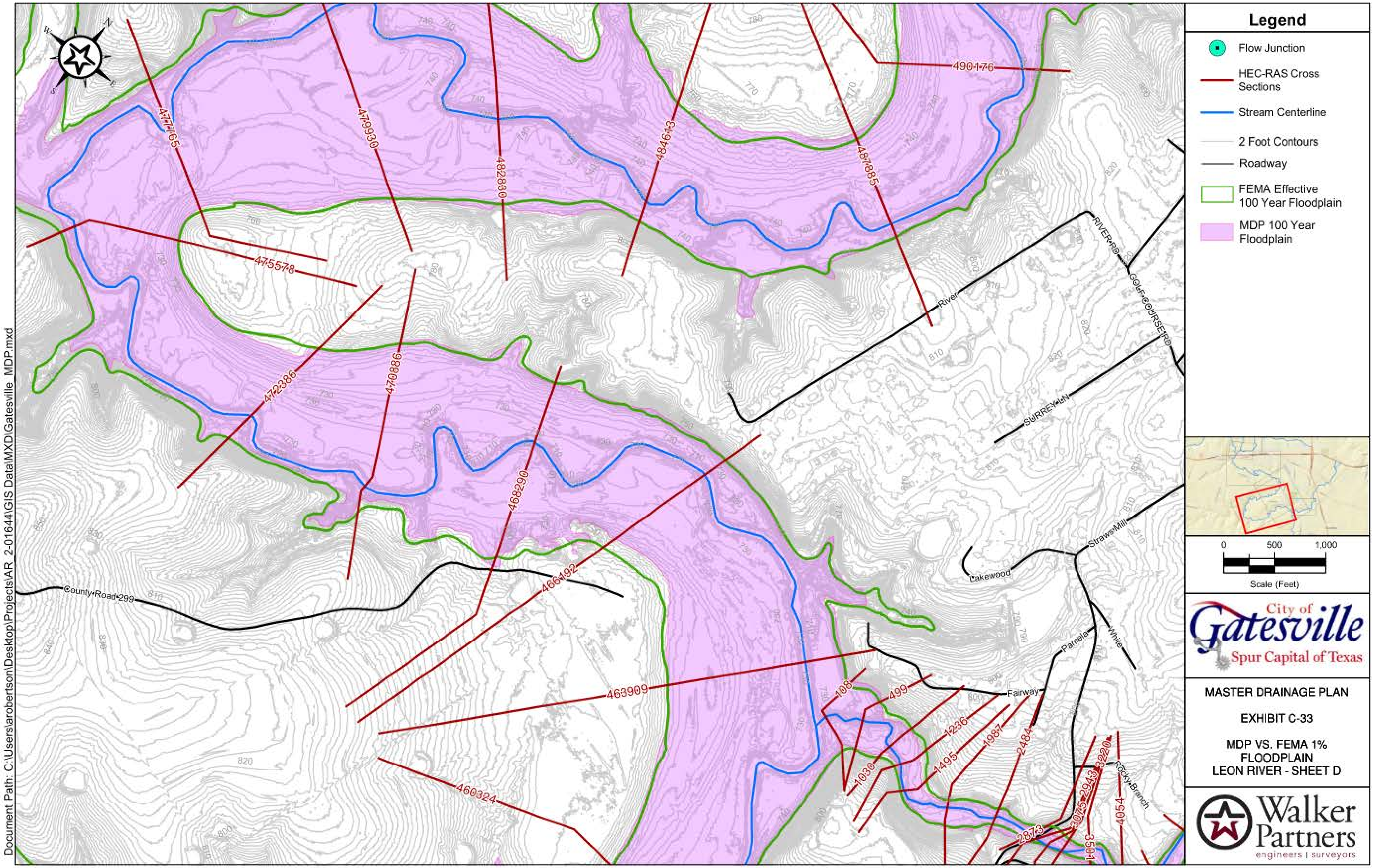

Legend
Flow Junction
HEC-RAS Cross Sections
Stream Centerline
2 Foot Contours
Roadway
FEMA Effective 100 Year Floodplain
MDP 100 Year Floodplain
0 200 400
Scale (Feet)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-29
MDP VS. FEMA 1% FLOODPLAIN
STREAM CG-3 - SHEET A
Walker Partners engineers | surveyors
CG5A
CG3
Old Osage
LOVERS LANE
LOWREY DR
MEARS DR
POWELL DR
JACKSON
JACKSON DR
OSAGE RD
OAK DR
N 26TH ST
SH-36
4626
4688
4831
5318
5540
5594
5921
6143
6407
6954
7209
7478
7658
8102
8367
8658
9242
9398
9757
9932
Document Path: C:\Users\arobertson\Desktop\Projects\AR 2-01644\GIS Data\MXD\Gatesville MDP.mxd

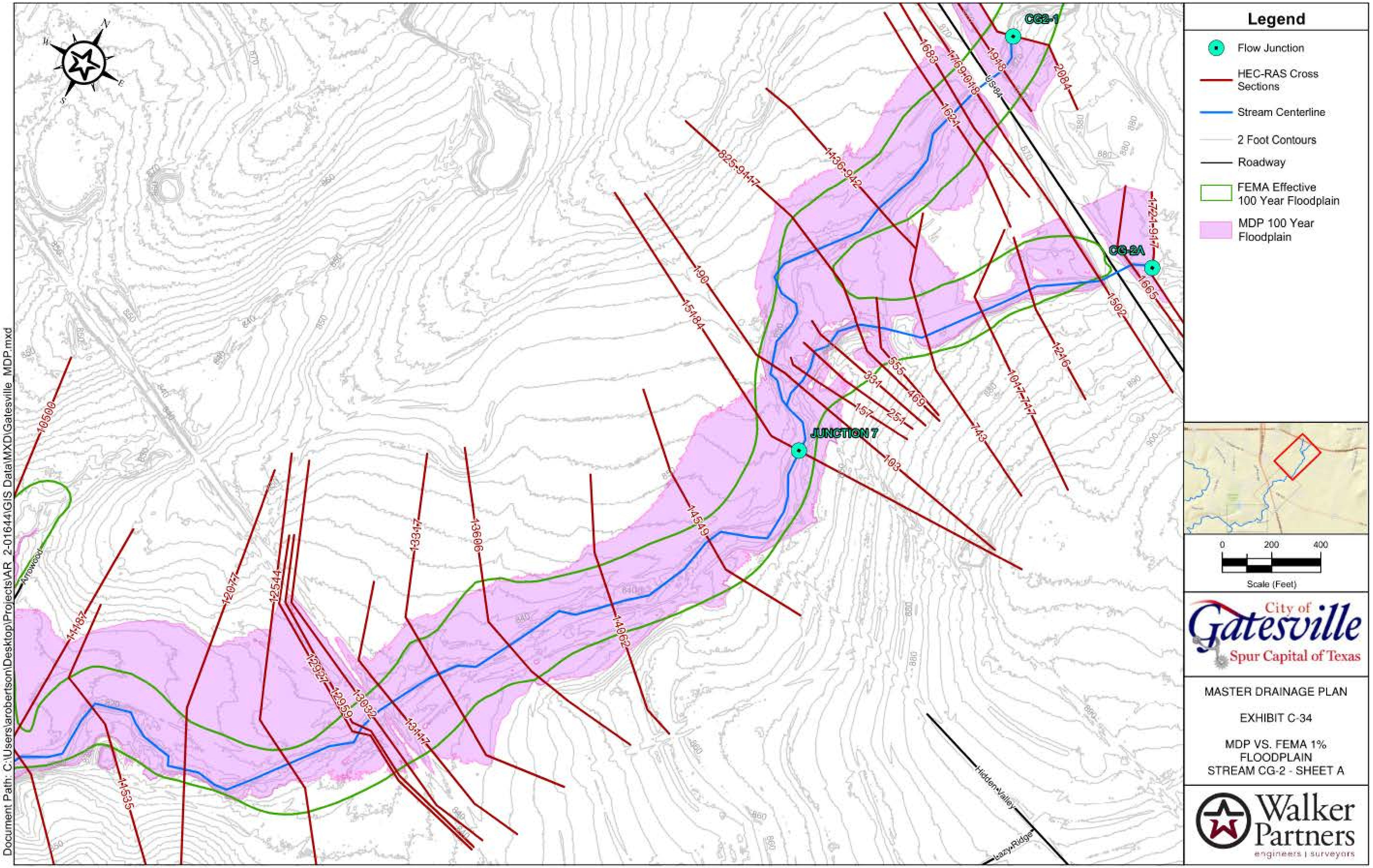

Legend
Flow Junction
HEC-RAS Cross Sections
Stream Centerline
2 Foot Contours
FEMA Effective 100 Year Floodplain
MDP 100 Year Floodplain
JUNCTION C
JUNCTION E
CG5A
INWOOD DR
SUN VALLEY AVE
VENUS AVE
MARY ST
BARNES ST
MILLS ST
LOUIS ST
CHURCH ST
N 16TH ST
N 18TH ST
N 19TH ST
Scale (Feet)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-30
MDP VS. FEMA 1% FLOODPLAIN
STREAM CG-3B - SHEET B
Walker Partners engineers | surveyors
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd

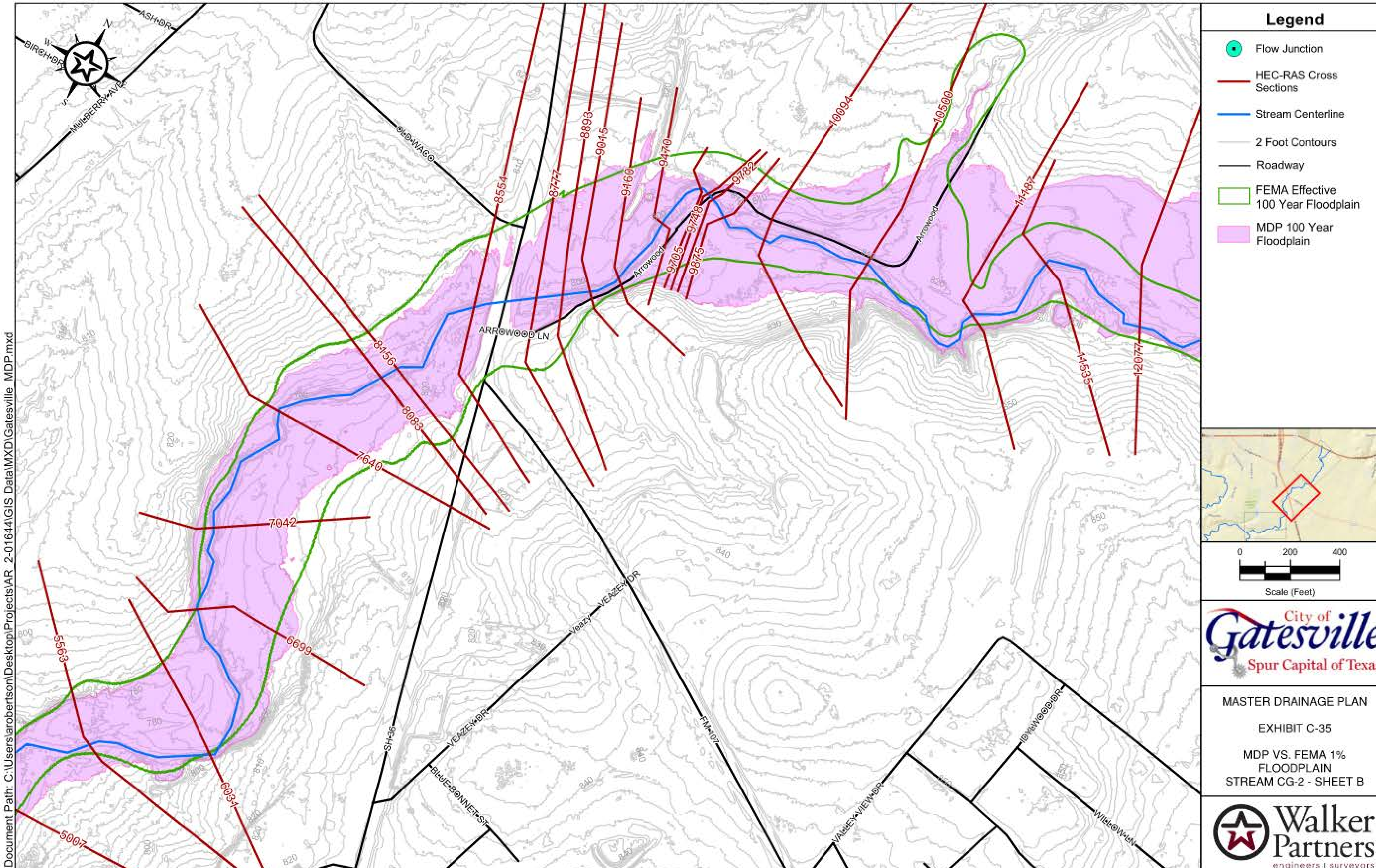


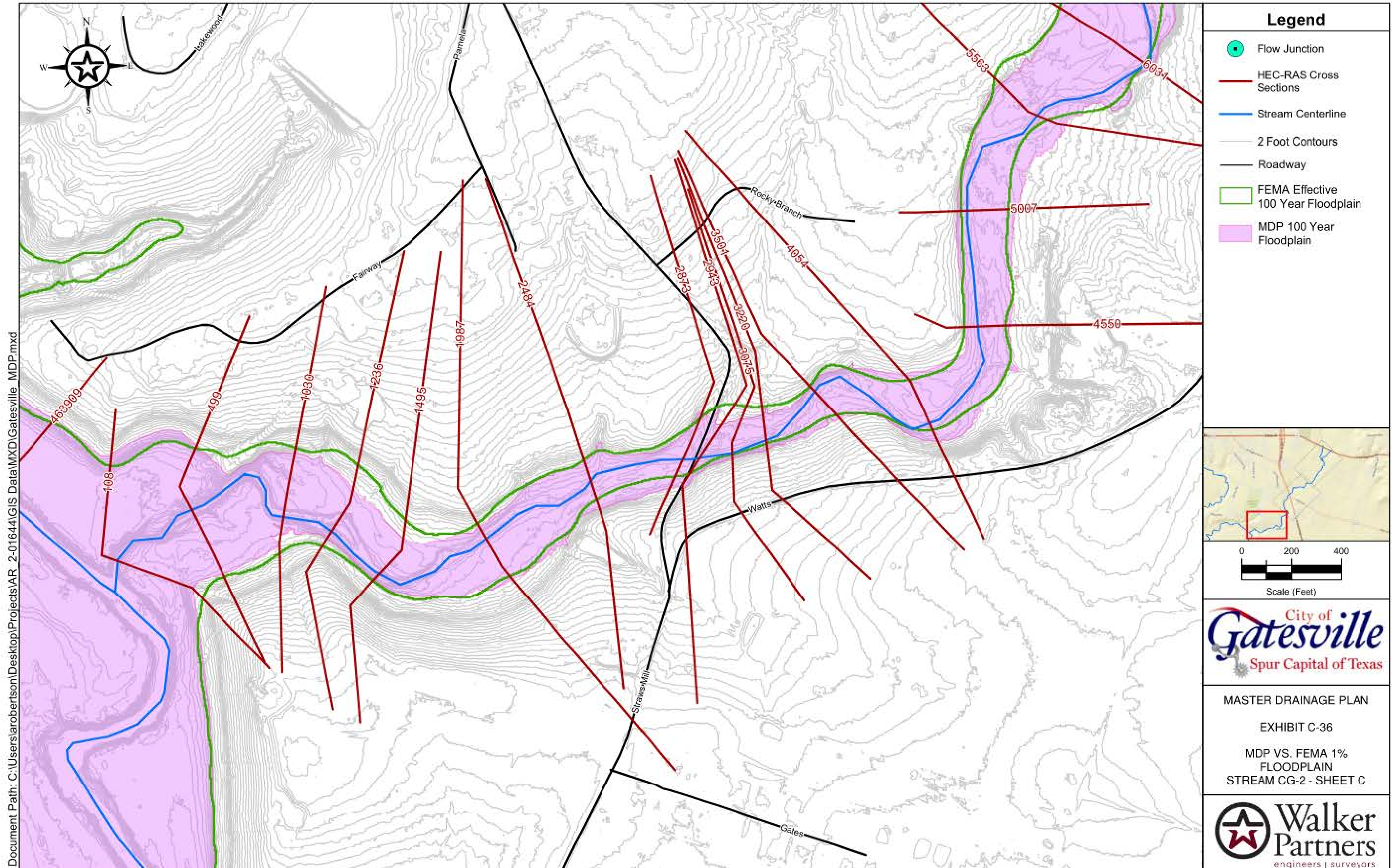
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd


Legend
Flow Junction
HEC-RAS Cross Sections
Stream Centerline
2 Foot Contours
Roadway
FEMA Effective 100 Year Floodplain
MDP 100 Year Floodplain
0 500 1,000
Scale (Feet)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-32
MDP VS. FEMA 1% FLOODPLAIN
LEON RIVER - SHEET C
Walker Partners engineers | surveyors
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd
494662
493848
494122
492861
490176
487885
484613
482830
479930
477765
475578
472386
470886
468290
466192
RIVER RD
SURREY LN
FOURS ST
S 14TH ST
PIDCOKE ST
ANDREWS ST
PARK ST
LIVE OAK ST
SOUTH ST


Legend
Flow Junction
HEC-RAS Cross Sections
Stream Centerline
2 Foot Contours
Roadway
FEMA Effective 100 Year Floodplain
MDP 100 Year Floodplain
0
500
1,000
Scale (Feet)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-33
MDP VS. FEMA 1% FLOODPLAIN
LEON RIVER - SHEET D
Walker Partners engineers | surveyors
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd
490176
477765
479930
482830
484613
487885
475578
472386
470886
468290
466192
463909
460324
County Road 299
River Rd
Golf Course Rd
Surrey Ln
Straws Mill
Lakewood
Pamela
White
Fairway
Rocky Branch

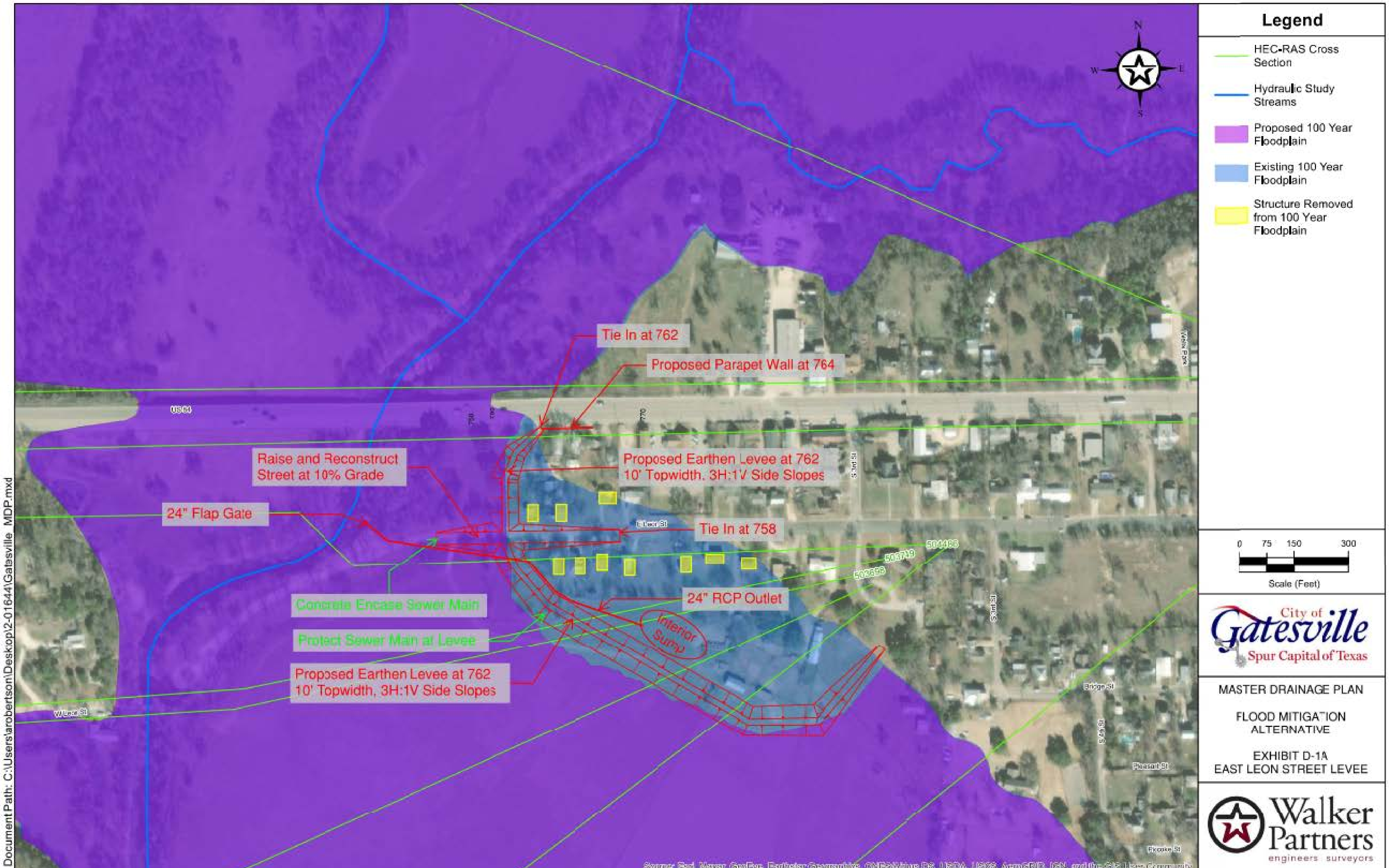

Legend
Flow Junction
HEC-RAS Cross Sections
Stream Centerline
2 Foot Contours
Roadway
FEMA Effective 100 Year Floodplain
MDP 100 Year Floodplain
0
200
400
Scale (Feet)
City of Gatesville
Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-34
MDP VS. FEMA 1% FLOODPLAIN
STREAM CG-2 - SHEET A
Walker Partners
engineers | surveyors
CG2-1
CG-2A
JUNCTION 7
Arrowood
Hidden Valley
Lazy Ridge
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd


Legend
Flow Junction
HEC-RAS Cross Sections
Stream Centerline
2 Foot Contours
Roadway
FEMA Effective 100 Year Floodplain
MDP 100 Year Floodplain
0 200 400
Scale (Feet)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-35
MDP VS. FEMA 1% FLOODPLAIN
STREAM CG-2 - SHEET B
Walker Partners engineers | surveyors
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd
ASH DR
BIRCH DR
MULBERRY AVE
OLD WACO
ARROWOOD LN
Arrowood
SH-36
FM-107
VEAZEY DR
Veazy
BLUE BONNET ST
VALLEY VIEW DR
IDYLWOOD DR
WILLOW LN
5007
5563
6031
6699
7042
7640
8083
8156
8554
8777
8893
9015
9460
9470
9705
9748
9782
9875
10094
10500
11487
11535
12077


Legend
Flow Junction
HEC-RAS Cross Sections
Stream Centerline
2 Foot Contours
Roadway
FEMA Effective 100 Year Floodplain
MDP 100 Year Floodplain
0
200
400
Scale (Feet)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
EXHIBIT C-36
MDP VS. FEMA 1% FLOODPLAIN
STREAM CG-2 - SHEET C
Walker Partners engineers | surveyors
Document Path: C:\Users\arobertson\Desktop\Projects\AR_2-01644\GIS Data\MXD\Gatesville_MDP.mxd
Lakewood
Pamela
Fairway
Rocky Branch
Watts
Straws Mill
Gates
463909
108
499
1030
1236
1495
1987
2484
2873
2943
3501
3220
3075
4054
5007
4550
5563
6031

Appendix D – Conceptual Mitigation Solutions

Exhibit D-1A	**East Leon Street – Levee Alternative**
Exhibit D-1A	**East Leon Street – Levee Alternative OPCC**
Exhibit D-1B	**East Leon Street – Buyout Alternative**
Exhibit D-1B	**East Leon Street – Buyout Alternative OPCC**
Exhibit D-2	**Leon Wastewater Treatment Plant**
Exhibit D-2	**Leon Wastewater Treatment Plant OPCC**
Exhibit D-3	**Straws Mill Road Low Water Crossing**
Exhibit D-3	**Straws Mill Road Low Water Crossing OPCC**
Exhibit D-4A	**Arrowood Lane Culvert Replacement – 10 Year**
Exhibit D-4A	**Arrowood Lane Culvert Replacement – 100 Year**
Exhibit D-4A	**Arrowood Lane Culvert Replacement OPCC**
Exhibit D-4B	**SH 36 Culverts**
Exhibit D-4B	**SH 36 Culverts OPCC**
Exhibit D-5	**FM 929 Culverts and Channel Improvements**
Exhibit D-5	**FM 929 Culverts and Channel Improvements OPCC**
Exhibit D-6A	**Sun Valley Neighborhood – Levee Alternative**
Exhibit D-6A	**Sun Valley Neighborhood – Levee Alternative OPCC**
Exhibit D-6B	**Sun Valley Neighborhood – Buyout Alternative**
Exhibit D-6B	**Sun Valley Neighborhood – Buyout Alternative OPCC**


Legend
HEC-RAS Cross Section
Hydraulic Study Streams
Proposed 100 Year Floodplain
Existing 100 Year Floodplain
Structure Removed from 100 Year Floodplain
Tie In at 762
Proposed Parapet Wall at 764
Raise and Reconstruct Street at 10% Grade
Proposed Earthen Levee at 762 10' Topwidth, 3H:1V Side Slopes
24" Flap Gate
Tie In at 758
Concrete Encase Sewer Main
24" RCP Outlet
Interior Sump
Protect Sewer Main at Levee
Proposed Earthen Levee at 762 10' Topwidth, 3H:1V Side Slopes
0 75 150 300
Scale (Feet)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
FLOOD MITIGATION ALTERNATIVE
EXHIBIT D-1A
EAST LEON STREET LEVEE
Walker Partners engineers surveyors
Document Path: C:\Users\arobertson\Desktop\2-01644\Gatesville MDP.mxd

Project Number:	Project Name:	Flooding Source:
1A	East Leon Street Levee Improvements	Leon River

Gatesville Spur Capital of Texas — Walker Partners

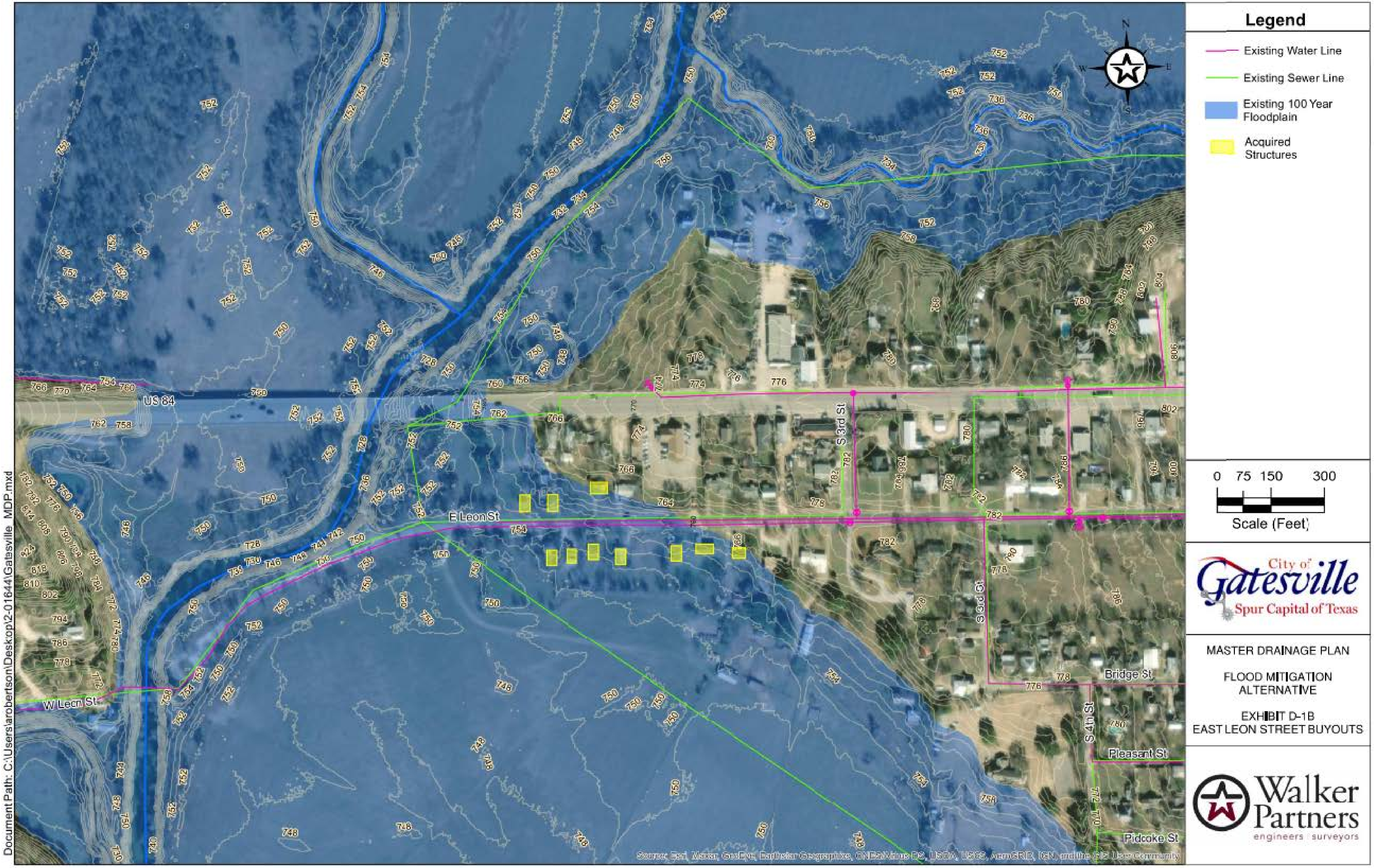
Recommended Improvements			Location (Nearest Street Intersection)	
_ Buyout	_ Channel Improvements	.. Levee	From:	US 84
_ Detention	. Structure Improvements	_ Other	To:	East Leon Street

Description	Est. Qty.	Unit	Unit Price	Total
Channel & Culvert Improvements				
Mobilization, Barricades & Incidentals (15%)	1	LS	$195,000.00	$195,000.00
Stormwater Pollution Prevention Plan	1	LS	$2,400.00	$2,400.00
Stormwater Pollution Prevention Plan Implementation	1	LS	$20,000.00	$20,000.00
Broadcast Seeding	28400	SY	$2.00	$56,800.00
Curlex Blanket (Green)	28400	SY	$3.00	$85,200.00
Remove Existing Roadway Including Concrete Curb & Gutter and Sidewalk	1780	SY	$10.00	$17,800.00
Strip and Stockpile Topsoil	12555.6	SY	$5.00	$62,777.78
Place and Compact Earthen Embankment	25570.4	CY	$25.00	$639,259.26
Water Utility Adjustment	2	EA	$15,000.00	$30,000.00
Wastewater Utility Adjustment	2	EA	$5,000.00	$10,000.00
Concrete Encase Wastewater Utility	2	EA	$5,000.00	$10,000.00
24" RCP (Class III) Including Excavation & Backfill	950	LF	$250.00	$237,500.00
Install 24" Flap Gate	1	EA	$2,500.00	$2,500.00
8" Lime Stabilization of Existing Sub-base Material	1780	SY	$7.00	$12,460.00
Hydrated Lime	33	TN	$280.00	$9,240.00
8" Cement Treated Base	1780	SY	$25.00	$44,500.00
2" H.M.A.C. (Crushed 'D')	196	TN	$170.00	$33,320.00
Metal Beam Guard Fence	0	LF	$40.00	$0.00
Concrete Parapet Wall	150	LF	$150.00	$22,500.00
Channel & Culvert Improvements Subtotal				**$1,491,257.04**
Contingency (25%)				$372,800.00
Engineering, Surveying, Management & Inspection (25%)				$372,800.00
Land Costs	5.85	AC	$20,000.00	$117,000.00
ROW Acquisition Services (6% Land Costs)				$7,020.00
Easement Acquisition ($0.50 per square foot)				$0.00
Easement Acquisition Services				$0.00
Total Estimated Project Cost				**$2,360,877.04**

Project Description

The East Leon Street Levee alternative includes construction of an earthen levee to protect 10 residential properties along East Leon Street. Downstream of the US 84 bridge, the channel of the Leon River turns towards the west but flows in its overbanks continue south and spread out towards the east flooding 10 insurable structures along East Leon Street. A 150-foot long, 2 foot high concrete floodwall is constructed along the sidewalk of US 84 at elevation 764. The earthen levee ties into the floodwall at elevation 762, and wraps around the neighborhood for 1,700 feet to tie back into the bluff behind 302 E. Leon Street. This alternative also includes raising the roadway by 8 feet at East Leon Street, which includes reconstruction of 500 feet of the street. The interior sump area is drained by 24" RCP pipe that runs up to E. Leon Street, and along E. Leon Street to an existing outfall channel where it discharges through a 24" flap gate into the Leon River.

C.I.P. Rank:	TBD	By: CBB	Date: 12/9/22


Legend
Existing Water Line
Existing Sewer Line
Existing 100 Year Floodplain
Acquired Structures
0 75 150 300
Scale (Feet)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
FLOOD MITIGATION ALTERNATIVE
EXHIBIT D-1B
EAST LEON STREET BUYOUTS
Walker Partners engineers | surveyors
US 84
E Leon St
W Leon St
S 3rd St
S 3rd Ct
S 4th St
Bridge St
Pleasant St
Pidcoke St
Document Path: C:\Users\arobertson\Desktop\2-01644\Gatesville_MDP.mxd

Project Number:	Project Name:	Flooding Source:
1B	East Leon Street Buyouts	Leon River

Recommended Improvements			Location (Nearest Street Intersection)	
. Buyout	_ Channel Improvements	_ Levee	From:	US 84
_ Detention	_ Structure Improvements	_ Other	To:	East Leon Street

Gatesville Spur Capital of Texas · Walker Partners

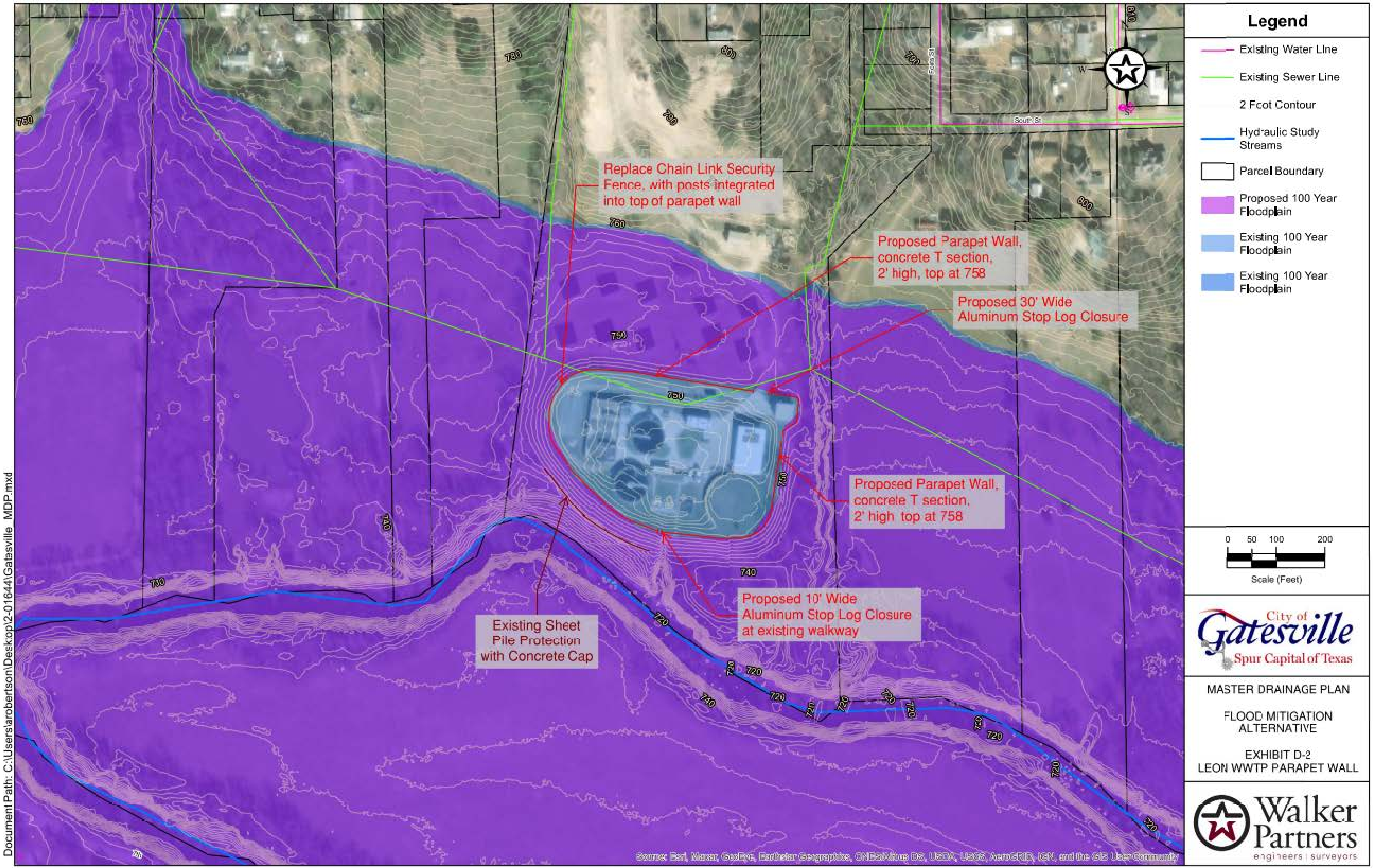
Description	Est. Qty.	Unit	Unit Price	Total
Property Buyouts				
Land Costs				$1,222,455.00
ROW Acquisition Services (6% Land Costs)				$73,350.00
Easement Acquisition ($0.50 per square foot)				$0.00
Easement Acquisition Services				$0.00
Channel & Culvert Improvements Subtotal				**$1,295,805.00**
Contingency (10%)				$129,600.00
Engineering, Surveying, Management & Inspection (25%)				$0.00
Total Estimated Project Cost				**$1,425,405.00**

Project Description

TheEast Leon Street Buyouts project includes the buyout of 10 residential properties along East Leon Street. Downstream of the US 84 bridge, the channel of the Leon River turns towards the west but flows in its overbanks continue south and spread out towards the east flooding 10 insurable structures along East Leon Street. The second alternative evaluated to mitigate this flood risk is the acquisition of these 10 structures.

The cost associated with the buyout of each property includes the appraisal and closing costs, demolition and disposal of the structure including hazardous materials (e.g. asbestos, lead paint), restoration of the lot to open space, and any difference between appraised and fair market value of the house.

C.I.P. Rank:	TBD	By:	CBB	Date:	11/23/22


Legend
Existing Water Line
Existing Sewer Line
2 Foot Contour
Hydraulic Study Streams
Parcel Boundary
Proposed 100 Year Floodplain
Existing 100 Year Floodplain
Existing 100 Year Floodplain
0 50 100 200
Scale (Feet)
City of Gatesville
Spur Capital of Texas
MASTER DRAINAGE PLAN
FLOOD MITIGATION ALTERNATIVE
EXHIBIT D-2
LEON WWTP PARAPET WALL
Walker Partners
engineers | surveyors
Replace Chain Link Security Fence, with posts integrated into top of parapet wall
Proposed Parapet Wall, concrete T section, 2' high, top at 758
Proposed 30' Wide Aluminum Stop Log Closure
Proposed Parapet Wall, concrete T section, 2' high top at 758
Proposed 10' Wide Aluminum Stop Log Closure at existing walkway
Existing Sheet Pile Protection with Concrete Cap
Document Path: C:\Users\arobertson\Desktop\2-01644\Gatesville MDP.mxd

Project Number:	Project Name:	Flooding Source:
02	Leon Wastewater Treatment Plant Parapet Wall	Leon River

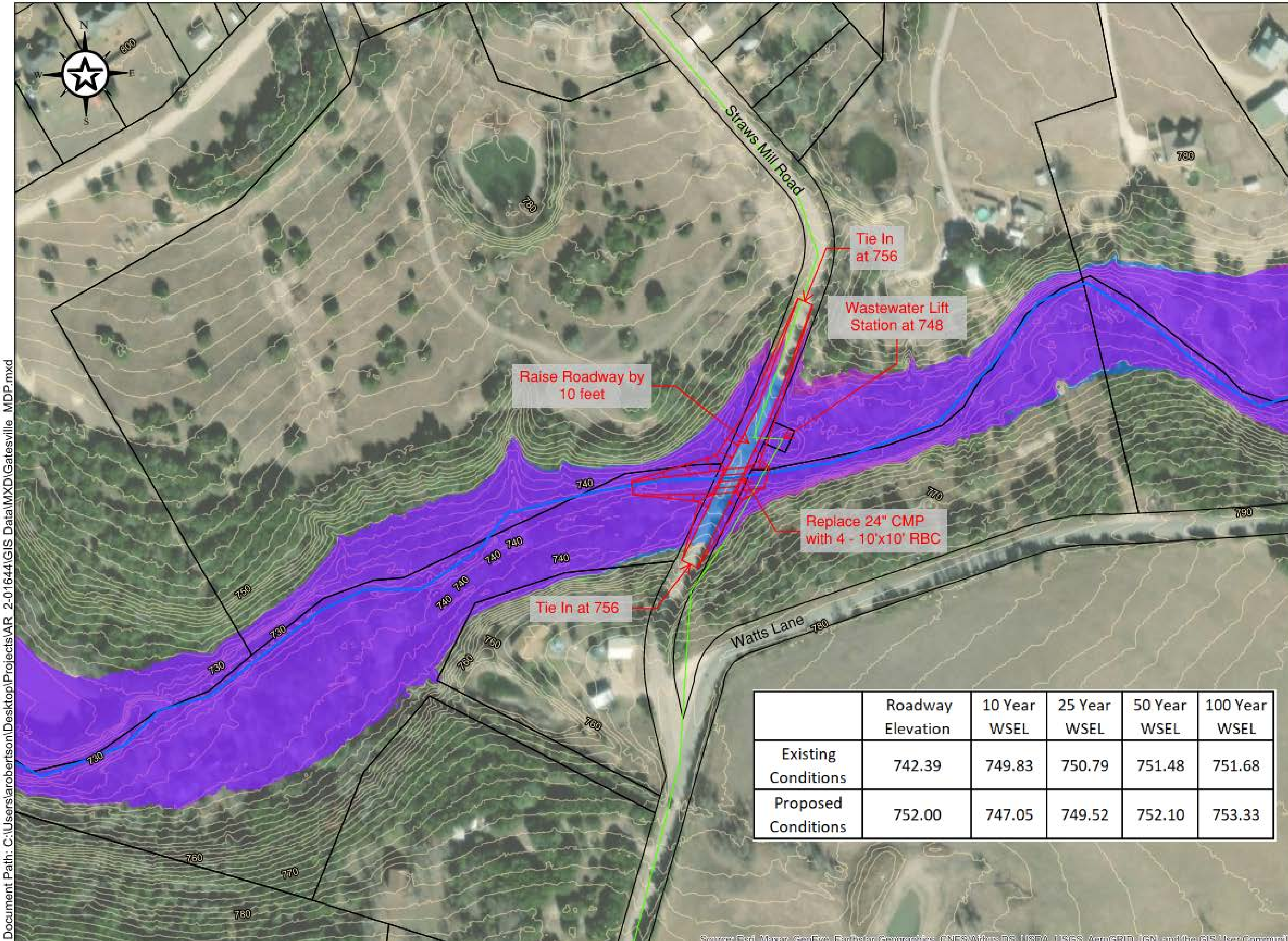
Recommended Improvements			Location (Nearest Street Intersection)	
__ Buyout	__ Channel Improvements	_.._ Levee	From:	Fennimore Street
__ Detention	_._ Structure Improvements	__ Other	To:	S. Lutterloh Avenue

Description	Est. Qty.	Unit	Unit Price	Total
Channel & Culvert Improvements				
Mobilization, Barricades & Incidentals (10%)	1	LS	$45,000.00	$45,000.00
Stormwater Pollution Prevention Plan	1	LS	$2,400.00	$2,400.00
Stormwater Pollution Prevention Plan Implementation	1	LS	$10,000.00	$10,000.00
Broadcast Seeding	1,000	SY	$2.00	$2,000.00
Curlex Blanket (Green)	1,000	SY	$3.00	$3,000.00
Remove and Store Existing Chain Link Security Fence	1,500	LF	$3.00	$4,500.00
Strip and Stockpile Topsoil	1,000	SY	$5.00	$5,000.00
Place Inverted T Concrete Parapet Wall - 2' High, with sleeves for fence posts	1,500	LF	$250.00	$375,000.00
Concrete Stop Log Frame	2	EA	$15,000.00	$30,000.00
Aluminum Stop Logs - 2 feet high	40	LF	$200.00	$8,000.00
Reinstall Chain Link Security Fence	1,500	LF	$6.00	$9,000.00
Channel & Culvert Improvements Subtotal				$493,900.00
Contingency (10%)				$49,400.00
Engineering, Surveying, Management & Inspection (20%)				$98,800.00
Land Costs	0	AC	$20,000.00	$0.00
ROW Acquisition Services (6% Land Costs)				$0.00
Easement Acquisition ($0.50 per square foot)				$0.00
Easement Acquisition Services				$0.00
Total Estimated Project Cost				**$642,100.00**

Project Description

The Leon WWTP Parapet Wall project includes construction of an inverted T shaped concrete parapet wall along the top of the existing earthen embankment to provide an additional 2 feet of protection against inundation by the Leon River. To maintain the existing access points, the parapet wall connects to a 30-foot wide stop log structure on the north side of the plant for vehicular access and a 10-foot wide stop log structure on the south side of the plant for access to the concrete outfall channel. The existing chain link security fence is re-installed on posts integrated into the top of the concrete parapet wall.

C.I.P. Rank:	TBD	By:	CBB	Date:	12/9/22



	Roadway Elevation	10 Year WSEL	25 Year WSEL	50 Year WSEL	100 Year WSEL
Existing Conditions	742.39	749.83	750.79	751.48	751.68
Proposed Conditions	752.00	747.05	749.52	752.10	753.33

Legend

- Existing Water Line
- Existing Sewer Line
- 2 Foot Contour
- Hydraulic Study Streams
- Parcel Boundary
- Proposed 100 Year Floodplain
- Existing 100 Year Floodplain

0 100 200
Scale (Feet)

City of Gatesville Spur Capital of Texas

MASTER DRAINAGE PLAN

FLOOD MITIGATION ALTERNATIVE

EXHIBIT D-3
STRAWS MILL ROAD LWC

Walker Partners engineers | surveyors

Project Number:	Project Name:	Flooding Source:
03	Straws Mill Road Low Water Crossing	Stream CG-2

Recommended Improvements			Location (Nearest Street Intersection)	
Buyout	Channel Improvements	Levee	From:	Rocky Branch
Detention	Structure Improvements	Other	To:	Watts

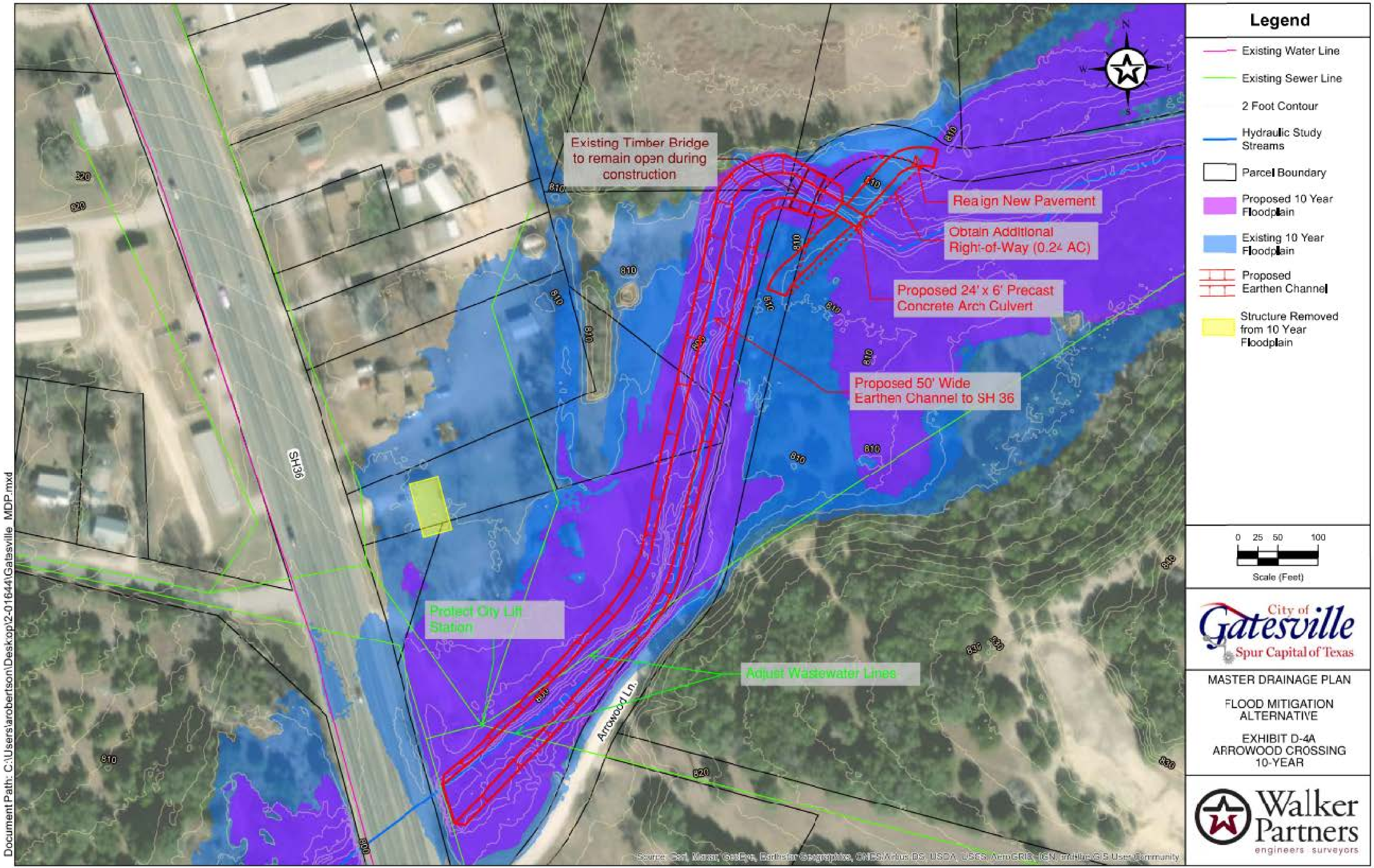
Description	Est. Qty.	Unit	Unit Price	Total
Channel & Culvert Improvements				
Mobilization, Barricades & Incidentals (15%)	1	LS	$89,000.00	$89,000.00
Stormwater Pollution Prevention Plan	1	LS	$2,400.00	$2,400.00
Stormwater Pollution Prevention Plan Implementation	1	LS	$20,000.00	$20,000.00
Broadcast Seeding	2900	SY	$2.00	$5,800.00
Curlex Blanket (Green)	2900	SY	$3.00	$8,700.00
Remove Existing Roadway Including Concrete Curb & Gutter and Sidewalk	1780	SY	$10.00	$17,800.00
Strip and Stockpile Topsoil	3620	SY	$5.00	$18,100.00
Place and Compact Earthen Embankment	6630	CY	$25.00	$165,750.00
4 - 10'x10' Reinf. Concrete Box (Class III) Including Excavation & Backfill	60	LF	$3,600.00	$216,000.00
Reinforced Concrete Headwall for 4-10'x10' RCB	2	EA	$35,000.00	$70,000.00
Channel Excavation	200	CY	$15.00	$3,000.00
Wastewater Utility Adjustment	2	EA	$5,000.00	$10,000.00
Concrete Encase Wastewater Utility	2	EA	$5,000.00	$10,000.00
8" Lime Stabilization of Existing Sub-base Material	720	SY	$7.00	$5,040.00
Hydrated Lime	14	TN	$280.00	$3,920.00
8" Cement Treated Base	720	SY	$25.00	$18,000.00
2" H.M.A.C. (Crushed 'D')	80	TN	$170.00	$13,600.00
Metal Beam Guard Fence	100	LF	$40.00	$4,000.00
Channel & Culvert Improvements Subtotal				$681,110.00
Contingency (25%)				$170,300.00
Engineering, Surveying, Management & Inspection (25%)				$170,300.00
Land Costs	0	AC	$20,000.00	$0.00
ROW Acquisition Services (6% Land Costs)				$0.00
Easement Acquisition ($0.50 per square foot)				$0.00
Easement Acquisition Services				$0.00
Total Estimated Project Cost				**$1,021,710.00**

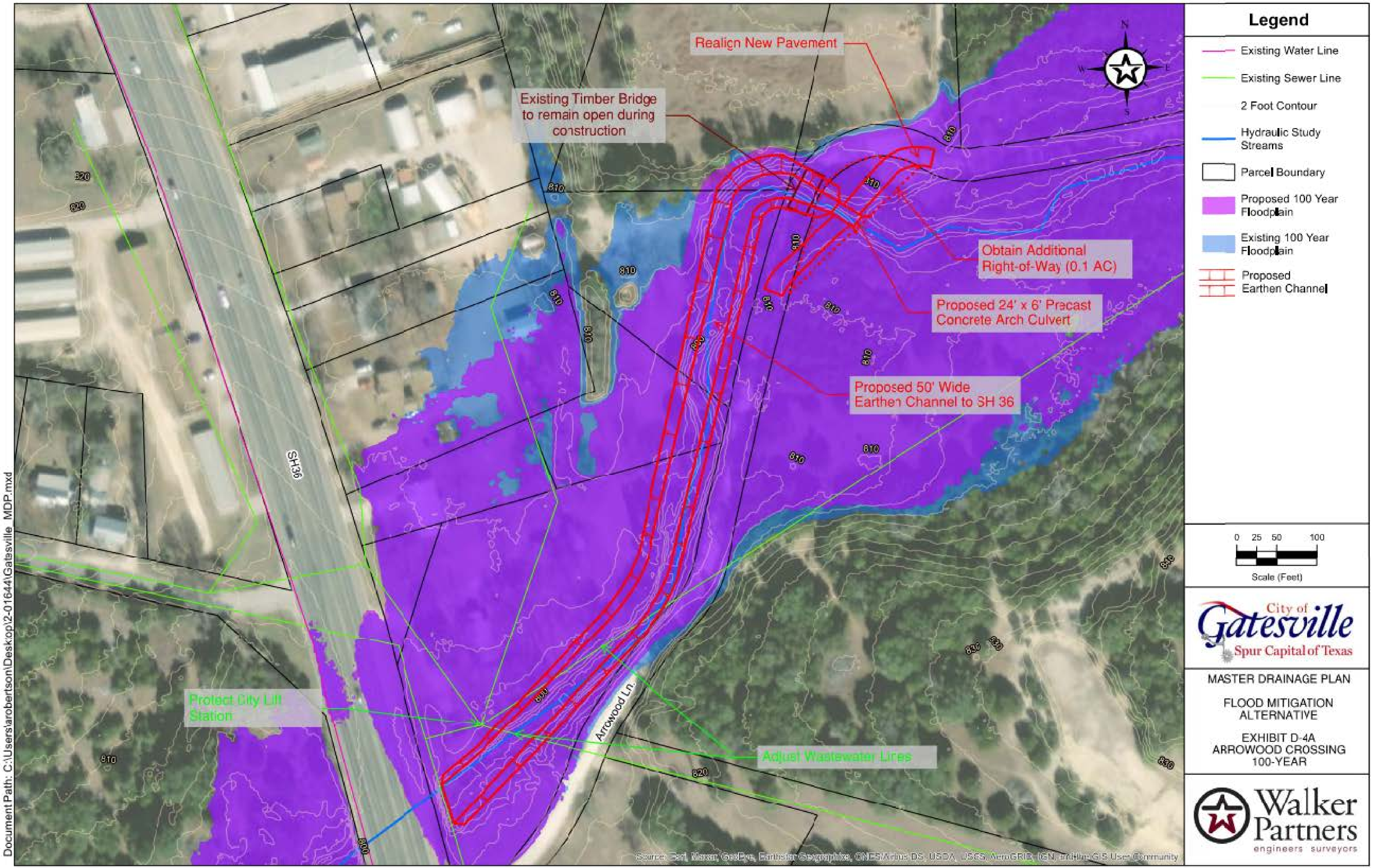
Project Description

The Straws Mill Road Low Water Crossing project includes raising the road by 10 feet and adding 4 10'x10' box culverts under the roadway to provide capacity to pass the 50-year event without overtopping.

The raised roadway ties into the existing roadway at elevation 756, and includes reconstruction of 500 feet of the street.

C.I.P. Rank:	TBD	By:	CBB	Date:	5/12/23


Legend
Existing Water Line
Existing Sewer Line
2 Foot Contour
Hydraulic Study Streams
Parcel Boundary
Proposed 10 Year Floodplain
Existing 10 Year Floodplain
Proposed Earthen Channel
Structure Removed from 10 Year Floodplain
0 25 50 100
Scale (Feet)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
FLOOD MITIGATION ALTERNATIVE
EXHIBIT D-4A ARROWOOD CROSSING 10-YEAR
Walker Partners engineers . surveyors
Existing Timber Bridge to remain open during construction
Realign New Pavement
Obtain Additional Right-of-Way (0.24 AC)
Proposed 24' x 6' Precast Concrete Arch Culvert
Proposed 50' Wide Earthen Channel to SH 36
Protect City Lift Station
Adjust Wastewater Lines
SH36
Arrowood Ln.
Document Path: C:\Users\arobertson\Desktop\2-01644\Gatesville_MDP.mxd


Realign New Pavement
Existing Timber Bridge to remain open during construction
Obtain Additional Right-of-Way (0.1 AC)
Proposed 24' x 6' Precast Concrete Arch Culvert
Proposed 50' Wide Earthen Channel to SH 36
Protect City Lift Station
Adjust Wastewater Lines
SH36
Arrowood Ln.
Legend
Existing Water Line
Existing Sewer Line
2 Foot Contour
Hydraulic Study Streams
Parcel Boundary
Proposed 100 Year Floodplain
Existing 100 Year Floodplain
Proposed Earthen Channel
0 25 50 100
Scale (Feet)
City of Gatesville Spur Capital of Texas
MASTER DRAINAGE PLAN
FLOOD MITIGATION ALTERNATIVE
EXHIBIT D-4A ARROWOOD CROSSING 100-YEAR
Walker Partners engineers surveyors
Document Path: C:\Users\arobertson\Desktop\2-01644\Gatesville_MDP.mxd

Project Number:	Project Name:	Flooding Source:
04A	Arrowood Lane Crossing Replacement	Stream CG-2

Gatesville Spur Capital of Texas
Walker Partners

Recommended Improvements			Location (Nearest Street Intersection)	
__ Buyout	. Channel Improvements	__ Levee	From:	Old Waco Road
__ Detention	. Structure Improvements	__ Other	To:	FM 107

Description	Est. Qty.	Unit	Unit Price	Total
Channel & Culvert Improvements				
Mobilization, Barricades & Incidentals (15%)	1	LS	$85,000.00	$85,000.00
Stormwater Pollution Prevention Plan	1	LS	$2,400.00	$2,400.00
Stormwater Pollution Prevention Plan Implementation	1	LS	$20,000.00	$20,000.00
Broadcast Seeding	8550	SY	$2.00	$17,100.00
Curlex Blanket (Green)	8550	SY	$3.00	$25,650.00
Remove Existing Roadway and Timber Bridge	940	SY	$10.00	$9,400.00
Strip and Stockpile Topsoil	8550	SY	$5.00	$42,750.00
Place and Compact Earthen Embankment	50	CY	$25.00	$1,250.00
24' x 6' Precast Concrete Arch Culvert Including Excavation & Backfill	30	LF	$8,000.00	$240,000.00
Precast Concrete Wingwalls for 24' x 6' Arch	2	EA	$20,000.00	$40,000.00
Channel Excavation	5,884	CY	$15.00	$88,260.00
Wastewater Utility Adjustment	2	EA	$5,000.00	$10,000.00
Concrete Encase Wastewater Utility	2	EA	$5,000.00	$10,000.00
8" Lime Stabilization of Existing Sub-base Material	940	SY	$7.00	$6,580.00
Hydrated Lime	18	TN	$280.00	$5,040.00
8" Cement Treated Base	940	SY	$25.00	$23,500.00
2" H.M.A.C. (Crushed 'D')	104	TN	$170.00	$17,680.00
Metal Beam Guard Fence	40	LF	$40.00	$1,600.00
Channel & Culvert Improvements Subtotal				**$646,210.00**
Contingency (25%)				$161,600.00
Engineering, Surveying, Management & Inspection (25%)				$161,600.00
Land Costs	0.24	AC	$50,000.00	$12,052.34
ROW Acquisition Services (6% Land Costs)				$730.00
Easement Acquisition ($0.50 per square foot)				$0.00
Easement Acquisition Services				$0.00
Total Estimated Project Cost				**$982,192.00**

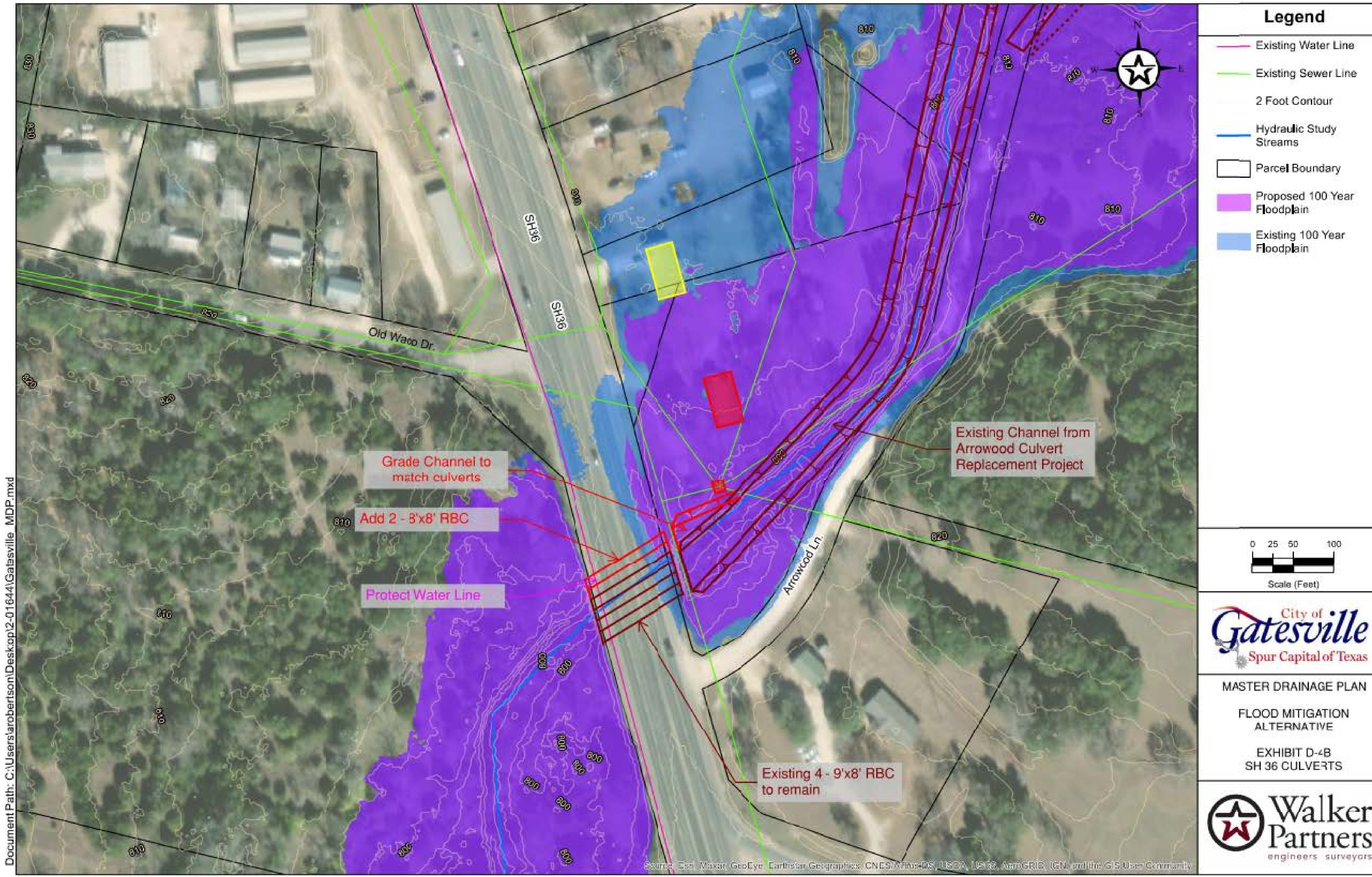
Project Description

The Arrowood Lane Crossing Replacement project includes replacing the existing timber bridge with a 24' x 6' precast concrete arch culvert to provide capacity to pass the 10-year event without overtopping and realigning the roadway roadway.

The realigned roadway ties into the existing roadway at elevation 810, and includes reconstruction of 500 feet of the street.

C.I.P. Rank:	TBD	By:	CBB	Date:	12/9/22

2-01644   C:\WP_Projects\Gatesville MDP\Report\Appendices\Full\Exhibit D-4A Arrowood Crossing - Culvert Replacement - EOPC


Legend
Existing Water Line
Existing Sewer Line
2 Foot Contour
Hydraulic Study Streams
Parcel Boundary
Proposed 100 Year Floodplain
Existing 100 Year Floodplain
0 25 50 100
Scale (Feet)
City of Gatesville
Spur Capital of Texas
MASTER DRAINAGE PLAN
FLOOD MITIGATION ALTERNATIVE
EXHIBIT D-4B
SH 36 CULVERTS
Walker Partners
engineers surveyors
SH36
Old Waco Dr.
Arrowood Ln.
Grade Channel to match culverts
Add 2 - 8'x8' RBC
Protect Water Line
Existing Channel from Arrowood Culvert Replacement Project
Existing 4 - 9'x8' RBC to remain
Document Path: C:\Users\arobertson\Desktop\2-01644\Gatesville_MDP.mxd

Project Number:	Project Name:	Flooding Source:
4B	SH 36 Culvert Improvements	Stream CG-2

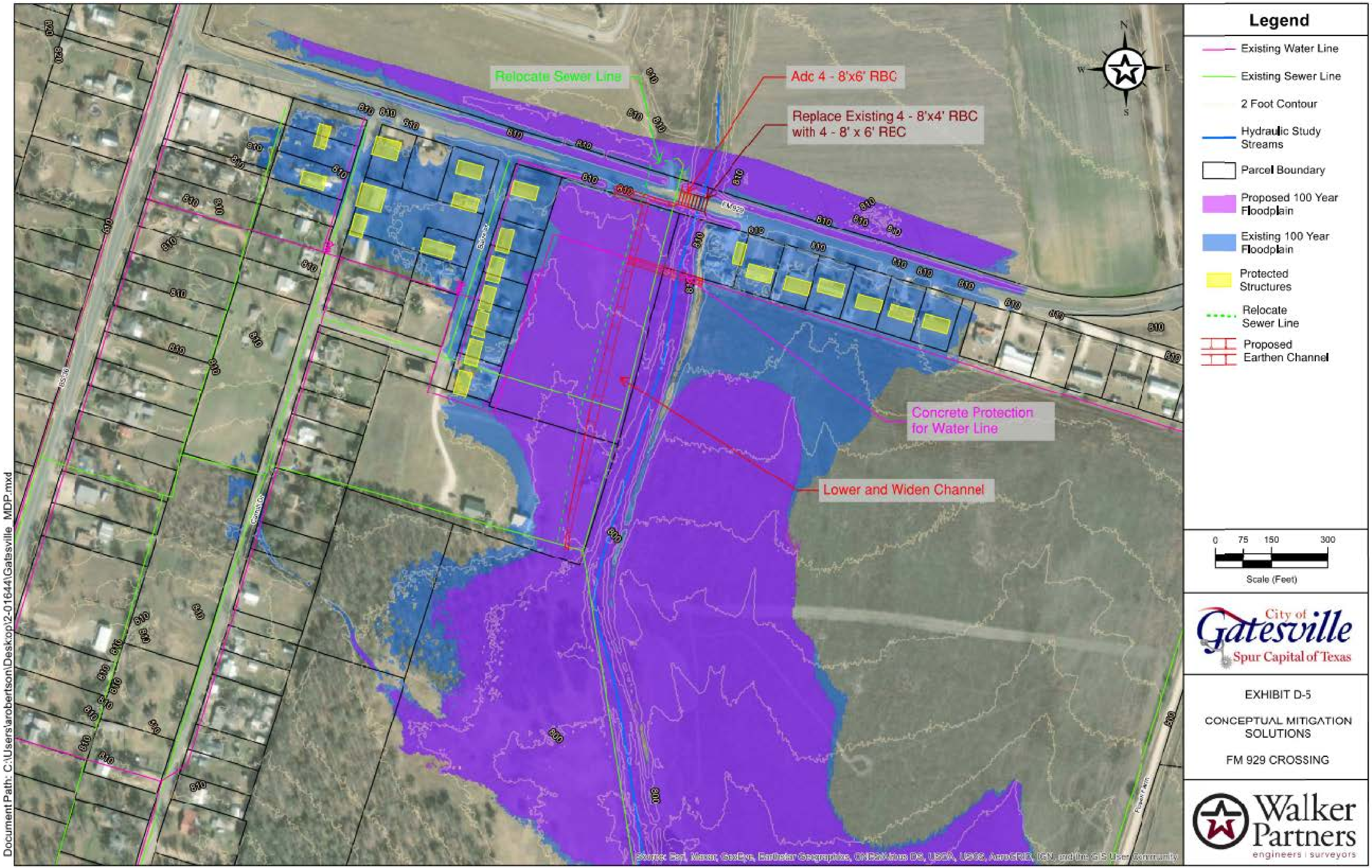
Recommended Improvements			Location (Nearest Street Intersection)	
__ Buyout	- Channel Improvements	__ Levee	From:	Old Waco Drive
__ Detention	- Structure Improvements	__ Other	To:	FM 170

Description	Est. Qty.	Unit	Unit Price	Total
Channel & Culvert Improvements				
Mobilization, Barricades & Incidentals (15%)	1	LS	$29,000.00	$29,000.00
Stormwater Pollution Prevention Plan	1	LS	$2,400.00	$2,400.00
Stormwater Pollution Prevention Plan Implementation	1	LS	$10,000.00	$10,000.00
Broadcast Seeding	0	SY	$2.00	$0.00
Curlex Blanket (Green)	0	SY	$3.00	$0.00
Remove Existing Roadway	140	SY	$10.00	$1,400.00
Strip and Stockpile Topsoil	0	SY	$5.00	$0.00
Place and Compact Earthen Embankment	0	CY	$25.00	$0.00
2 - 8'x8' Reinf. Concrete Box (Class III) Including Excavation & Backfill	60	LF	$1,600.00	$96,000.00
Reinforced Concrete Headwall for 2-8'x8' RCB	2	EA	$20,000.00	$40,000.00
Channel Excavation	20	CY	$15.00	$300.00
Protect Waste Line	1	EA	$10,000.00	$10,000.00
Concrete Encase Water Utility	1	EA	$20,000.00	$20,000.00
8" Lime Stabilization of Existing Sub-base Material	140	SY	$7.00	$980.00
Hydrated Lime	3	TN	$280.00	$840.00
8" Cement Treated Base	140	SY	$25.00	$3,500.00
2" H.M.A.C. (Crushed 'D')	16	TN	$170.00	$2,720.00
Metal Beam Guard Fence	40	LF	$40.00	$1,600.00
Channel & Culvert Improvements Subtotal				**$218,740.00**
Contingency (25%)				$54,700.00
Engineering, Surveying, Management & Inspection (25%)				$54,700.00
Land Costs	0	AC	$20,000.00	$0.00
ROW Acquisition Services (6% Land Costs)				$0.00
Easement Acquisition ($0.50 per square foot)				$0.00
Easement Acquisition Services				$0.00
Total Estimated Project Cost				**$328,140.00**

Project Description

At the crossing of SH 36 and Stream CG-2, the existing 4 - 9'x8' box culverts have sufficient capacity to pass the 100-year flows, but flow accumulates on the upstream side that floods 2 residential structures. The upstream WSEL can be lowered by adding 2 additional 8'x8' box culverts under SH 36, removing one of the two structures from the 100-year floodplain.

C.I.P. Rank: TBD	By: CBB	Date: 12/9/22	


Relocate Sewer Line
Add 4 - 8'x6' RBC
Replace Existing 4 - 8'x4' RBC with 4 - 8' x 6' RBC
Concrete Protection for Water Line
Lower and Widen Channel
Legend
Existing Water Line
Existing Sewer Line
2 Foot Contour
Hydraulic Study Streams
Parcel Boundary
Proposed 100 Year Floodplain
Existing 100 Year Floodplain
Protected Structures
Relocate Sewer Line
Proposed Earthen Channel
0 75 150 300
Scale (Feet)
City of Gatesville Spur Capital of Texas
EXHIBIT D-5
CONCEPTUAL MITIGATION SOLUTIONS
FM 929 CROSSING
Walker Partners engineers | surveyors
Document Path: C:\Users\arobertson\Desktop\2-01644\Gatesville_MDP.mxd

Project Number:	Project Name:	Flooding Source:
5	FM 929 Culvert and Channel Improvements	Stream CG-4

Gatesville Spur Capital of Texas — Walker Partners

Recommended Improvements			Location (Nearest Street Intersection)	
__ Buyout	_·_ Channel Improvements	__ Levee	From:	Baize Drive
__ Detention	_·_ Structure Improvements	__ Other	To:	Powell Farm Road

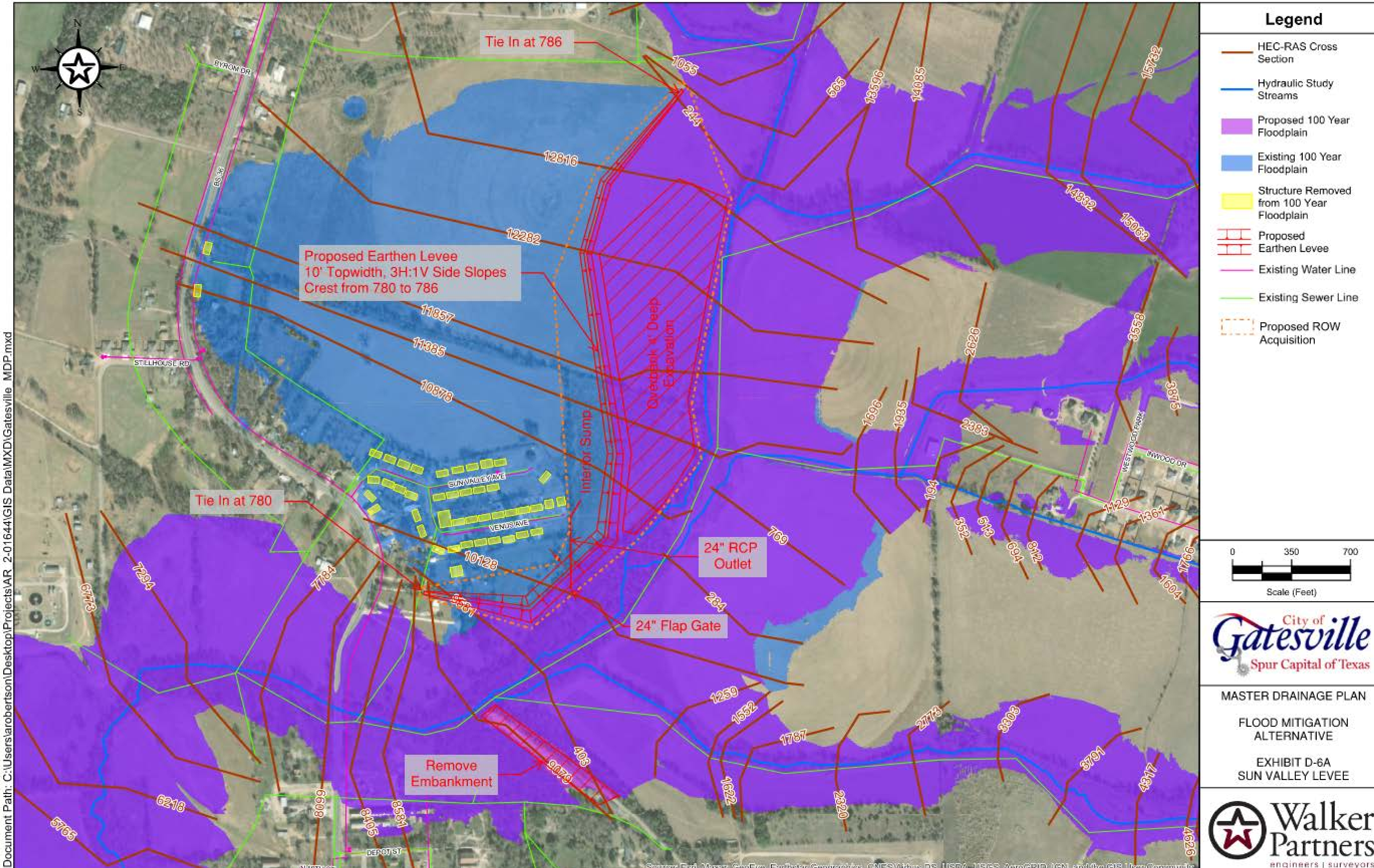
Description	Est. Qty.	Unit	Unit Price	Total
Channel & Culvert Improvements				
Mobilization, Barricades & Incidentals (15%)	1	LS	$126,000.00	$126,000.00
Stormwater Pollution Prevention Plan	1	LS	$2,400.00	$2,400.00
Stormwater Pollution Prevention Plan Implementation	1	LS	$20,000.00	$20,000.00
Broadcast Seeding	0	SY	$2.00	$0.00
Curlex Blanket (Green)	0	SY	$3.00	$0.00
Remove Existing Roadway	290	SY	$10.00	$2,900.00
Strip and Stockpile Topsoil	0	SY	$5.00	$0.00
Place and Compact Earthen Embankment	2770	CY	$25.00	$69,250.00
8 - 8'x6' Reinf. Concrete Box (Class III) Including Excavation & Backfill	60	LF	$6,400.00	$384,000.00
Reinforced Concrete Headwall for 8-8'x6' RCB	2	EA	$20,000.00	$40,000.00
Channel Excavation	15,820	CY	$15.00	$237,300.00
Relocate Wastewater Line	1	EA	$50,000.00	$50,000.00
Concrete Encase Water Utility	1	EA	$10,000.00	$10,000.00
8" Lime Stabilization of Existing Sub-base Material	290	SY	$7.00	$2,030.00
Hydrated Lime	6	TN	$280.00	$1,680.00
8" Cement Treated Base	290	SY	$25.00	$7,250.00
2" H.M.A.C. (Crushed 'D')	32	TN	$170.00	$5,440.00
Metal Beam Guard Fence	40	LF	$40.00	$1,600.00
Channel & Culvert Improvements Subtotal				$959,850.00
Contingency (25%)				$240,000.00
Engineering, Surveying, Management & Inspection (25%)				$240,000.00
Land Costs	4.5	AC	$20,000.00	$90,000.00
ROW Acquisition Services (6% Land Costs)				$5,400.00
Easement Acquisition ($0.50 per square foot)				$0.00
Easement Acquisition Services				$0.00
Total Estimated Project Cost				**$1,535,250.00**

Project Description

At the crossing of FM 929 and Stream CG-4, the existing 4 - 8'x4' box culverts do not have sufficient capacity to pass the 100-year flows. The roadway is very flat, and it acts like a flow spreader distributing the overflows across 3 blocks downstream flooding 19 insurable structures before flow can make its way back to the Stream CG-4 channel.

The FM 929 Culvert and Channel Improvements project includes replacing the existing culverts with 4-8'x6' box culverts and the addition of 4-8'x6' box culverts under the roadway to provide capacity to pass the 100-year event without overtopping, along with channel improvements with a bottom width of 120 feet extending 1,300 feet downstream to lower the channel flowline by 2 feet at FM 929, increase channel capacity and lower the tailwater.

C.I.P. Rank:	TBD	By: CBB	Date: 12/9/22


Legend
HEC-RAS Cross Section
Hydraulic Study Streams
Proposed 100 Year Floodplain
Existing 100 Year Floodplain
Structure Removed from 100 Year Floodplain
Proposed Earthen Levee
Existing Water Line
Existing Sewer Line
Proposed ROW Acquisition
0 350 700
Scale (Feet)
City of Gatesville
Spur Capital of Texas
MASTER DRAINAGE PLAN
FLOOD MITIGATION ALTERNATIVE
EXHIBIT D-6A
SUN VALLEY LEVEE
Walker Partners
engineers | surveyors
Tie In at 786
Proposed Earthen Levee
10' Topwidth, 3H:1V Side Slopes
Crest from 780 to 786
Overbank 4' Deep Excavation
Interior Sump
Tie In at 780
24" RCP Outlet
24" Flap Gate
Remove Embankment
SUN VALLEY AVE
VENUS AVE
STILLHOUSE RD
BYROM DR
DEPOT ST
Document Path: C:\Users\arobertson\Desktop\Projects\AR 2-01644\GIS Data\MXD\Gatesville MDP.mxd

Project Number:	Project Name:	Flooding Source:
6A	Sun Valley Neighborhood Levee Improvements	Stillhouse Branch

Gatesville Spur Capital of Texas — Walker Partners

Recommended Improvements			Location (Nearest Street Intersection)	
Buyout	Channel Improvements	Levee	From:	Sun Valley Avenue
Detention	Structure Improvements	Other	To:	Venus Avenue

Description	Est. Qty.	Unit	Unit Price	Total
Channel & Culvert Improvements				
Mobilization, Barricades & Incidentals (5%)	1	LS	$49,000.00	$49,000.00
Stormwater Pollution Prevention Plan	1	LS	$2,400.00	$2,400.00
Stormwater Pollution Prevention Plan Implementation	1	LS	$20,000.00	$20,000.00
Broadcast Seeding	15400	SY	$2.00	$30,800.00
Curlex Blanket (Green)	15400	SY	$3.00	$46,200.00
Strip and Stockpile Topsoil	16100	SY	$5.00	$80,500.00
Place and Compact Earthen Embankment	17600	CY	$15.00	$264,000.00
Unclassified Overbank Excavation	69800	CY	$6.00	$418,800.00
Unclassified Embankment Excavation	7407	CY	$12.00	$88,884.00
Water Utility Adjustment	0	EA	$15,000.00	$0.00
Wastewater Utility Adjustment	0	EA	$5,000.00	$0.00
Concrete Encase Wastewater Utility	0	EA	$5,000.00	$0.00
24" RCP (Class III) Including Excavation & Backfill	60	LF	$250.00	$15,000.00
Install 24" Flap Gate	1	EA	$2,500.00	$2,500.00
Channel & Culvert Improvements Subtotal				**$1,018,084.00**
Contingency (25%)				$254,500.00
Engineering, Surveying, Management & Inspection (25%)				$254,500.00
Land Costs	3.17	AC	$20,000.00	$63,400.00
ROW Acquisition Services (6% Land Costs)				$3,810.00
Easement Acquisition ($0.50 per square foot)				$0.00
Easement Acquisition Services				$0.00
Total Estimated Project Cost				**$1,594,294.00**

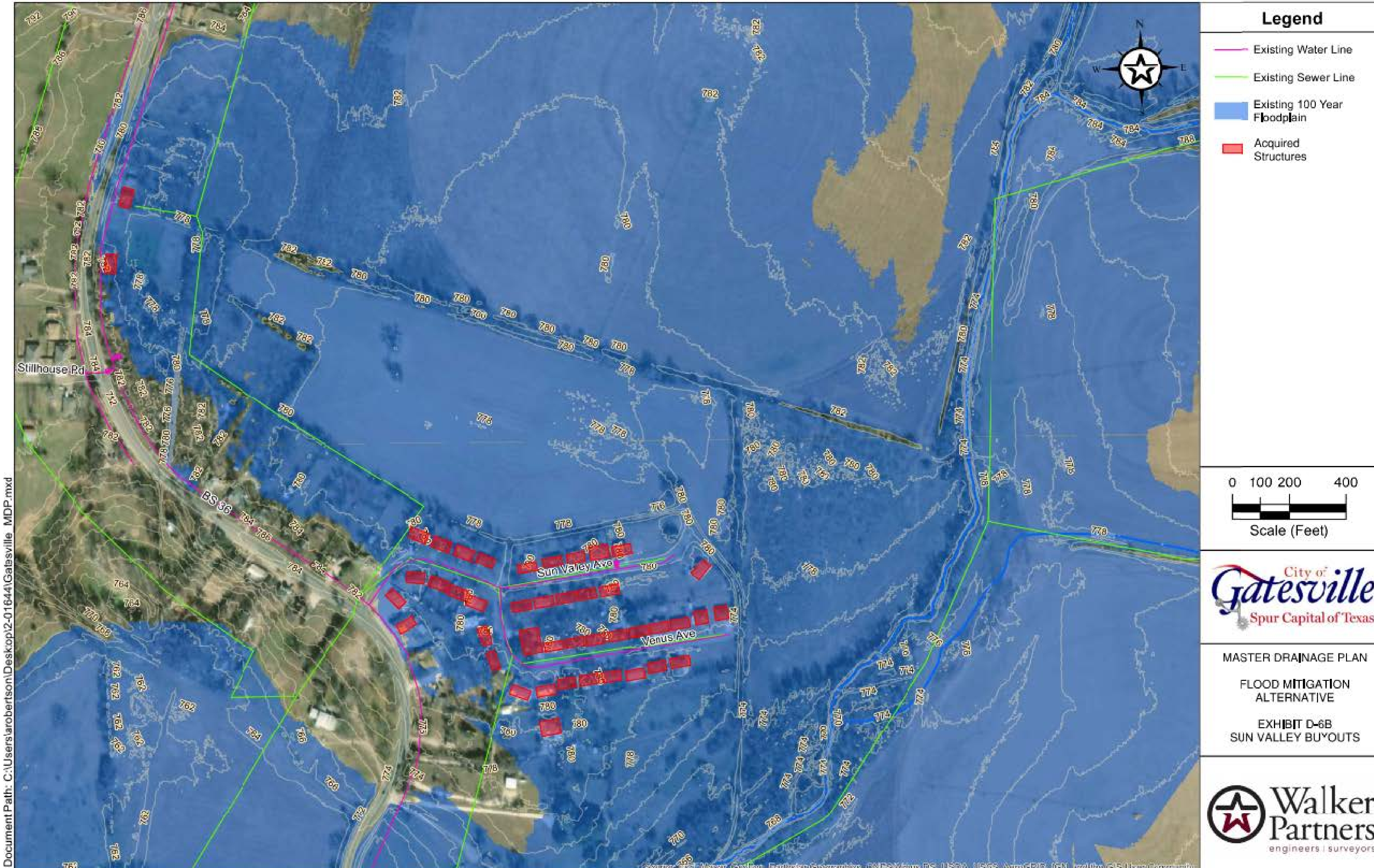
Project Description

The Sun Valley Neighborhood Buyouts project includes the buyout of 45 residential properties along Sun Valley Avenue, Venus Avenue and State School Road. Upstream of the State School Road bridge, flow in the right overbank of Stillhouse Branch spreads out over a large agricultural area and inundated 2 blocks of houses in the Sun Valley neighborhood, as well as several houses along State School Road.

The west end of the earthen levee ties into natural ground at elevation 780, and wraps around the neighborhood for 4,000 feet to tie back into high ground at elevation 786 behind 410 State School Road. The interior sump area is drained by 24" RCP pipe that runs over to an existing drainage ditch and underneath the levee to an existing outfall channel where it discharges through a 24" flap gate into Stillhouse Branch.

C.I.P. Rank:	TBD	By:	CBB	Date:	5/12/23

Document Path: C:\Users\arobertson\Desktop\2-01644\Gatesville_MDP.mxd



Project Number:	Project Name:	Flooding Source:
6B	Sun Valley Neighborhood Buyouts	Stillhouse Branch

Gatesville Spur Capital of Texas
Walker Partners

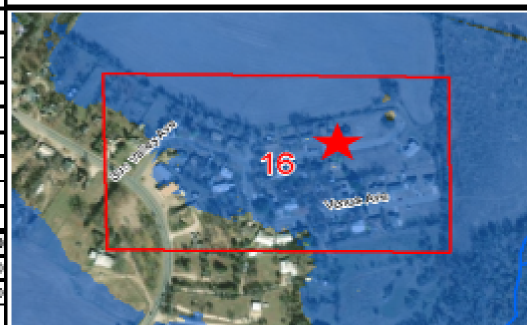
Recommended Improvements			Location (Nearest Street Intersection)	
X Buyout	_ Channel Improvements	_ Levee	From:	Sun Valley Avenue
_ Detention	_ Structure Improvements	_ Other	To:	Venus Avenue

Description	Est. Qty.	Unit	Unit Price	Total
Property Buyouts				
Land Costs				$8,753,115.00
ROW Acquisition Services (6% Land Costs)				$525,190.00
Easement Acquisition ($0.50 per square foot)				$0.00
Easement Acquisition Services				$0.00
Channel & Culvert Improvements Subtotal				**$9,278,305.00**
Contingency (20%)				$1,855,700.00
Engineering, Surveying, Management & Inspection (25%)				$0.00
Total Estimated Project Cost				**$11,134,005.00**

Project Description

The Sun Valley Neighborhood Buyouts project includes the buyout of 45 residential properties along Sun Valley Avenue, Venus Avenue and State School Road. Upstream of the State School Road bridge, flow in the right overbank of Stillhouse Branch spreads out over a large agricultural area and inundated 2 blocks of houses in the Sun Valley neighborhood, as well as several houses along State School Road. The second alternative evaluated to mitigate this flood risk is the acquisition of these 45 structures.

The cost associated with the buyout of each property includes the appraisal and closing costs, demolition and disposal of the structure including hazardous materials (e.g. asbestos, lead paint), restoration of the lot to open space, and any difference between appraised and fair market value of the house.



C.I.P. Rank:	TBD	By:	CBB	Date:	12/9/22

2-01644 C:\WP_Projects\Gatesville MDP\Report\Appendices\Full\Exhibit D-6B Sun Valley Neighborhood - Buyout Alternative - EOPC

Appendix E – Digital Data on TWDB FIF Category 1 Project One-Drive

40021_Gatesville_Master_Drainage_Plan
- **01_TechnicalReport**
  - **01_Final**
    - **Final Report.pdf, Final Report.doc**
- **02_Models**
  - **01_Hydrologic**
    - **08_40021_HECHMSVer4.9_Leon_River_Basin**
  - **02_Hydraulic**
    - **08_40021_HECRASVer6.2_Leon_River_Basin**
- **03_GIS**
  - **01_ElevationData**
  - **02_ShpFiles**
    - **08_40021_GatesvilleMDP.gdb, utilities**
  - **03_MapsandFigures**
    - **Gatesville_MDP.mxd**
- **04_Supporting**
  - **01 Public_Outreach**
  - **02 References**
    - **LIDAR QC Report, Leon WPP, etc.**
  - **03 USACE**
    - **Leon River RAS original**