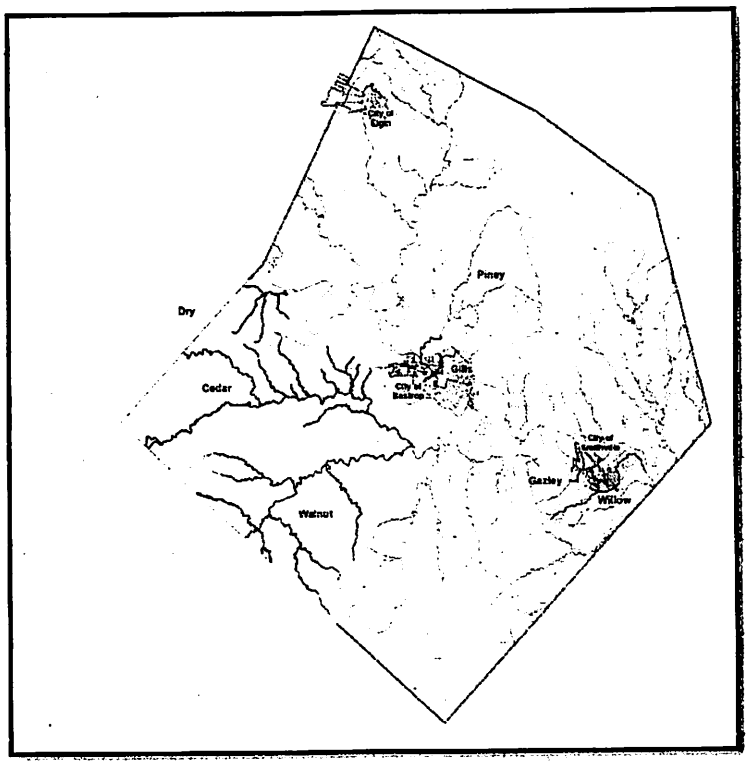
Bastrop County
Flood Protection Planning Studies
FINAL SUMMARY REPORT

Prepared for:

Bastrop County
City of Bastrop
City of Smithville
Texas Water Development Board



Prepared by:

Halff Associates Inc.

9500 Amberglen Blvd., Bldg. F, Ste. 125
Austin, Texas 78729
TBPE Firm #312

JUNE 2018

AVO 30601

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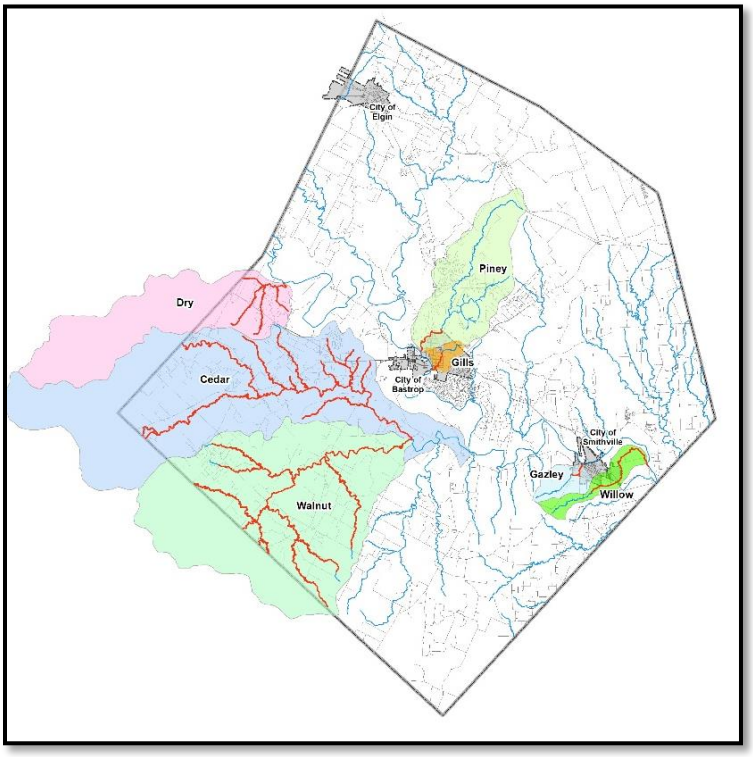

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Texas Water Development Board

P.O. Box 13231, 1700 N. Congress Ave.
Austin, TX 78711-3231, www.twdb.texas.gov
Phone (512) 463-7847, Fax (512) 475-2053

Ms. Carolyn Dill, PE
County Engineer
Bastrop County
211 Jackson Street
Bastrop, TX 78602

RE: Flood Protection Planning Contract with Bastrop County, Contract Nos. 0848322056 and 0804830834, Comments on Draft Report Entitled "Bastrop County Flood Protection Planning Studies (Bastrop County, City of Bastrop, City of Smithville)"

Dear Ms. Dill:

Staff members of the Texas Water Development Board (TWDB) have completed a review of the draft report prepared under the above-referenced contracts. ATTACHMENT 1 provides the comments resulting from this review. As stated in the TWDB contracts, Bastrop County will consider revising the final report in response to comments from the Executive Administrator and other reviewers. In addition, Bastrop County will include a copy of the Executive Administrator's draft report comments in the Final Report.

Please note: The TWDB logo should not be used in your Final Report.

The TWDB looks forward to receiving one (1) electronic copy of the entire Final Report in Portable Document Format (PDF) and five (5) bound double-sided copies. **Please further note, that in compliance with Texas Administrative Code Chapters 206 and 213 (related to Accessibility and Usability of State Web Sites), the digital copy of the final report must comply with the requirements and standards specified in statute. For more information, visit http://www.sos.state.tx.us/tac/index.shtml.** If you have any questions on accessibility, please contact David Carter with the Contract Administration Division at (512) 936-6079 or David.Carter@twdb.texas.gov.

Bastrop County shall also submit one (1) electronic copy of any computer programs or models, and, if applicable, an operations manual developed under the terms of this Contract.

If you have any questions or need any further information, please feel free to contact Ms. Kathy Hopkins of TWDB's Flood Mitigation Planning staff at 512-463-6198 or kathy.hopkins@twdb.texas.gov.

Sincerely,

John T. Dupnik, P.G.
Deputy Executive Administrator
Water Science and Conservation

Date: 2-28-19

Attachment

c w/o att.: Kathy Hopkins, Flood Mitigation Planning

Attachment 1

Bastrop County Flood Protection Planning Study
Cities of Bastrop and Smithville, and Bastrop County
TWDB Contract Nos. 0848322056 and 0804830834
Texas Water Development Board Comments to Draft Report

REQUIRED CHANGES

General Draft Report Comments:

In general, the study follows standard methodologies and practice. Mitigation alternatives identified may be eligible for funding under the Texas Water Development Board's financial assistance programs. Application requirements and eligibility criteria are identified by Texas Water Development Board rules specified in Section 363 of the Texas Administrative Code (TAC). The report would be appropriate for use in support of an application to the Board for financing the proposed improvements. All additional information required by Board rules, 31 TAC 363.401-404, as well as necessary information to make legal findings as required by Texas Water Code chapter 17.771-776, would be required at the time of the loan application.

Please conduct a final edit of the document for grammar, spelling, typographical errors, and inconsistent usage of acronyms, and abbreviations. Please spell out all acronyms, with the acronym in parentheses, the first time they are used. Please include a list of acronyms used in the report after the Table of Contents.

Specific Draft Report Comments:

1. (All Annexes) Explain the reasons the two routing methods (Muskingum-Cunge and Modified Puls) were applied for different reaches.

2. Annex 4, Dry Creek
   Appendix A.1, the two profiles show flow over bank even for a 2-yr event along entire length, but cross-sections show all high frequency floods (for example, 2-yr, 5-yr) are well within the channels. Please explain the contradictions.

   Also, please provide an explanation of the colored areas in the cross-sections (for example, page 1 in Appendix A.5, right below the 2nd profile). Same question for cross-section graphs in other hydraulic reports.

3. Annex 6, Willow Creek and Gazley Creek
   Page 11, "Modified Puls method was applied to route the hydrographs for the main channels of Willow Creek and Gazley Creek where detailed hydraulic models were developed". Please explain why Modified Puls was used for channel routing if detailed hydraulic models have been developed.

4. Annex 8, Piney Creek
   Page 7, "The Piney Creek watershed has a median percent sand soil value of 0% resulting in a subbasin average initial loss of 1.11 inches, only slightly higher than the default rate of 0.75 inches for Clay soils." This is confusing. Please explain (1) what "median percent sand soil value of 0%" means; (2) if this is for 1% storm; (3) 1.11 inches is greater than the sand initial loss (assuming 1% storm). A soil either with 0% or median percent sand cannot have initial loss rate this high.

   Annex 8, Appendix I (PDF version) – The table of contents does not list "Appendix I" as "Environmental Constraints", it is listed as "Electronic Data".

   Annex 8, Appendix J (PDF version) – "Electronic Data" should be listed as "Appendix J", not "Appendix I".

March 8, 2019 AVO 30601

Kathy Hopkins, CFM, CTCM
Mitigation Specialist - Texas Water Development Board
1700 North Congress Ave.
Austin, Texas 78711-3231
Sent via email.

RE: Bastrop County Flood Protection Planning Study – Comment Response
TWDB Contract Nos. 0848322056, 0804830834, and 0704830725

Dear Kathy Hopkins,

Halff Associates, Inc. (Halff) is sending this letter in response to Texas Water Development Board (TWDB) review comments of the Bastrop County Flood Protection Planning reports for the above referenced TWDB contracts. The following TWDB review comments were received by the County on February 19, 2019 and are included for reference along with Halff's response.

TWDB Specific Draft Report Comments:

1. (All Annexes) Explain the reasons the two routing methods (Muskingum-Cunge and Modified Puls) were applied for different reaches.

   Response: Muskingum-Cunge channel routing is used for areas along a creek where detailed hydraulic models are not available to estimate channel attenuation. The Muskingum-Cunge approach estimates storage and channel attenuation using a single channel cross-section to represent the routing reach. Modified Puls channel routing utilizes detailed hydraulic models with an array of discharges to calculate channel attenuation and storage. The Modified Puls channel routing is considered a more comprehensive routing approach as it is based on multiple hydraulic cross-sections representing geometric changes along a routing reach.

2. Annex 4, Dry Creek

   Appendix A.1, the two profiles show flow over bank even for a 2-yr event along entire length, but cross-sections show all high frequency floods (for example, 2-yr, 5-yr) are well within the channels. Please explain the contradictions.

   Response: Appendix A.1 page 2 and 3 display water surface elevation and left/right overbank profiles along Dry Creek in Bastrop County. The left/right overbank profiles are based on the Bank Stations placed in each of the hydraulic cross-sections. In this study, the Bank Stations are located in the channel to represent the section of the channel that has a lower roughness coefficient as observed by field reconnaissance and review of aerial imagery. The Dry Creek East cross-sections on pages 4-27 show the computed water surface elevations to be contained within the higher channel. It

should also be noted that the hydraulic cross-sections are displayed with an exaggerated vertical scale for reporting purposes.

Also, please explain what the colored areas in cross-sections (for example, page 1 in Appendix A.5, right below the 2nd profile). Same question for cross-section graphs in other hydraulic reports.

Response: The cross-section layout page in question is included to show how the cross-sections are spatially modeled. The colored areas in the cross-section layouts (example: A.5, page 1) are described below.

- *Blue Lines: Is the stream centerline*
- *Black Arrow: Indicates flow direction*
- *Green Lines: Indicate the hydraulic cross-section layout*
- *Red Dots: indicate the bank station locations*
- *Green Triangles: Indicate ineffective area locations*
- *Thick Black Lines along Cross-Section: Indicate blocked obstruction locations*
- *Grey Areas with Black Outline between Cross-Sections: Indicate creek crossings (culverts/bridges) or inline weirs. If the cross-sections are located in close proximity, this grey area appears like a black line.*

The colored areas in the hydraulic cross-sections (example: A.5, pages 4-11) are described below.

- *Black Lines (thick): Indicates the ground profile of the cross-section*
- *Red Dots: indicate the bank station locations*
- *Blue, Red, Neon Green, Turquoise Solid and Dash Lines: Indicate water surface elevations for the respective frequency events*
- *Green Lines with Triangles: Indicate ineffective area extents*
- *Green Hatch Area: Indicates ineffective areas*
- *Black Areas: Indicate blocked obstruction areas*
- *Grey Areas with Black Outline: Indicate creek crossings (culverts/bridges) or inline weirs. This is generally the roadway deck, piers, embankments, roadway railing, top of dam, or top of an inline structure.*

3. Annex 6, Willow Creek and Gazley Creek

Page 11, "Modified Puls method was applied to route the hydrographs for the main channels of Willow Creek and Gazley Creek where detailed hydraulic models were developed". Please explain why use Modified Puls for channel routing if detailed hydraulic models have been developed.

Response: Similar to comment 1 response, Modified Puls channel routing is considered a more comprehensive routing approach as it is based on multiple hydraulic cross-sections representing geometric changes along a routing reach. Since hydraulic models were developed along the main stem of both Willow and Gazley Creeks, these

hydraulic models were utilized to develop a discharge versus volume (storage) relationship for each routing reach. Once the channel routing relationships are developed using the hydraulic model, those relationships are entered into the hydrologic model to calculate runoff.

4. Annex 8, Piney Creek

   Page 7, "The Piney Creek watershed has a median percent sand soil value of 0% resulting in a subbasin average initial loss of 1.11 inches, only slightly higher than the default rate of 0.75 inches for Clay soils." This is confusing. Please explain (1) what "median percent sand soil value of 0%" means; (2) if this is for 1% storm; (3) 1.11 inches is greater than the sand initial loss (assuming 1% storm). A soil either with 0% or median percent sand cannot have initial loss rate this high.

   Response: (1) On a subbasin scale, a 0% median sand soil value represent a subbsain with soils comprised of high impermeable clayey soils. The soils in the Piney Creek watershed are predominately clay as displayed in Appendix B-2 exhibit.
   (2) The median percent sand value is specific for the 1% annual chance storm event.
   (3) The subbasin average initial loss is incorrectly reported as 1.11 inches. The sentence will be corrected to: "The Piney Creek watershed is predominately composed of clay soils with a median 0% sand value resulting in an average initial loss of 0.86 inches, only slightly higher than the default rate of 0.75 inches for Clay soils."

   Annex 8, Appendix I (PDF version) – The table of contents does not list "Appendix I" as "Environmental Constraints", it is listed as "Electronic Data".
   Response: This has been corrected.

   Annex 8, Appendix J (PDF version) – "Electronic Data" should be listed as "Appendix J", not "Appendix I".
   Response: This has been corrected.

In addition, Halff is pleased to submit the Final Summary Report for the Bastrop County Flood Protection Planning Study. Enclosed with this letter is a thumb drive containing PDF files of the Final Summary Report along with nine (9) Annex study reports summarized below:

Final Summary Report
Annex 1: LiDAR Acquisition
Annex 2: Cedar Creek Hydrology
Annex 3: Cedar Creek Hydraulics
Annex 4: Dry Creek Hydraulics
Annex 5: Cedar Creek and Dry Creek Alternatives
Annex 6: Willow Creek and Gazley Creek Flood Protection Planning Study
Annex 7: Walnut Creek Flood Protection Planning Study
Annex 8: Piney Creek Flood Protection Planning Study
Annex 9: Gills Branch Flood Protection Planning Study

Please do not hesitate to contact me at (512) 777-4547 or email me at pMorales@halff.com if you have any questions. Halff appreciates working with Bastrop County and the TWDB on the Flood Protection Planning study which will help to reduce flood risk.

Sincerely,
HALFF ASSOCIATES, INC.

Paul Morales, PE, CFM, CPESC

Copy:
Carolyn Dill, PE (Bastrop County)

SUMMARY REPORT
BASTROP COUNTY FLOOD PROTECTION PLANNING STUDY

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Bastrop County Interim Feasibility Study Cedar Creek, Technical Report Notebook Engineering Analysis – Hydraulics, Dry Creek, Moss Branch, Red Gully Creek, Cottonwood Creek, and Tributary 4 (pdf)

APPENDIX A. HEC-RAS RESULTS – PROFILES AND CROSS-SECTIONS

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ANNEX 9 – PHASE 4: GILLS BRANCH FLOOD PROTECTION PLANNING STUDY

Bastrop County Flood Protection Planning Study – Gills Branch (pdf)

APPENDIX A. COMPUTED PEAK DISCHARGE
- A.1. Computed Subbasin Discharge
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PROJECT INTRODUCTION

This report summarizes and compiles engineering work submitted for the Bastrop County Flood Protection Planning Studies. The multiple reports, models, analysis, mapping and supporting data from this multi-phase effort are included in ANNEX 1 through ANNEX 9 of this report.

Upon award of a Texas Water Development Board (TWDB) Flood Protection Planning Grant in 2007, Bastrop County began a phased county-wide drainage study in partnership with TWDB and the U. S. Army Corps of Engineers (USACE). Between 2007 and 2010 LiDAR data collection, hydrology, and hydraulic studies were completed for selected streams within the Cedar Creek, Dry Creek watersheds and development of alternative. The study was to proceed in a phased progression encompassing several watersheds throughout the County. However, in September 2010 wildfires devastated Bastrop County diverting county funding and attention away from the drainage study. The agreement between the County and the USACE ended after completion of alternatives formulation for Cedar Creek and Dry Creek watersheds in December 2012.

In September 2014, Bastrop County and the City of Smithville added Willow Creek and Gazley Creeks to the Bastrop County Flood Protection Planning Grant. During the 2015 Memorial Day storm event, the City of Smithville received 8 inches of rainfall causing extensive street flooding and structure flooding of approximately 20 homes within the City. The City of Smithville is extended the scope to include development of a two-dimensional (2D) model to create a comprehensive study of Willow and Gazley Creeks and it's affects to the City's drainage infrastructure.

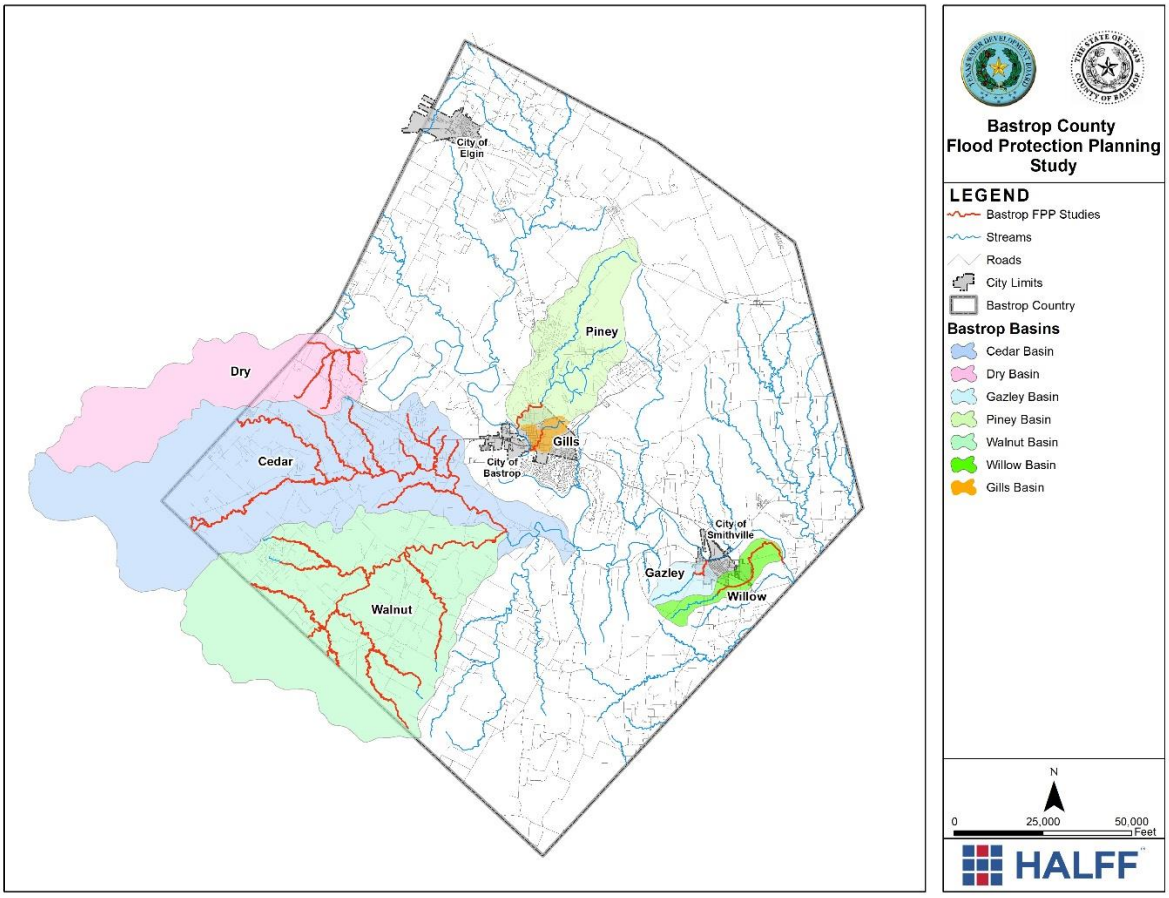
In April 2016, Bastrop County and the City of Bastrop incorporated additional analysis of Piney Creek and Gills Branch. During the 2015 Memorial Day storm event, the City experienced significant flooding in the Gills Branch watershed and roadway overtopping along Gills Branch and Piney Creek.

The image on the next page identifies the watershed studies conducted as part of the Bastrop County FPP and the following summarizes the phases associated to the detailed ANNEX for each of the watershed studies.

Phase 1A – County-Wide LiDAR

In 2007, Bastrop County initiated Phase 1A which established a working relationship with the participating entities and acquired county-wide Light Detection and Ranging (LiDAR) terrain data to be used in subsequent phases to develop H&H analysis. Cooperating partners in the effort included the Capital Area Council of Governments (CAPCOG) and Texas Natural Resources Information System (TNRIS).

See **ANNEX 1** of this summary report for all detailed LiDAR reports and supporting data submitted for Phase 1A.



Phase 1B – Cedar Creek and Dry Creek

Under the direction of the USACE, Halff Associates, Inc. (Halff) initiated Phase 1B, which included new hydrologic and hydraulic (H&H) studies of Cedar Creek and Dry Creek. Halff performed the new H&H analysis of Dry Creek, Cedar Creek, and their tributaries including Maha Creek. This study also included the identification of flood damages, evaluation of alternatives to reduce damages, and recommendation of flood damage reduction improvements, which meet state and federal criteria. Finally, upon completion of the studies, a preliminary report was prepared to describe the flood damage reduction improvements for Cedar Creek and Dry Creek watersheds.

See **ANNEX 2** for the *Cedar Creek Watershed – Hydrology Engineering Analysis* for a detailed report and supporting data submitted for Phase 1B.

See **ANNEX 3** for the *Cedar Creek, Lytton Springs Creek, Maha Creek, Greens Creek, and Long Branch South – Hydraulics Engineering Analysis* for a detailed report and supporting data submitted for Phase 1B.

See **ANNEX 4** for the *Dry Creek, Moss Branch, Red Gully Creek, Cottonwood Creek, and Tributary 4 – Hydraulics Engineering Analysis* for a detailed report and supporting data submitted for Phase 1B.

See **ANNEX 5** for the *Cedar Creek and Dry Creek Watersheds – Flood Reduction Alternatives Engineering Analysis* for a detailed report and supporting data submitted for Phase 1B.

Phase 2 – Walnut Creek

In 2010 preliminary hydrologic and hydraulic analyses of Walnut Creek and its tributaries were initiated. Through a combination of the economic downturn and the impacts caused by the Bastrop County fire in 2011, Bastrop County requested that the Phase 2 USACE feasibility study terminate. Following the request, the USACE amended existing contracts to allow the preliminary feasibility study to terminate in 2012. Walnut Creek was re-started as part of Phase 4 discussed below.

Phase 3 – Willow Creek and Gazley Creek

In 2014, the City of Smithville was interested in participating in the Bastrop County FPP and the County was once again ready to initiate studies. Although Bastrop County terminated the contracts with the USACE, Bastrop County still had available TWDB funds under the FPP grant. The City of Smithville studies include new 1-dimensional riverine analysis of Willow Creek and Gazley Creek and a 2D analysis of the City's internal storm drain system. This study also includes the identification of flood damages, evaluation of alternatives to mitigate flooding, and environmental constraints and benefit-cost analysis.

See **ANNEX 6** for the *Willow Creek and Gazley Creek, Bastrop County FPP Study* for a detailed report and supporting data submitted for Phase 3.

Phase 4 – Walnut Creek, Piney Creek and Gills Branch

In 2016, Bastrop County and the City of Bastrop once initiated studies under the Drainage Master Plan. The scoped studies include the completion of the FPP studies that have been initiated/completed to date including Walnut Creek that was initiated in Phase 2 in Bastrop County, as well as new studies for Piney Creek and Gills Branch in the City of Bastrop. In addition to the H&H analysis and damage reduction alternatives, the final FPP reports will include environmental constraints and benefit-cost analysis for all flood reduction alternatives.

See **ANNEX 7** for the *Walnut Creek, Bastrop County FPP Study* for a detailed report and supporting data submitted for Phase 4.

See **ANNEX 8** for the *Piney Creek, Bastrop County FPP Study* for a detailed report and supporting data submitted for Phase 4.

See **ANNEX 9** for the *Gills Branch, Bastrop County FPP Study* for a detailed report and supporting data submitted for Phase 4.

TOPOGRAPHIC DATA DEVELOPMENT

The primary source of topographic data used in these studies was developed from the 2007-2008 Capital Area Council of Governments (CAPCOG) & Texas Water Development Board / Texas Natural Resources Information System (TNRIS) LiDAR data. This LiDAR data was used to generate a FEMA-compliant, seamless terrain dataset. See **ANNEX 1** includes a detailed report and supporting data that explains the terrain development methodologies and results.

HYDROLOGIC ANALYSIS

All hydrologic analysis performed for these studies was developed using USACE Fort Worth District methods and procedures. This methodology consists of using a Block and Uniform loss rate combined with Snyder's Unit hydrograph approach. Flood events developed and discussed in the reports are in terms of the percent Annual Chance Exceedance (ACE) terminology. Eight frequency flows developed for the watershed studies include the 2- (50% ACE), 5- (20% ACE), 10- (10% ACE), 25- (4% ACE), 50- (2% ACE), 100- (1% ACE), 250- (0.4% ACE), and 500- (0.2% ACE) flood events. The hydrologic models are simulated using the USACE Hydrologic Engineering Center's (HEC) Hydrologic Modeling System (HEC-HMS). The following table summarizes the contributing drainage areas for each of the studied watersheds. Detailed hydrologic reports, models and supporting data for all watershed study areas are included in **ANNEX 2 - 9**.

Watershed Name	Drainage Areas (sq. mi.)
Cedar Creek	142.8
Dry Creek	55.0
Walnut Creek	136.0
Willow Creek	8.4
Gazley Creek	5.8
Piney Creek	38.0
Gills Branch	2.7
TOTAL	388.6

HYDRAULIC ANALYSIS

Hydraulic analysis consisted of the development of new hydraulic simulations along the studied streams. Hydraulic simulations are simulated using the USACE Hydrologic Engineering Center's (HEC) River Analysis System (HEC-RAS). The types of hydraulic studies performed for this study were "with survey" or "without survey." The "with survey" study type is a Detailed study that incorporated LiDAR data supplemented with newly obtained survey data. The "without survey" study type is a Limited Detailed study that only incorporated LiDAR data and field measurements of the hydraulic features. The following table summarizes the modeled stream miles for each of the studied streams. Hydraulic reports, models and supporting data for all studied watersheds are included in the reports located in **ANNEX 2 – 9**.

Stream Name	Stream Miles (mi)
Cedar Creek	29.6
Lytton Springs Creek	1.3
Maha Creek	11.8
Green Creek	6.5
Long Branch South	6.4
Dry Creek	3.9
Moss Creek	1.8
Red Gully Creek	3.5
Cottonwood Creek	3.8
Dry Creek East Trib. 4	1.9
Walunt Creek	19.9
Alum Creek South	9.7
Bee Creek	4.4
Cat Branch	0.5
Elm Creek South	5.1
Lentz Branch	8.2
Little Alum South	10.1
Lower Elm Creek	4.2
Lytton Creek	6.0
Upper Elm Creek	8.0
Willow Creek	6.9
Gazley Creek	1.6
Piney Creek	3.2
Gills Branch	1.8
TOTAL	160.2

Alternative Development and Benefit-Cost Analysis

The alternatives developed for each of the watershed studies analyzed conceptual mitigation alternatives to reduce flooding impacts along the studied streams. Both structural and non-structural alternatives were considered. The newly updated hydrologic and hydraulic analyses allowed for the identification of damage centers. Conceptual (high level) mitigation alternatives were developed including a conceptual layout, conceptual opinion of probable cost, and benefit to cost comparison. Detailed reports and supporting data explaining the methodologies,

assumptions and results for the alternatives development and benefit-cost analysis are included reports located in **ANNEX 5 – 9.**

PUBLIC MEETINGS

In accordance with the TWDB flood Protection Planning Grant requirements, public meetings were conducted for each of the communities that participated in this study. The following summarizes the public meetings held for this study.

- Halff Associates presented the Bastrop County Flood Protection Planning Study Final Report to the Bastrop County Commissioners Court on February 20, 2018.

- Halff Associates presented the Willow Creek and Gazley Creek study results at the Smithville City Council meeting on July 8, 2018.

- Halff Associates presented the Gills Branch and Piney Creek study results at Bastrop City Council workshop on February 20, 2018. TWDB presented on funding avenues for proposed mitigation alternatives. The meeting was a workshop open to the public, with the City of Bastrop mayor, City Council, City Manager, Director of Planning and Engineering, and Director of Public Works in attendance.