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Still Creek Flood Protection Study

Prepared for:
Texas Water Development Board and
City of Bryan, Texas

Prepared by:

FREESE AND NICHOLS, INC.
4055 International Plaza, Suite 200
Fort Worth, Texas 76109
817-735-7300

BRY10455

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by
Scott K. Hubley, P.E., CFM
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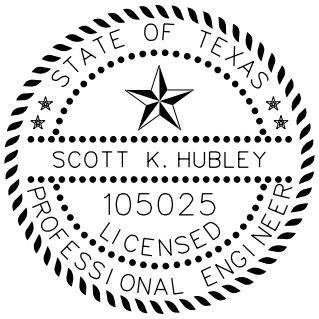

FREESE AND NICHOLS, INC.
TEXAS REGISTERED
ENGINEERING FIRM
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Still Creek Flood Protection Study

Table of Contents

List of Figures

List of Tables

Appendices

1 Executive Summary

Freese and Nichols (FNI) was contracted by the City of Bryan (City) to conduct a detailed study of flooding issues within the Still Creek watershed and to develop a set of recommended improvements to mitigate these issues. According to City records, the majority of homeowners who have filed flood insurance claims within the Still Creek watershed are concentrated in the Lynndale Acres subdivision, where the most severe flooding in the watershed occurs. In addition to this area, the City's capital improvement plan database indicates five other areas in the watershed where flooding problems currently exist, including overtopping of Still Creek crossings at Tennessee Avenue, Woodville Road, Southside Drive, West Martin Luther King Jr. Street, and West 17th Street. This detailed study describes FNI's recommended improvements to these six areas, including supporting calculations, opinions of probable construction cost, and documentation of three public meetings that were held in order to gather input from area residents regarding current flooding problems and their preferences for proposed improvements.

The most severe flooding in the watershed occurring in the Lynndale Acres subdivision was determined to result from two causes: inadequate flow capacity in Still Creek and inadequate infrastructure to accommodate drainage from a large local drainage area east of Old Hearne. According to FNI's detailed hydraulic analysis, 40 homes are at risk of flooding above their finished floor elevations during the 100-year storm event. The City has also recorded complaints from Lynndale Acres residents about neighborhood flooding during two storms in 2007 and in 2009. FNI obtained rainfall data for these storms, entered them into the hydraulic models, and found model results to be in general agreement with resident comments.

In order to reduce 100-year peak flows in Still Creek to a level that does not flood any homes and can be accommodated by the existing channel, FNI recommends that two regional detention ponds be constructed east of Bonham Elementary School and near the intersection of Wilkes Street and Bonham Street, respectively. The detention pond near Bonham Elementary will also provide adequate storage to prevent 100-year peak flows from a large local drainage area from overtopping Old Hearne Road and flooding homes in Lynndale Acres. FNI also recommends adding or replacing existing culvert barrels within Lynndale Acres to properly accommodate 100-year peak flows and enclosing drainage ditches in new storm drain along Old Hearne Road and Wilkes Street to provide additional capacity. Together, these improvements remove all 40 homes from the risk of flooding during the 100-year storm event. The estimated construction cost of the recommended improvements is $7,892,600. The net present benefits of this project to residents of Lynndale Acres as determined by standard FEMA Benefit Cost Analysis methodology is $11,504,004. Accounting for maintenance costs in addition to construction costs yields a total cost of $7,969,190 and a benefit-cost ratio of 1.44 for this project.

FNI also examined existing flooding conditions at five other road crossings in the Still Creek watershed – Tennessee Avenue, Woodville Road, Southside Drive, West Martin Luther King Jr. Street, and West 17th Street – and has recommended a combination of channel, culvert, and roadway improvements as appropriate in order to accommodate 100-year peak flows at each crossing without overtopping. The total estimated construction cost of these improvements is approximately $2,019,000. FNI recommends that the City include these projects in their capital improvement plan for consideration of funding.

2 Introduction

The City of Bryan (City) has contracted Freese and Nichols, Inc. (FNI) to perform a detailed study of existing flooding issues within the Still Creek watershed. Still Creek flows generally from northeast to southwest until it reaches its confluence with Thompsons Creek near the intersection of State Hwys 21 and 47. Refer to Appendix A-1 for a location map identifying the boundaries of the Still Creek watershed.

Still Creek watershed has experienced frequent flooding in recent years. The following table summarizes significant flood events in the Still Creek watershed:

Date	Damage	Comments
April 25, 2009	Twelve residences in the Lynndale Acres subdivision are flooded	Louisiana Street was overtopped and several residences on Old Hearne Road, McHaney Street, and Louisiana Street suffered flood damage.
May 1, 2007	Fourteen residences in the Lynndale Acres subdivision are flooded	Louisiana Street was overtopped and several residences on Old Hearne Road, McHaney Street, and Louisiana Street suffered flood damage.

A severe rain storm occurred early in the morning on April 25, 2009, in the Lynndale Acres subdivision. The rain apparently started between 3:30 and 4 AM. Residents noted that their homes began flooding between 4 and 4:30 AM.

The City staff conducted a door-to-door survey of the neighborhood to determine the number of homes that received flood damage. A total of twelve homes received flood damage. No one answered the door at several of the residences. Therefore, it is possible that additional residences received water damage. The residences confirmed by the City of Bryan as having received flood damage from the storm are as follows:

- Louisiana Street – 5 homes
- Old Hearne Road – 2 homes
- McHaney Street – 5 homes

The bridge over Still Creek at Old Hearne Road did not appear to have been overtopped. However, the depth of the water was sufficient to cause a backwater affect in the drainage channel along the north side of Old Hearne Road. Eventually this situation diverted more runoff through the box culvert in front of 2914 Old Hearne Road than it could handle and the serious flooding occurred.

The City of Bryan does not have any information as to the intensity of the rainfall. However, residents' testimony indicated that duration of the storm was 20 to 30 minutes and that the rainfall was intense.

The second recorded event occurred on May 1, 2007. This incident occurred as a result of a similar intensity storm as the 2009 storm. It was of short duration with a relatively high intensity. As a result a rapid rise of water was experienced in the Lynndale Acres subdivision. The residences confirmed by the City of Bryan as having flood damage from this storm are as follows:

- Old Hearne Road – 1 home
- Louisiana Street – 6 homes
- McHaney Street – 6 homes
- Russell Street – 1 home

According to City records, National Flood Insurance Program records, and comments from area residents, the majority of homes that have flooded in the Still Creek watershed over the past 30 years are concentrated in the Lynndale Acres subdivision. According to HEC-RAS hydraulic models provided by the city, several road crossings of Still Creek and its tributaries are in danger of overtopping during 2-year frequency rainfall events, including West Martin Luther King Jr. Street and West 17th Street. Other road crossings in the Still Creek watershed with drainage issues include Woodville Road and Southside Drive. This report provides a summary of FNI's study methodologies, results, and recommendations for mitigating each flooding hazard.

In compliance with Texas Water Development Board report requirements, this report does not specifically name any addresses or owners of properties affected by flooding. Therefore, for the purposes of this report, all property references have been anonymized through the use of a unique two-letter Property ID: AA, AB, AC, etc. Refer to Appendix A-2 for a map depicting the location of each two-letter Property ID.

3 Data Collection

The City provided FNI with a comprehensive set of information about the watershed, including GIS data, digital hydrologic and hydraulic models of Still Creek, and records of previous flooding events. The GIS data included aerial photographs, 2-foot topographic contours, parcels and building footprints, storm sewer utilities, sewer utilities, water utilities, stream centerlines, and floodplains for 100-year and 500-year storm events.

The HEC-HMS and HEC-RAS models provided by the City were developed as part of a separate project in January 2011 to update the existing Still Creek floodplains. These one-dimensional models were based upon field survey of channel sections and structures throughout the watershed. FNI used these models as the basis for hydraulic analysis of road crossing alternatives in this study. Parts of these models were also used to develop boundary conditions for FNI's InfoWorks SD two-dimensional hydraulic model of the Lynndale Acres subdivision.

The City also provided a capital improvement plan (CIP) database of existing flooding problems within the Still Creek watershed. The CIP database lists thirteen (13) existing drainage problems within the Still Creek Watershed. Of these thirteen (13) projects, seven (7) are described as very localized flooding or maintenance issues and thus were not included in this study. Five (5) CIP projects represent riverine flooding or roadway overtopping and are located on the main channel of Still Creek or one of its tributaries. These projects include addressing overtopping of West Martin Luther King Jr. Street, West 17th Street, Woodville Road, Southside Drive, and Tennessee Avenue and are addressed as part of this study. The remaining CIP project involves the flooding of multiple homes in the Lynndale Acres residential subdivision and is also addressed as part of this study.

Finally, the City provided a list of properties whose owners had filed claims with the National Flood Insurance Program between April 1977 and April 2009. Of the 77 claims filed throughout Bryan, Texas during this period, 17 claims were filed by homeowners in the Still Creek watershed. Of these 17 claims, 15 were filed by homeowners in the Lynndale Acres subdivision, generally bounded by Old Hearne Road to the north, Missouri Avenue to the south, Wilkes Street to the west, and Wilhelm Drive to the east.

FNI conducted two site visits on January 26, 2011 and July 27, 2011. The January visit included taking photographs of drainage facilities in and near Lynndale Acres, along with verifying Manning's *n* values for the area and planning for survey locations. The July visit included taking additional clarifying photographs of drainage facilities in Lynndale Acres, along with visiting and photographing culvert crossings of Still Creek and its tributaries at Woodville Road, Southside Drive, West Martin Luther King Jr. Street, and West 17th Street. Georeferenced photos from these site visits are included on the disc in Appendix F.

Strong Surveying was subcontracted by FNI to conduct topographic survey of the Lynndale Acres subdivision. The initial survey, conducted in April 2011, included finished floor elevations of eight homes along Louisiana Avenue, six homes along McHaney Drive, one home on Missouri Drive, and three homes along Old Hearne Road. Street cross sections were also provided at 100-foot intervals along Louisiana Avenue, McHaney Drive, Russell Drive, and Old

Hearne Road. Centerline elevations for Louisiana Avenue and Old Hearne Road were also provided. A second survey of finished floor elevations for an additional 60 homes was conducted in September 2011, including nine homes along Louisiana Avenue, four homes along McHaney Drive, two homes along Missouri Avenue, five homes along Russell Drive, one home on Indiana Avenue, ten homes along Old Hearne Road, nineteen homes along Wilkes Street, and ten homes along Bonham Drive. Digital versions of the AutoCAD survey files and associated spreadsheets are included on the disc in Appendix F.

At the conclusion of the data collection phase, FNI developed a memorandum documenting the data collection task and making recommendations for further analysis. The memorandum concluded that the Lynndale Acres subdivision represented the most severe flood hazard in the watershed and warranted further study. The nature of the flooding involves the overtopping of multiple residential streets as well as flow into and through the yards of several residents. The development of a two-dimensional (2D) hydraulic model was recommended to adequately assess the nature of the flooding and develop proposed improvements. In addition, it was recommended that proposed improvements be developed for the five (5) other existing CIP projects that had been identified throughout the watershed. In summary, the following locations and road crossings were recommended for further study:

1. Lynndale Acres Subdivision
2. Tennessee Avenue
3. Woodville Road
4. Southside Drive
5. West Martin Luther King Jr. Street
6. West 17th Street

4 Public Involvement

Three public meetings were held in order to gather input from residents in the watershed. The first meeting was held on January 26, 2011 at Bonham Elementary School in order to gather specific information about any observed flooding events. FNI provided comment forms to residents which asked for descriptions of specific drainage or flooding problems their properties had encountered, along with descriptions of flooding in yards, streets, and ditches. Residents were also encouraged to offer any other comments they had. Only two residents attended the public meeting. Due to the poor turnout at the meeting, comment forms were mailed to each property owner within the study area. Seven comment forms were completed by residents in response to this public outreach, and City staff transcribed verbal comments from another two residents. Comments generally communicated specific flooding depths in houses, yards, ditches, and streets, which provided FNI with enough specific information to verify results of the existing conditions hydraulic model. The meeting minutes, comment forms and resident responses summarized by Property ID are provided in Appendix B.

A second public meeting was held on July 27, 2011 at Bonham Elementary School to present the results of the completed existing conditions hydraulic model, to present a set of proposed alternatives for flood mitigation, and to gather feedback from residents regarding any preference for additional conveyance, detention, or buyouts as potential solutions. Approximately twelve residents attended the second public meeting, and two attendees filled out a comment form. The public meeting presentation, meeting minutes, comment forms and resident responses summarized by Property ID are provided in Appendix B. Following the meeting, approximately 80 comment forms were mailed to area residents with letters encouraging them to fill out the forms and submit them to the City. One resident completed and submitted a comment form. There was no strong consensus from the residents in favor of any particular mitigation alternative.

The final public meeting was held on November 1, 2011 at Bonham Elementary School to present a proposed hybrid mitigation solution that includes two detention sites, storm drain conveyance improvements, and culvert capacity improvements. Six residents attended the third public meeting. No comment forms were distributed at this meeting. All residents in attendance communicated general support of FNI's recommendations and enthusiasm for future design and construction. The public meeting presentation and meeting minutes are provided in Appendix B.

5 Lynndale Acres

The Lynndale Acres subdivision was determined to experience the most severe flooding within the Still Creek Watershed.

5.1 Description of Existing Flooding Problems

Lynndale Acres is located in the upper reaches of the Still Creek Watershed. For the purposes of this study, Lynndale Acres is bounded by Old Hearne Road to the north, Missouri Avenue to the south, Wilkes Street to the west, and Wilhelm Drive to the east.

The Lynndale Acres subdivision has a history of flooding as evidenced by the historical National Flood Insurance Program (NFIP) claims originating in the neighborhood. In recent years, storms in 2007 and 2009 resulted in extensive flooding within the Lynndale Acres subdivision. On May 1, 2007, fourteen (14) residences reported flooding, and on April 25, 2009, twelve (12) homes reported flooding due to rising waters of Still Creek. Note that NFIP claims were not filed by all homeowners who reported flooding to the City.

Still Creek runs from the northeast to the southwest through Lynndale Acres and crosses Old Hearne Road, Wilkes Street and Missouri Avenue. Review of the existing conditions models indicates that Still Creek has inadequate capacity through the study reach. Still Creek exists in a relatively natural state through this reach and has approximately 2-year capacity before it begins to overtop its banks and spill out into the neighborhood. Forty-eight (48) homes are located within the limits of the 100-year floodplain of Still Creek. Likewise, the Lynndale Acres culverts along Still Creek do not have adequate capacity as summarized in Table 5-1 below.

Table 5-1. Lynndale Acres culvert capacities

Road	Culvert size	Return event capacity	100-year overtop depth
Old Hearne Road	2-6'x6' RCB	< 2-yr	0.81
Wilkes Street	2-6' CMP	< 2-yr	1.16
Missouri Avenue	2-7'x7' RCB	2-yr	1.68

In addition to the inadequate channel capacity within Still Creek, there is a large local drainage area to the east of Old Hearne Road that generates a substantial volume of runoff during a significant rain event. The natural topography directs the runoff through the homes of Lynndale Acres towards Still Creek. The existing drainage infrastructure within the Lynndale Acres subdivision consists of small roadside ditches and driveway culverts which follow the roadways and eventually drain to Still Creek. The combination of the large volume of water and the inadequate infrastructure within the Lynndale Acres subdivision result in overtopping of Old Hearne Road and extensive flooding of the residences and roadways throughout the project area.

5.2 Existing Conditions Analysis

The City of Bryan provided existing conditions HEC-HMS and HEC-RAS models of the Still Creek Main Stem including the reach within the limits of the Lynndale Acres subdivision. In this model, the flooding in the Lynndale Acres Subdivision was modeled in HEC-RAS 1D via the use of a lateral weir and an "overflow" channel. Unfortunately, this configuration does not adequately represent the flooding behavior that was reported by the residents. Therefore, FNI developed a 2D hydraulic model to better understand the complex flooding regimes within the Lynndale Acres subdivision. Revisions to the hydrologic model were necessary to provide appropriate inputs to the 2D model. The existing conditions analysis is discussed in more detail in the following sections.

5.2.1 Hydrologic Analysis

The Still Creek watershed has a total drainage area of 17.03 square miles. Lynndale Acres is located within the upper reaches of Still Creek. The contributing drainage area of Still Creek at the Missouri Avenue crossing in Lynndale Acres is approximately 514.6 acres.

The City provided a single hydrologic model in HEC-HMS format which represented the watershed as a set of 53 subbasins, 1 pond, and 53 routing reaches. Meteorologic models of precipitation included in the HEC-HMS model are 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year frequency storms based on Brazos County depth-duration information provided by the City. Rainfall losses and runoff transformation models are based on the NRCS curve number and unit hydrograph methods. Runoff hydrographs are routed through river reaches using the Modified-Puls routing method in conjunction with rating curves from the provided HEC-RAS Still Creek hydraulic model. See Appendix A-3 for a hydrologic map of the Still Creek watershed corresponding to this HEC-HMS model.

The existing detention pond located at the western corner of the Bonham Elementary campus was added to the existing HEC-HMS model based on record drawings of the detention pond provided by the City of Bryan. The existing outlet consists of a 12-inch pipe at elevation 332.86. Any overflow above the top of the pond at elevation 339.00 was modeled as flowing across a 150-foot spillway. The elevation-area curve of the existing pond is shown below in Table 5-2. The as-builts are included on the disc in Appendix F.

Table 5-2. Elevation-area curve for existing detention pond at Bonham Elementary.

Elevation (ft)	Area (ac)
332.85	0.000
333.00	0.008
334.00	0.170
339.00	0.350
340.00	3.000

Table 5-3 below lists all basins in and upstream of Lynndale Acres, along with their hydrologic parameters and peak runoff flows as computed by HEC-HMS.

Table 5-3. Subbasin parameters and flows (existing HEC-HMS model)

Subbasin	Area (sq mi)	Curve number	Impervious %	Lag time (min)	Peak flow (cfs)
A1	0.008095	80	54.84	6.48	38
A2	0.005086	79.98	20.1	6.94	22.5
B	0.049891	79.94	23.63	10.64	194.5
C	0.006892	80	23.07	11.09	26.5
D	0.06607	80	17.47	9.57	264.8
F	0.079572	80	6.58	22.61	227.9
G	0.037355	75.74	34.03	16.49	121.8
H	0.017697	79.45	27.27	10.68	69
I2	0.00965	78.4	49.09	8.31	41.6
K2	0.032167	80	33.22	10.54	127.5
N	0.016309	80	4.18	17.99	51.2
O2	0.007803	75.85	32.09	9.02	31.3
Q2	0.006745	75.47	24.09	12.9	23.5
U2	0.036066	79.94	26.03	13.79	128.9
W5490	0.052296	78.78	17.26	12.46	189.3
W5491	0.055978	78.12	32.76	12.29	207.1
W5492	0.041643	78.03	23.56	10.15	161.8
W5493	0.070326	77.95	20.58	14.89	237.8
W5500	0.145434	79.3	19.89	14.21	506.8
W5501	0.058977	75.79	21.95	14.6	196.8

The existing HEC-HMS model was adequate for assessing the flooding at the existing road overtopping locations but more detail was needed for the development of the 2D model for Lynndale Acres. As the first step in developing a more detailed two-dimensional hydraulic model of Lynndale Acres, FNI subdivided the two large drainage basins covering the Lynndale Acres subdivision (W5480 and W5490) into 23 smaller basins. Times of concentration and runoff curve numbers were calculated for each basin in a manner consistent with the overall HEC-HMS model. These smaller basins were added to the HEC-HMS model in order to generate a set of runoff hydrographs for input into the 2D hydraulic model. These hydrographs were later distributed as point sources of time-varying 2D flow on the surface of the InfoWorks SD hydraulic model. See Appendix A-4 for the subdivided hydrologic map of the Lynndale Acres subdivision.

Table 5-4 below lists all basins in Lynndale Acres used to generate inflow hydrographs for the InfoWorks SD 2D hydraulic model, along with their hydrologic parameters and peak flows as computed by HEC-HMS. These basins were part of a separate HEC-HMS model used exclusively for generating 2D inflow hydrographs.

Table 5-4. Subbasin parameters and flows (existing HMS model for InfoWorks input)

Subbasin	Area (sq mi)	Curve number	Impervious %	Lag time (min)	Peak flow (cfs)
A1	0.008095	80	54.84	6.48	38
A2	0.005086	79.98	20.1	6.94	22.5
B	0.049891	79.94	23.63	10.64	172.2
C	0.006892	80	23.07	11.09	27.9
D	0.06607	80	17.47	9.57	264.8
F	0.079572	80	6.58	22.61	228.0
H	0.017697	79.45	27.27	10.68	69.7
I	0.005636	77.26	47.63	8.34	20.6
J	0.004014	80	51.13	6.72	15.9
K	0.005005	80	27	9.94	17.5
L	0.004638	80	12.65	10.89	15.2
M	0.013432	80	36.92	8.47	50.7
N	0.016309	80	4.18	17.99	64.3
O	0.003708	77.9	51.85	8.19	16.1
P	0.004095	74	14.19	9.02	15.5
Q	0.003103	74.06	11.45	12.9	10.4
R	0.003643	76.67	34.85	13.16	13.0
S	0.003924	79.96	45.5	8.6	16.8
T	0.005169	80	38.76	7.12	23.3
U	0.016871	79.88	34.19	7.3	74.8
V	0.019195	80	18.86	11.9	71.6

5.2.2 Radar Rainfall Analysis

FNI contracted with Vieux, Inc. to provide gauge-adjusted radar rainfall data for the historical storm events of May 1, 2007 and April 25, 2009. The radar rainfall analysis provides valuable information because there is no available rain gauge data within the Still Creek watershed. The radar rainfall data can provide detailed information for areas without a gauge by using nearby gauges to ground truth the radar data. The result of the analysis is a time series of the storm event recorded in precipitation depth (inches) at 15-minute increments for the duration of each storm. As discussed later, the hydraulic models were executed using the time series from these historical storms to validate the model and compare its results to the resident comments. In addition to the time-series data, Vieux, Inc. also provided a depth-duration-frequency analysis of these historical storms. The frequency analysis determined that the 2007 storm was a 2-year event and the 2009 storm was a 1-year event. The entire report from Vieux Inc. is included in Appendix E.

5.2.3 Hydraulic Analysis Software

Hydraulic modeling was performed using the InfoWorks SD software version 11.5.0.21007, produced by Innovyze Software. InfoWorks SD is a fully dynamic simulation engine integrated

with a two-dimensional (2D) engine to accurately model overland flow patterns concurrent with closed pipe hydraulics.

5.2.4 2D Hydraulic Model Elements

Dynamic storm sewer and overland flow routing was performed within InfoWorks SD. The storm sewer routing was limited to major culverts crossing roadways. A two-dimensional (2D) mesh was created from a combination of 2-ft topographic information provided by the City and field-surveyed road cross sections. Three-dimensional (3D) breaklines were created from the field survey and incorporated into the mesh to accurately represent the geometry of the roadway and ditches. Building footprints are integrated into the mesh and are represented as voids where water is not allowed to flow. The building footprints were comprised of City planimetric data. The mesh also included spatially varying roughness elements to capture the increased resistance associated with fences, landscaping, and other features that affect the ability of water to flow across the surface. Roughness coefficients were assigned based on a combination of field visits and aerial photography. Driveway culverts were not explicitly modeled using 1D links; rather, the increased resistance encountered at driveway culverts was represented by increased Manning's *n* values. Table 5-5 below summarizes the Manning's *n* values used throughout the 2D mesh. The combination of the 2-ft topographic information, field survey, 3D breaklines, building voids, and Manning's *n* values resulted in a 32.97-acre mesh consisting of 1713 triangles. Appendix A-6 depicts the limits of the 2D mesh and major elements.

Table 5-5. Manning's n values used in InfoWorks SD 2D hydraulic model

Surface type	Manning's *n* value
Roadway	0.02
Fences, brush, back yards	0.05
Ditches, driveway culverts	0.035

5.2.5 2D Boundary Conditions

The main channel of Still Creek was not modeled directly within InfoWorks SD. The existing HEC-RAS model accurately depicts the flooding behavior associated with the main channel because it meets the basic requirements for 1D steady state modeling. The channel geometry is relatively uniform and can be adequately described by the cross sections within HEC-RAS. In addition, the flow is moving downstream in a single direction. InfoWorks SD was used as a tool to primarily model the floodwaters from the local drainage area moving through the homes in the Lynndale Acres subdivision. The 2D model is required to depict shallow flooding with water moving through obstructions in multiple directions as is common in Lynndale Acres.

The existing hydrologic and hydraulic models of Still Creek were used to develop the boundary conditions for the 2D mesh. A hydrograph-based (dynamic) 2D analysis, in which flow varies over time, requires consideration of a stage hydrograph at any outfall location. A stage hydrograph is simply a time-varying water surface elevation at the downstream end of the system. The ideal source for a stage hydrograph for hypothetical storm events would be an unsteady hydraulic model of the receiving channel. Because an unsteady model of Still Creek was not available, a stage hydrograph was approximated using the paired hydrologic and hydraulic models provided by the City. A rating curve (stage versus discharge) was extracted for

each cross section through the study reach. Also, flow hydrographs (discharge versus time) through the study reach were extracted from HEC-HMS. Using interpolation, the flow hydrographs were paired with the rating curves to develop stage hydrographs (stage versus time) at each cross section. The boundary condition along Still Creek was subdivided into ten segments to account for the varying water surface elevations along the stream. Each of these ten segments was then assigned to a corresponding HEC-RAS cross section, and a stage hydrograph was developed for each of the ten segments using the procedure described above. These stage hydrographs were then inserted into InfoWorks SD as level events and applied to the ten 2D boundaries along the edge of the 2D mesh. This process allows for consideration of the time varying water surface elevations during a storm event and ensures that the hydraulic mesh will have appropriate tailwater conditions throughout the simulation. The stage hydrographs are included on the disc in Appendix F.

5.2.6 2D Point Sources

Hydrographs developed in HEC-HMS were extracted and entered into InfoWorks SD for hydraulic simulation. The majority of the flow is generated by offsite runoff and was entered as an inflow time series to the upstream end of the culvert crossing Old Hearne Road. The rain falling directly on Lynndale Acres was modeled using a group of 21 subcatchments. The hydrographs produced in HEC-HMS for these subcatchments were applied at 2D point sources at discrete locations throughout the mesh. This method of approximating the contribution of local runoff was considered acceptable since the vast majority of the floodwaters moving through the mesh originate from the offsite drainage areas. All of the input hydrographs to the InfoWorks SD model, along with the model itself, are included on the disc in Appendix F.

5.2.7 2D Model Results

The InfoWorks SD model was executed for the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year frequency storms. Appendix A-7 depicts the maximum inundation during the 100-year storm event. It was determined that 17 homes in Lynndale Acres are at risk of flooding in the 2-year event while 41 homes are at risk of flooding in the 100-year event. It should be noted that 18 of these homes are at risk of flooding directly from the main channel while the remaining 23 are at risk due to the local flooding problem. Table 5-6 below summarizes the number of homes at risk of flooding in each return event.

Table 5-6. Homes subject to flooding in each return event

2-year	5-year	10-year	25-year	50-year	100-year	500-year
17	25	30	36	41	41	54

The InfoWorks SD model was also executed for the 2007 and 2009 historical storms. The results of the model for the historical runs were compared to the resident comments describing the flooding and found to be in general agreement. Table 5-7 below summarizes resident comments and compares them with results from the InfoWorks SD 2D model. Refer to Appendix A-7b for a depiction of the flooded structures under existing conditions and Appendix A-7c for a map provided by the City depicting resident reports of flooding in 2007 and in 2009.

Table 5-7. Resident comments compared with InfoWorks SD 2D model results

Prop. ID	Resident Comments	2D Comparison (2007)	2D Comparison (2009)
NN	Front and back yards both flood. 15-20" twice. Inside house once. Louisiana Street, other neighborhood streets flood	18" in front, none in back, Louisiana St doesn't overtop	13" in front, none in back, Louisiana St doesn't overtop
NO	Under heavy rain water backs up and floods property. Water never came into house. Replaced A/C 10-12 years ago (1989-1991). Bar ditch, whole yard 18" deep (knee deep), truck flooded in low point of driveway. Fence flooded 16". Within 4-5" of finished floor. Road crests, constant flow, 3" over crown. Louisiana overtopped 5 times since 1984. Breaks in front of house before McHaney/Louisiana intersection. Hasn't seen Old Hearne Rd overtop.	6" at fence, 7" in front yard. Flow from HEC-RAS model not accounted for	4" at fence, 12" in front yard
PP	Flooding has never gotten closer than 15 feet to house. Creek fills up quickly during rain, but holds at higher level for a long time. He thinks it is due to blockages downstream where the channel hasn't been cleaned for many years. No flooding in other side yard. Back corner closest to creek floods <8" because his storage building is 8" off the ground on blocks and it has never flooded.	N/A – not part of Lynndale Acres 2D model	N/A – not part of Lynndale Acres 2D model
KE	Sewer backs up into house. New sewer pipes installed in 2008/2009 seem to have solved this problem. Water comes into yard from neighbor on McHaney, then immediately flows behind neighbor's house at [Property ID JU]. Two sheds in corner of property are sometimes flooded 4-5". This has happened twice since 2006. House is not threatened. (2nd comment form for same property: Adjoining lot is high and doesn't get any standing water. Rainwater drains into small ditch and then into creek.)	6" at sheds	2.5" at sheds
KF	In the past 18 years, house and workshop have never flooded. Water has backed up to the sidewalk and within 2" of coming into the workshop. Entire yard, ditches, and street have flooded from Old Hearne Rd to Bonham Park but didn't come up to foundation.	1" below workshop finished floor	2 feet below workshop finished floor
PD	In back yard about 1.5 years ago (2009), had 5" of rain; water came into house. Flooding is mainly in back yard after a lot of rain. Seems like yard is getting a lot from neighbors' back yards, across the middle and towards house. Yard is very low.	N/A – not part of Lynndale Acres 2D model	N/A – not part of Lynndale Acres 2D model
NF	Water runs through side yards (front to back) many times, but water never enters home. House behind his floods because water hits her back door which is a sliding window and living room floor is recessed. Does not think culverts in front of home are flowing full when water starts to pass into back yard. Surface flow in back yard flows SE to NW with enough depth and velocity to move landscape timbers stacked three high. School had temporary driveway on other side of Old Hearne that was in place during last flooding. He thinks Old Hearne overtopped at that point and water passed from the school side to his side because it was backed up by the temporary driveway. (City notes: Temporary driveway shows up in aerial dated 8/30/06 but not there on 10/21/05 or 10/30/08.)	1.5" in side yard	1" in side yard
NN	Water got in the house twice between 2005 and 2009. Flooded 18" in front and back yards, and on the street.	18" in front, none in back	12" in front, none in back

5.3 Proposed Alternatives Analysis

Based on the results of the existing conditions analysis, it was determined that drainage improvements are necessary to reduce the risk of flood damages within the Lynndale Acres subdivision. The goal of the drainage improvements is to provide 100-year flood protection for homes in the Lynndale Acres subdivision. A series of alternatives was developed for flood damage reduction, including structural and non-structural measures. Structural measures included detention and conveyance improvements. Non-structural measures considered were property acquisitions. Conceptual improvement alternatives were developed and presented for public feedback.

5.3.1 Conceptual Framework for Improvement Alternatives

The results of the existing conditions analysis indicate that Lynndale Acres suffers from two distinct sources of flooding. The first source of flooding is the main channel of Still Creek, which does not have adequate capacity to convey the existing 100-year peak discharge of 2170 cfs (at HEC-HMS element J3410a). The existing channel and culverts can currently accommodate approximately 700 cfs without flooding homes adjacent to the channel. The second source of flooding is the lack of adequate infrastructure to convey the runoff from the large local drainage area through Lynndale Acres towards Still Creek.

Typical structural improvement options for this project area consist of conveyance improvements or detention. The ideal solution would be a single detention pond that eliminates the local flooding problem while also reducing discharges in the main channel to approximately 700 cfs. To determine if this solution would be feasible, subbasins composing the local drainage area were completely removed from the HEC-HMS model, representing the maximum possible detention effectiveness. Unfortunately, this only reduces the 100-year peak discharge in the channel to approximately 1513 cfs – well above the target discharge. Based on these results, it was determined that a two-part solution would be required to solve the flooding in Lynndale Acres. One set of improvements would need to address the main channel flooding while another set of improvements would be necessary to address the local flooding. The proposed improvement alternatives are discussed in more detail below.

5.3.2 Regional Detention

Regional detention was the first improvement alternative considered. Detention ponds could store runoff during a storm event and slowly release it at a rate equal to the capacity of Still Creek, thereby reducing the risk for flood damage. There are several tracts of vacant land in the upstream watershed that are suitable locations for detention facilities. One detention pond would need to be located within the drainage area contributing to the local flooding overtopping Old Hearne Road and the other would need to be located within the drainage area contributing directly to the main channel of Still Creek. For the purposes of the public meeting, three potential detention sites were identified in the main channel watershed while only one potential detention site was viable for the local watershed. Rough calculations were performed to determine the required amount of detention volume. It was determined that approximately 80 acre-feet of detention storage volume is necessary to achieve 100-year flood protection for the homes within Lynndale Acres. The potential detention sites are shown in Appendix A-8. The benefits of regional detention would extend for some distance downstream along Still Creek and would not just benefit the Lynndale Acres subdivision.

5.3.3 Conveyance Improvements

Conveyance improvements were the second improvement alternative considered. Conveyance improvements in the form of larger pipes or channels would be required to provide 100-year flood protection to Lynndale Acres. Channel improvements for Still Creek would be required through Lynndale Acres from Old Hearne Road continuing south to Missouri Avenue. The existing natural Still Creek channel would need to be improved to a structural channel with vertical walls at a depth of approximately 7 feet and a top width of approximately 35 feet. In addition, the culverts at Old Hearne Road, Wilkes Street, and Missouri Avenue would need to be replaced. The channel improvements would likely require an individual 404 permit from the United States Army Corps of Engineers (USACE) and extensive environmental mitigation costs. In addition, construction would be expensive due to the limited working space behind the existing homes along the creek. The prospect of intrusive construction coupled with the likely loss of trees was not well-received by the residents.

In addition to the channel improvements, a storm sewer system would be required to provide adequate capacity for the local flooding problem. The proposed storm sewer system would begin along Old Hearne Road, run southwest along McHaney Drive, and outfall into Still Creek in Bonham Park downstream of Missouri Avenue. The net result of this storm sewer system would be to collect runoff from the large local drainage area and bypass it through the Lynndale Acres subdivision, thereby providing 100-year flood protection for the homes that suffer from the local drainage problem. This component would have the added benefit of decreasing discharges in the main channel of Still Creek along the reach through Lynndale Acres. Construction of a major storm drain system through the residential streets of Lynndale Acres would be very intrusive to the neighborhood and would likely encounter several utility conflicts which would increase the cost of the project. The conveyance improvements alternatives are depicted in Appendix A-9.

The disadvantages of this alternative are potential downstream impacts. Providing additional conveyance would allow runoff to move downstream more quickly, eliminating the unintended detention effect created by the floodwaters stored in the homes and yards of Lynndale Acres. This would merely move the problem downstream, resulting in increased flooding and erosion elsewhere.

5.3.4 Property Acquisitions

The third alternative considered is the non-structural measure of property acquisitions. To eliminate all the homes from the 100-year flood hazard area, approximately 40 homes would need to be purchased. Based on the appraisal information from the Brazos County Appraisal District and assuming 20% above the appraised value, the total cost of purchasing the homes at risk of flooding in the Lynndale Acres subdivision would be $3,974,700. In addition to the initial cost of purchasing the homes, there would be a long term maintenance cost to the City of Bryan to maintain those properties and there would be a significant loss in tax revenue due to the vacant lots. The other disadvantage is that the flooding hazard would not be addressed and the roadways would still be unsafe.

5.4 Recommended Improvements

In order to fully address both causes of flooding in the Lynndale Acres subdivision, FNI recommends a hybrid solution incorporating preferred aspects of the detention and conveyance improvement alternatives. Specifically, FNI recommends construction of two stepped regional detention ponds north of the subdivision, culvert improvements at three road crossings in Lynndale Acres, and enclosed drainage facilities along Old Hearne Road and Wilkes Street. Refer to Appendix A-10 for a general schematic of these improvements. The proposed pond grading alters the boundaries of the existing hydrologic subbasins; therefore a slightly altered set of proposed subbasins was developed for the proposed HEC-HMS model. Refer to Appendix A-5 for a map of the subbasins after the recommended improvements are constructed.

Pond A would be constructed in the vacant area northeast of Bonham Drive and northwest of Wilkes Street, extending northwest along Bonham Drive to the boundary of Primrose Lane RV Park. Pond B would be constructed in the vacant area northeast of Old Hearne Road and southeast of Bonham Elementary School, extending northeast to the corner of Bonham Drive and Siegert Drive. Pond A serves to detain peak flows in the main channel of Still Creek, reducing the peak discharge through Lynndale Acres. Pond B serves to detain runoff from the large local drainage area northeast of Old Hearne Road and release it into the main channel after the peak of the storm. Refer to Appendices A-11 and A-12 for grading details of Pond A and Pond B, respectively.

In addition, FNI recommends installing extra culvert barrels and replacing others at the Old Hearne Road, Wilkes Street, and Missouri Avenue crossings of Still Creek. Specifically, FNI recommends installing an additional 6’x6’ culvert barrel at Old Hearne Road, replacing the 6’-diameter corrugated metal pipes at Wilkes Street with 3-8’x6’ reinforced concrete box culverts, and installing an additional 9’x7’ culvert barrel at Missouri Avenue. This additional culvert capacity will further reduce peak water surface elevations in Still Creek throughout the Lynndale Acres subdivision.

Finally, in order to provide additional drainage capacity along Old Hearne Road and Wilkes Street, FNI recommends that existing drainage ditches along these roadways be converted to underground storm drain in conjunction with planned widening projects. Refer to Appendix A-10 for a general schematic of the proposed storm drain layout. Table 5-8 below summarizes the approximate hydraulic grade line (HGL) calculations for each length of pipe. Peak flows used are based on HEC-HMS model peak 100-year flows from reach elements RN, RF, and B. Each road was assumed to accommodate 30 cfs of flow during the 100-year storm. Friction slopes were calculated in Bentley FlowMaster V8i software using Manning's equation with a roughness coefficient of 0.013. The starting HGL for the Wilkes storm drain is equal to the 100-year water surface elevation immediately downstream of the Old Hearne Road crossing in the proposed HEC-RAS model, and the starting HGL for the Old Hearne Road storm drain is equal to the maximum 100-year stage of the school detention pond in the proposed HEC-HMS model. Each pipe was sized such that the approximate HGL remains at least one foot below the road elevation.

Table 5-8. Approximate HGL calculations for proposed storm drain

Road	Pipe Length (ft)	HMS Element	Peak Flow (cfs)	Less 30 cfs Road Capacity (cfs)	Selected Pipe Size	Friction Slope (ft/ft)	Start HGL	End HGL	Upstream Road Elev
Wilkes St	1300	B	187	157	5'x4'	0.0041	336.5	341.8	345.5
Old Hearne Rd	500	RF	279	249	7'x4'	0.00439	342.0	344.2	346.0
Old Hearne Rd	500	0.5*RF	140	110	4'x3'	0.0079	344.2	348.1	350.0
Old Hearne Rd	600	RN	51	21	24"	0.00862	348.1	353.3	356.0

The total estimated design and construction costs for these improvements is $7,892,600. See Appendix C for complete opinions of probable construction cost.

FNI recommends concurrent construction of Pond B and the storm drain along Old Hearne, as they should be designed to work together. Pond A can be constructed either concurrently with Pond B or as part of a separate construction phase, as land acquisition and/or funding allows. If the ponds are constructed in separate phases, the first pond to be constructed, whether A or B, provides a peak flow reduction of approximately 730 cfs at the Old Hearne crossing of Still Creek. The next pond to be constructed provides the remaining reduction of approximately 410 cfs.

5.5 Benefit-Cost Analysis

FEMA's standard Benefit-Cost Analysis (BCA) methodology provides an approach for estimating flooding damage costs for a particular structure under a given flooding condition. To aid in preparation of a BCA, FEMA has published a Benefit-Cost Analysis Toolkit software package. FNI used version 4.5.5.0 of this software to calculate the benefit-cost ratio (BCR) of this project considering 111 structures located within the Lynndale Acres subdivision and along the northwest side of Wilkes Street. A complete list of structures considered in the analysis is included in Appendix D.

Damages were calculated through the application of standard U.S. Army Corps of Engineers depth-damage functions, which relate flooding depth to total damages, including damage to the structure, loss of the structure's contents, and the cost of resident displacement during repairs. These damages are calculated for four storm recurrence intervals and converted to a net present value in order to facilitate a straightforward comparison to project cost. The estimated damages to a particular structure caused by a particular storm is chiefly dependent upon the finished floor elevation of the structure, the maximum water surface elevation at the structure, and the value and square footage of the structure. FNI obtained surveyed finished floor elevations for 77 structures in this analysis; the remaining 34 elevations were estimated based on 2-foot contours. Maximum existing 10-year, 50-year, 100-year, and 500-year water surface elevations for each structure were obtained from either the adjacent existing HEC-RAS model cross-section (for structures along the channel banks) or from the existing InfoWorks SD model's 2D simulation triangles. Maximum proposed water surface elevations for structures along the channel banks were obtained from a proposed HEC-RAS model. Finally, structure values and square footages were obtained from Brazos County Appraisal District data in a geodatabase provided by the City. This information is all provided digitally in Appendix F.

Comparing estimated damages to a structure before and after a certain mitigation activity provides a dollar value of benefit for that structure. Dividing the total benefits provided by a mitigation activity by its cost provides a benefit-cost ratio (BCR) that can be used to quantify the cost-effectiveness of proposed mitigation activities. The base cost of $7,892,600 for FNI's recommended improvements does not include yearly maintenance of the ponds. A conservative estimate of $50/home/year, or $76,590 net present value, was applied to the BCA in order to account for maintenance. This increases the total recommended project cost to $7,969,190 present value. The net present value of total benefits afforded to all 111 homes in this analysis is $11,504,004. The end result is an overall cost-effective BCR of 1.44. A summary of benefits, costs, and BCRs is provided in Appendix D. The BCA database and the complete BCA output PDF is also presented digitally on Appendix F.

5.6 Environmental Assessment

Environmental permit issues associated with the proposed alternatives that could affect costs or schedules for implementation include endangered species issues and Section 404 permitting for activities conducted in waters of the U.S. Cultural resources (archaeological/historical) could also be an issue but the developed nature of the area may preclude the requirement for archaeological or historical building surveys.

The Navasota ladies' tresses (*Spiranthes parksii*) is an endangered orchid found in Brazos County. It grows along margins of post oak (*Quercus stellata*) woodlands in sandy loams along intermittent tributaries of rivers in areas where factors limit competing vegetation in the herbaceous layer. Other associated species include water oak (*Q. nigra*), blackjack oak (*Q. marilandica*), and yaupon (*Ilex vomitoria*). There are some intermittent (or perennial) streams and there are some sandy loam soils (Boonville-Urban land complex, Rosanky-Urban land complex, Tabor-Urban land complex, and Zack-Urban land complex) in the area. FNI does not consider these issues to be a significant because of the urban development in the area.

Authorization from the U.S. Army Corps of Engineers (USACE) under Section 404 of the Clean Water Act would be required for most activities (excavation, fill, channelization, etc.) conducted in waters of the U.S. This would include wetlands, streams, and open waters. Still Creek and its tributaries would be considered waters of the U.S. (i.e., jurisdictional waters). The recommended hybrid solution consists of detention ponds, storm drain improvements, and culvert improvements. The detention ponds are expected to have minimal environmental impacts as they are not located on the main channel of Still Creek within the jurisdictional waters. Likewise, the storm drain improvements along Old Hearne Road and Wilkes Street are located within the footprint of the existing roadways and would not have any environmental impacts. The culvert improvements at Old Hearne Road, Wilkes Street, and Missouri Avenue can most likely be completed under USACE Nationwide Permit 14 for linear transportation projects. If a pre-construction notification or permit application is required to be submitted to the USACE, then mitigation would be required to compensate for unavoidable impacts. Mitigation can be expensive with costs for example in the range of $250-$500 per linear foot of stream impact and $20,000+ per credit (acre) of wetland impacts. For the purposes of this study, environmental impacts were estimated as 1-2% of total project costs.

6 Tennessee Avenue

6.1 Existing Conditions

Tennessee Avenue crosses the main stem of Still Creek in the northeast portion of the Still Creek watershed, just downstream of Lynndale Acres. The area draining to this crossing is primarily developed single-family residential along with undeveloped agricultural land. This runoff is conveyed by surface drainage to the creek. The City of Bryan CIP database lists the Tennessee Avenue bridge as having drainage issues, experiencing flooding and overtopping during storm events.

The existing HEC-HMS and HEC-RAS models received from the City were used for the existing analysis. The main stem of the creek is conveyed through three 10'x7' RCB culverts under the road, as pictured in Figure 6-1 and Figure 6-2 below, and the road is overtopped beginning in the 2-year storm event. The existing 100-year peak discharge at Tennessee Avenue is 2412 cfs, far above the existing culvert capacity of approximately 800 cfs. Tennessee Avenue is considered a local street according to the City of Bryan thoroughfare plan.

Figure 6-1. Still Creek main stem upstream of Tennessee Avenue

Figure 6-2. Still Creek main stem downstream of Tennessee Avenue

6.2 Proposed Improvements

If the proposed Lynndale Acres improvements described in Section 5.4 of this report are constructed, the 100-year peak discharge at Tennessee Avenue will be decreased from 2412 cfs to approximately 1193 cfs. Assuming a 100-year peak discharge at Tennessee Avenue of 1193 cfs, Tennessee Avenue will be overtopped by 0.92 feet at 2.4 feet per second during the 100-year storm, meeting City of Bryan stormwater design guidelines. Therefore, no improvements are recommended at this culvert.

7 West Fork

7.1 Existing Conditions

The West Fork of Still Creek is located in the northern portion of the Still Creek watershed. The West Fork begins just upstream of Hampton Road and conveys runoff between homes and along fence lines before crossing Woodville Road, as shown in Appendix A-13. The area is mainly residential and is built out. Residents in the area have complained about ditch maintenance and flooding along the creek. The project area includes approximately 570 LF of channel extending from Hampton Road to Woodville Drive.

The existing models received from the City were used for the existing analysis. The amount of runoff in the creek upstream of Woodville Drive was determined by subdividing the drainage area W5400 in the HEC-HMS model provided by the City. The creek drains approximately 62.7 acres of residential area upstream of Woodville Road. The existing channel is conveyed through two 3'x2' RCBs under Hampton Road and three 36-inch RCPs under Woodville Road. The West Fork upstream of Woodville Road between 2504 and 2506 Woodville Road is pictured in Figure 7-1, and the upstream face of the culvert at Woodville Road is pictured in Figure 7-2. The West Fork within the project area generally does not have a positive grade. As a result, debris is captured and causes a reduction in channel capacity, as shown in Figure 7-3 and Figure 7-4 below.

Figure 7-1. West Fork between 2504 and 2506 Woodville Road

Figure 7-2. 3-36-inch Culverts upstream of Woodville Drive

Figure 7-3. Debris captured in the West Fork downstream of Hardwood Drive

Figure 7-4. West Fork is conveyed under the fence at 2507 Hardwood Drive

7.2 Proposed Improvements

Storm drain improvements are proposed in this area to prevent future flooding and maintenance issues. Due to spatial constraints in the residential area and maintenance costs of an open channel, it is proposed to enclose the existing creek in a storm drain system. The proposed storm drain consists of 1-7'x'4' RCB that begins upstream of Hardwood Drive. The storm drain follows the existing creek and extends approximately 570 LF from Hardwood Drive to downstream of Woodville Drive, as shown in Appendix A-14. Approximately four (4) curb inlets and three (3) drop inlets will be required to capture surface runoff in the streets as well as between the homes. Minor grading and rock riprap will be required at the outfall.

The proposed storm drain system is designed to convey the 100-year storm event because it is replacing an existing channel. The project cost for proposed storm drain improvements is approximately $447,000, and an opinion of probable construction cost is attached in Appendix C.

8 Southside Drive

8.1 Existing Conditions

Southside Drive and Staunton Drive both cross the West Fork of Still Creek in the northern portion of the Still Creek watershed. The area is mostly built out with single family residential homes, as shown in Appendix A-15, and runoff is drained through surface drainage in the streets and ditches. Residents in the area have complained of street and ditch flooding in the past. The West Fork is vegetated for 265 LF between Staunton and Southside Drives, as shown in Figure 8-1. The channel then is concrete lined between 2309 and 2311 Southside Drive for approximately 100 LF before it outfalls into the Still Creek Main Stem, as shown in Figure 8-2.

The existing models received from the City were used for the existing analysis. The West Fork is conveyed through three 36-inch RCPs at Staunton Drive and three 24-inch RCPs at Southside Drive. Both roads begin overtopping during the 2-year storm event. Once the roads are overtopped, water flows southwest along the streets and into a creek approximately 1,200 LF from Tributary B. The City hydrologic model represented this situation by creating a diversion in the HEC-HMS model. This diversion reduces the flow along the West Fork. The excess runoff in the streets causes a potential for safety hazards for pedestrians and vehicles. The roadside ditches also have insufficient capacity to convey the additional runoff.

Figure 8-1. West Fork upstream of Southside Drive

Figure 8-2. West Fork between 2309 and 2311 Southside Drive

8.2 Proposed Improvements

Culvert and channel improvements are proposed in this area to prevent Staunton and Southside Drives from overtopping during the 100-year storm event. This eliminates the spillover to the receiving creek southwest of the West Fork. For the purposes of this analysis, it was assumed that water does not escape the West Fork of Still Creek, and all runoff remains in the watershed. Proposed facilities were sized accordingly. The culvert improvements include the construction of 3-7'x3' RCBs at Southside Drive and 3-6'x3' RCBs at Staunton Drive to convey the West Fork without overtopping the road during the 100-year event. It is also proposed to relocate the culvert at Southside Drive to the East of 2311 Southside Drive, as shown in Appendix A-17. Staunton Drive is to be raised approximately 0.6 ft, which requires approximately 275 LF of road improvements.

Proposed channel improvements include resizing the West Fork channel for approximately 635 LF beginning at Staunton Drive and ending downstream of Southside Drive. The existing channel is to be redirected through the proposed culverts east of 2311 Southside Drive. A 5-ft bottom width vegetated channel with 4:1 side slopes at a 0.8-percent slope is proposed for 265 LF between Staunton Drive and Southside Drive. The existing 50 ft right-of-way is wide enough so that the proposed channel would not need additional easement acquisition. It should be noted that while the parcels show that this land appears to be City-owned property, residents appear to be using the land for various reasons including storage and yard space. Downstream of Southside Drive, a 10-ft bottom width vegetated channel with 4:1 side slopes and 0.9-percent slope is proposed to extend 370 LF from the proposed relocated Southside Drive culverts to the existing West Fork channel.

The proposed channel and culvert improvements prevent overtopping of the roads and channel during the 100-year event, so the diversion discussed in the Existing Conditions section is no longer applicable. The proposed culvert and channel improvements are designed for the total amount of runoff without the existing diversion. The proposed improvements will cost approximately $505,000, and an opinion of probable construction cost is provided in Appendix C.

9 West Martin Luther King Jr. Street

9.1 Existing Conditions

West Martin Luther King Jr. Street crosses Tributary B of Still Creek in the northeast portion of the Still Creek watershed. Runoff from the area is conveyed by surface drainage to the creek. The area includes an older neighborhood that is mostly built out as well as a school to the southwest of the crossing. West Martin Luther King Jr. Street is the primary access route to this school. The resident at 1408 West Martin Luther King Jr. Street has complained of creek drainage problems in the past, according to the City of Bryan drainage work orders database.

The existing models received from the City were used for the existing analysis. Tributary B is conveyed through one 10'x5' RCB culvert under the road, as pictured in Figure 9-1 and Figure 9-2, and the road is overtopped beginning in the 2-year storm event. West Martin Luther King Jr. Street is considered a minor collector road, according to the City of Bryan thoroughfare plan.

Figure 9-1. Tributary B Upstream of W MLK Jr. St.

Figure 9-2. Tributary B Downstream of W MLK Jr. St.

9.2 Proposed Improvements

Culvert improvements and downstream grading are proposed in this area to reduce street flooding. It is proposed to add 2-12'x6' RCBs to the existing 1-10'x5' RCB to prevent the 100-year storm event from overtopping the roadway, as shown in Appendix A-18. It is also proposed to lower the flowline of the channel approximately 0.8 ft, and raise the road about 1.3 ft at the culvert crossing. Lowering the channel requires approximately 300 LF of downstream grading, and raising the road requires approximately 300 LF of road improvements. The downstream channel grading will include replacing the concrete pilot channel and small pedestrian bridge. The total estimated construction cost for these improvements is approximately $481,000, and an opinion of probable construction cost is provided in Appendix C.

10 West 17th Street

10.1 Existing Conditions

West 17th Street crosses Tributary B to Still Creek in the northeast portion of the Still Creek watershed. Runoff from the area is drained through surface and subsurface drainage to the creek. The area includes an older neighborhood that is mostly built out. Residents in the area have complained of drainage problems at West 17th Street, and the street has multiple existing buried sanitary sewer and water distribution lines, as shown in Appendix A-19. Downstream of West 17th Street, there is a sanitary sewer line crossing the creek that is protected by concrete, pictured in Figure 10-1 below.

The existing models received from the City were used for the existing analysis. Tributary B is conveyed through two 36-inch RCPs under West 17th Street, as shown in Figure 10-2, and West 17th Street begins overtopping during the 2-year storm event. West 17th Street is considered a local street, according to the City of Bryan Thoroughfare Plan.

Figure 10-1. Sanitary sewer protection downstream of West 17th Street

Figure 10-2. Two 36-inch RCPs downstream of West 17th Street

10.2 Proposed Improvements

Culvert improvements are proposed at West 17th Street and Still Creek Tributary B to prevent the 25-year storm event from overtopping the road. It is proposed to replace the two 36-inch RCPs with 4-12'x4' RCBs and to raise the road approximately 1 ft, as shown in Appendix A-20. Raising the road requires approximately 350 LF of roadway improvements. The total estimated construction cost for improvements at West 17th Street is approximately $586,000 and an opinion of probable construction cost is provided in Appendix C.

11 Conclusions and Recommendations

Freese and Nichols (FNI) was contracted by the City of Bryan to conduct a detailed study of flooding issues within the Still Creek watershed and to develop a set of recommended improvements to mitigate these issues. The most severe flooding in the watershed occurring in the Lynndale Acres subdivision was determined to result from two causes: inadequate flow capacity in Still Creek and inadequate infrastructure to accommodate drainage from a large local drainage area east of Old Hearne. Table 11-1 below summarizes the number of homes experiencing significant flooding above the finished floor elevation under existing conditions.

Table 11-1. Homes subject to flooding in each return event

2-year	5-year	10-year	25-year	50-year	100-year	500-year
17	25	30	36	41	41	54

In order to reduce 100-year peak flows in Still Creek to a level that does not flood any homes and can be accommodated by the existing channel, FNI recommends that two large regional detention ponds be constructed east of Bonham Elementary School and near the intersection of Wilkes Street and Bonham Street, respectively. The detention pond near Bonham Elementary will also provide adequate storage to prevent 100-year peak flows from the large local drainage area from overtopping Old Hearne Road and flooding homes in Lynndale Acres. FNI also recommends adding or replacing existing culvert barrels within Lynndale Acres to properly accommodate 100-year peak flows, and enclosing drainage ditches in new storm drain along Old Hearne Road and Wilkes Street to provide additional capacity. Together, these improvements remove all 40 homes from the risk of flooding during the 100-year storm event. The estimated construction cost of the recommended improvements is $7,892,600. The net present benefits of this project to residents of Lynndale Acres as determined by standard FEMA Benefit Cost Analysis methodology is $11,504,004. Accounting for maintenance costs in addition to construction costs yields a total of $7,969,190 and a benefit-cost ratio of 1.44 for this project.

In consideration of the widespread nature of flooding in the Lynndale Acres subdivision, and because of the substantial cost of the improvements recommended in this report, FNI recommended that the City seek federal funding for design and construction of improvements. FNI assisted the City in preparing an application for the FEMA's Severe Repetitive Loss Grant program, which provides federal funding to cover up to 90% of cost-beneficial projects. The grant application was submitted for consideration in October 2011 for FEMA's Fiscal Year 2012 SRL program.

FNI also examined existing flooding conditions at five other road crossings in the Still Creek watershed – Tennessee Avenue, Woodville Road, Southside Drive, West Martin Luther King Jr. Street, and West 17th Street – and has recommended a combination of channel, culvert, and roadway improvements as appropriate in order to accommodate 100-year peak flows at each crossing without overtopping. The total estimated construction cost of these improvements is

approximately $2,019,000. FNI recommends that the City include these projects in their capital improvement plan for consideration of funding.

Once the Lynndale Acres improvements are designed and constructed, the risk of flooding at Tennessee Avenue will be reduced to an acceptable level, as defined by the City of Bryan's stormwater design guidelines. The risk of overtopping at Woodville Road, Southside Drive, West Martin Luther King Jr. Street, and West 17th Street crossings would be unaffected by the recommended improvements in Lynndale Acres, so design and construction of improvements at each of these crossings can proceed independently as funding allows.

Appendix A

Exhibits

Still Creek Watershed Overview

Figure A-1

Still Creek Watershed Study
Bryan, Texas

Verbal Scale: 1" = 150' Date: October, 2011
Absolute Scale: 1 = 1,800 Job No.: BRY10455
H:\STORMWATER\FINAL_EXHIBITS\FinalReport\....mxd

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N

0 1,500 3,000 6,000 Feet

Legend

- Still Creek watershed
- Existing subbasins
- Bryan city limits

SANDY POINT RD
N HARVEY MITCHELL PW
BRITTEN RD
BURT RD
LOST PINE DR
MUMFORD RD
N TEXAS AV
WILKES ST
N EARL RUDDER FW
OLD RELIANCE RD
W 17TH ST
WACO ST
SMETANA RD
W SH 21
E WJB PW
BOONVILLE RD
SH 47
SHILOH AV
S TEXAS AV
E VILLA MARIA RD
BRIARCREST DR
S COLLEGE AV
BARAK LN
N HARVEY MITCHELL PKWY

W5501 W5430 W5400 W5491 W5492 W5500 W5410 W5440 W5493 W5490 G A2 A1 B H I2 C D W5390 W5380 O2 Q2 K2 F U2 N W5480 W4810 W3650 W5210 W5280 W5170 W5650 W4950 W5270 W5640 W3660 W4970 W5550 W3690 W5090 W5110 W5620 W5770 W5660 W5580 W5010 W5630 W4150 W5560 W4140 W5590 W4130 W4100 W4160 W4350 W4520 W5760 W4080 W4210 W4270 W4030 W4090 W4190 W3980 W3790 W3780 W3930 W3940 W3840 W3890

Anonymized Property ID Map

Figure A-2

Still Creek Watershed Study
Bryan, Texas

Verbal Scale: 1" = 200' Date: October, 2011
Absolute Scale: 1 = 2400 Job No.: BRY10455
H:\STORMWATER\FINAL_EXHIBITS\FinalReport\....mxd

N

0 100 200 400 Feet

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p: (817) 735-7300 f: (817) 735-7491

TG PA PZ OY OX OW OV PF PE PD PC PB PO PN PM PL PK OU OT OS OR OQ OP OO ON OM OA NV NU NT NS NR NQ NP NO LA NM NL NK NJ NI NH NG NF NE ND NC NB NA NZ MY MX MW MV MU MT MS MR MQ MP MO MN MM ML MK MJ MI MH MG MF ME MD MC LY LX LW LV LU LT LS KY KX KW KV KU KT KS KR KQ KP KO KN KM KL KK KJ KI KH KG KF KE KD KC KB KA JY JX JW JV JU JT JS JR JQ JP JO JJ JI JH JG

Still Creek

Legend

- Parcels
- Structures
- Stream flow line

Existing Model Subbasins

Figure A-3

Still Creek Watershed Study
Bryan, Texas

Verbal Scale: 1" = 500' Date: October, 2011
Absolute Scale: 1 = 6,000 Job No.: BRY10455
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N

0 400 800 1,600 Feet

Legend

- Existing subbasins
- Stream flow line
- 10-ft contours
- 2-ft contours

Existing flowpaths

Type

- Channel
- Pipe
- Shallow
- Sheet

W5400 W5410 W5430 W5390 W5480 W5491 W5492 W5493 W5501 W5500 W5490 W5210

A1 A2 B C D F G H I2 K2 N O2 Q2 U2

Still Creek

Existing Model Subbasins for InfoWorks

Figure A-4

Still Creek Watershed Study
Bryan, Texas

Verbal Scale: 1" = 500' Date: October, 2011
Absolute Scale: 1 = 6,000 Job No.: BRY10455
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FREESE NICHOLS
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Fort Worth, Texas 76109-4895
p: (817) 7357-7300 f: (817) 735-7491

N

0 250 500 1,000 Feet

Legend

- Existing subbasins for InfoWorks
- Stream flow line

Existing flowpaths for InfoWorks

Type

- Channel
- Pipe
- Shallow
- Sheet

Still Creek

A1 A2 B C D E F G H I J K L M N O P Q R S T U V

STEVENS DR
WOODKNOLL DR
VERSON DR
CANDY LN
KIM ST
KERRY LN
BONHAM DR
REDSKIN
STEELER
N EARL RUDDER FW ACCESS RD
N EARL RUDDER FW
SIEGERT DR
OLD HEARNE RD
GLACIER DR
BIG BEND DR
LIGHTFOOT LN
MISSOURI AV
MCHANEY DR
RUSSELL DR
YELLOWSTONE DR
YOSEMITE DR
TETON DR
BIGHORN DR
WILKES ST
WOODWARD DR
ARIZONA AV
MINNESOTA AV
WILHELM DR
LIVE OAK DR
OKLAHOMA AV
MONTANA AV
ALABAMA AV
GEORGIA AV
HEFTI CR
ORLAN DR
TABOR RD
ELKHORN TR
NUCHES LN
AUTRY LN
COLSON RD
STONE MEADOW CR

Recommended Improvement Subbasins

Figure A-5

Still Creek Watershed Study
Bryan, Texas

Verbal Scale: 1" = 500' Date: October, 2011
Absolute Scale: 1 = 6,000 Job No.: BRY10455
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N

0 400 800 1,600 Feet

Legend

- Proposed subbasins
- Stream flow line

Proposed flowpaths

Type

- Channel
- Pipe
- Shallow
- Sheet

W5400 W5410 W5430 W5440 W5390 W5480 W5210 W5490 W5491 W5492 W5493 W5500 W5501 B2 B A1 A2 D C I2 H O2 Q2 K2 F N U2 G

Still Creek

VILLAGE PARK NORTHSIDE DR EMERALD DR NORMALVERN ST MARGARET ST STAUNTON DR SOUTHSIDE DR TIMBERLINE DR LOG HOLLOW DR AUGUSTA DR FOXWOOD DR LAURA LN WOODY LN WOODBEND DR WATERWOOD LN HARDWOOD DR WOODVILLE RD MARSH ST WOOD RD N SSOW VIKING DR REDSKIN STEELER STEVENS DR OLD HEARNE RD CANDY LN KIM ST BONHAM DR GLACIER DR LIGHTFOOT LN TETON DR YOSEMITE DR YELLOWSTONE DR WILKES ST WOODWARD DR MISSOURI AV MCHANEY DR LOUISIANA AV N TEXAS AV MCHANEY DR OKLAHOMA AV ALABAMA AV GEORGIA AV TENNESSEE AV MONTANA AV WILLHELM DR LIVE OAK DR HEFTI CR TABOR RD SIEGERT DR ELAINE DR SHIRLEY DR NANCY ST RABBIT LN N EARL RUDDER FWY FAIR LANE ST HAWKS OWEN ST CLARKS LN CHARLES AV DRILLERS DR COLSON RD NUCHES LN AUTRY LN ELKHORN TR STONE MEADOW CR STONE VIEW CT KOALA CARRABBA ST LESH 21

InfoWorks SD 2D Model Overview

Figure A-6

Still Creek Watershed Study
Bryan, Texas

Verbal Scale: 1" = 150' Date: October, 2011
Absolute Scale: 1 = 1,800 Job No.: BRY10455
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N

0 75 150 300 Feet

2-6'x6' culvert

36" culvert

0 15 30 60 Feet

2D boundary conditions set using time-varying tailwater developed from Halff RAS model

4'x4' culvert

10'x4' culvert

24" culvert

24" culvert

24" culvert

24" culvert

OLD HEARNE RD

WILKES ST

MCHANEY DR

LOUISIANA AV

RUSSELL DR

INDIANA AV

WILLHELM DR

MISSOURI AV

WOODWARD DR

Still Creek

XS44332
XS44225
XS44091
XS43851
XS43801
XS43569
XS43435
XS43276
XS43142
XS945

Legend

- Stream flow line
- Node
- 2D point source
- Weir
- River element
- Culvert
- Culvert inlet/outlet
- 2D boundary
- 2D limits
- 2D mesh

Roughness (Manning's n)

- 0.02
- 0.035
- 0.05

Existing Inundation Map (100-year event)

Figure A-7

Still Creek Watershed Study
Bryan, Texas

Verbal Scale: 1" = 150' Date: October, 2011
Absolute Scale: 1 = 1,800 Job No.: BRY10455
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N

0 75 150 300 Feet

Legend

- FEMA 100-yr floodplain
- 2D limits

2D depth

Depth

- 0 - 0.5'
- 0.5 - 1'
- 1 - 1.5'
- 1.5 - 2'
- 2 - 3'
- 3 - 4'
- 4 - 5'
- 5 - 7.5'
- 7.5 - 10'

BIG BEND DR
YELLOWSTONE DR
WILKES ST
MISSOURI AV
WOODWARD DR
Still Creek
McHANEY DR
LOUISIANA AV
RUSSELL DR
INDIANA AV
OLD HEARNE RD
WILHELM DR

Existing Structure Flooding

Figure A-7b

Still Creek Watershed Study
Bryan, Texas

Verbal Scale: 1" = 150' Date: October, 2011
Absolute Scale: 1 = 1,800 Job No.: BRY10455
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N

0 75 150 300 Feet

FREESE NICHOLS
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Overtops in 5-yr
Overtops in 2-yr
Overtops in 5-yr
Overtops in 2-yr
Does not overtop
Overtops in 2-yr
Overtops in 5-yr
Overtops in 2-yr
Overtops in 2-yr
Overtops in 25-yr

BIG BEND DR
YELLOWSTONE DR
WILKES ST
MISSOURI AV
McHANEY DR
RUSSELL DR
LOUISIANA AV
INDIANA AV
WILLHELM DR
OLD HEARNE RD
Still Creek

NV NU NT NS NR NQ NP NO NN NM NL NK NX NZ LA TZ KX KW KV KU KT KS KL KR KM KK KJ KI KH KG KF KZ KA KB KC KD KE JY JW JV JU JT JS JR JQ JJ JP JI JH JG JO JN JM GZ HN HM HL HK HJ GO GN GM GL KO KP KQ MJ MI MZ MH MG LX MF LW LV LU LT ME MD MW MV MU MT MS MR MQ MP MO MN MM ML MK NJ NI NH NG NF NE ND NC NB NA NZ MY MX LO LN

Legend

- Roads
- Stream flow line
- 2007 or 2009 flood complaints

Flooded Structures by Frequency

2-year 10-year 100-year

	Summary of Inundation Depth by Frequency Event (ft)						
	2y	5y	10y	25y	50y	100y	500y
No. structures	17	25	30	36	41	41	54
Min depth	0.02	0.02	0.05	0.01	0.01	0.05	0.01
Max depth	1.79	2.35	2.58	2.85	3.11	3.22	3.57
Average depth	0.46	0.53	0.57	0.65	0.71	0.85	0.96

DISCLAIMER : This is a product of the City of Bryan Geographic Information System. The data depicted here have been developed with extensive cooperation from other city departments, as well as other federal, state and local government agencies. The City of Bryan expressly disclaims responsibility for damages or liability that may arise from the use of this map.

PROPRIETARY INFORMATION: Any resale of this information is prohibited, except in accordance with a licensing agreement.

CITY OF BRYAN
The Good Life, Texas Style.

1 inch = 150 feet

BONHAM ELEMENTARY SCHOOL

Legend

- STILL CREEK APPROX FLOODPLAIN
- 2007 FLOODED RESIDENCES
- 2009 FLOODED RESIDENCES
- STORM FLOW 2009
- FLOODED PROPERTIES
- CONTOURS MAJOR (10 ft)
- CONTOURS MINOR (2 ft)
- STREETS
- BCAD PARCELS
- BRYAN CITY LIMITS
- CREEKS
- COB BUILDING FOOTPRINTS

Regional Detention Alternatives

Figure A-8

Still Creek Watershed Study
Bryan, Texas

Verbal Scale: 1" = 300' Date: October, 2011
Absolute Scale: 1 = 3,600 Job No.: BRY10455
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CITY OF BRYAN

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N

0 150 300 600 Feet

Legend

- Possible pond locations
- Stream flow line
- 2-ft contours
- 10-ft contours

STEVENS DR
STEELER
REDSKIN
CARDINAL
BETHANY DR
TABOR RD
N EARL RUDDER FW
N EARL RUDDER FW ACCESS RD
N EARL RUDDER FW W FRONTAGE RD
N EARL RUDDER FW E FRONTAGE RD
N EARL RUDDER FW RAMP
WOODKNOLL DR
KEYSTONE CR
IVERSON DR
CANDY LN
KIM ST
KERRY LN
WILKES ST
BONHAM DR
SIEGERT DR
LIGHTFOOT LN
GLACIER DR
BIG BEND DR
MISSOURI AV
OLD HEARNE RD
McHANEY DR
LOUISIANA AV
NUCHES LN

Conveyance Improvement Alternatives

Figure A-9

Still Creek Watershed Study
Bryan, Texas

Verbal Scale: 1" = 200' Date: October, 2011
Absolute Scale: 1 = 2,400 Job No.: BRY10455
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N

0 100 200 400 Feet

420 LF 4x4 RCB

1400 LF channel widening
Approx. 35-ft top width

750 LF 6x6 RCB

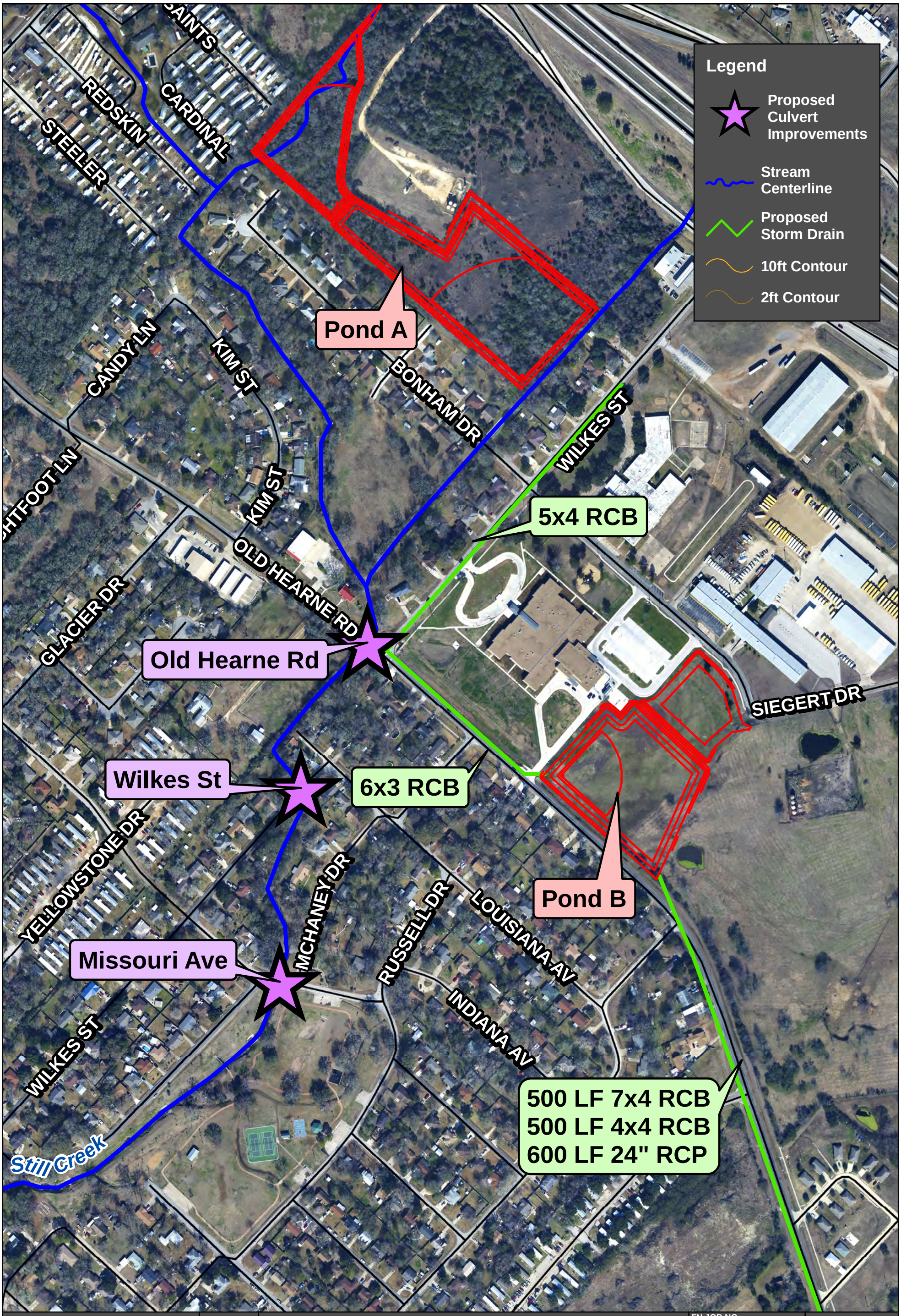
1200 LF 6x6 RCB

GLACIER DR
BIG BEND DR
WILKES ST
McHANEY DR
OLD HEARNE RD
SIEGERT DR
YELLOWSTONE DR
WOODWARD DR
MCHANEY DR
RUSSELL DR
LOUISIANA AV
WILLHELM DR
INDIANA AV
MISSOURI AV
LIVE OAK DR
Still Creek

360 350 340 330 320

Legend

- Storm drain
- Channel improvements
- Stream flow line
- 2-ft contours
- 10-ft contours



0 150 300 Feet

N

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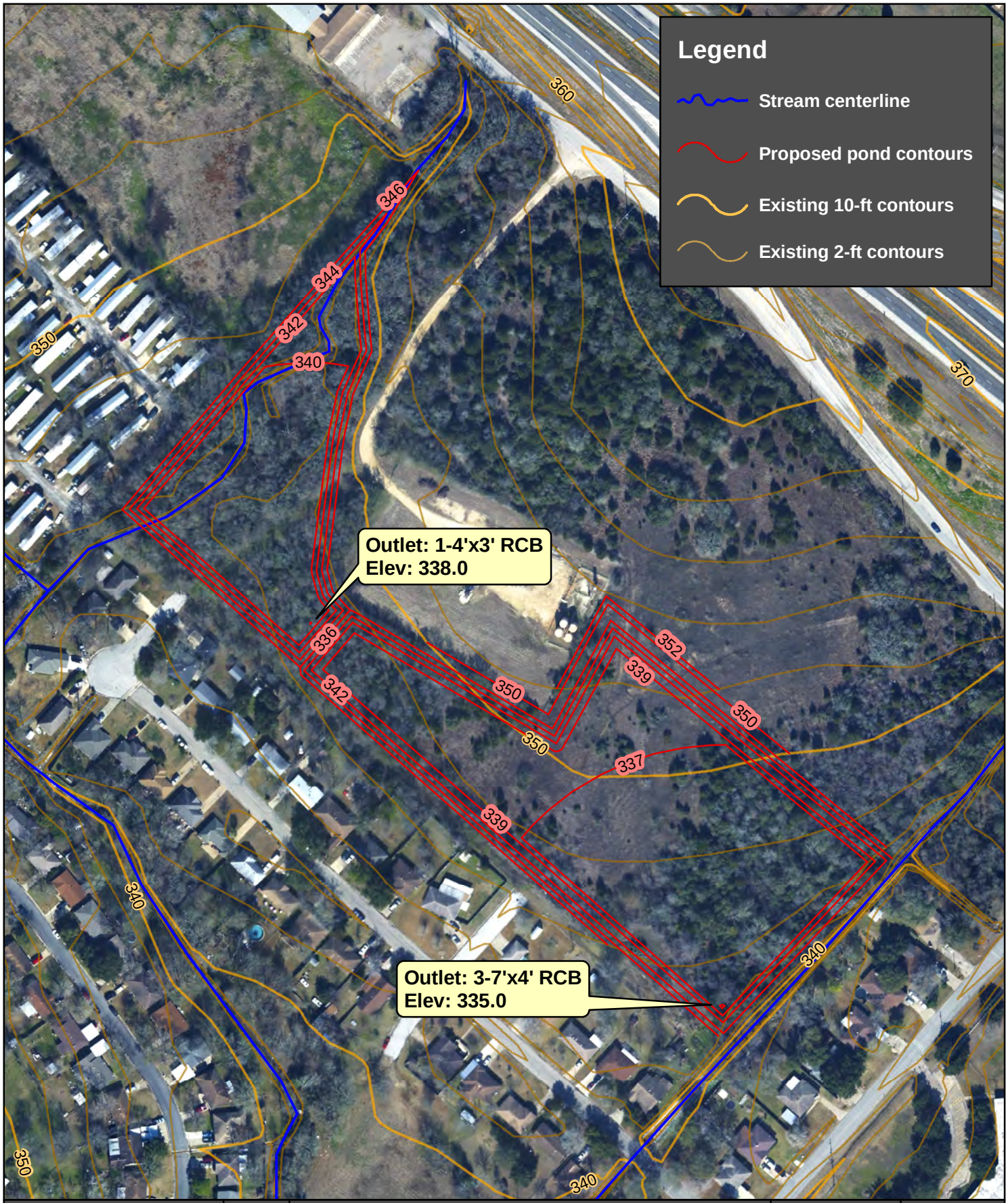
Still Creek Watershed Study

City of Bryan, Texas

Recommended Improvements Overview

FN JOB NO	BRY10455
FILE	H:\STORMWATER\FINAL_EXHIBITS\Final Report\....mxd
DATE	October, 2011
SCALE	1:3,600
DRAFTED	RCT

FIGURE A-10



Still Creek Watershed Study

City of Bryan, Texas

Recommended Alternative: Pond A Detail

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SCALE	1:2,400
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FIGURE A-11

0 75 150 Feet

N

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Still Creek Watershed Study

City of Bryan, Texas

Recommended Alternative: Pond B Detail

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DATE	October 2011
SCALE	1:1,800
DRAFTED	JGJ

FIGURE A-12

0 100 200 Feet

N

Still Creek Watershed Study

City of Bryan, Texas

West Fork Existing

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SCALE	1:2,400
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FIGURE A-13

0 50 100 Feet

N

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Still Creek Watershed Study

City of Bryan, Texas

West Fork Proposed

FN JOB NO	BRY10455
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SCALE	1:1,200
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FIGURE A-14

0 100 200 Feet

N

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Still Creek Watershed Study

City of Bryan, Texas

Southside Drive Existing

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DATE	October, 2011
SCALE	1:2,400
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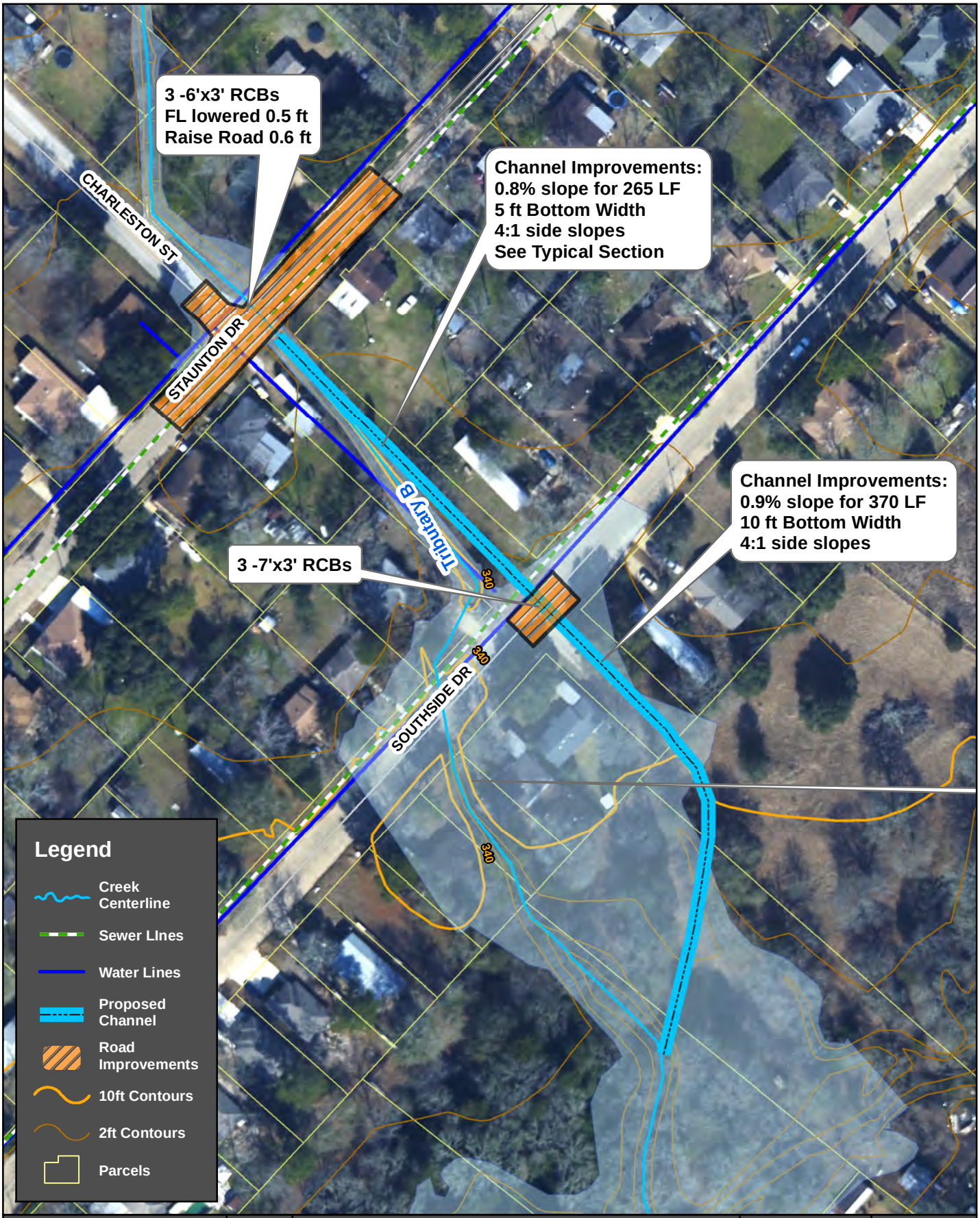
FIGURE A-15



0 50 100 Feet

N

Still Creek Watershed Study

City of Bryan, Texas

Southside Drive Proposed

FN JOB NO	BRY10455
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DATE	October, 2011
SCALE	1:1,200
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FIGURE A-16

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0 100 200 Feet

N

Still Creek Watershed Study

City of Bryan, Texas

West MLK Existing

FREESE AND NICHOLS
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Fort Worth, TX 76109 - 4895
P: 817-735-7300 F: 817-735-7300

FN JOB NO	BRY10455
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DATE	October, 2011
SCALE	1:2,400
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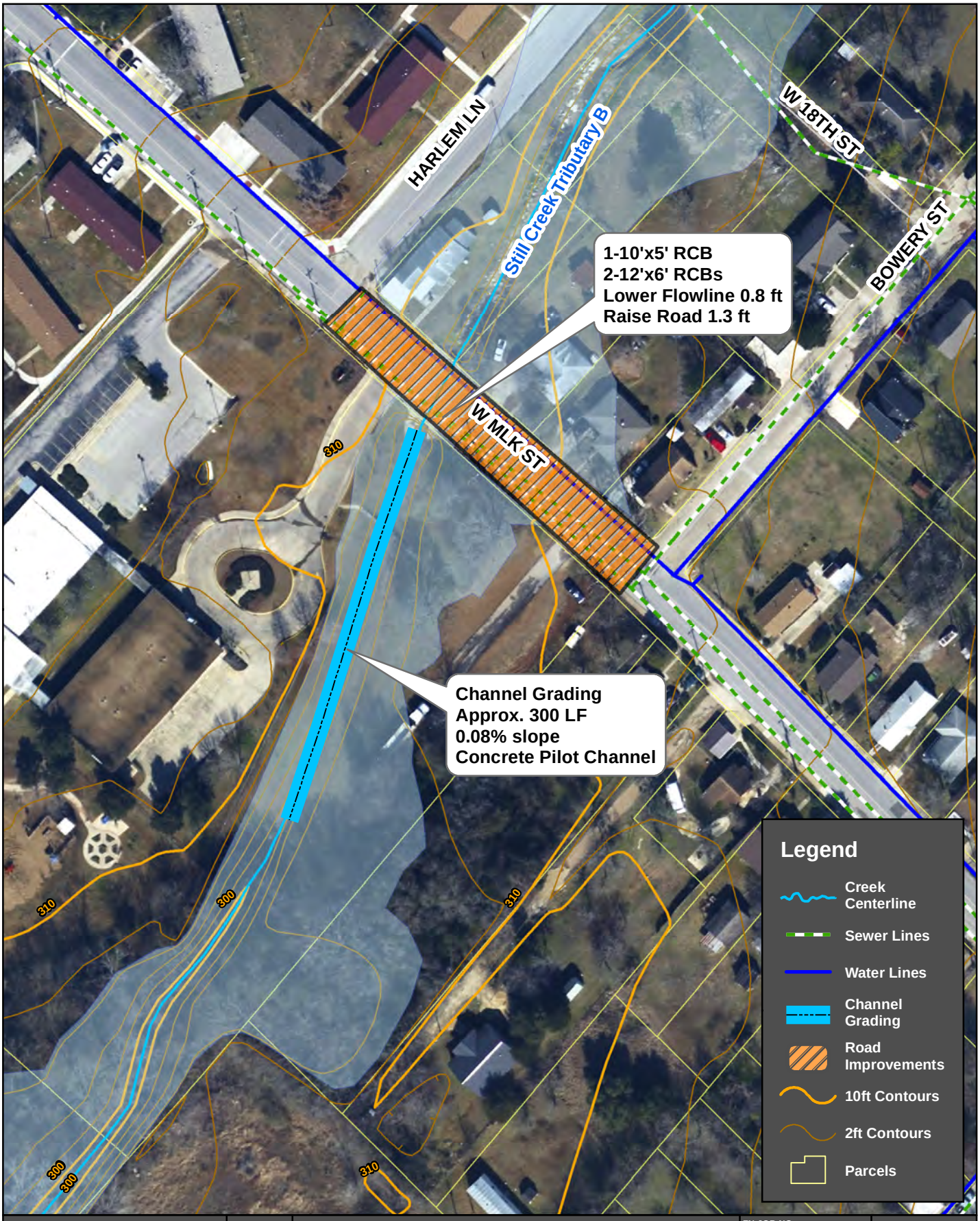
FIGURE A-17



0 50 100 Feet

N

Still Creek Watershed Study

City of Bryan, Texas

West MLK Proposed

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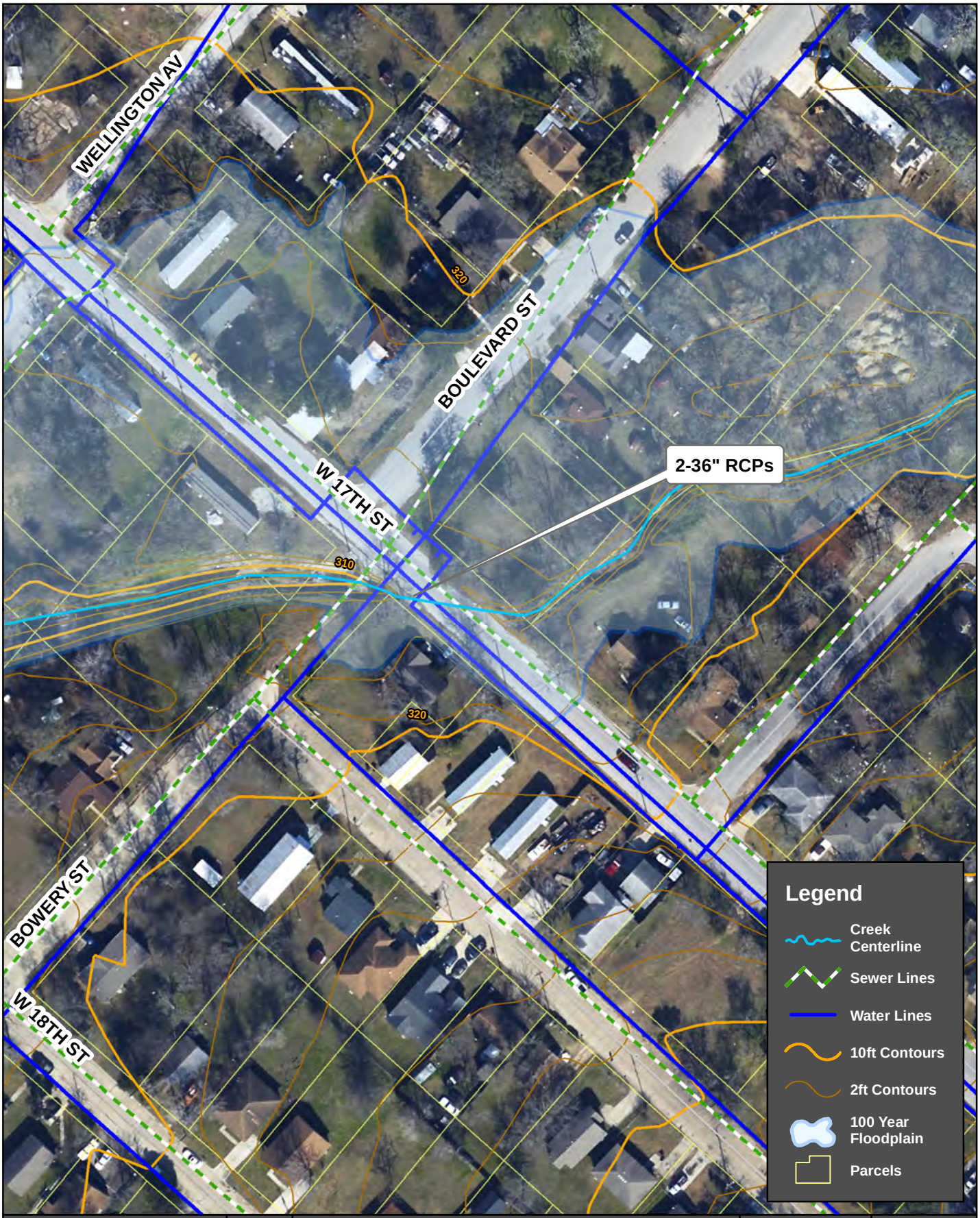
FILE	H:\STORMWATER\FINAL_EXHIBITS\Final Report\....mxd
DATE	September, 2011
SCALE	1:1,200
DRAFTED	RCT

FIGURE
A-18



0 50 100 Feet

N

Still Creek Watershed Study

City of Bryan, Texas

West 17th Existing

FREESE AND NICHOLS
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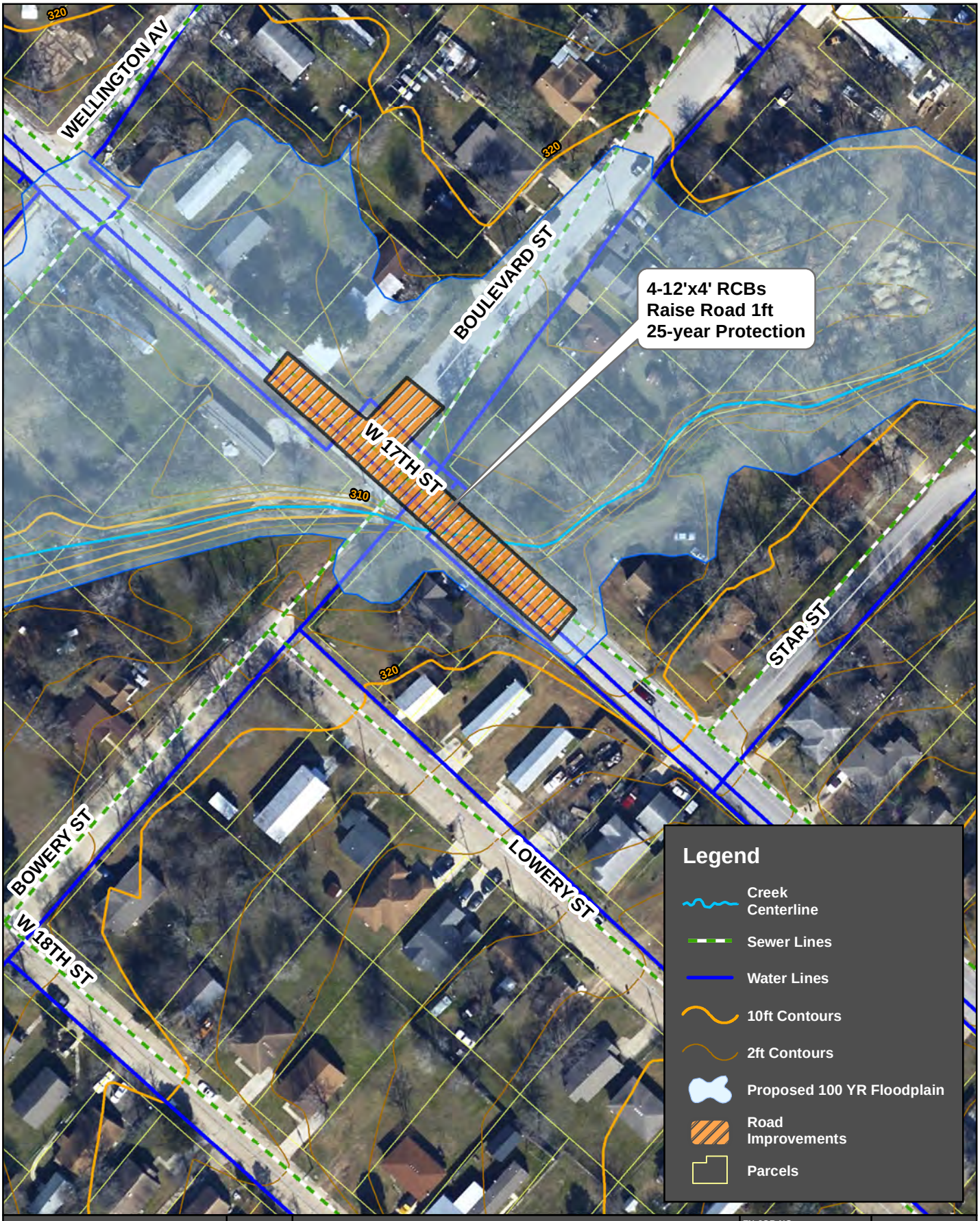
Fort Worth, TX 76109 - 4895
P: 817-735-7300 F: 817-735-7300

FN JOB NO	BRY10455
FILE	H:\STORMWATER\FINAL_EXHIBITS\Final Report\...mxd
DATE	October, 2011
SCALE	1:1,200
DRAFTED	RCT

FIGURE A-19



0 50 100 Feet

N

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Fort Worth, TX 76109 - 4895
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Still Creek Watershed Study

City of Bryan, Texas

West 17th Proposed

FN JOB NO	BRY10455
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DATE	October, 2011
SCALE	1:1,200
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FIGURE
A-20

Appendix B

Public Meeting Documentation

MEETING MINUTES

FREESE AND NICHOLS

Innovative approaches
Practical results
Outstanding service

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PROJECT: City of Bryan Still Creek Watershed Study
NAME OF MEETING: Public Meeting #1
RECORDED BY: Scott Hubley
DATE: January 26, 2011
LOCATION: Bonham Elementary School
ATTENDEES: Jason Barfknecht, Brett McCully, Paul Kaspar, Alton Rogers, Councilman Madison – City of Bryan
Kathy Hopkins – TWDB
Mike Wayts, Scott Hubley, Garrett Johnston – FNI
Resident Sign-in Sheet Attached

The following reflects our understanding of the items discussed during the subject meeting. If you do not notify us within five working days, we will assume that you are in agreement with our understanding.

ITEM	DESCRIPTION	PRESENTER
1	Brett introduced the project team members and gave some project background then discussed the project process. The goal of the meeting was to collect information about existing flooding problems in the Still Creek watershed.	Brett
2	Two residents attended the public meeting. The project team discussed the existing drainage problems with these residents. Their comments forms are attached.	Brett
3	Because of the low turnout, comment forms will be mailed to all affected property owners asking for 2 week turnaround on comments. After receipt of the comment forms, FNI will summarize all public comments in technical memo.	Scott
4	Meeting adjourned at 7:15 pm.	All

ACTION ITEMS			
WHAT	**WHO**	**WHEN**	**STATUS**
1. Send comment letters to residents	Brett	1/28/11	In progress
2. Provide postcard and public notice to TWDB	Brett	1/28/11	In progress
3.			
4.			
5.			

SIGN IN SHEET

CITY OF BRYAN

STILL CREEK WATERSHED STUDY

PUBLIC MEETING #1

6:00 PM, JANUARY 26, 2011

BONHAM ELEMENTARY SCHOOL

NAME	ADDRESS	PHONE	EMAIL
Property ID NR			
Property ID NS			

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The Good Life, Texas Style.

FREESE AND NICHOLS

Still Creek Watershed Study

Public Meeting #1
January 26, 2011

Public Comment Form

Contact Information

Full Nam

Phone/Er

Address:

May we c

Best way

Property ID NR

Questions

What specific drainage or flooding problems has your property encountered and when?

Front and back yards Floods really bad. When it rains hard. I've seen it Flooded about 15-20 inches Two times. One time it Flooded the inside of the house.

Please describe any other flooding that you've experienced (yard, streets, cars, ditches, etc.).

I've also seen Louisiana street and other neighborhood Streets Flooded.

Other Comments:

CITY OF BRYAN
The Good Life, Texas Style.

FREESE AND NICHOLS

Still Creek Watershed Study
Public Meeting #1
January 26, 2011

Public Comment Form

Contact Information

Full Nam Property ID NS

Phone/Er

Address:

May we

Best way

Questions

What specific drainage or flooding problems has your property encountered and when?

Under Heavy Rain water Backsup + Floods Property only in intense rains. Never had water in house - replaced A/C 10-12 yrs ago

Please describe any other flooding that you've experienced (yard, streets, cars, ditches, etc.).

Backditch, whole yard, Rearend in truck 16" in Fence. 18" Deep in yard / knee deep

Other Comments:

4-5" w/in FFE

After road crosk, just constant flow - 3" over crown overtops Louisiana 5 times since '84

Breaks in front of two house before int of McHaney / Louisiana.

Hasn't seen Old Ham Rd overtop

1 Hr delay from heavy rain

CITY OF BRYAN
STILL CREEK WATERSHED STUDY
PUBLIC MEETING #2

CITY OF BRYAN

Texas Water Development Board

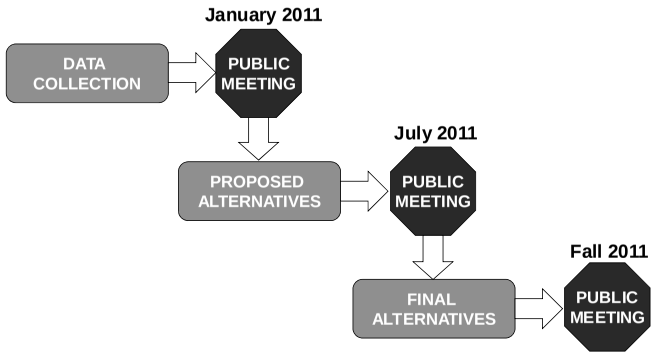
FREESE AND NICHOLS

July 28, 2011

Presentation Outline

- Study Overview
- Existing Conditions
- Improvement Options
- Proposed Alternatives
- Your Questions and Comments

Project Schedule



Study Overview

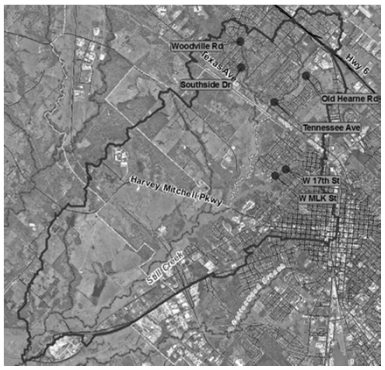
Still Creek Watershed

- Road overtopping at several locations in watershed
- Repetitive flooding of homes in Lynndale Acres

Study Overview

Still Creek Watershed

- **Road overtopping at several locations in watershed**
- Repetitive flooding of homes in Lynndale Acres

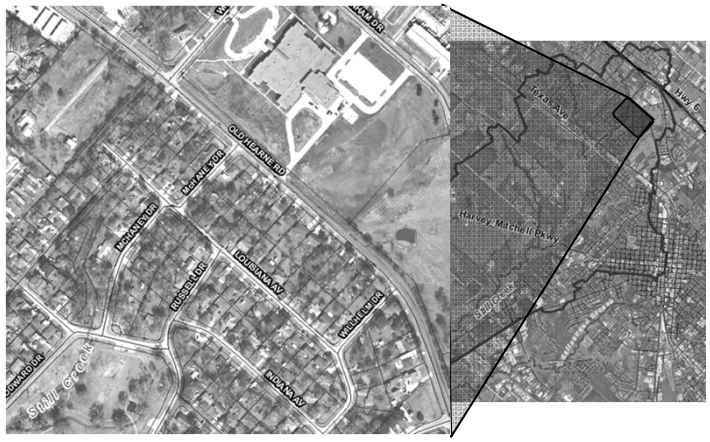


Study Overview

Still Creek Watershed

- Road overtopping at several locations in watershed
- **Repetitive flooding of homes in Lynndale Acres**

Study Overview



Flooding History

- 29 flood insurance claims in the past 32 years
- Recent storm events
  - May 1, 2007: 2-year storm floods 14 homes
  - April 25, 2009: 1-year storm floods 12 homes
- 9 public comment forms received
  - "Entire yard, ditches, and street have flooded from Old Hearne Rd to Bonham Park"
  - "Water runs through side yards and backyard"
  - "Whole yard 18 inches deep"

Existing Conditions

- Two major causes of flooding
  - Channel has insufficient capacity
  - Inadequate infrastructure for large local drainage area

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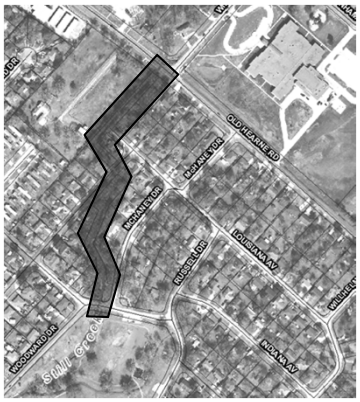

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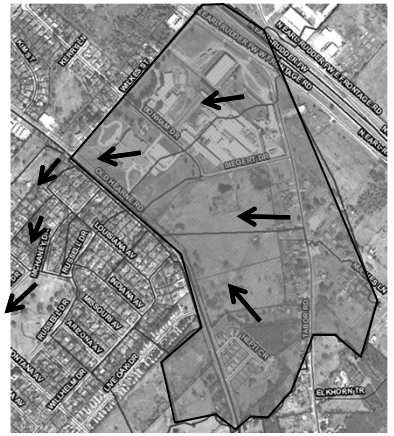

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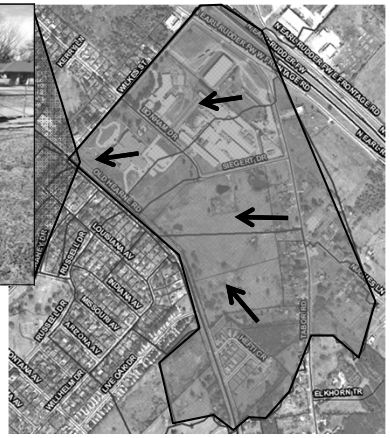

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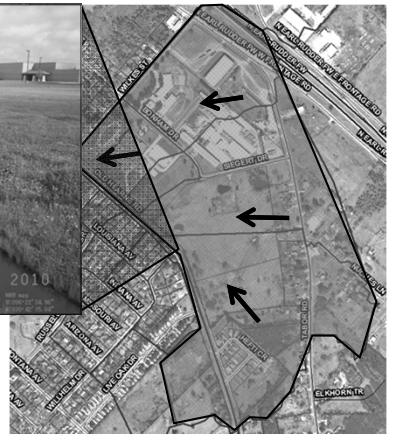

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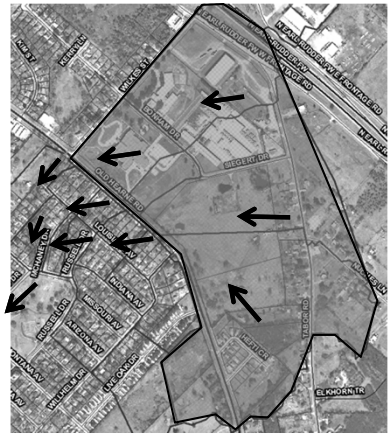

Existing Conditions

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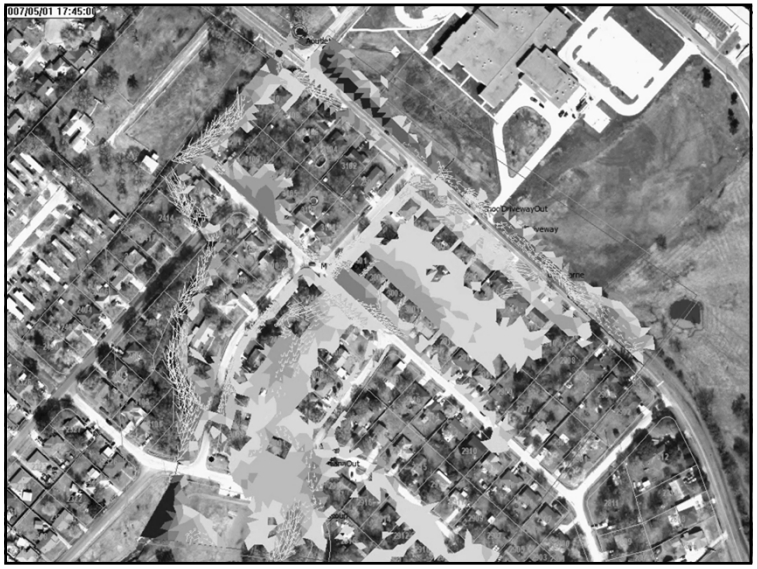
Hydraulic Model



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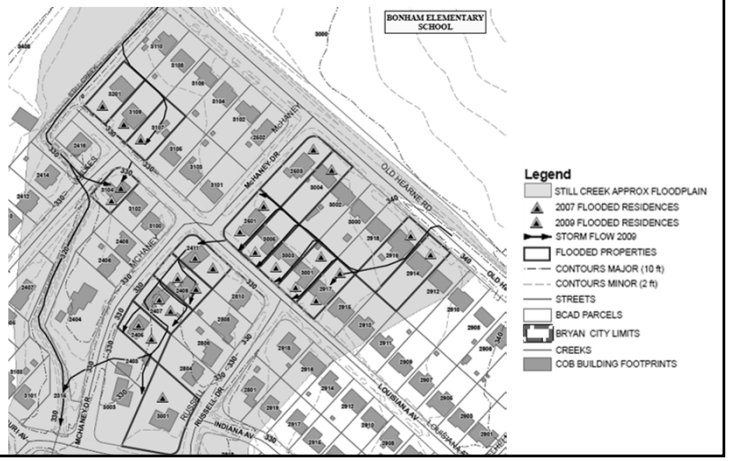

Model Results

Resident Comment	Model Results (2007 storm)	Model Results (2009 storm)
Front, back yards flood: 15-20" twice	18" in yard	13" in yard
Sheds flooded 4-5" twice since 2006	6" at sheds	3" at sheds
Workshop has come within 2" of flooding once	Within 1" of workshop	Within 2' of workshop
Yard and street floods 18"	18" in yard	12" in yard

Improvement Options

Goal: Flood damage reduction

Two-part solution required:

(1) Address insufficient channel capacity

(2) Address inadequate infrastructure for large local drainage area

Improvement Options

- Approaches:
  - **Bigger pipes/channels:** Provide extra capacity (conveyance), move excess rainfall downstream
  - **Detention ponds:** Store excess rainfall upstream, release slowly into existing channel
  - **Buyouts:** Remove homes from flooding area

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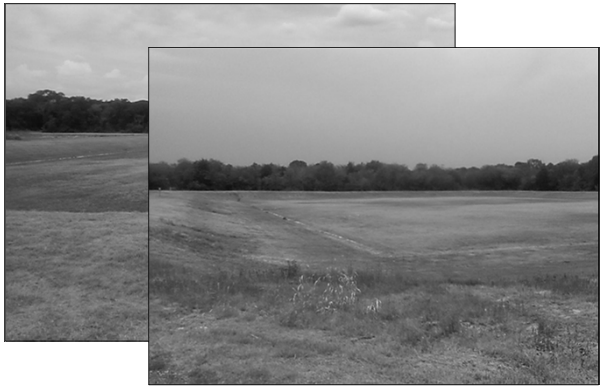
Improvement Options



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Proposed Alternatives

- Main channel
  - Conveyance option
  - Pond options (1 of 3)
  - Buyouts
- Local drainage area
  - Conveyance option
  - Pond option
  - Buyouts

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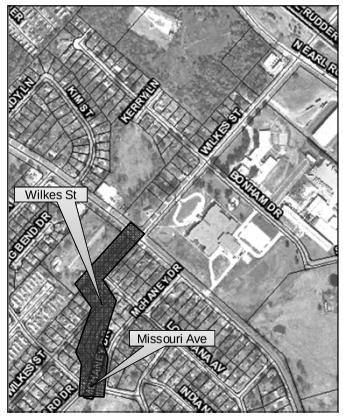

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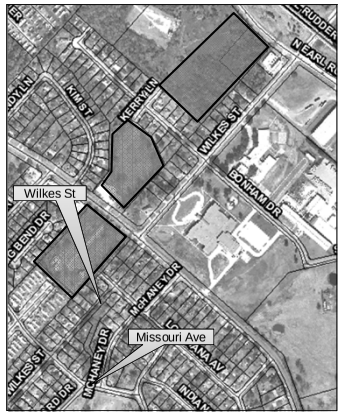

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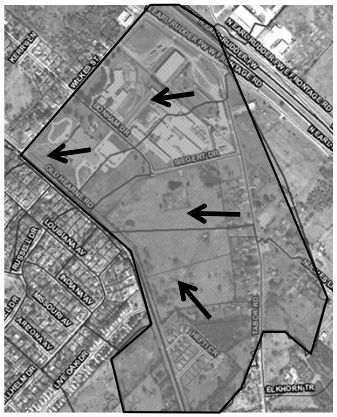

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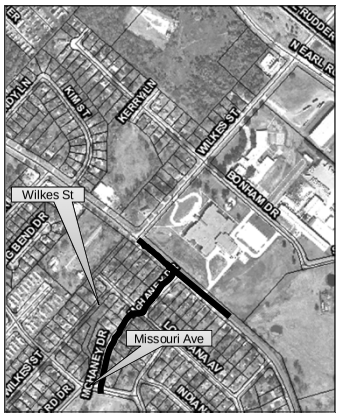

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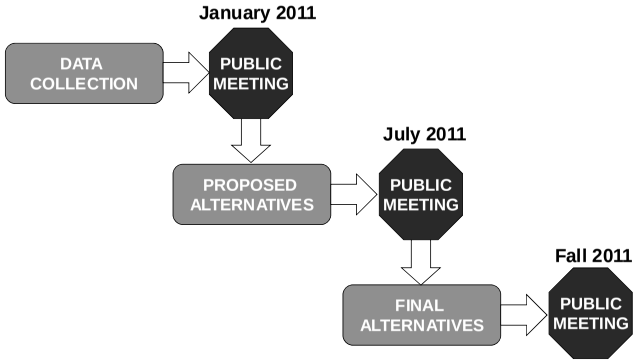
- **Local drainage area**
  - Conveyance option
  - Pond option
  - **Buyouts**

Summary

- Main channel
  - Conveyance option
  - Pond options (1 of 3)
  - Buyouts
- Local drainage area
  - Conveyance option
  - Pond option
  - Buyouts

Next Steps



Next Steps

- After watershed study is completed in Fall of 2011, project will be added to City CIP for design and construction
- Schedule for implementation will be dependent on funding (Bond or Grant)

Questions

Contact:

Brett McCully, P.E.
Assistant City Engineer
979-209-5030
bmccully@bryantx.gov

MEETING MINUTES

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PROJECT: City of Bryan Still Creek Watershed Study
NAME OF MEETING: Public Meeting #2
RECORDED BY: Garrett Johnston
DATE: July 28, 2011, 6:30 PM
LOCATION: Bonham Elementary School
ATTENDEES: Jayson Barfknecht, Paul Kaspar, Paul Madison, Brett McCully – City of Bryan
Kathy Hopkins – TWDB
Mike Wayts, Scott Hubley, Katie Hogan, Garrett Johnston – FNI
Residents of Lynndale Acres (sign-in sheet attached)

The following reflects our understanding of the items discussed during the subject meeting. If you do not notify us within five working days, we will assume that you are in agreement with our understanding.

ITEM	DESCRIPTION	PRESENTER
1.	Brett introduced the project team members and discussed the study's purpose and schedule. Mike gave an overview of the watershed study, described FNI's existing conditions model of Lynndale Acres, demonstrated its correlation with resident comments, and presented several alternatives for mitigating flooding issues, emphasizing the need for two separate solutions to mitigate flooding along Still Creek and flooding across Old Hearne. Brett solicited feedback from the residents as to their preferred alternatives and reviewed the study schedule. The presentation file has been attached as a separate document.	Brett and Mike
2.	Residents responded with verbal comments and questions throughout the presentation. These comments can be generally categorized under the following themes: • Residents noted that the 2007 and 2009 storms flooded more than the 14 and 12 homes, respectively, that were reported to City of Bryan staff. (This matches results from FNI's existing conditions model, which shows extensive flooding beyond 14 homes in both storms.) • Residents stated that flooding near McHaney Dr, Russell Dr, and Indiana Ave has occurred since the late 1970s (flooding from the main channel), but that homes along Old Hearne Rd were not flooded prior to removal of the tree line along Old Hearne Rd and construction of Bonham Elementary (flooding from local drainage area north/northeast of Old Hearne Rd). • Residents expressed a desire to redirect flood waters coming from north of Old Hearne Rd. • Residents suggested mowing channels and ditches and clearing them of debris.	Residents
3.	Two public comment forms were completed by residents and returned. The forms are included with these minutes.	Residents
4.	Meeting was adjourned at approximately 8:45 PM.	All

ACTION ITEMS			
WHAT	**WHO**	**WHEN**	**STATUS**
1. Refine cost estimates for proposed alternatives	FNI	9/1/11	In progress
2. Perform benefit/cost analysis for each alternative	FNI	9/1/11	In progress
3. Prepare draft report	FNI	9/30/11	In progress
4. Prepare for Public Meeting #3 in Fall 2011	All	9/30/11	In progress

PAGE	DATE	Lyndale Acres Public Meeting # 2
	July 28, 2011	Sign-In Sheet

NOTES

Name	Address	Phone #
Brent McCall	C.O.B.	209-5030
Property ID NM		
Property ID KU		
Property ID KD		
Property ID NN		
Property ID KJ		
Property ID JX		
Property ID NR		
Property ID NL		
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Still Creek Watershed Study
Public Meeting #2
July 28, 2011

Public Comment Form

Contact Information

Full Nam Property ID NX

Phone/En

Address:

May we c

Best way

What is your preferred approach for addressing the **main channel** flooding? (circle one)

Conveyance *Detention* *Buyouts*

Why do you prefer this option?

Least destructive and seems like it is the best option for a resolution to the flooding.

Please make sure to research the flooding patterns at Bonham Park into Russell & Indiana ditches.

Why do you not prefer the other options?

They will not solve the flooding in the park or our house on Indiana.

(over: more questions on back)

What is your preferred approach for addressing the **local drainage area** flooding? (circle one)

Conveyance *Detention* *Buyouts*

Why do you prefer this option?

none

none

Why do you not prefer the other options?

none

Are there any other comments you would like to share?

Contact for further questions/comments:

Brett McCully, P.E.
Assistant City Engineer
City of Bryan
300 South Texas Avenue
979-209-5030
bmccully@bryantx.gov

CITY OF BRYAN
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Texas Water Development Board

FREESE AND NICHOLS

Still Creek Watershed Study

Public Meeting #2
July 28, 2011

Public Comment Form

Contact Information

Property ID NL

Full Name:

Phone/Ema

Address:

May we co

Best way t

What is your preferred approach for addressing the **main channel** flooding? (circle one)

Conveyance *Detention* *Buyouts*

Why do you prefer this option?

To preserve the look of the area.

Why do you not prefer the other options?

a lot of them don't work as designed.

(over: more questions on back)

What is your preferred approach for addressing the **local drainage area** flooding? (circle one)

Conveyance *Detention* *Buyouts*

Why do you prefer this option?

I believe this is best to solve the problem for people on old Hearne Rd.

Why do you not prefer the other options?

Not sure they work.

Are there any other comments you would like to share?

Contact for further questions/comments:
Brett McCully, P.E.
Assistant City Engineer
City of Bryan
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979-209-5030
bmccully@bryantx.gov

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Texas Water Development Board

FREESE AND NICHOLS

Still Creek Watershed Study
Public Meeting #2
July 28, 2011

Public Comment Form

RECEIVED BY

Contact Information

Property ID KD

Full Name:

Phone/Ema

Address:

May we con

Best way to

What is your preferred approach for addressing the **main channel** flooding? (circle one)

Conveyance *Detention* *Buyouts*

Why do you prefer this option?

There appears to be a natural flow of rainwater from old Hearne Rd. to lower level via McHaney Dr., crossing Missouri Ave, to Bonham Park ← where the detention/collection pond could be located, thus affecting only a few properties.

Why do you not prefer the other options?

The "conveyance" solution would disrupt the flow of traffic (re: elem. school) since there are few roads leading into Lyndale Acres Subdivision.

(over: more questions on back)

What is your preferred approach for addressing the **local drainage area** flooding? (circle one)

Conveyance *Detention* *Buyouts*

Why do you prefer this option?

All four houses on the South side (2400'A) of McHaney flooded severely in the two situations discussed at the public meeting #2.

Why do you not prefer the other options?

Are there any other comments you would like to share?

However, if conveyance is more feasible, dredge & widen the existing creek.

Contact for further questions/comments:
Brett McCully, P.E.
Assistant City Engineer
City of Bryan
300 South Texas Avenue
979-209-5030
bmccully@bryantx.gov

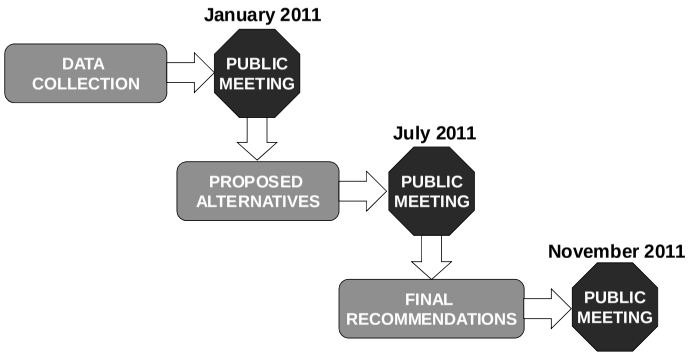
CITY OF BRYAN
STILL CREEK WATERSHED STUDY
PUBLIC MEETING #3

November 1, 2011

Presentation Outline

- Study Review
  - Existing Conditions
  - Improvement Options
- New Information
  - Recommended Improvements
- Your Questions and Comments

Project Schedule



Study Overview

Still Creek Watershed

- Road overtopping at several locations in watershed
- Repetitive flooding of homes in Lynndale Acres

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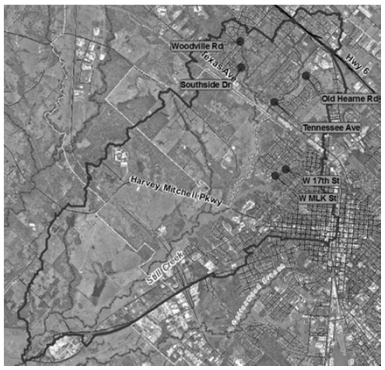

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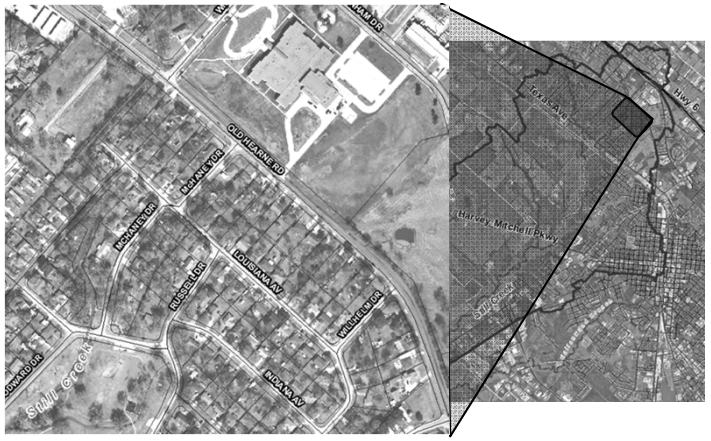

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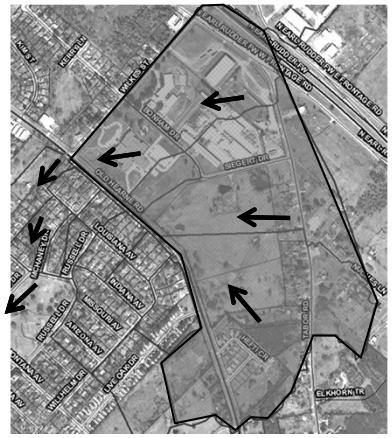

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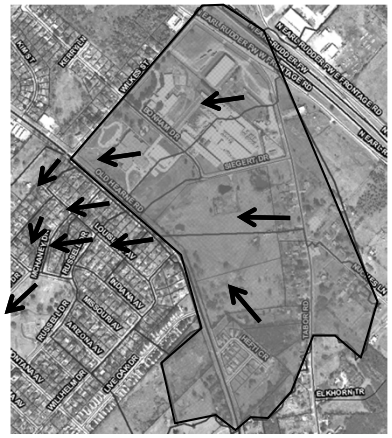

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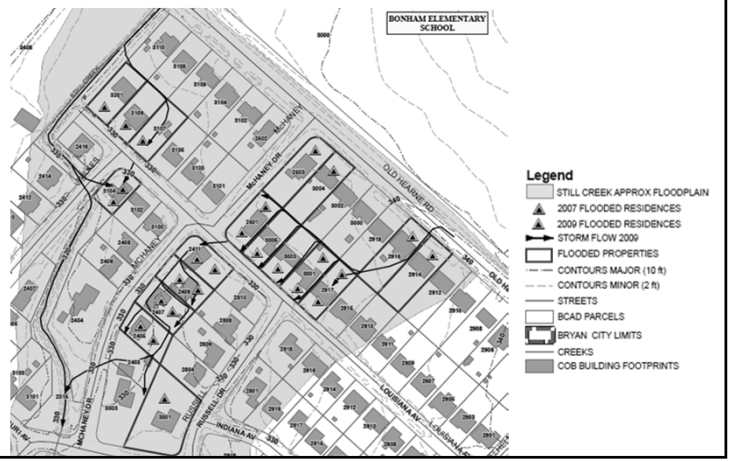

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Improvement Options

Goal: Flood damage reduction

Two-part solution required:

(1) Address insufficient channel capacity

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Improvement Options

- Approaches:
  - **Bigger pipes/channels:** Provide extra capacity (conveyance), move excess rainfall downstream
  - **Detention ponds:** Store excess rainfall upstream, release slowly into channel
  - **Buyouts:** Remove homes from flooding area

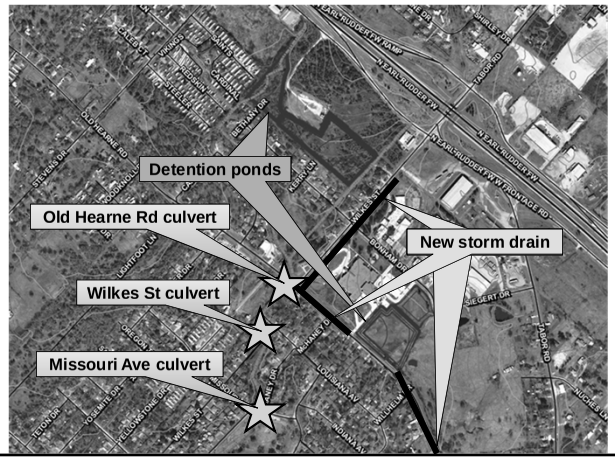
Improvement Options

- **Public input**
  - 80 comment forms distributed
  - 3 comment forms received by City
  - Verbal discussion from July meeting also considered

Improvement Options

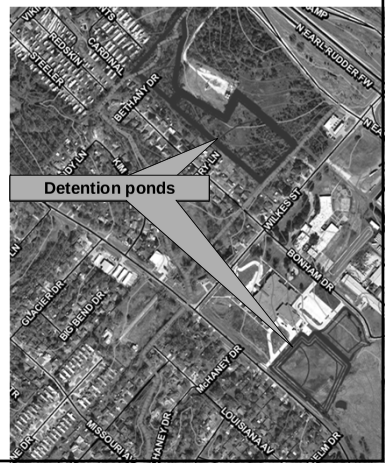
	Environmental impact	Convenience	Public input	Cost
Bigger pipes and channels	✗	✗	✓	$$$
Detention ponds	✓	✓	✗	$$
Buyouts	✓	✗	✓	$

Recommended Improvements - Hybrid



Recommended Improvements

- **Detention ponds**
  - School providing land for one pond
  - Doesn't move problem downstream
  - Rainfall flows through Lynndale Acres across **6-hr** period instead of rushing through in **1 hr**
  - Low environmental impacts
  - Minimal construction disruption

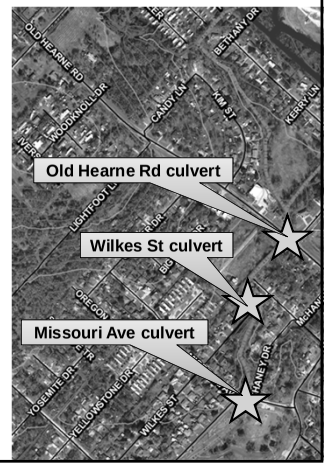


Recommended Improvements

- **Enclosed storm drain**
  - Take advantage of planned roadway improvements to Old Hearne and Wilkes
  - Minimal disruption and cost

Recommended Improvements

- **Culvert improvements**
  - Increases capacity to prevent road overtopping
  - Add a culvert barrel at Old Hearne and Missouri – utilizes existing culverts
  - Replace culverts at Wilkes



Recommended Improvements

- **Review of advantages:**
  - Hybrid of ponds, pipes, culvert improvements
  - School providing land for one pond
  - Doesn't move the problem downstream
  - Rainfall flows through Lynndale Acres across 6 hrs instead of rushing through in 1 hr
  - Minimal disruption from construction
  - Low environmental impacts; preserves natural look

Next Steps

- Incorporate public comments into final report along with recommendations
- Final report will be submitted to City Council for approval and incorporation into Capital Improvement Plan for design and construction
- Schedule for implementation will be dependent on funding (bond or grant)
  - State grant has already been applied for

Questions

Contact:

Brett McCully, P.E.
Assistant City Engineer
979-209-5030
bmccully@bryantx.gov

MEETING MINUTES

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PROJECT:	City of Bryan Still Creek Watershed Study
NAME OF MEETING:	Public Meeting #3
RECORDED BY:	Garrett Johnston
DATE:	November 1, 2011, 6:30 PM
LOCATION:	Bonham Elementary School
ATTENDEES:	Paul Kaspar, Brett McCully – City of Bryan Kathy Hopkins – TWDB Mike Wayts, Scott Hubley, Garrett Johnston – FNI Residents of Lynndale Acres (sign-in sheet attached)

The following reflects our understanding of the items discussed during the subject meeting. If you do not notify us within five working days, we will assume that you are in agreement with our understanding.

ITEM	DESCRIPTION	PRESENTER
1.	Brett introduced the project team members and discussed the study's purpose and schedule. Mike gave an overview of the watershed study and reviewed the causes of existing flooding in Lynndale Acres, the development of FNI's existing conditions model, and general improvement options for flood mitigation. Mike reviewed pros and cons of each alternative (channelization, detention, and buyouts) and presented FNI's recommended hybrid improvement consisting of two detention ponds, culvert improvements, and storm drain improvements along Old Hearne Rd and Wilkes St. Mike discussed the advantages of the recommended improvements, emphasizing cooperation from the school district, fixing the problem without moving it downstream, and minimizing construction disruption and environmental impacts. Brett discussed presenting FNI's recommendations to City Council and incorporating the improvements into the City's Capital Improvement Plan, and discussed potential schedules for design and construction dependent on approval and funding from TWDB and FEMA. The presentation file has been attached as a separate document.	Brett and Mike
2.	Residents responded with verbal comments after the end of the presentation. These comments are summarized below. • Residents asked if buyouts were seriously considered, and mentioned that several residents along the south side of McHaney may be open to this option. Mike and Brett explained that buyouts are not a good solution to a neighborhood-wide flooding problem that can be solved by other means. • Several residents expressed a desire for sidewalks to be added to Old Hearne Road along with other future improvements. • Residents expressed some concern regarding the likelihood of FEMA funding, timing of design and construction, and cooperation from private landowners. • All residents communicated general support of FNI's recommendations and enthusiasm for future design and construction.	Residents

ITEM	DESCRIPTION	PRESENTER
3.	Meeting was adjourned at approximately 7:30 PM.	All

ACTION ITEMS			
WHAT	**WHO**	**WHEN**	**STATUS**
1. Review draft report and submit comments to FNI	City of Bryan	11/14/11	In progress
2. Present recommended improvements to City Council	City of Bryan	11/22/11	
3. Address SRL grant comments from Kathy	FNI	11/30/11	In progress
4. Prepare final report	FNI	11/30/11	Pending comments from City

SIGN IN SHEET

CITY OF BRYAN

STILL CREEK WATERSHED STUDY

PUBLIC MEETING #3

6:30 PM, NOVEMBER 1, 2011

BONHAM ELEMENTARY SCHOOL

NAME	ADDRESS	PHONE	EMAIL
Property ID NL			
Property ID NM			
Property ID NN			
Property ID KD			
Property ID KU			
Property ID JX			

CITY OF BRYAN
STILL CREEK WATERSHED STUDY
PUBLIC MEETING #3

CITY OF BRYAN

Texas Water Development Board

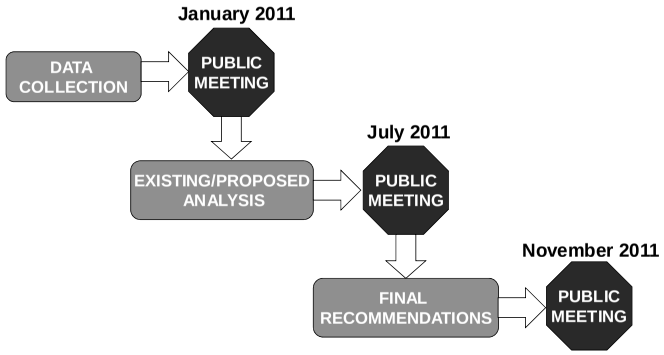
FREESE AND NICHOLS

November 1, 2011

Presentation Outline

- Study Review
  - Existing Conditions
  - Improvement Options
- New Information
  - Recommended Improvements
- Your Questions and Comments

Project Schedule



Study Overview

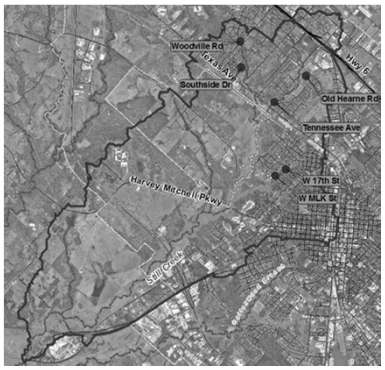
Still Creek Watershed

- Road overtopping at several locations in watershed
- Repetitive flooding of homes in Lynndale Acres

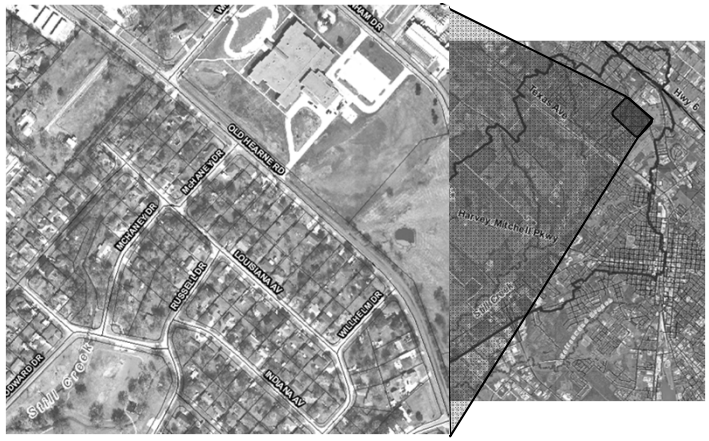
Study Overview

Still Creek Watershed

- **Road overtopping at several locations in watershed**
- Repetitive flooding of homes in Lynndale Acres



Study Overview



Existing Conditions

- Two major causes of Lynndale Acres flooding
  - Channel has insufficient capacity
  - Inadequate infrastructure for large local drainage area

Existing Conditions

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Existing Conditions

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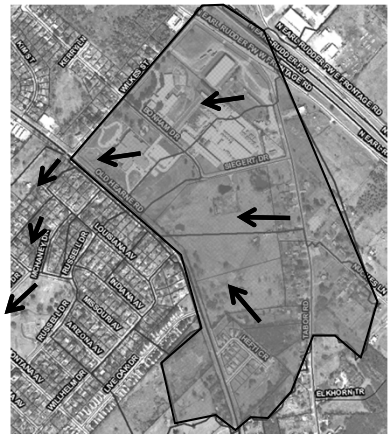
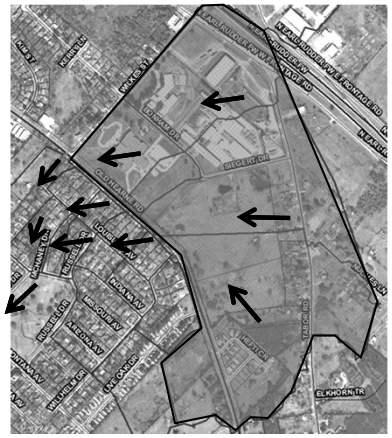
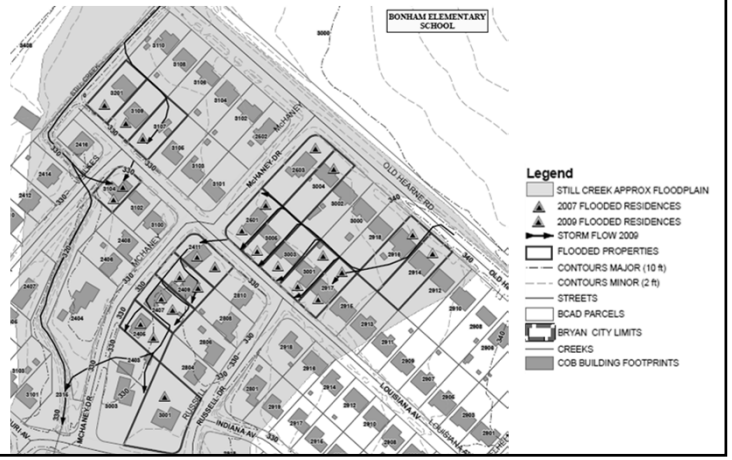


Existing Conditions

- Two major causes of Lynndale Acres flooding
  - Channel has insufficient capacity
  - **Inadequate infrastructure for large local drainage area**



Observed Flooding



Model Results

Resident Comment	Model Results (2007 storm)	Model Results (2009 storm)
Front, back yards flood; 15-20" twice	18" in yard	13" in yard
Sheds flooded 4-5" twice since 2006	6" at sheds	3" at sheds
Workshop has come within 2" of flooding once	Within 1' of workshop	Within 2' of workshop
Yard and street floods 18"	18" in yard	12" in yard

Improvement Options

Goal: Flood damage reduction

Two-part solution required:

(1) Address insufficient channel capacity

(2) Address inadequate infrastructure for large local drainage area

Improvement Options

- Approaches:
  - **Bigger pipes/channels:** Provide extra capacity (conveyance), move excess rainfall downstream
  - **Detention ponds:** Store excess rainfall upstream, release slowly into channel
  - **Buyouts:** Remove homes from flooding area

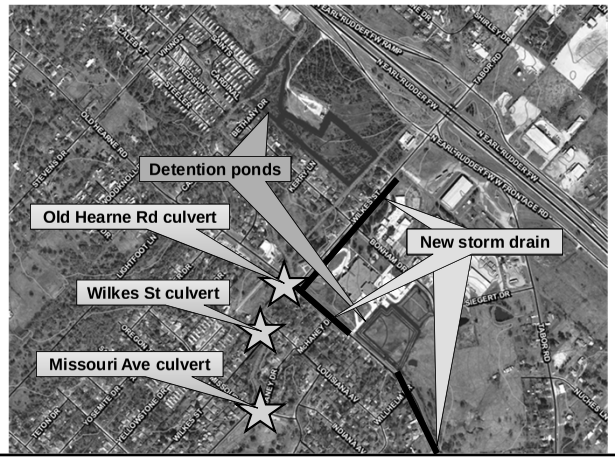
Improvement Options

- **Public input**
  - 80 comment forms distributed
  - 3 comment forms received by City
  - Verbal discussion from July meeting also considered

Improvement Options

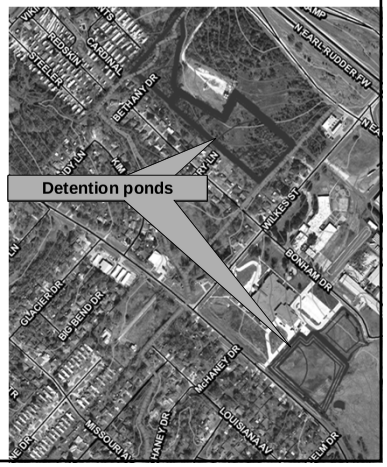
	Environmental impact	Convenience	Public input	Cost
Bigger pipes and channels	✗	✗	✓	$$$
Detention ponds	✓	✓	–	$$
Buyouts	✓	✗	✓	$

Recommended Improvements - Hybrid



Recommended Improvements

- **Detention ponds**
  - School providing easement for one pond
  - Doesn't move problem downstream
  - Low environmental impacts
  - Minimal construction disruption

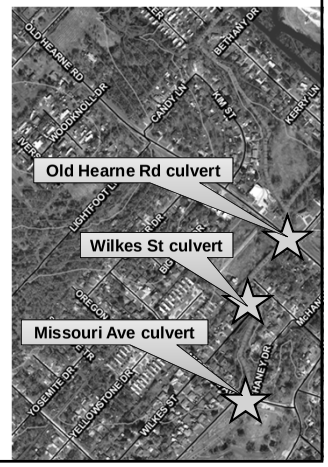


Recommended Improvements

- **Enclosed storm drain**
  - Take advantage of planned roadway improvements to Old Hearne and Wilkes
  - Minimal disruption and cost

Recommended Improvements

- **Culvert improvements**
  - Increases capacity to prevent road overtopping
  - Add a culvert barrel at Old Hearne and Missouri – utilizes existing culverts
  - Replace culverts at Wilkes



Recommended Improvements

- **Review of advantages:**
  - Hybrid of ponds, pipes, culvert improvements
  - School providing easement for one pond
  - Doesn't move the problem downstream
  - Minimal disruption from construction
  - Low environmental impacts; preserves natural look

Next Steps

- Incorporate public comments into final report along with recommendations
- Project will be presented to City Council and consideration given for incorporation into Capital Improvement Plan
- Schedule for implementation will be dependent on funding (bond or grant)
  - FEMA grant has already been applied for through state

Questions

Contact:

Brett McCully, P.E.
Assistant City Engineer
979-209-5030
bmccully@bryantx.gov

Appendix C

Opinions of Probable Construction Cost

OPINION OF PROBABLE CONSTRUCTION COST

FREESE AND NICHOLS

Innovative approaches
Practical results
Outstanding service

Still Creek Watershed Study
Conceptual Improvement Alternatives

DETENTION PONDS

October 7, 2011

ESTIMATOR	CHECKED BY	ACCOUNT NO
JGJ	SKH	BRY10455

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
	PONDS SE OF BONHAM ELEMENTARY				**$2,182,000**
1	PROPERTY ACQUISITION	1	LS	$101,300.00	$101,300
2	CLEARING AND GRUBBING	6.1	AC	$6,750.00	$41,200
3	EXCAVATION AND HAUL	80,040	CY	$16.20	$1,296,700
4	6x3 RCB	830	LF	$256.50	$212,900
5	30" RCP	80	LF	$108.00	$8,700
6	RIPRAP	500	CY	$135.00	$67,500
7	SODDING	29,300	SY	$3.38	$99,100
8	BERM COMPACTION	2,420	CY	$40.50	$98,100
9	EROSION CONTROL	1	EA	$27,000.00	$27,000
10	HEADWALL	2	EA	$13,500.00	$27,000
11	SPILLWAY	2	EA	$33,750.00	$67,500
12	UTILITY ADJUSTMENTS	1	LS	$135,000.00	$135,000
	PONDS AT WILKES/HWY 6				**$2,652,700**
13	PROPERTY ACQUISITION	1	LS	$141,800.00	$141,800
14	CLEARING AND GRUBBING	9.2	AC	$6,750.00	$62,100
15	EXCAVATION AND HAUL	123,370	CY	$16.20	$1,998,600
16	4x3 RCB	60	LF	$175.50	$10,600
17	7x4 RCB	240	LF	$364.50	$87,500
18	RIPRAP	500	CY	$135.00	$67,500
19	SODDING	44,640	SY	$3.38	$150,900
20	BERM COMPACTION	300	CY	$40.50	$12,200
21	EROSION CONTROL	1	EA	$27,000.00	$27,000
22	SPILLWAY	2	EA	$33,750.00	$67,500
23	HEADWALL	2	EA	$13,500.00	$27,000
		SUBTOTAL:			**$4,834,700**
		ENVR MITIGATION		**2%**	**$96,700**
		SUBTOTAL:			**$4,931,400**
		ENGR, SURVEY, GEO		**15%**	**$739,800**
		SUBTOTAL:			**$5,671,200**
	DETENTION PONDS PROJECT TOTAL				**$5,671,200**

OPINION OF PROBABLE CONSTRUCTION COST

FREESE AND NICHOLS

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Practical results
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Still Creek Watershed Study
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STORM DRAIN IMPROVEMENTS

October 7, 2011

ESTIMATOR	CHECKED BY	ACCOUNT NO
JGJ	SKH	BRY10455

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
	OLD HEARNE RD STORM DRAIN				**$670,200**
1	24" RCP	600	LF	$81.00	$48,600
2	4x3 RCB	500	LF	$270.00	$135,000
3	7x4 RCB	500	LF	$337.50	$168,800
4	JUNCTION BOX	1	EA	$20,300.00	$20,300
5	MANHOLES	7	EA	$6,075.00	$42,600
6	10' CURB INLETS	32	EA	$4,725.00	$151,200
7	24" LATERALS	1,280	LF	$81.00	$103,700
	WILKES ST STORM DRAIN				**$498,500**
8	5x4 RCB	1,300	LF	$283.50	$368,600
9	MANHOLES	3	EA	$6,075.00	$18,300
10	10' CURB INLETS	14	EA	$4,725.00	$66,200
11	24" LATERALS	560	LF	$81.00	$45,400
		SUBTOTAL:			**$1,168,700**
		ENVR MITIGATION		**0%**	**$0**
		SUBTOTAL:			**$1,168,700**
		ENGR, SURVEY, GEO		**15%**	**$175,400**
		SUBTOTAL:			**$1,344,100**
STORM DRAIN IMPROVEMENTS PROJECT TOTAL					**$1,344,100**

OPINION OF PROBABLE CONSTRUCTION COST

FREESE AND NICHOLS

Innovative approaches
Practical results
Outstanding service

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Conceptual Improvement Alternatives

OLD HEARNE RD CULVERT IMPROVEMENTS — October 7, 2011

ESTIMATOR	CHECKED BY	ACCOUNT NO
JGJ	SKH	BRY10455

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
	GENERAL				**$13,600**
1	TRAFFIC CONTROL	1	LS	$6,800.00	$6,800
2	EROSION CONTROL AND SWPPP	1	LS	$6,800.00	$6,800
	CULVERT IMPROVEMENTS				**$110,500**
3	6x6 RCB	80	LF	$351.00	$28,100
4	HEADWALL	2	EA	$13,500.00	$27,000
5	REMOVE EXISTING HEADWALL	2	EA	$1,350.00	$2,700
6	UTILITY ADJUSTMENTS	3	EA	$13,500.00	$40,500
7	ROCK RIPRAP	90	CY	$135.00	$12,200
	ROADWAY IMPROVEMENTS				**$3,600**
8	REMOVE EXISTING PAVEMENT	54	SY	$10.80	$600
9	ASPHALT PAVEMENT AND SUBGRADE	54	SY	$54.00	$3,000
		SUBTOTAL:			**$127,700**
		ENVR MITIGATION		**2%**	**$2,600**
		SUBTOTAL:			**$130,300**
		ENGR, SURVEY, GEO		**15%**	**$19,600**
		SUBTOTAL:			**$149,900**
OLD HEARNE RD CULVERT IMPROVEMENTS PROJECT TOTAL					**$149,900**

OPINION OF PROBABLE CONSTRUCTION COST

FREESE AND NICHOLS

Innovative approaches
Practical results
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WILKES ST CULVERT IMPROVEMENTS

October 7, 2011

ESTIMATOR	CHECKED BY	ACCOUNT NO
JGJ	SKH	BRY10455

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
	GENERAL				**$13,600**
1	TRAFFIC CONTROL	1	LS	$6,800.00	$6,800
2	EROSION CONTROL AND SWPPP	1	LS	$6,800.00	$6,800
	CULVERT IMPROVEMENTS				**$128,100**
3	REMOVE EXISTING PIPE	80	LF	$40.50	$3,300
4	8x6 RCB	120	LF	$567.00	$68,100
5	HEADWALL	2	EA	$13,500.00	$27,000
6	REMOVE EXISTING HEADWALL	2	EA	$1,350.00	$2,700
7	UTILITY ADJUSTMENTS	1	EA	$13,500.00	$13,500
8	ROCK RIPRAP	100	CY	$135.00	$13,500
	ROADWAY IMPROVEMENTS				**$7,000**
9	REMOVE EXISTING PAVEMENT	107	SY	$10.80	$1,200
10	ASPHALT PAVEMENT AND SUBGRADE	107	SY	$54.00	$5,800
		SUBTOTAL:			**$148,700**
		ENVR MITIGATION		**2%**	**$3,000**
		SUBTOTAL:			**$151,700**
		ENGR, SURVEY, GEO		**15%**	**$22,800**
		SUBTOTAL:			**$174,500**
WILKES ST CULVERT IMPROVEMENTS PROJECT TOTAL					**$174,500**

OPINION OF PROBABLE CONSTRUCTION COST

FREESE AND NICHOLS

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Still Creek Watershed Study
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MISSOURI AVE CULVERT IMPROVEMENTS

October 7, 2011

ESTIMATOR	CHECKED BY	ACCOUNT NO
JGJ	SKH	BRY10455

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
	GENERAL				**$13,600**
1	TRAFFIC CONTROL	1	LS	$6,800.00	$6,800
2	EROSION CONTROL AND SWPPP	1	LS	$6,800.00	$6,800
	CULVERT IMPROVEMENTS				**$77,300**
3	9X7 RCB	40	LF	$513.00	$20,600
4	HEADWALL	2	EA	$13,500.00	$27,000
5	REMOVE EXISTING HEADWALL	2	EA	$1,350.00	$2,700
6	UTILITY ADJUSTMENTS	1	EA	$13,500.00	$13,500
7	ROCK RIPRAP	100	CY	$135.00	$13,500
	ROADWAY IMPROVEMENTS				**$4,500**
8	REMOVE EXISTING PAVEMENT	67	SY	$10.80	$800
9	ASPHALT PAVEMENT AND SUBGRADE	67	SY	$54.00	$3,700
		SUBTOTAL:			**$95,400**
		ENVR MITIGATION		**2%**	**$2,000**
		SUBTOTAL:			**$97,400**
		ENGR, SURVEY, GEO		**15%**	**$14,700**
		SUBTOTAL:			**$112,100**
MISSOURI AVE CULVERT IMPROVEMENTS PROJECT TOTAL					**$112,100**

OPINION OF PROBABLE CONSTRUCTION COST

FREESE AND NICHOLS

Innovative approaches
Practical results
Outstanding service

Still Creek Watershed Study
Conceptual Improvement Alternatives

W MLK JR ST CULVERT IMPROVEMENTS

August 17, 2011

ESTIMATOR	CHECKED BY	ACCOUNT NO
KMH	SKH	BRY10455

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
	GENERAL				**$30,000**
1	TRAFFIC CONTROL	1	LS	$10,000.00	$10,000.00
2	SITE PREPARATION	1	AC	$10,000.00	$10,000.00
3	EROSION CONTROL AND SWPPP	1	LS	$10,000.00	$10,000.00
	CULVERT IMPROVEMENTS				**$152,000**
4	12X6 RCB	100	LF	$600.00	$60,000.00
5	HEADWALL	2	EA	$10,000.00	$20,000.00
6	REMOVE EXISTING HEADWALL	2	EA	$1,000.00	$2,000.00
7	UTILITY ADJUSTMENTS	1	LS	$50,000.00	$50,000.00
8	ROCK RIPRAP	200	CY	$100.00	$20,000.00
	ROADWAY IMPROVEMENTS				**$99,525**
9	REMOVE EXISTING CONCRETE PAVEMENT	1,450	SY	$8.00	$11,600.00
10	FILL TO RAISE ROAD	280	CY	$20.00	$5,600.00
11	8" CONCRETE PAVEMENT	1,450	SY	$40.00	$58,000.00
12	6" LIME STABILIZED SUBGRADE	1,450	SY	$5.00	$7,250.00
13	SODDING	335	SY	$5.00	$1,675.00
14	4 FT CONCRETE SIDEWALK	270	SY	$20.00	$5,400.00
15	10 FT CURB INLET	2	EA	$5,000.00	$10,000.00
	CHANNEL GRADING				**$26,850**
16	EXCAVATE AND HAUL	340	CY	$15.00	$5,100.00
17	CONCRETE PILOT CHANNEL	350	SY	$25.00	$8,750.00
18	SODDING	600	SY	$5.00	$3,000.00
19	REMOVE AND REPLACE PEDESTRIAN BRIDGE	1	LS	$10,000.00	$10,000.00
		SUBTOTAL:			**$309,000**
		CONTINGENCY		**35%**	**$108,150**
		SUBTOTAL:			**$418,000**
		DESIGN FEES		**15%**	**$62,700**
		SUBTOTAL:			**$480,700**
	W MLK JR ST CULVERT IMPROVEMENTS PROJECT TOTAL				**$481,000**

OPINION OF PROBABLE CONSTRUCTION COST

FREESE AND NICHOLS

Innovative approaches
Practical results
Outstanding service

Still Creek Watershed Study
Conceptual Improvement Alternatives

W 17TH ST CULVERT IMPROVEMENTS

August 17, 2011

ESTIMATOR	CHECKED BY	ACCOUNT NO
KMH	SKH	BRY10455

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
	GENERAL				**$30,000**
1	TRAFFIC CONTROL	1	LS	$10,000.00	$10,000.00
2	SITE PREPARATION	1	AC	$10,000.00	$10,000.00
3	EROSION CONTROL AND SWPPP	1	LS	$10,000.00	$10,000.00
	CULVERT IMPROVEMENTS				**$281,400**
4	12X4 RCB	280	LF	$480.00	$134,400.00
5	HEADWALL	2	EA	$12,500.00	$25,000.00
6	REMOVE EXISTING HEADWALL	2	EA	$1,000.00	$2,000.00
7	UTILITY ADJUSTMENTS	1	LS	$100,000.00	$100,000.00
8	ROCK RIPRAP	200	CY	$100.00	$20,000.00
	ROADWAY IMPROVEMENTS				**$65,350**
9	REMOVE EXISTING CONCRETE PAVEMENT	1,050	SY	$8.00	$8,400.00
10	FILL TO RAISE ROAD	175	CY	$20.00	$3,500.00
11	6" CONCRETE PAVEMENT	1,050	SY	$30.00	$31,500.00
12	6" LIME STABILIZED SUBGRADE	1,050	SY	$5.00	$5,250.00
13	SODDING	300	SY	$5.00	$1,500.00
14	4 FT CONCRETE SIDEWALK	260	SY	$20.00	$5,200.00
15	10 FT CURB INLET	2	EA	$5,000.00	$10,000.00
		SUBTOTAL:			**$377,000**
		CONTINGENCY		**35%**	**$131,950**
		SUBTOTAL:			**$509,000**
		DESIGN FEES		**15%**	**$76,350**
		SUBTOTAL:			**$585,350**
W 17TH ST CULVERT IMPROVEMENTS PROJECT TOTAL					**$586,000**

OPINION OF PROBABLE CONSTRUCTION COST

FREESE AND NICHOLS

Innovative approaches
Practical results
Outstanding service

Still Creek Watershed Study
Conceptual Improvement Alternatives

WOODVILLE RD CULVERT IMPROVEMENTS

August 18, 2011

ESTIMATOR	CHECKED BY	ACCOUNT NO
KMH		BRY10455

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
	GENERAL				**$30,000**
1	TRAFFIC CONTROL	1	LS	$10,000.00	$10,000.00
2	SITE PREPARATION	1	AC	$10,000.00	$10,000.00
3	EROSION CONTROL AND SWPPP	1	LS	$10,000.00	$10,000.00
	STORM DRAIN IMPROVEMENTS				**$252,385**
4	7x4 RCB	570	LF	$260.00	$148,200.00
5	HEADWALL	2	EA	$15,000.00	$30,000.00
6	10 FT CURB INLET	4	EA	$5,000.00	$20,000.00
7	4 FT DROP INLET	3	EA	$5,000.00	$15,000.00
8	REMOVE EXISTING HEADWALL	2	EA	$1,000.00	$2,000.00
9	SODDING	1,583	SY	$5.00	$7,916.67
10	UTILITY ADJUSTMENTS	1	LS	$20,000.00	$20,000.00
11	REMOVE AND REPLACE EXISTING WOOD FENCE	175	LF	$50.00	$8,750.00
12	ROCK RIPRAP	5	CY	$100.00	$518.52
	ROADWAY IMPROVEMENTS				**$4,456**
13	REMOVE EXISTING ASPHALT PAVEMENT	102	SY	$8.00	$817.78
14	6" HMAC PAVEMENT	102	SY	$25.00	$2,550.00
15	8" LIME STABILIZED SUBGRADE	102	SY	$5.00	$510.00
16	SODDING	44	SY	$5.00	$222.22
17	4 FT CONCRETE SIDEWALK	18	SY	$20.00	$355.56
		SUBTOTAL:			**$287,000**
		CONTINGENCY		**35%**	**$100,450**
		SUBTOTAL:			**$388,000**
		DESIGN FEES		**15%**	**$58,200**
		SUBTOTAL:			**$446,200**
	WOODVILLE RD CULVERT IMPROVEMENTS PROJECT TOTAL				**$447,000**

OPINION OF PROBABLE CONSTRUCTION COST

FREESE AND NICHOLS

Innovative approaches
Practical results
Outstanding service

Still Creek Watershed Study
Conceptual Improvement Alternatives

SOUTHSIDE DR CHANNEL IMPROVEMENTS — August 17, 2011

ESTIMATOR	CHECKED BY	ACCOUNT NO
KMH	SKH	BRY10455

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
	GENERAL				**$30,000**
1	TRAFFIC CONTROL	1	LS	$10,000.00	$10,000.00
2	SITE PREPARATION	1	AC	$10,000.00	$10,000.00
3	EROSION CONTROL AND SWPPP	1	LS	$10,000.00	$10,000.00
	CULVERT IMPROVEMENTS				**$141,867**
4	6x3 RCB	96	LF	$200.00	$19,200.00
5	7x3 RCB	96	LF	$250.00	$24,000.00
6	HEADWALL	4	EA	$10,000.00	$40,000.00
7	UTILITY ADJUSTMENTS	1	LS	$50,000.00	$50,000.00
8	ROCK RIPRAP	87	CY	$100.00	$8,666.67
	ROADWAY IMPROVEMENTS				**$73,600**
9	REMOVE EXISTING CONCRETE PAVEMENT	1,100	SY	$8.00	$8,800.00
10	FILL TO RAISE ROAD	210	CY	$20.00	$4,200.00
11	6" CONCRETE PAVEMENT	1,100	SY	$30.00	$33,000.00
12	6" LIME STABILIZED SUBGRADE	1,100	SY	$5.00	$5,500.00
13	SODDING	420	SY	$5.00	$2,100.00
14	10 FT CURB INLET	4	EA	$5,000.00	$20,000.00
	CHANNEL IMPROVEMENTS				**$79,500**
15	EXCAVATE AND HAUL	3,500	CY	$15.00	$52,500.00
16	CONCRETE CHANNEL	300	SY	$25.00	$7,500.00
17	SODDING	3,900	SY	$5.00	$19,500.00
		SUBTOTAL:			**$325,000**
		CONTINGENCY		**35%**	**$113,750**
		SUBTOTAL:			**$439,000**
		DESIGN FEES		**15%**	**$65,850**
		SUBTOTAL:			**$504,850**
	SOUTHSIDE DR CHANNEL IMPROVEMENTS PROJECT TOTAL				**$505,000**

Appendix D

Benefit-Cost Analysis Output Summary

Total Benefits: **$11,504,004** Total Costs: **$7,969,190** BCR: **1.44**

Project Number: BRY10455 Disaster #: Program: Agency: **Freese and Nichols, Inc.**

State: **Texas** Point of Contact: Garrett Johnston Analyst: Garrett Johnston

Project Summary:

Project Number: BRY10455 Disaster #:

Program: Agency: Freese and Nichols, Inc.

Analyst: Garrett Johnston

Point of Contact: Garrett Johnston Phone Number: 817-735-7300

Address: 4055 International Plaza, Suite 200, Fort Worth, Texas, 76109

Email: jgj@freese.com

Comments:

Structure Summary For:

Property ID KE

Structure Type: Building Historic Building: No Contact:

Benefits: $1,231,448 Costs: $71,795 BCR: 17.15

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	17.15	$1,231,448	$71,795

Property ID KF

Structure Type: Building Historic Building: No Contact:

Benefits: $151,772 Costs: $71,795 BCR: 2.11

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	2.11	$151,772	$71,795

Total Benefits: **$11,504,004** Total Costs: **$7,969,190** BCR: **1.44**

Project Number: BRY10455 Disaster #: Program: Agency: **Freese and Nichols, Inc.**

State: **Texas** Point of Contact: Garrett Johnston Analyst: Garrett Johnston

Property ID KC

Structure Type: Building Historic Building: No Contact:

Benefits: $180,866 Costs: $71,795 BCR: 2.52

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	2.52	$180,866	$71,795

Property ID KG

Structure Type: Building Historic Building: No Contact:

Benefits: $102,778 Costs: $71,795 BCR: 1.43

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	1.43	$102,778	$71,795

Property ID KB

Structure Type: Building Historic Building: No Contact:

Benefits: $210,721 Costs: $71,795 BCR: 2.94

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	2.94	$210,721	$71,795

Property ID KL

Structure Type: Building Historic Building: No Contact:

Benefits: $17,153 Costs: $71,795 BCR: 0.24

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.24	$17,153	$71,795

Total Benefits: **$11,504,004** Total Costs: **$7,969,190** BCR: **1.44**

Project Number: BRY10455 Disaster #: Program: Agency: **Freese and Nichols, Inc.**

State: **Texas** Point of Contact: Garrett Johnston Analyst: Garrett Johnston

Property ID KH

Structure Type: Building Historic Building: No Contact:

Benefits: $54,845 Costs: $71,795 BCR: 0.76

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.76	$54,845	$71,795

Property ID KA

Structure Type: Building Historic Building: No Contact:

Benefits: $193,056 Costs: $71,795 BCR: 2.69

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	2.69	$193,056	$71,795

Property ID KZ

Structure Type: Building Historic Building: No Contact:

Benefits: $214,658 Costs: $71,795 BCR: 2.99

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	2.99	$214,658	$71,795

Property ID KX

Structure Type: Building Historic Building: No Contact:

Benefits: $131,471 Costs: $71,795 BCR: 1.83

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	1.83	$131,471	$71,795

Total Benefits: **$11,504,004** Total Costs: **$7,969,190** BCR: **1.44**

Project Number: BRY10455 Disaster #: Program: Agency: **Freese and Nichols, Inc.**

State: **Texas** Point of Contact: Garrett Johnston Analyst: Garrett Johnston

Property ID KY

Structure Type: Building Historic Building: No Contact:

Benefits: $149,752 Costs: $71,795 BCR: 2.09

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	2.09	$149,752	$71,795

Property ID LA

Structure Type: Building Historic Building: No Contact:

Benefits: $6,101 Costs: $71,795 BCR: 0.08

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.08	$6,101	$71,795

Property ID MW

Structure Type: Building Historic Building: No Contact:

Benefits: $705,936 Costs: $71,795 BCR: 9.83

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	9.83	$705,936	$71,795

Property ID NQ

Structure Type: Building Historic Building: No Contact:

Benefits: $72,294 Costs: $71,795 BCR: 1.01

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	1.01	$72,294	$71,795

Total Benefits: **$11,504,004** Total Costs: **$7,969,190** BCR: **1.44**

Project Number: BRY10455 Disaster #: Program: Agency: **Freese and Nichols, Inc.**

State: **Texas** Point of Contact: Garrett Johnston Analyst: Garrett Johnston

Property ID NJ

Structure Type: Building Historic Building: No Contact:

Benefits: $125,464 Costs: $71,795 BCR: 1.75

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	1.75	$125,464	$71,795

Property ID MZ

Structure Type: Building Historic Building: No Contact:

Benefits: $576,490 Costs: $71,795 BCR: 8.03

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	8.03	$576,490	$71,795

Property ID JV

Structure Type: Building Historic Building: No Contact:

Benefits: $161,698 Costs: $71,795 BCR: 2.25

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	2.25	$161,698	$71,795

Property ID JW

Structure Type: Building Historic Building: No Contact:

Benefits: $118,257 Costs: $71,795 BCR: 1.65

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	1.65	$118,257	$71,795

Total Benefits: **$11,504,004** Total Costs: **$7,969,190** BCR: **1.44**

Project Number: BRY10455 Disaster #: Program: Agency: **Freese and Nichols, Inc.**

State: **Texas** Point of Contact: Garrett Johnston Analyst: Garrett Johnston

Property ID JX

Structure Type: Building Historic Building: No Contact:

Benefits: $89,463 Costs: $71,795 BCR: 1.25

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	1.25	$89,463	$71,795

Property ID JY

Structure Type: Building Historic Building: No Contact:

Benefits: $43,354 Costs: $71,795 BCR: 0.60

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.60	$43,354	$71,795

Property ID MK

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Property ID MX

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Total Benefits: **$11,504,004** Total Costs: **$7,969,190** BCR: **1.44**

Project Number: BRY10455 Disaster #: Program: Agency: **Freese and Nichols, Inc.**

State: **Texas** Point of Contact: Garrett Johnston Analyst: Garrett Johnston

Property ID ML

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Property ID MC

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Property ID MY

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Property ID MM

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Total Benefits: **$11,504,004** Total Costs: **$7,969,190** BCR: **1.44**

Project Number: BRY10455 Disaster #: Program: Agency: **Freese and Nichols, Inc.**

State: **Texas** Point of Contact: Garrett Johnston Analyst: Garrett Johnston

Property ID MD

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Property ID NZ

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Property ID LS

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Property ID MN

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Total Benefits: **$11,504,004** Total Costs: **$7,969,190** BCR: **1.44**

Project Number: BRY10455 Disaster #: Program: Agency: **Freese and Nichols, Inc.**

State: **Texas** Point of Contact: Garrett Johnston Analyst: Garrett Johnston

Property ID JO

Structure Type: Building Historic Building: No Contact:

Benefits: $207,873 Costs: $71,795 BCR: 2.90

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	2.90	$207,873	$71,795

Property ID ME

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Property ID NA

Structure Type: Building Historic Building: No Contact:

Benefits: $20,378 Costs: $71,795 BCR: 0.28

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.28	$20,378	$71,795

Property ID LT

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Total Benefits: **$11,504,004** Total Costs: **$7,969,190** BCR: **1.44**

Project Number: BRY10455 Disaster #: Program: Agency: **Freese and Nichols, Inc.**

State: **Texas** Point of Contact: Garrett Johnston Analyst: Garrett Johnston

Property ID MO

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Property ID JG

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Property ID JP

Structure Type: Building Historic Building: No Contact:

Benefits: $185,209 Costs: $71,795 BCR: 2.58

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	2.58	$185,209	$71,795

Property ID MF

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Total Benefits: **$11,504,004** Total Costs: **$7,969,190** BCR: **1.44**

Project Number: BRY10455 Disaster #: Program: Agency: **Freese and Nichols, Inc.**

State: **Texas** Point of Contact: Garrett Johnston Analyst: Garrett Johnston

Property ID NB

Structure Type: Building Historic Building: No Contact:

Benefits: $168,070 Costs: $71,795 BCR: 2.34

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	2.34	$168,070	$71,795

Property ID LU

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Property ID MP

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Property ID JH

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Total Benefits: **$11,504,004** Total Costs: **$7,969,190** BCR: **1.44**

Project Number: BRY10455 Disaster #: Program: Agency: **Freese and Nichols, Inc.**

State: **Texas** Point of Contact: Garrett Johnston Analyst: Garrett Johnston

Property ID JQ

Structure Type: Building Historic Building: No Contact:

Benefits: $101,517 Costs: $71,795 BCR: 1.41

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	1.41	$101,517	$71,795

Property ID MG

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Property ID NC

Structure Type: Building Historic Building: No Contact:

Benefits: $155,604 Costs: $71,795 BCR: 2.17

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	2.17	$155,604	$71,795

Property ID LV

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Total Benefits: **$11,504,004** Total Costs: **$7,969,190** BCR: **1.44**

Project Number: BRY10455 Disaster #: Program: Agency: **Freese and Nichols, Inc.**

State: **Texas** Point of Contact: Garrett Johnston Analyst: Garrett Johnston

Property ID MQ

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Property ID JI

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Property ID JR

Structure Type: Building Historic Building: No Contact:

Benefits: $124,625 Costs: $71,795 BCR: 1.74

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	1.74	$124,625	$71,795

Property ID MH

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Total Benefits: **$11,504,004** Total Costs: **$7,969,190** BCR: **1.44**

Project Number: BRY10455 Disaster #: Program: Agency: **Freese and Nichols, Inc.**

State: **Texas** Point of Contact: Garrett Johnston Analyst: Garrett Johnston

Property ID ND

Structure Type: Building Historic Building: No Contact:

Benefits: $195,494 Costs: $71,795 BCR: 2.72

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	2.72	$195,494	$71,795

Property ID LW

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Property ID MR

Structure Type: Building Historic Building: No Contact:

Benefits: $134,611 Costs: $71,795 BCR: 1.87

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	1.87	$134,611	$71,795

Property ID JJ

Structure Type: Building Historic Building: No Contact:

Benefits: $139,975 Costs: $71,795 BCR: 1.95

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	1.95	$139,975	$71,795

Total Benefits: **$11,504,004** Total Costs: **$7,969,190** BCR: **1.44**

Project Number: BRY10455 Disaster #: Program: Agency: **Freese and Nichols, Inc.**

State: **Texas** Point of Contact: Garrett Johnston Analyst: Garrett Johnston

Property ID JS

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Property ID MI

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Property ID NE

Structure Type: Building Historic Building: No Contact:

Benefits: $117,839 Costs: $71,795 BCR: 1.64

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	1.64	$117,839	$71,795

Property ID LX

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Total Benefits: **$11,504,004** Total Costs: **$7,969,190** BCR: **1.44**

Project Number: BRY10455 Disaster #: Program: Agency: **Freese and Nichols, Inc.**

State: **Texas** Point of Contact: Garrett Johnston Analyst: Garrett Johnston

Property ID MS

Structure Type: Building Historic Building: No Contact:

Benefits: $221,905 Costs: $71,795 BCR: 3.09

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	3.09	$221,905	$71,795

Property ID JT

Structure Type: Building Historic Building: No Contact:

Benefits: $43,575 Costs: $71,795 BCR: 0.61

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.61	$43,575	$71,795

Property ID MJ

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Property ID NF

Structure Type: Building Historic Building: No Contact:

Benefits: $715,511 Costs: $71,795 BCR: 9.97

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	9.97	$715,511	$71,795

Total Benefits: **$11,504,004** Total Costs: **$7,969,190** BCR: **1.44**

Project Number: BRY10455 Disaster #: Program: Agency: **Freese and Nichols, Inc.**

State: **Texas** Point of Contact: Garrett Johnston Analyst: Garrett Johnston

Property ID LY

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Property ID NG

Structure Type: Building Historic Building: No Contact:

Benefits: $152,792 Costs: $71,795 BCR: 2.13

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	2.13	$152,792	$71,795

Property ID MT

Structure Type: Building Historic Building: No Contact:

Benefits: $194,230 Costs: $71,795 BCR: 2.71

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	2.71	$194,230	$71,795

Property ID JU

Structure Type: Building Historic Building: No Contact:

Benefits: $1,267,533 Costs: $71,795 BCR: 17.65

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	17.65	$1,267,533	$71,795

Total Benefits: **$11,504,004** Total Costs: **$7,969,190** BCR: **1.44**

Project Number: BRY10455 Disaster #: Program: Agency: **Freese and Nichols, Inc.**

State: **Texas** Point of Contact: Garrett Johnston Analyst: Garrett Johnston

Property ID NH

Structure Type: Building Historic Building: No Contact:

Benefits: $121,937 Costs: $71,795 BCR: 1.70

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	1.70	$121,937	$71,795

Property ID MU

Structure Type: Building Historic Building: No Contact:

Benefits: $203,809 Costs: $71,795 BCR: 2.84

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	2.84	$203,809	$71,795

Property ID NI

Structure Type: Building Historic Building: No Contact:

Benefits: $107,662 Costs: $71,795 BCR: 1.50

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	1.50	$107,662	$71,795

Property ID MV

Structure Type: Building Historic Building: No Contact:

Benefits: $708,443 Costs: $71,795 BCR: 9.87

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	9.87	$708,443	$71,795

Total Benefits: **$11,504,004** Total Costs: **$7,969,190** BCR: **1.44**

Project Number: BRY10455 Disaster #: Program: Agency: **Freese and Nichols, Inc.**

State: **Texas** Point of Contact: Garrett Johnston Analyst: Garrett Johnston

Property ID OM

Structure Type: Building Historic Building: No Contact:

Benefits: $19,120 Costs: $71,795 BCR: 0.27

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.27	$19,120	$71,795

Property ID KI

Structure Type: Building Historic Building: No Contact:

Benefits: $145,860 Costs: $71,795 BCR: 2.03

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	2.03	$145,860	$71,795

Property ID NK

Structure Type: Building Historic Building: No Contact:

Benefits: $70,264 Costs: $71,795 BCR: 0.98

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.98	$70,264	$71,795

Property ID KQ

Structure Type: Building Historic Building: No Contact:

Benefits: $63,499 Costs: $71,795 BCR: 0.88

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.88	$63,499	$71,795

Total Benefits: **$11,504,004** Total Costs: **$7,969,190** BCR: **1.44**

Project Number: BRY10455 Disaster #: Program: Agency: **Freese and Nichols, Inc.**

State: **Texas** Point of Contact: Garrett Johnston Analyst: Garrett Johnston

Property ID ON

Structure Type: Building Historic Building: No Contact:

Benefits: $73,345 Costs: $71,795 BCR: 1.02

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	1.02	$73,345	$71,795

Property ID PB

Structure Type: Building Historic Building: No Contact:

Benefits: ($4) Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	($4)	$71,795

Property ID KJ

Structure Type: Building Historic Building: No Contact:

Benefits: $148,358 Costs: $71,795 BCR: 2.07

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	2.07	$148,358	$71,795

Property ID NR

Structure Type: Building Historic Building: No Contact:

Benefits: $26,226 Costs: $71,795 BCR: 0.37

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.37	$26,226	$71,795

Total Benefits: **$11,504,004** Total Costs: **$7,969,190** BCR: **1.44**

Project Number: BRY10455 Disaster #: Program: Agency: **Freese and Nichols, Inc.**

State: **Texas** Point of Contact: Garrett Johnston Analyst: Garrett Johnston

Property ID PK

Structure Type: Building Historic Building: No Contact:

Benefits: ($776) Costs: $71,795 BCR: (0.01)

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	(0.01)	($776)	$71,795

Property ID NL

Structure Type: Building Historic Building: No Contact:

Benefits: $70,531 Costs: $71,795 BCR: 0.98

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.98	$70,531	$71,795

Property ID OO

Structure Type: Building Historic Building: No Contact:

Benefits: $61,620 Costs: $71,795 BCR: 0.86

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.86	$61,620	$71,795

Property ID PC

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Total Benefits: **$11,504,004** Total Costs: **$7,969,190** BCR: **1.44**

Project Number: BRY10455 Disaster #: Program: Agency: **Freese and Nichols, Inc.**

State: **Texas** Point of Contact: Garrett Johnston Analyst: Garrett Johnston

Property ID KK

Structure Type: Building Historic Building: No Contact:

Benefits: $250,614 Costs: $71,795 BCR: 3.49

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	3.49	$250,614	$71,795

Property ID NS

Structure Type: Building Historic Building: No Contact:

Benefits: $124,920 Costs: $71,795 BCR: 1.74

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	1.74	$124,920	$71,795

Property ID PL

Structure Type: Building Historic Building: No Contact:

Benefits: ($27) Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	($27)	$71,795

Property ID NM

Structure Type: Building Historic Building: No Contact:

Benefits: $60,977 Costs: $71,795 BCR: 0.85

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.85	$60,977	$71,795

Total Benefits: **$11,504,004** Total Costs: **$7,969,190** BCR: **1.44**

Project Number: BRY10455 Disaster #: Program: Agency: **Freese and Nichols, Inc.**

State: **Texas** Point of Contact: Garrett Johnston Analyst: Garrett Johnston

Property ID OP

Structure Type: Building Historic Building: No Contact:

Benefits: $24,662 Costs: $71,795 BCR: 0.34

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.34	$24,662	$71,795

Property ID PD

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Property ID NT

Structure Type: Building Historic Building: No Contact:

Benefits: $164,064 Costs: $71,795 BCR: 2.29

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	2.29	$164,064	$71,795

Property ID PM

Structure Type: Building Historic Building: No Contact:

Benefits: ($114) Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	($114)	$71,795

Total Benefits: **$11,504,004** Total Costs: **$7,969,190** BCR: **1.44**

Project Number: BRY10455 Disaster #: Program: Agency: **Freese and Nichols, Inc.**

State: **Texas** Point of Contact: Garrett Johnston Analyst: Garrett Johnston

Property ID OQ

Structure Type: Building Historic Building: No Contact:

Benefits: $12,063 Costs: $71,795 BCR: 0.17

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.17	$12,063	$71,795

Property ID PE

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Property ID NU

Structure Type: Building Historic Building: No Contact:

Benefits: $133,946 Costs: $71,795 BCR: 1.87

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	1.87	$133,946	$71,795

Property ID PN

Structure Type: Building Historic Building: No Contact:

Benefits: ($52) Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	($52)	$71,795

Total Benefits: **$11,504,004** Total Costs: **$7,969,190** BCR: **1.44**

Project Number: BRY10455 Disaster #: Program: Agency: **Freese and Nichols, Inc.**

State: **Texas** Point of Contact: Garrett Johnston Analyst: Garrett Johnston

Property ID NO

Structure Type: Building Historic Building: No Contact:

Benefits: $55,052 Costs: $71,795 BCR: 0.77

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.77	$55,052	$71,795

Property ID OR

Structure Type: Building Historic Building: No Contact:

Benefits: $3,375 Costs: $71,795 BCR: 0.05

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.05	$3,375	$71,795

Property ID PF

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Property ID NV

Structure Type: Building Historic Building: No Contact:

Benefits: $84,829 Costs: $71,795 BCR: 1.18

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	1.18	$84,829	$71,795

Total Benefits: **$11,504,004** Total Costs: **$7,969,190** BCR: **1.44**

Project Number: BRY10455 Disaster #: Program: Agency: **Freese and Nichols, Inc.**

State: **Texas** Point of Contact: Garrett Johnston Analyst: Garrett Johnston

Property ID PO

Structure Type: Building Historic Building: No Contact:

Benefits: ($52) Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	($52)	$71,795

Property ID OS

Structure Type: Building Historic Building: No Contact:

Benefits: $4,652 Costs: $71,795 BCR: 0.06

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.06	$4,652	$71,795

Property ID NP

Structure Type: Building Historic Building: No Contact:

Benefits: $74,922 Costs: $71,795 BCR: 1.04

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	1.04	$74,922	$71,795

Property ID OT

Structure Type: Building Historic Building: No Contact:

Benefits: $1,275 Costs: $71,795 BCR: 0.02

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.02	$1,275	$71,795

Total Benefits: **$11,504,004** Total Costs: **$7,969,190** BCR: **1.44**

Project Number: BRY10455 Disaster #: Program: Agency: **Freese and Nichols, Inc.**

State: **Texas** Point of Contact: Garrett Johnston Analyst: Garrett Johnston

Property ID OU

Structure Type: Building Historic Building: No Contact:

Benefits: $1,640 Costs: $71,795 BCR: 0.02

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.02	$1,640	$71,795

Property ID OV

Structure Type: Building Historic Building: No Contact:

Benefits: ($648) Costs: $71,795 BCR: (0.01)

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	(0.01)	($648)	$71,795

Property ID OW

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Property ID OX

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Total Benefits: **$11,504,004** Total Costs: **$7,969,190** BCR: **1.44**

Project Number: BRY10455 Disaster #: Program: Agency: **Freese and Nichols, Inc.**

State: **Texas** Point of Contact: Garrett Johnston Analyst: Garrett Johnston

Property ID OY

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Property ID PZ

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Property ID PA

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,795 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,795

Property ID TG

Structure Type: Building Historic Building: No Contact:

Benefits: $0 Costs: $71,740 BCR: 0.00

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.00	$0	$71,740

Total Benefits: **$11,504,004** Total Costs: **$7,969,190** BCR: **1.44**

Project Number: BRY10455 Disaster #: Program: Agency: **Freese and Nichols, Inc.**

State: **Texas** Point of Contact: Garrett Johnston Analyst: Garrett Johnston

Property ID OA

Structure Type: Building Historic Building: No Contact:

Benefits: $3,694 Costs: $71,795 BCR: 0.05

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Flood	0.05	$3,694	$71,795

Appendix E

Vieux, Inc. Rainfall Analysis

Radar Rainfall Analysis Report
Still Creek, Bryan, TX
2 Rainfall Events

Prepared for Freese and Nichols, Inc.
In support of the City of Bryan, TX

June 10th, 2011

350 David L. Boren Blvd., Suite 2500
Norman, Oklahoma 73072
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Table of Contents

Overview

The following rainfall event analyses are performed for Freese and Nichols, Inc. in support of the City of Bryan, TX. Two significant rainfall events that occurred on May 1st, 2007 and April 25th, 2009 were processed for Still Creek. The event ranges for both events are shown in Table 1. The radar rainfall product consists of gauge-adjusted radar rainfall (GARR) produced in 5-minute increments for both events.

Table 1 Rainfall event analysis periods.

Analysis Dates	Start Time (CDT)	End Time (CDT)
May 1st, 2007	2007-05-01 06:00	2007-05-02 04:00
April 25th, 2009	2009-04-24 14:00	2009-04-25 08:00

Radar data used in production of GARR is produced by the National Weather Service (NWS) Next Generation Radar (NEXRAD) system. NEXRAD Level II radar data is often referred to as Base Data and contains the full spatial/temporal/data resolution reflectivity data from the radar. Level II radar data measures reflectivity in decibels of reflectance (dBZ), and at a spatial resolution of 0.5-degree by 0.25-km every 4 – 10 minutes with a data resolution of 0.5 dBZ amounting to 256 data levels of data. The primary radar data source used to process both events was Level II NEXRAD data from KGRK located near Ft. Hood, TX.

Because the radar measures reflectivity in polar coordinates centered on the radar installation, the 1-degree azimuth increases in width as range increases from the radar. Range resolution of Level II data is 1-km and is measured out to 230 km from the radar. Due to the proximity of KGRK to the target area, the polar coordinates defining resolution is approximately 1.7 km.

Rain gauge data and locations were collected for fourteen stations. Five gauges consisting primarily of 15-minute data were provided by the United States Geological Survey (USGS). Hourly data was obtained from one National Weather Service (NWS) Automated Surface Observing Systems (ASOS) station as well as one station from the NWS Cooperative Observer Programs (COOP). In addition, daily rainfall data was used from seven NWS COOP gauges.

Freese and Nichols, Inc. provided a basin shapefile of Still Creek. Figure 1 depicts the spatial distribution of the rain gauge network and Still Creek basin. For the gauges shown in Figure 1, the ID, name, source and data interval of each gauge is listed in Table 2. Radar data review, preparation and sampling the radar over the gauges/basin was achieved using software developed at Vieux, Inc.

Fourteen gauges and one NEXRAD radar are used to produce GARR for each event. The methodology used in production of the GARR is described in the next section followed by the GARR results for each event.

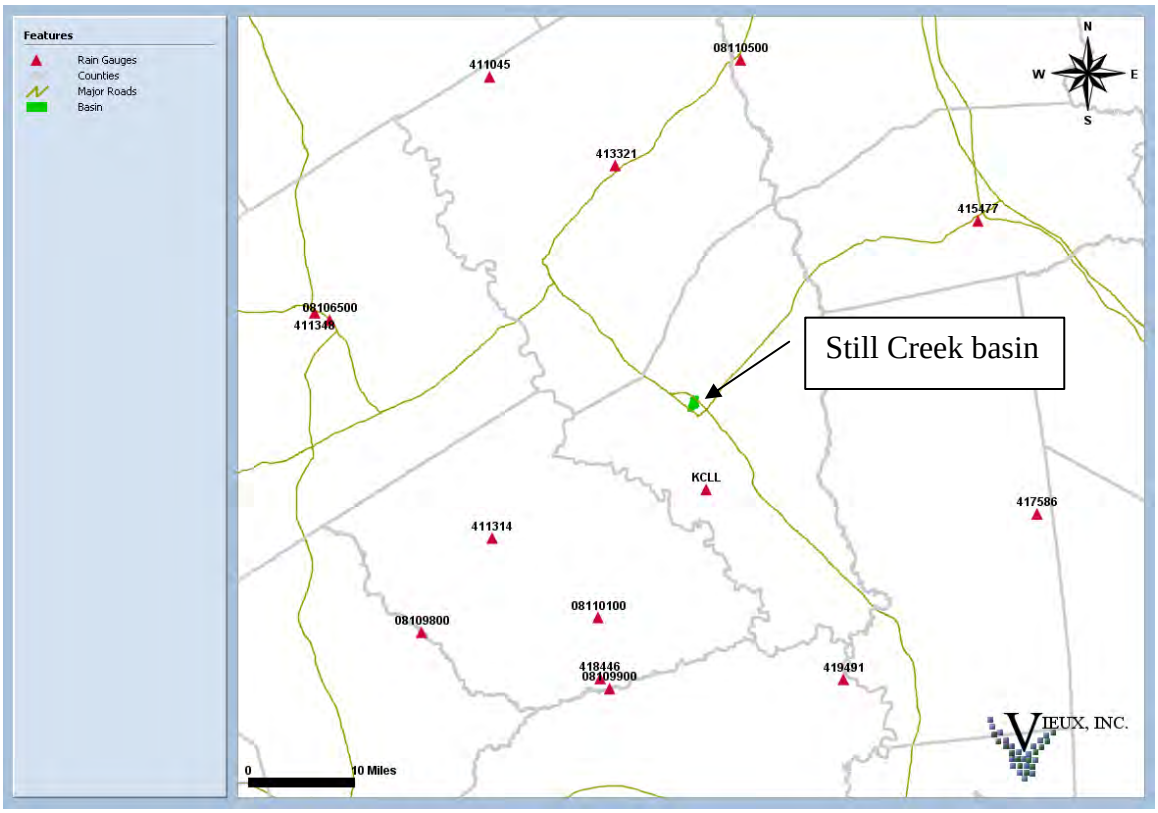

Figure 1 Spatial distribution of the rain gauge network and Still Creek basin.

Table 2 Rain gauge details.

Gauge ID	Station Name	Source	Data Interval
KCLL	Easterwood Field Apt	NWS - ASOS	Hourly
411045	Bremond	NWS - COOP	Daily
411314	Caldwell	NWS - COOP	Daily
411348	Cameron	NWS - COOP	Daily
413321	Franklin	NWS - COOP	Daily
415477	Madisonville	NWS - COOP	Daily
417586	Richards	NWS - COOP	Daily
418446	Somerville Dam	NWS - COOP	Daily
419491	Washington State Park	NWS - COOP	Hourly
08109800	Yegua Creek nr Dime Box	USGS	15-min
08109900	Somerville Lake nr Somerville	USGS	15-min
08110100	Davidson Creek nr Lyons	USGS	15-min
08110500	Navasota River nr Easterly	USGS	15-min
08106500	Little River nr Cameron	USGS	15-min

Methodology

Gauge-adjusted Radar Rainfall (GARR)

Statistical control of the data makes radar rainfall measurements more accurate. By statistical comparison between the radar and rain gauge accumulations during a calibration interval, statistical outliers may be identified. In addition, radar data is enhanced by correcting it for systematic errors called bias. This procedure helps improve the accuracy of the rainfall product. The bias correction factors are multiplicative factors applied to the radar that enhances the accuracy of the radar rainfall for any sample period.

Accuracy of radar rainfall over specific target areas may be enhanced by comparison and adjustment to rain gauge networks. The method of adjustment depends on the hydrologic application and the spatial extent of the area of interest. The local bias (LB) approach to adjusting the radar rainfall uses the ratio of gauge to radar accumulations from surrounding gauges with the closest gauge having the most weight. The LB approach distributes the variation of bias over the region for a given event period.

A Local Bias (LB) method was used for gauge adjustment of the radar. The LB uses the ratio between the sum of each gauge divided by the sum of the sampled radar values over each gauge. All radar/gauge (RG) pairs were then checked for statistical outliers. The bias of each qualified remaining RG pair was then surfaced over the analysis area using a weighted distance technique. The resulting LB value over each radar bin is the multiplicative factor that adjusts the radar. For example, a bias of 1.5 can be interpreted as a 33% underestimation by the radar. The three parameters used to quantify the LB value are: 1) average difference (AD), 2) calibrated average difference (CAD), and 3) relative dispersion (RD). All three of these parameters are expressed as an absolute percentage about the mean. The basin is then filtered spatially from the final adjusted radar bins using an area-averaged technique.

At a given location, radar measurement may differ from rain gauge measurement for several reasons. Radar collects data by sampling a relatively large volume of the atmosphere while rain gauges measure at a point. Another source of difference is that radar measures above the ground, while rain gauges measure close to the ground. Additionally, the differences between the radar data and the rain gauge data can be affected by specific storm characteristics and season of the year. By adjusting the radar data with rain gauge data, better maps of rainfall are produced than either sensor system could produce alone.

Storm Return Intervals

Storm return intervals for several durations were determined based on the NWS HYDRO-35 and TP-40 Precipitation Frequency documents that contain depth, duration and frequency values for the United States. These point rainfall thresholds are shown in Table 3 and were used to identify the maximum return interval for the Still Creek basin throughout each event. The TP-40 document has a minimum duration of 30-minutes, thus the HYDRO-35 document was used for the 5-minute and 15-minute durations. The HYDRO-35 document also had a minimum frequency of 2 years.

Table 3 Point rainfall thresholds for various return intervals.

Source	HYDRO-35	HYDRO-35	TP-40	TP-40	TP-40	TP-40	TP-40	TP-40
Duration	5-min	15-min	30-min	1-hr	2-hr	3-hr	6-hr	12-hr
Frequency	Depth (in.)	Depth (in.)	Depth (in.)	Depth (in.)	Depth (in.)	Depth (in.)	Depth (in.)	Depth (in.)
1 year	---	---	1.45	1.80	2.10	2.30	2.70	3.15
2 year	0.53	1.15	1.75	2.20	2.60	2.80	3.40	3.85
5 year	0.60	1.32	2.20	2.75	3.40	3.70	4.45	5.30
10 year	0.66	1.45	2.50	3.15	3.95	4.40	5.25	6.25
25 year	0.74	1.64	2.90	3.60	4.60	5.05	6.20	7.50
50 year	0.81	1.80	3.25	4.05	5.10	5.70	7.00	8.50
100 year	0.88	1.95	3.50	4.50	5.60	6.30	7.90	9.50

(*Hydro-35 Source*: NOAA Technical Memorandum NWS HYDRO-35, 1977)
(*TP-40 Source*: Weather Bureau Technical Paper No. 40, 1961)

Accumulated rainfall totals were obtained using a time-series of the GARR basin values at 5-minute increments at 5-min, 15-min, 30-min, 1-hr, 2-hr, 3-hr, 6-hr and 12-hr durations. The totals were calculated by summing the GARR basin values to produce aggregated rainfall for each duration. The maximum rainfall amount for any duration are then compared to the thresholds presented above in Table 3. The approach does not apply an areal reduction factors in computing return intervals for a basin. And the return interval is computed for the interval with maximum rainfall amounts, and does not consider the storm total unless it happens to be the highest return interval. The following section presents the GARR results for each event.

Results

The GARR statistics for each event are listed in Table 4. The **Event Date** shown in Table 4 corresponds to the day or portion of the day when most of the rainfall occurred for that GARR event period. The May 1st, 2007 event was split into two periods to improve gauge-adjustment of the radar and the GARR statistics for each portion of the event are shown in Table 4 as E01a and E01b.

The **Bias** value shown in Table 4 is the sum of the gauges divided by the sum of the sampled radar values over the gauges. Those rain events with the lowest CAD values shown in Table 4 represent the best agreement between GARR and gauge values for all radar/gauge pairs used to adjust the radar. On average, lower values of CAD imply higher statistical confidence in the reliability of the dataset. Typically, stratiform rainfall events (i.e., low spatial variability) have lower CAD values than convective rainfall events (i.e., high spatial variability). For these two events, the event CAD averaged 10.9%, indicating that the mean GARR agrees with the mean gauge accumulation to within ±5.4%. Available gauges were evaluated for statistical consistency before being used to adjust the radar.

Table 4 GARR statistics for each event.

Event #	Event Date	Gauges Used (14)	Bias	AD (%)	CAD (%)	RD (%)
E01a	2007-05-01	6	1.778	39.5	14.0	16.6
E01b	2007-05-01	9	1.610	32.1	7.2	9.0
E02	2009-04-25	5	0.684	69.8	11.4	13.9

Statistical review of the data can provide an indication of data quality. Depending on the quality of the radar and gauge data, CAD values for individual events less than 10% are considered excellent, 10 – 20% are considered good, and 20 – 30% are considered fair. However, CAD may not serve as a reliable indicator of data quality when abrupt changes in bias occur within the analysis period, particularly when compensating over- and under-estimation results due to using an assumed Z-R relationship throughout the period while atmospheric conditions merit different Z-R coefficients. The effects from abrupt changes in Z-R are mitigated by splitting the event periods. A synopsis for each event is described below in terms of the specific processing protocol applied to each event period and GARR information.

Event 1: 2007-05-01

The analysis period was from 2007-05-01 06:00 CDT to 2007-05-02 04:00 CDT (2007-05-01 11:00 UTC to 2007-05-02 09:00 UTC). The event was then split into two periods at 2007-05-01 13:00 CDT (2007-05-01 18:00 UTC) to improve gauge-adjustment of the radar. Gauges 08109800, 08109900, 08110100, 411314, 417586, 419491 and KCLL did not meet statistical criteria for gauge-adjustment of the radar and were not used to adjust the radar during Event 1a. Gauges 08109800, 08109900, 08110100 and 419491 did not meet statistical criteria for gauge-adjustment of the radar and were not used to adjust the radar during Event 1b.

A convective Z-R relationship was used to convert radar reflectivity to rainfall rate. Tables 5 and 6 summarize the results for each RG pair used for final radar adjustment, where G_i is the gauge estimate, R_i is the non-adjusted radar estimate, R_i* is the GARR estimate, Diff* (in) is the difference in inches between the gauge and GARR estimate, and Diff* (%) is the percent difference between the gauge and GARR estimate. Figure 2 shows the scatter plots of the final remaining RG pairs after gauge-adjustment of the radar. Figure 3 depicts the GARR storm total for the KGRK polar bins encompassing Still Creek basin.

Table 5 Summary of individual RG pairs for Event 1a.

Gauge Name	Gauge ID	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)
Navasota River nr Easterly	08110500	0.39	0.34	0.50	-0.11	-28.2
Cameron	411348	1.13	0.81	1.41	-0.27	-23.8
Bremond	411045	0.82	0.46	0.81	0.00	0.6
Madisonville	415477	1.85	0.88	1.77	0.07	4.0
Franklin	413321	0.57	0.30	0.51	0.07	11.5
Little River nr Cameron	08106500	1.41	0.68	1.19	0.22	15.7

Table 6 Summary of individual RG pairs for Event 1b.

Gauge Name	Gauge ID	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)
Little River nr Cameron	08106500	1.22	1.15	1.47	-0.25	-20.7
Navasota River nr Easterly	08110500	1.32	0.85	1.45	-0.13	-10.1
Richards	417586	0.68	0.60	0.73	-0.05	-7.5
Easterwood Field Apt	KCLL	0.18	0.12	0.18	0.00	0.6
Caldwell	411314	0.30	0.21	0.29	0.00	1.0
Bremond	411045	3.82	2.16	3.77	0.05	1.4
Madisonville	415477	2.16	1.04	2.04	0.12	5.5
Franklin	413321	2.47	1.27	2.25	0.21	8.6
Cameron	411348	1.57	1.11	1.42	0.14	9.1

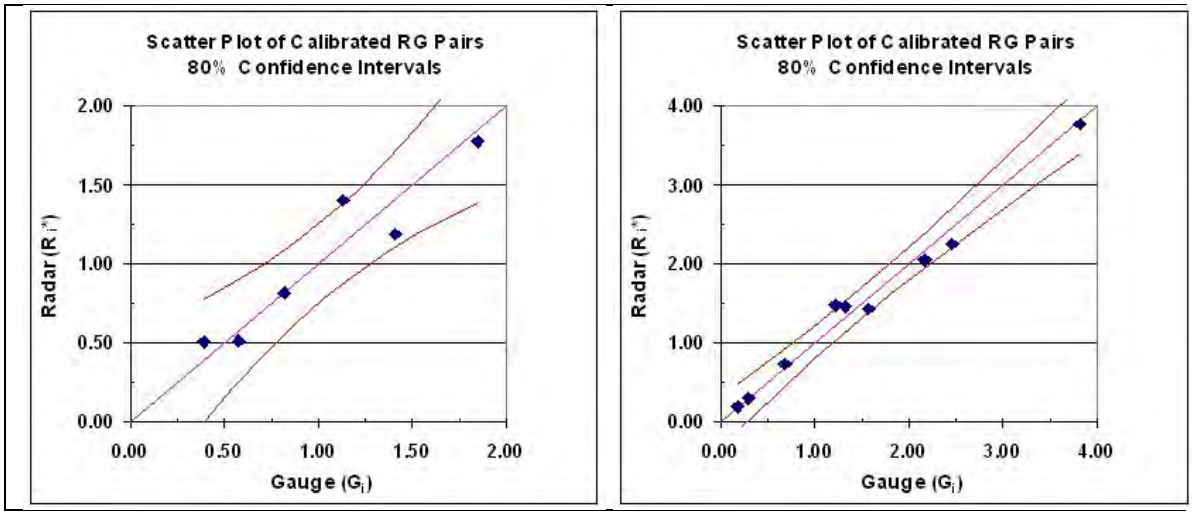

Figure 2 Scatter plots of gauge-adjusted RG pairs for Event 1a (left) and 1b (right).

Figure 3 GARR storm total for Event 1.

The GARR storm total for Still Creek basin is 3.38 inches. The storm return intervals for Still Creek basin are presented in Table 7. The value of the maximum depth (in.) was also converted to maximum hourly rate (in/hr) for each duration. The highest frequency for the durations tested is the 1-hour duration with a depth of 2.42 inches and a corresponding frequency exceeding 2-years.

Table 7 Storm return interval analysis for Still Creek basin during Event 1.

Duration	Depth (in.)	Rate (in/hr)	Time (CDT)	Frequency
5-min	0.31	3.70	2007-05-01 16:55	< 2-yr
15-min	0.79	3.16	2007-05-01 17:05	< 2-yr
30-min	1.30	2.61	2007-05-01 17:20	< 1-yr
1-hr	2.42	2.42	2007-05-01 17:45	> 2-yr
2-hr	2.57	1.29	2007-05-01 18:35	> 1-yr
3-hr	2.58	0.86	2007-05-01 18:40	> 1-yr
6-hr	2.58	0.43	2007-05-01 18:40	< 1-yr
12-hr	3.38	0.28	2007-05-01 18:40	> 1-yr

Event 2: 2009-04-25

The analysis period was from 2009-04-24 14:00 CDT to 2009-04-25 08:00 CDT (2009-04-24 19:00 UTC to 2009-04-25 13:00 UTC). Gauges 08109900 and 08110100 were not consistent with the radar or surrounding gauges and were not used to adjust the radar during Event 2. Gauges 08109800 and 419491 did not meet statistical criteria for gauge-adjustment of the radar and were not used to adjust the radar during Event 2. A convective Z-R relationship was used to convert radar reflectivity to rainfall rate. Table 8 summarizes the results for each RG pair used for final radar adjustment, where G_i is the gauge estimate, R_i is the non-adjusted radar estimate, R_i* is the GARR estimate, Diff* (in) is the difference in inches between the gauge and GARR estimate, and Diff* (%) is the percent difference between the gauge and GARR estimate. Figure 4 shows the scatter plot of the final remaining RG pairs after gauge-adjustment of the radar. Figure 5 depicts the GARR storm total for the KGRK polar bins encompassing Still Creek basin.

Table 8 Summary of individual RG pairs for Event 2.

Gauge Name	Gauge ID	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)
Navasota River nr Easterly	08110500	0.94	1.40	1.13	-0.19	-19.9
Easterwood Field Apt	KCLL	0.19	0.52	0.22	-0.03	-15.9
Little River nr Cameron	08106500	0.09	0.11	0.09	0.00	-1.0
Somerville Dam	418446	0.63	1.24	0.59	0.04	5.7
Franklin	413321	1.03	0.94	0.88	0.15	14.4

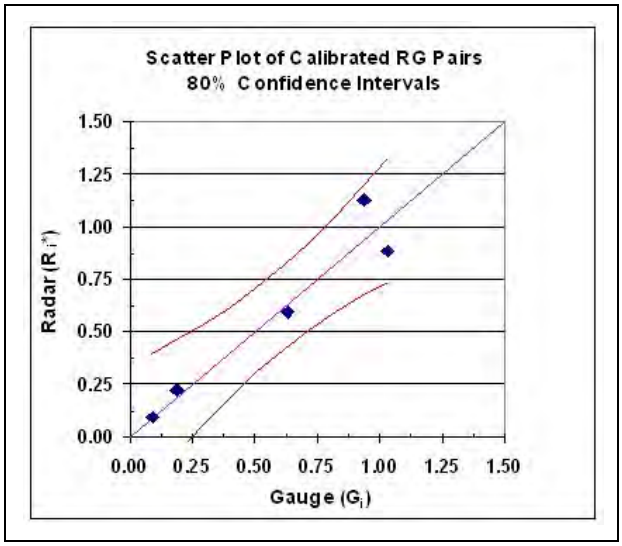

Figure 4 Scatter plot of gauge-adjusted RG pairs for Event 2.

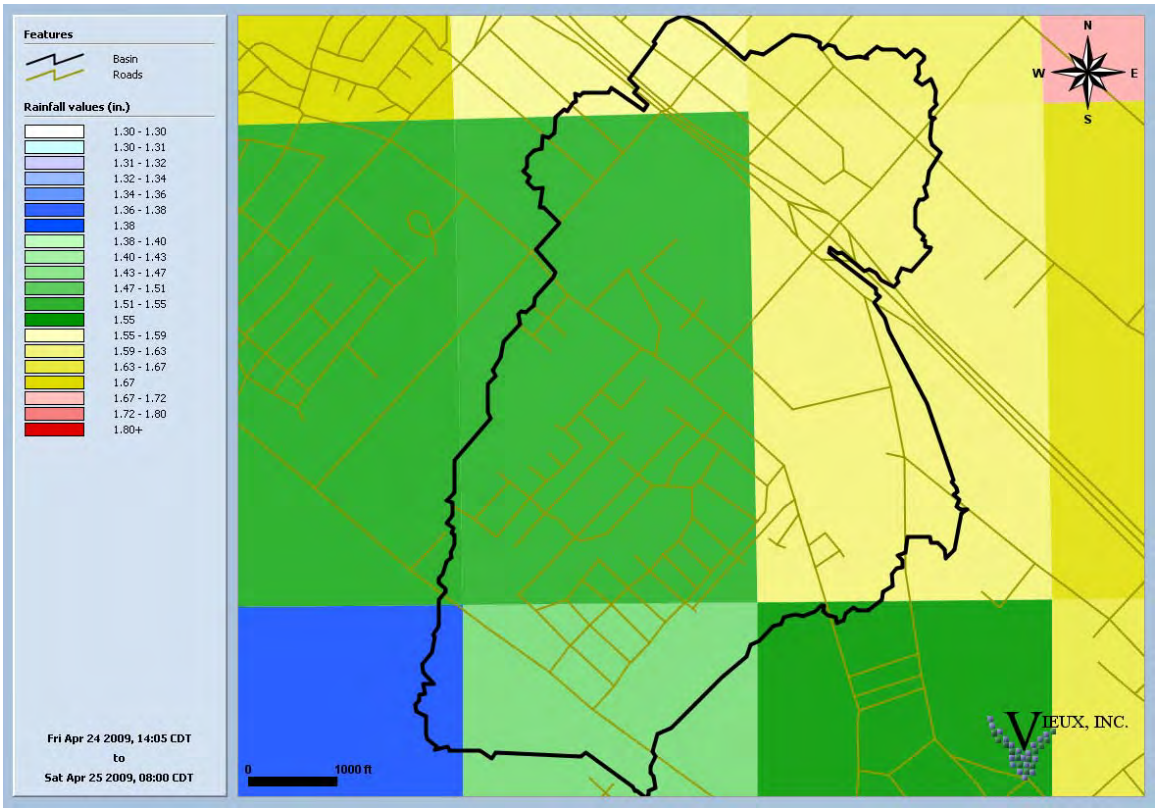

Figure 5 GARR storm total for Event 2.

The GARR storm total for Still Creek basin is 1.52 inches. The storm return intervals for Still Creek basin are presented in Table 9. The value of the maximum depth (in.) was also converted to maximum hourly rate (in/hr) for each duration. The highest frequency for the durations tested is the 1-hour duration with a depth of 1.18 inches and a corresponding frequency exceeding 1-year.

Table 9 Storm return interval analysis for Still Creek basin during Event 2.

Duration	Depth (in.)	Rate (in/hr)	Time (CDT)	Frequency
5-min	0.19	2.30	2009-04-25 03:35	< 2-yr
15-min	0.49	1.95	2009-04-25 03:40	< 2-yr
30-min	0.73	1.45	2009-04-25 03:55	< 1-yr
1-hr	1.18	1.18	2009-04-25 04:20	> 1-yr
2-hr	1.44	0.72	2009-04-25 04:50	< 1-yr
3-hr	1.50	0.50	2009-04-25 04:50	< 1-yr
6-hr	1.52	0.25	2009-04-25 05:00	< 1-yr
12-hr	1.53	0.13	2009-04-25 05:00	< 1-yr

Metadata

Data accompanying this document provides a continuous rainfall record of the Still Creek basin and 12 surrounding KGRK polar radar bins in 5-minute intervals for both the 2007-05-01 and 2009-04-25 rainfall events. The data are provided in CSV format (1 CSV file per ID for each event) in the CSV subfolder. Shapefiles of both the basin and polar radar bins are located in the Shapefile subfolder. The data file documentation follows:

CSV metadata:

- Separate CSV files for the basin and polar radar bins.
- Comma-delimited text files, 1st column contains date, 2nd column contains rainfall values.
- Time stamps (yyyy/mm/dd hh:mm) are in CDT.
- Data values represent 5-min accumulation (inches) at end of interval.
- The polar radar bin ID in each filename uses the "ID" field from the polar radar bin shapefile.
- The basin ID in the filename is called "Basin".

Shapefile metadata:

- NAD 1983, State Plane Texas Central (feet).

Appendix F

Disc – Digital Models, Photos, GIS Data, and Survey