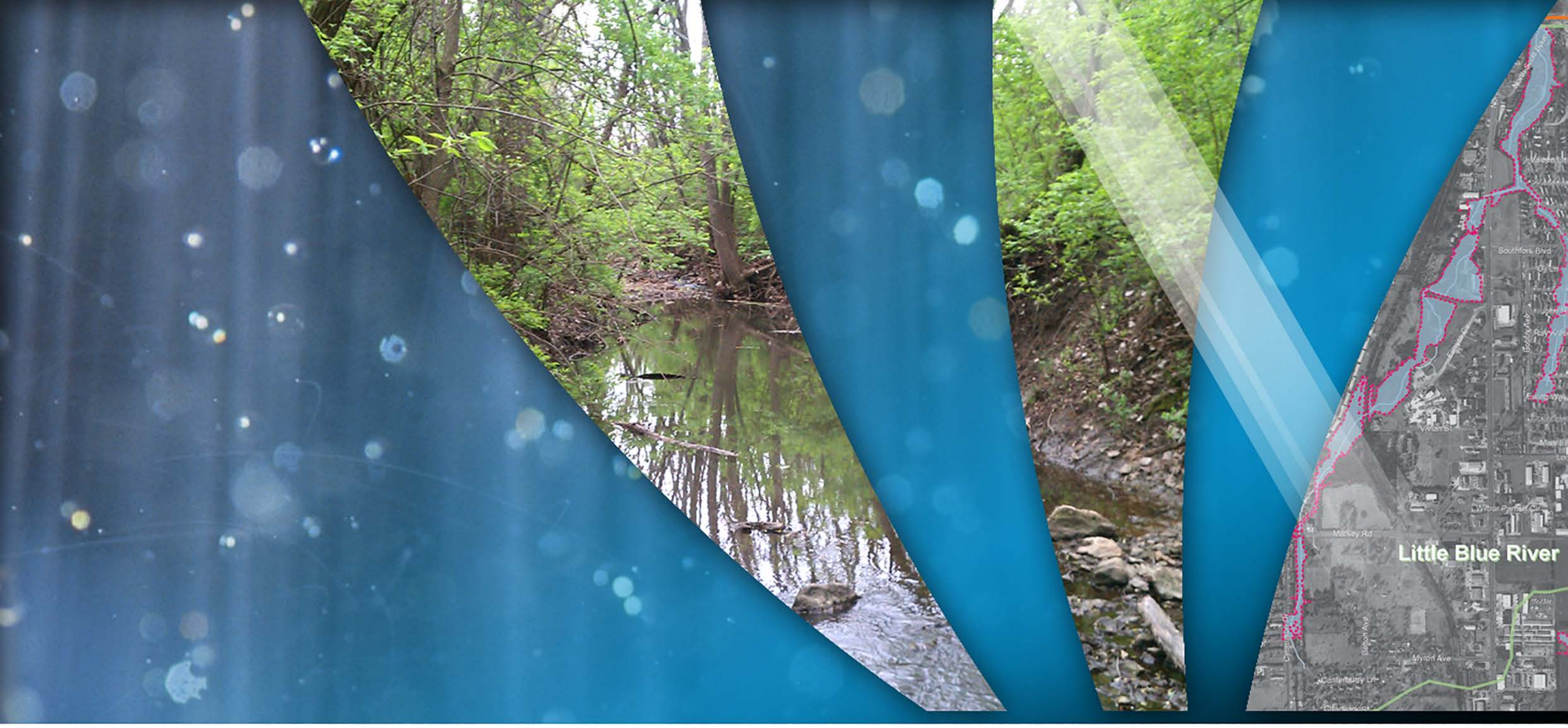

STORMWATER MASTER PLAN

City of Belton, MO

Final Draft – December 2012

PREPARED BY:

OLSSON ASSOCIATES

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A) GENERAL: PURPOSE AND OVERVIEW OF THE PLAN

This Stormwater Master Plan is designed to provide the City a clear road map to address current and future stormwater management needs for flood control, stream stability, water quality and water resource protection. The plan will:

- ❑ Help the City prioritize, budget and address immediate and long-term stormwater problems and maintenance issues in a systematic manner.
- ❑ Allow the City to proactively forecast, evaluate, and manage the stormwater-related impacts that result from future development or other changes in the city's watersheds.
- ❑ Help the City achieve financial savings through comprehensive watershed-based planning and coordination with other City projects and infrastructure master planning.
- ❑ Support the City's compliance with EPA water quality mandates.

The plan is organized into the following Parts:

Part A: General Information
Part B: Recommended Action Plan
Part C: Additional Management Tools and Case Studies
Part D: Data Sources, Methodology and Standards

An overview map of the City of Belton and its primary watersheds is provided in Figure A-1.

B) RECOMMENDED ACTION PLAN

The Recommended Action Plan is the heart of the Master Plan, designed to provide the City a clear and concise prioritized plan of recommended actions to achieve the stormwater management goals stated above. The recommended actions are grouped into: 1) capital improvement projects; 2) maintenance actions; 3) funding mechanisms; and 4) future planning and prevention measures.

1. *Capital Improvement Projects*

Through the public outreach, investigations and analyses efforts, a recommended prioritized capital improvement plan was developed that includes 30 projects throughout Belton (see attached Figure A-2) at a total estimated cost of approximately $15 million (see "Capital Improvement Project List" on the following page). The projects are aimed at addressing historical flooding and erosion problems caused by insufficient or absent public drainage systems. The projects were organized into three Priority Groups where: Group 1 projects are characterized by the most severe and widespread stormwater problems; Group 2 projects are moderately severe; and Group 3 projects are generally isolated problems and the least severe. The projects were then prioritized within each of the three Groups using a cost-benefit scoring system that quantifies a project's benefit potential relative to cost. The benefit score is based on meeting key criteria related to frequency and severity of home flooding, street flooding, synergy with other City projects, and regional benefit. The "Priority Score" shown in the following Capital Improvement Project List is the project's benefit score divided by the estimated cost. Included in this Project List is a cumulative capital project costs column along with estimated additional 25-year maintenance costs of new storm drainage system that would be added by the project only.

Capital Improvement Project List - Prioritization by Grouping and Scoring
Belton, MO

Project	Project Location	100-yr Flood Impacts Homes (Factors 1-3)	Street Flooding (Factors 4-7)	Erosion Threatens Infrastructure (Factors 8-12)	System Condition (Factors 13-14)	Water Quality Benefits (Factors 15-16)	(A) Benefit Score	(B) Project Costs	Cummulative Project Costs	(C) Added 25-Yr. Maint. Costs	(D) Project + Maint. Costs	Priority Score (1000xA/D)	Other Considerations: Benefits other public infrastructure	Other Considerations: High probability of outside cost sharing/support	Other Considerations: Regional, long-term benefits	Other Considerations: High aesthetic value
PRIORITY 1 PROJECTS																
WF-3	Pacific Dr. and Sunrise Dr.	180	90				270.0	$259,001	$259,001	$11,850	$270,851	1.00				
WF-4	Westside Dr. and Lacy Ln.	900	90		10		1000.0	$2,677,989	$2,936,990	$85,425	$2,763,414	0.36	Y			
OC-1	Hight Ave. and Bryan Way	300	112.5	60			472.5	$1,502,384	$4,439,374	$0	$1,502,384	0.31				
WF-1	Sunset Ln. and N Hillcrest Dr.	540	90	30			660.0	$2,243,225	$6,682,599	$18,825	$2,262,050	0.29	Y			
WF-2	Sunrise Dr. and Buena Vista Dr.	120	45				165.0	$646,815	$7,329,414	$2,150	$648,965	0.25	Y			
OC-2	Valentine Ave. and 162nd St.	360	75				435.0	$1,945,563	$9,274,977	$0	$1,945,563	0.22	Y			Y
Markey Lake*	South of US 71 and Hwy. Y	24	7	2		20	53.0	$1,117,749	$10,392,726	$450,000	$1,567,749	0.08	Y	Y	Y	Y
Total Project Costs - Priority 1 Group								**$10,392,726**								
PRIORITY 2 PROJECTS																
OC-6	162nd St. and Slater Ave.	120					120.0	$41,990	$41,990	$2,175	$44,165	2.72				
OC-8	Richmond Ave. and E 160th St.	120	60				180.0	$70,843	$112,833	$1,125	$71,968	2.50	Y			
OC-2 ALT	Valentine Ave. and 162nd St.	120					120.0	$53,811	$166,644	$0	$53,811	2.23				
WF-12	Baldwin St. and Lynn St.	180	90				270.0	$676,927	$843,571	$6,225	$683,152	0.40				
WF-14	Walnut St. and Scott Ave.	60					60.0	$28,191	$871,762	$500	$28,691	2.09				
OC-9	South of Bel-Ray Blvd. and Middleton	60	150				210.0	$361,559	$1,233,321	$3,575	$365,134	0.58				
WF-11	South of Margaret Ln. and South Ave	40	90				130.0	$239,844	$1,473,165	$5,475	$245,319	0.53	Y			
WF-6	Cherry Hill Rd. and Orchard Dr.	60				40	100.0	$142,281	$1,615,446	$52,550	$194,831	0.51	Y			
OC-5	North of Slater Ave. and E 160th Ter.	40					40.0	$141,746	$1,757,194	$9,500	$151,246	0.26				
OC-4	Terry Ave. and Valentine St.	60					60.0	$242,543	$1,999,737	$0	$242,543	0.25	Y			
WF-5	N Cleveland Ave. and Tervis Ave.		90	30			120.0	$794,493	$2,794,230	$38,275	$832,768	0.14	Y			
Total Project Costs - Priority 2 Group								**$2,794,230**								
PRIORITY 3 PROJECTS																
WF-20	East of Brian Ave. and S Scott Ave.		72	30			102.0	$28,650	$28,650	$0	$28,650	3.56				
OC-6	Kay Ave. and 158th Ter.	60					60.0	$21,468	$50,118	$0	$21,468	2.79				
WF-19	Black Cherry Ct.	60					60.0	$27,000	$77,118	$0	$27,000	2.22				
OC-7	Terry Ave. and 161st Ter.	180					180.0	$84,553	$161,671	$9,800	$94,353	1.91				
WF-17	Plaza Acres Ct.	40					40.0	$37,291	$198,962	$2,200	$39,491	1.01				
WF-7	South of Pawnee Ln. and W Cambridge Rd.			90			90.0	$135,000	$333,962	$0	$135,000	0.67				
WF-13	Kent Dr. and Brentwood Dr.	120					120.0	$257,330	$591,292	$8,750	$266,080	0.45				
WF-15	East of S Cedar St. and E Cambridge Rd.			30			30.0	$85,000	$676,292	$0	$85,000	0.35	Y			
WF-10	Prairie Ln. and Park Ave.				5		5.0	$15,000	$691,292	$0	$15,000	0.33				
WF-16	West of S Cedar St. and W Cambridge Rd.			60			60.0	$193,750	$885,042	$0	$193,750	0.31	Y			
WF-9	North end of Kendi Ln.			30	25		55.0	$217,500	$1,102,542	$0	$217,500	0.25	Y			
WF-21	Hollywood Blvd. and S Scott Ave.		90				90.0	$429,750	$1,532,292	$500	$430,250	0.21	Y			
WF-8	South of Cherry Hill Dr. and E 171st St.			55	40		95.0	$475,500	$2,007,792	$0	$475,500	0.20	Y			
WF-18	181st Ter. and Mary Way	40					40.0	$376,394	$2,384,186	$0	$376,394	0.11				
Total Project Costs - Priority 3 Group								**$2,384,186**								

** Project to move forward only if majority of project is funded through private-public benefit district.*

A brief overview description of each of the Priority Group 1 projects is provided below:

WF-3 | Pacific Drive and Sunrise Drive. Residential flooding along East Pacific Drive and street flooding on East Pacific Drive are caused by excess stormwater flowing from the north of 206 East Pacific Drive. The conceptual improvement for this area involves berming and new storm sewer. The berm will be placed on the north side of East Pacific Drive to direct water into the new stormwater system that will be placed north of East Pacific Drive and outlet to the open channel south of East Pacific Drive.

WF-4 | Westside Drive and Lacy Lane. The flooding problem in this area consists of numerous flooding complaints throughout the Lacy Estates subdivision. The stormwater system in this area is undersized and not capable of handling the runoff generated. Analysis of the problem area revealed that the solution for this problem involves the extension of the stormwater system and upsizing the current system. Several inlets will also need to be added to capture the stormwater and convey it into the system.

OC-1 | Hight Avenue and McKinley Street. Residential and street flooding exists throughout this area. The existing stormwater main trunk line is undersized for the stormwater generated in the neighborhood. The undersized line causes flooding residences and street flooding. The solution for this area involves replacing the main trunk line from McKinley Street to the system outlet at Somerset Park.

WF-1 | Sunset Lane and North Hillcrest Drive. Numerous residential flooding and street flooding locations exist in this area. The flooding in this area is a result of an undersized system and bypass flow from the upper portion of the watershed. The excess water causes frequent flooding and is also partially responsible for surcharging sanitary sewer in the area. A detailed analysis of the area was performed and a replacement stormwater system was determined to be the most cost effective solution. The stormwater system will extend from Westover Road and following the existing storm sewer alignment outlet into Hargis Lake. Portions of the system will also extend onto Hargis Lane, North Hillcrest Road, and Hillcrest Court.

WF-2 | Sunrise Drive and Buena Vista Drive. Numerous residential and street flooding complaints along with flash flooding contribute to the flooding in this area. Undersized culverts and undersized storm sewer system cause the flooding in this area. The undersized system causes street flooding at West Sunrise Drive, Buena Vista Drive and Park Avenue. The undersized system also causes home flooding on West Sunrise Drive and Buena Vista Drive. After analysis of the system the most cost effective solution was determined to be the replacement of the culverts on West Sunrise Drive and Park Avenue. The storm inlet will also need replacement along a portion of Buena Vista Drive.

OC-2 | Valentine Avenue and 162nd Street. Street and residential flooding in this area is caused by an undersized culvert and insufficient open channel capacity in Oil Creek. The culvert restricts the water flowing in Oil Creek and causes a backup to occur that ponds up water and causes flooding in homes upstream of the culvert. The homes north of 162nd Street flood due to limited channel capacity along Oil Creek. The solution to the flooding problems in this area involve the replacement of the culvert with a bridge and widening Oil Creek to provide greater conveyance to prevent flooding of the homes north of 162nd Street.

2. *Maintenance Actions*

The City's storm drainage system was surveyed and inventoried, and it was determined the public system includes 48 miles of pipes and culverts with over 2,000 inlets and manholes. Long-term maintenance of this system is necessary to prevent future flooding problems, roadway failures, sewer back-ups and other impacts to property and infrastructure. The entire drainage system was visually inspected at inlets, pipe outfalls, junction boxes and manholes to assess the condition of the system. Each structure was rated as either "new", "good", "fair" or "poor" based on visual criteria such as debris accumulation, cracking, settlement, and current or potential structure failure. All "poor" and "fair" condition structures were identified in the project GIS base map for use by the City. Pipe video inspections were not performed, but are recommended in locations where poor structure conditions were identified in order to determine potential pipe repair or replacement extents. From this field inventory, recommendations for maintenance actions were developed. On a site by site basis the actions are relatively minor, but across the entire 48 miles of pipe the required resources to maintain the system annually will be significant and is estimated at $500,000/year for staff salaries, equipment and occasional contracting costs for minor reconstruction work. The recommended actions are outlined and organized by:

- *Immediate Repairs.* These repairs are focused on structures in poor condition where failures have occurred or are imminent.
- *Long-term Maintenance Actions.* These repairs are characterized by frequent sediment and debris removals, minor inlet repairs (grate replacements, etc.) and monitoring.

3. *Funding Mechanisms*

The City of Belton does not currently have a dedicated source of revenue necessary to maintain the existing system or make improvements to address critical flooding and erosion issues. Stormwater maintenance and improvement costs are likely to increase due to inflation, infrastructure degradation that increases with age, and expanding state and federal stormwater program requirements. The present value estimated costs of needed improvements and ongoing maintenance outlined above are summarized below:

- ❑ Priority 1 capital improvements: $10.4M
- ❑ Priority 2 and 3 capital improvements: $5.2M
- ❑ Ongoing annual maintenance costs: $500,000

Due to the variety of needed stormwater management expenditures, a variety of funding mechanisms should be explored to maintain and improve the level of stormwater management service to the citizens, primarily:

- General Obligation (GO) Bonds
- Stormwater Utility
- Sales Tax

Each mechanism has been used by numerous municipalities both locally and across the country in order to fund stormwater improvements and maintenance. There is no one-size-fits-all approach, as each option carries its share of advantages and disadvantages, and proper application depends ultimately on the community's goals, needs and financial position. The table below briefly summarizes each option. Please note the estimated citizen impact costs below are approximate and would need to be calculated in full detail when a funding method is chosen for implementation.

Funding Option	Basic Structure	Recommended Application	Fund Generation, City & Citizen Impact	Advantages	Disadvantages or Limitations
GO Bonds	Low interest debt instrument typically used by cities to fund public infrastructure (same as Belton's 2006 bond issue)	Funding of initial Priority 1 capital projects estimated at $10.4M.	Funding amount limited by City's bonding capacity. City obligated to repay bond holders at specified rate.	+ Large amount of funds available up front to address most severe problems quickly + Low interest + Belton is familiar with the bonding process	- City pays interest - Not practical for multiple small cost repairs
Utility	Property owners are charged a fixed monthly fee to fund the stormwater program, typically based on an Equivalent Residential Unit (ERU) [(1)]	1. Fund annual maintenance of the existing system at $500k/yr. 2. Fund smaller Priority 2 and 3 capital projects, $5.2M over 10 years.	1. Cost per ERU estimated at $4.00/mo. to cover annual maintenance. 2. Cost per ERU estimated at approximately $8.00/mo. to fund annual maintenance and Priority Group 2 and 3 capital projects	+ Steady, predictable annual funding stream + Fee structure to citizens is equitable, based on runoff generation + Provides built-in incentive to reduce impervious area on properties	- Takes time to build funds; not ideal for completing urgent capital projects
Sales Tax	A dedicated amount of local sales tax is authorized for public improvements and maintenance.	1. Fund annual maintenance of the existing system at $500k/yr. 2. Fund smaller Priority 2 and 3 capital projects, $5.2M over 10 years.	1/4-cent sales tax would be needed to generate $500,000/yr covering annual maintenance. Additional 1/4cent could be added for 10 years to fund Priority 2 & 3 projects.	+ Part of the revenue is generated by out-of-town visitors + Stormwater can be combined with Parks program, which has been successful and voter-supported in many other cities	- Revenue can fluctuate greatly from year to year - Takes time to build funds; not ideal for completing urgent capital projects

(1) Equivalent Residential Unit is a common stormwater utility measuring unit that is calculated based on the average impervious area (rooftop, driveway, etc.) on a typical single family lot. The ERU can be applied to commercial, industrial, school, church and other non-residential properties, which are then charged a fee for multiple ERUs as determined by the impervious area on the property.

A property tax is another revenue generation option, but is less common and not recommended over the above options due to the fact the rate charged is based upon property value and not runoff generation or watershed impact. The average rate per parcel that would need to be charged across all parcels in Belton – residential, commercial, industrial and undeveloped areas – is approximately $5-$6/month for annual maintenance, and an additional $5/month to cover Priority 2 and 3 project costs, if desired. This is an approximation based on the total number of parcels currently in Belton.

Actual rates will vary widely depending on land use and value, and would need to be calculated using specific property values for more exact revenue forecasting.

Based on Olsson's initial analysis and research, it is recommended the City explore utilizing a combination of general obligation bonds for initial Priority 1 Group Project implementation and a Stormwater Utility to fund annual ongoing maintenance.

4. ***Planning and Prevention Measures***

The Master Plan outlines key recommended planning measures that should be undertaken in order to proactively manage current and future growth and development impacts on the natural and constructed drainage system. These measures include:

A. Immediate Actions

Water Quality Ordinance and Criteria. New ordinances and criteria are outlined that provide for post-construction water quality management and are required to meet EPA and Missouri Department of Natural Resources regulations.

Stream Buffer Modifications. A stream buffer ordinance is recommended that provides a minimum width based on typical stream meander, and then provides incentives to developers to dedicate more buffer area in select locations. This would tie to recommendations provided in the Conservation Overlay Zoning District section.

Private Development Detention Strategies by Watershed. Recommendations are provided that define four stormwater detention strategies for new development that is dependent upon downstream conditions in the watershed. The strategies aim to address flooding (extreme flood events), stream erosion (frequent flood events), combination of both (comprehensive) and special detention areas where regional management controls are planned. The criteria is based upon the most recent American Public Work Association, Kansas City Metropolitan Chapter Design Criteria. Figure A-3 illustrates where each of the four recommended on-site detention strategies are to be applied.

Floodplain Management Policies. The City should continue to apply the floodplain regulations throughout the City while adding two enhancements to reduce and manage future flood risk:

- Requiring all construction adjacent to an open channel to have a finish floor or low opening a minimum of 1 foot above the ultimate conditions 1% chance flood elevation.
- Complete Letter of Map Revision (LOMR) in a timely manner for all changes in the FEMA floodplain, including fill, roadway structures, and other enhancements.

Public Education and Outreach. Recommended regular practices include informing the public of flood risk and water quality protection practices through website postings, educational flyers and signage, public open house events, newsletters and radio.

B. Mid- to Long-Term Actions

Conservation Overlay Zoning Districts. This section recommends the creation of a new Conservation Overlay District (COD) zone to apply to areas mapped the attached Figure A-4. The COD applies as an overlay, regardless of the underlying zoning, designed to protect the water quality of key water resources without hampering development by offering density trade-offs and incentives built into the policy.

The COD would apply to all new projects in the mapped areas. It would have four categories of Standards for review: Site Planning, Landscape Design, Erosion Control and “Green” Stormwater Management. The design criteria is set up with incentive levels to encourage applicants to go above and beyond the base requirements.

Benefit District Policy for Regional Detention and BMPs. Opportunities will continue to present themselves in Belton in the future for the placement of regional Best Management Practices (BMPs) and detention facilities for regional flood control and water quality protection. Regional facilities allow planned development to occur in upland areas and the treatment or detention to occur further downstream in the watershed, freeing up valuable land on development sites. To fund these regional BMPs, the watershed development that contributes to them would be asked to contribute towards the facility and in return would be able to forgo detention on the development site. To determine a fair “fee in lieu of on-site detention” for any development that might pay into a regional facility, a case study was completed to compare the cost of detention of several type of development. The following table provides a breakdown of typical per-acre on-site detention costs for new development sites:

On-Site Detention Costs per Site Acre

Development Size	*Site Percent Impervious*		
	<40%	40-70%	>70%
Less than 25 ac	$1,004	$1,287	$1,717
Greater than 25 ac	$501	$785	$1,215

C) ADDITIONAL MANAGEMENT TOOLS & CASE STUDIES

Additional information and alternative management methods were analyzed and recommendations made for potential application and use in the City of Belton, including:

1. Ultimate development conditions floodplain delineations
2. “Green” Neighborhood Improvement Project recommendations
3. Off-line detention concepts in flood zones
4. Floodplain fill impact analyses
5. Stream geomorphic review and recommendations
6. Functional GIS database mapping system for use by City staff in the future

UPDATING THE PLAN

The Belton Stormwater Master Plan will provide guidance for the City as it maintains and improves the stormwater system. As the City grows, accomplishes recommended actions, and new issues arise, the Plan should continue to be updated in order to best serve the City long term.

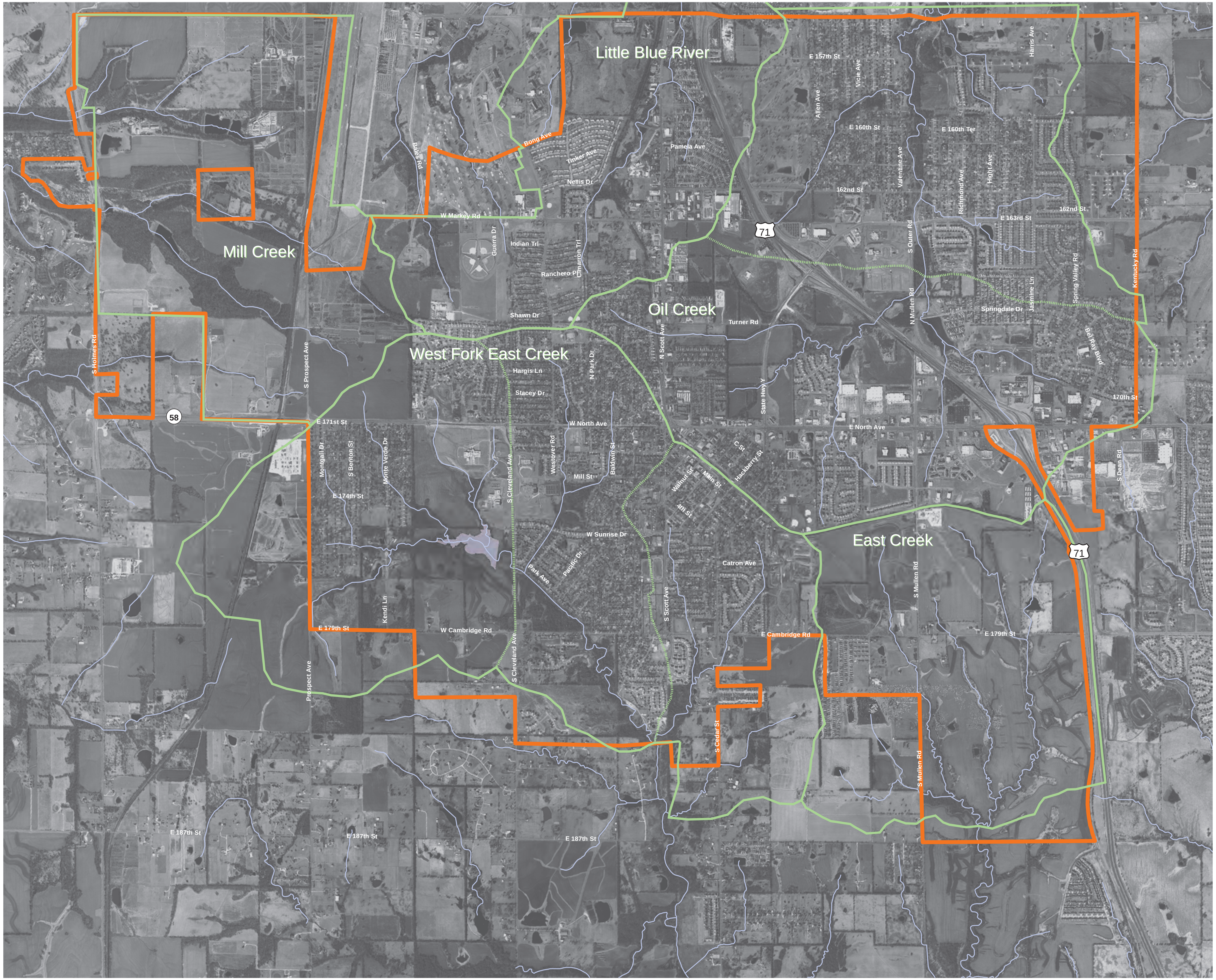

Figure A-1
City of Belton, Missouri
Watershed Map

Legend

- Watersheds
- Sub Watersheds
- Stream Centerline
- City Limits

1 inch = 2,500 feet

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09/04/2012

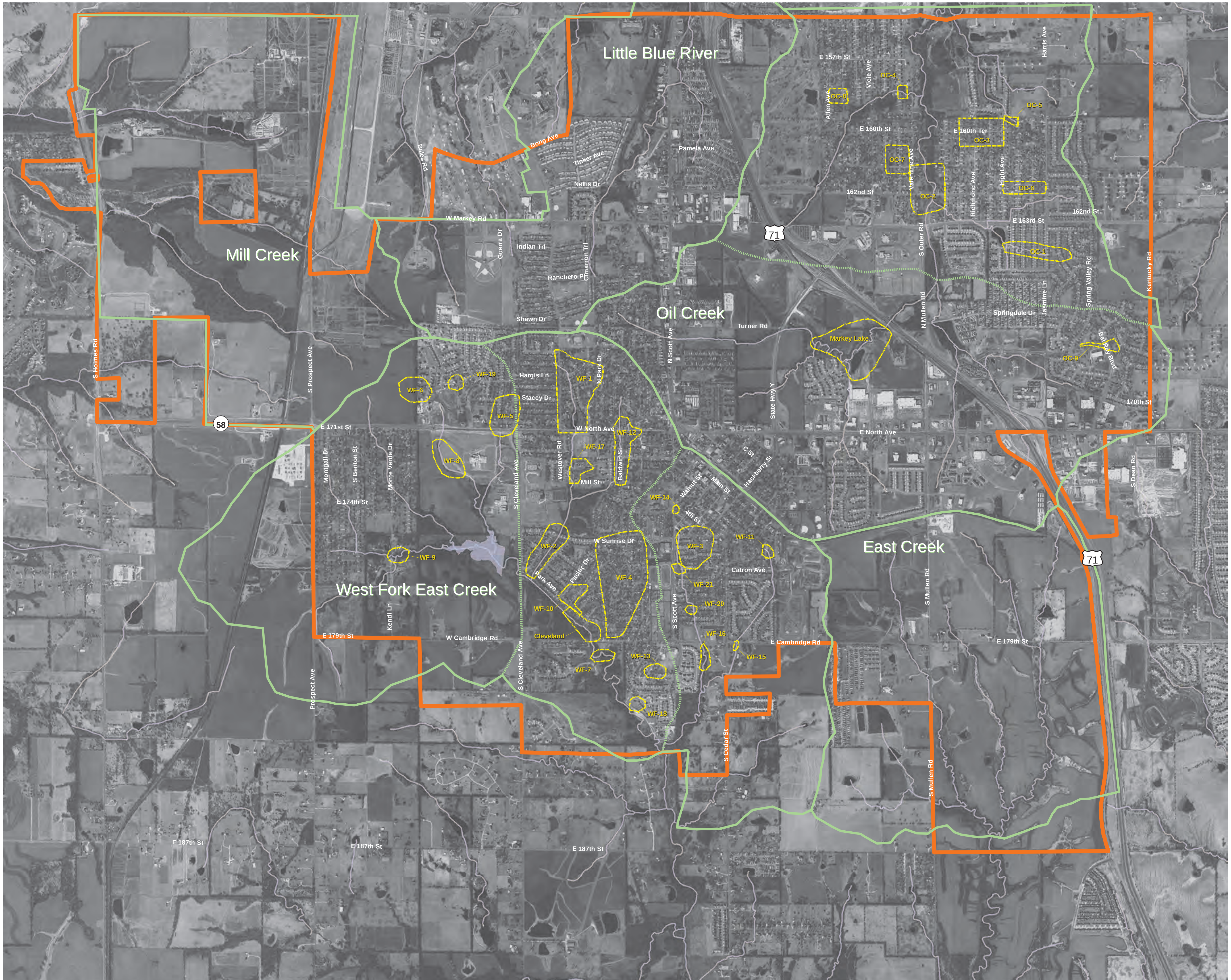

Figure A-2
City of Belton, Missouri
Project Area Locations

Legend

- Watersheds
- Sub Watersheds
- Stream Centerline
- Project Areas
- City Limits

1 inch = 2,500 feet

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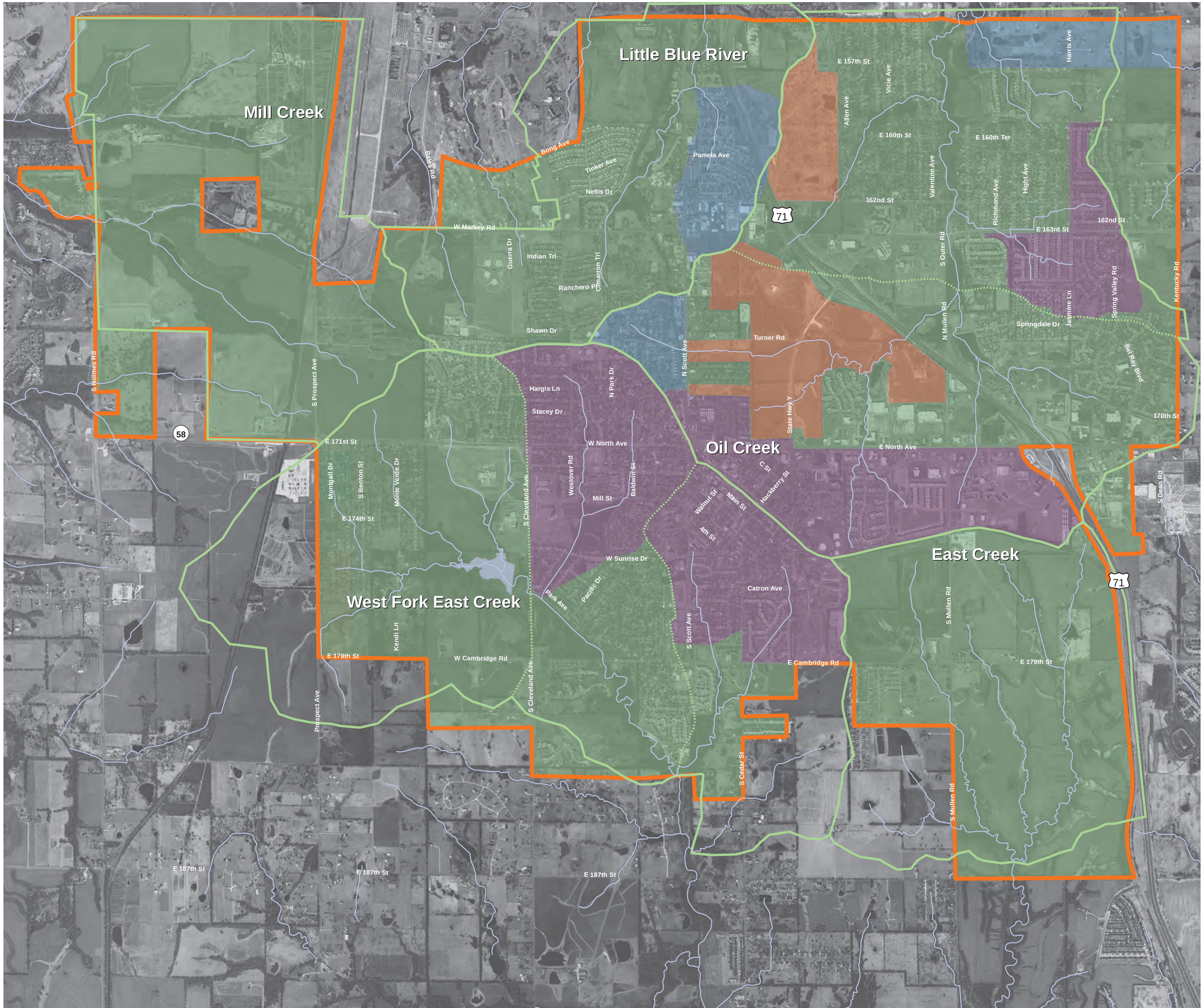
09/04/2012

Figure A-3
City of Belton, Missouri
Private Development Detention Strategies by Watershed



Legend

Det Zone Strategy

- Comprehensive
- Extreme
- Frequent
- Special

- Stream Centerline
- Watersheds
- Sub Watersheds
- City Limits

1 inch = 2,500 feet

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09/05/2012

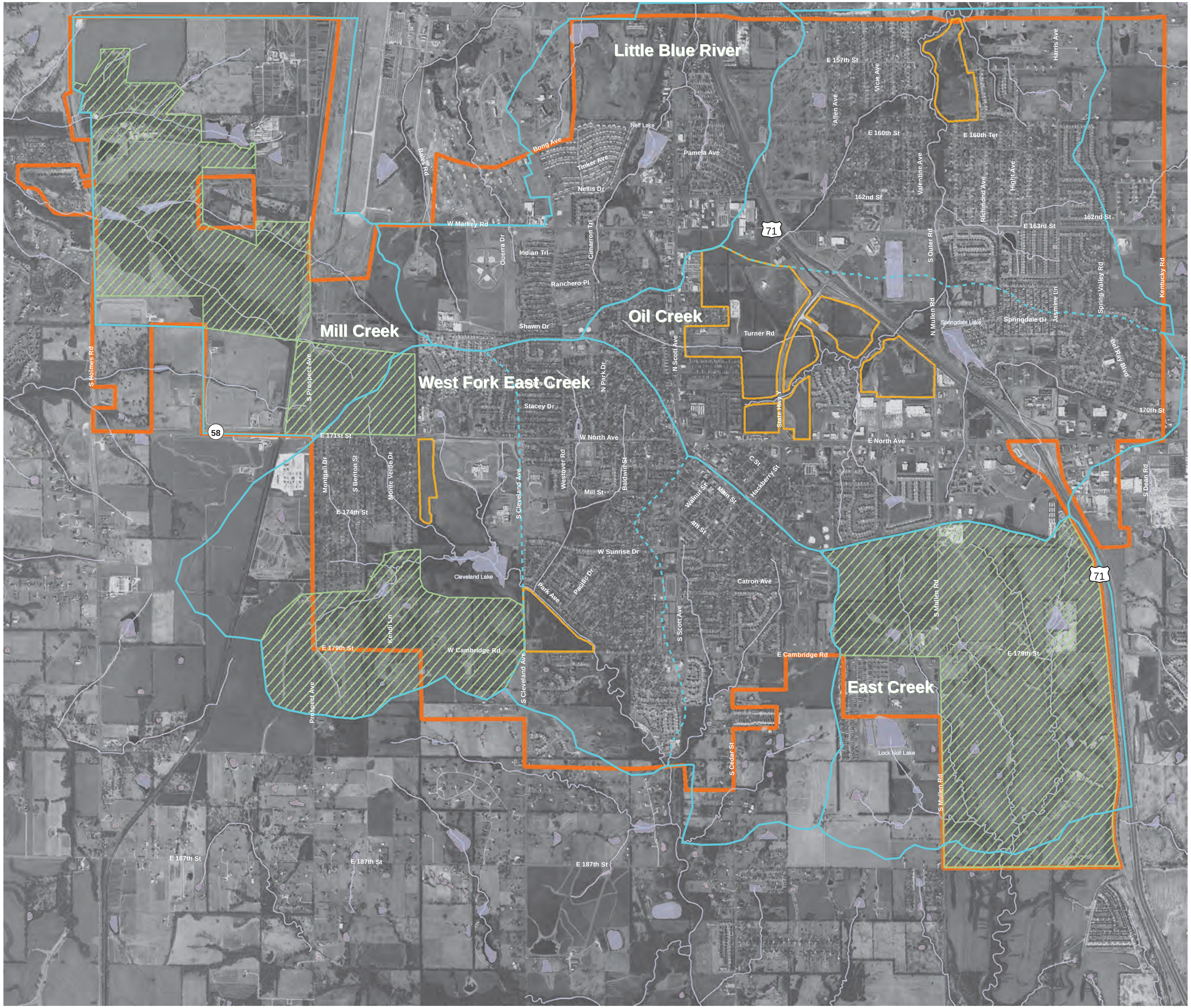

Figure A-4
City of Belton, Missouri
Conservation Overlay Zoning and Future Development

Legend

- Watersheds
- Sub Watersheds
- Stream Centerline
- Lakes
- City Limits

Projected Development Areas

- Future Development Areas
- Recommended Conservation Overlay Zoning

1 inch = 2,500 feet

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OLSSON ASSOCIATES

09/05/2012

B-1. OVERVIEW

This section outlines all the recommended stormwater management actions for the City of Belton. The action items are based upon the analyses described in Part C, which include city-wide resident stormwater questionnaire mailings, detailed drainage system and floodplain modeling, field investigations of stream conditions and flood problem areas, public input meetings, and comprehensive GIS mapping and analysis. The recommendations are targeted at addressing flooding, erosion and water quality issues in the City and are organized as follows:

- ❑ Capital Projects
- ❑ Maintenance Actions
- ❑ Funding Mechanisms
- ❑ Planning and Prevention Measures

B-2. CAPITAL PROJECTS

A total of 30 projects were identified throughout the City of Belton to address historical and/or future flooding, erosion and water quality problems. Each project area was initially identified through resident complaints, then verified and quantified through detailed modeling. Each project solution was derived through an alternative analysis where the final solution was arrived at using a cost-benefit analysis. The projects were then prioritized using a standard scoring system, modified to fit the City of Belton and it's specific issues.

B-2.1. Prioritization Methodology and Rationale

First, projects are organized into three Priority Groupings based on the following criteria:

<u>Priority 1 Group Projects</u> must meet at least 2 of the following 5 criteria:

1) Four (4) or more homes flood in the 1% chance event, or at least three (3) homes have experienced repetitive flooding losses as reported by residents (flood damage at least twice in the last 10 years).
2) Arterial or collector streets flood in the 1% or more frequent event by more than 6" in depth.
3) Improvements can be combined with other planned city projects (i.e. roadway, sewer, water, parks, etc), OR improvements provide benefit to other infrastructure (i.e. sewer I&I reduction, pavement protection/rehab, etc.)
4) Project has a high probability (75% chance or better) of receiving cost-share support (developer benefit district, outside funding, etc)
5) Provides regional, long-term flood reduction, erosion control and water quality benefits.

<u>Priority 2 Group Projects</u> must meet any 2 of the following 6 criteria; <u>Priority 3 Group Projects</u> must meet 1 of the following 6 criteria:

1) 1-3 homes flood in the 1% chance event or at least 1 home has experienced repetitive flooding losses reported by residents (at least twice in the last 10 years).
2) Any public street floods in the 1% chance or more frequent event by more than 6" in depth.
3) Same as item 3 above
4) Same as item 4 above
5) Same as item 5 above
6) Project provides recreational, local water quality, or neighborhood enhancement benefits.

After the projects are grouped, each project is scored using the "Project Rating Table" and a Priority Rating assigned in order to rank the projects within each of the three Priority Groups.

B-2.2. Prioritized Project Listing

Projects were grouped by priority as described in the previous section. The following table shows the projects in the prioritized grouping. Detailed project scoring sheets for each project are provided in Appendix D.

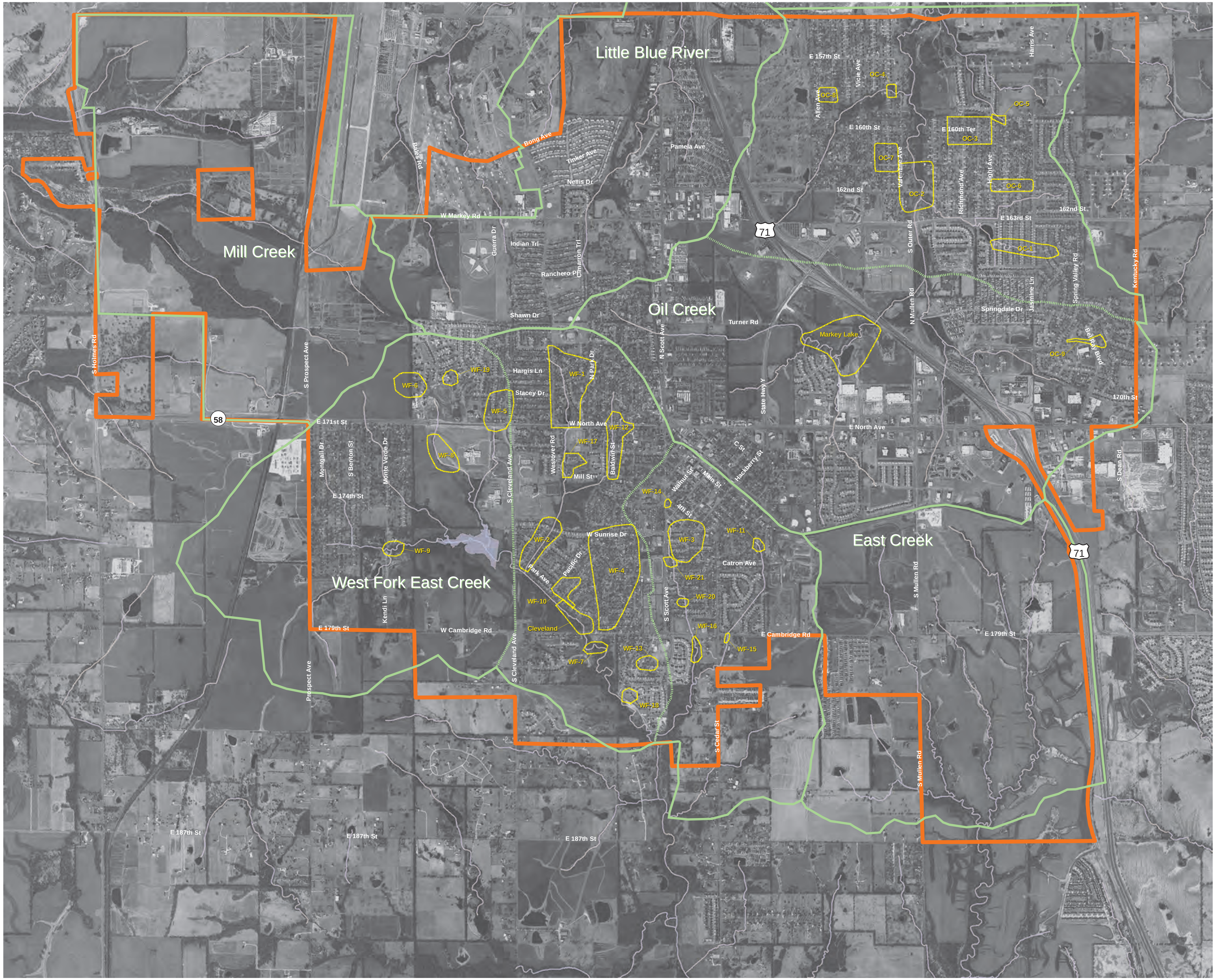
Table B-1

Capital Improvement Project List - Prioritization by Grouping and Scoring
Belton, MO

Project	Project Location	100-yr Flood Impacts Homes (Factors 1-3)	Street Flooding (Factors 4-7)	Erosion Threatens Infrastructure (Factors 8-12)	System Condition (Factors 13-14)	Water Quality Benefits (Factors 15-16)	(A) Benefit Score	(B) Project Costs	Cummulative Project Costs	(C) Added 25-Yr. Maint. Costs	(D) Project + Maint. Costs	Priority Score (1000xA/D)	Other Considerations: Synergy with other public infrastructure**	High probability of outside cost sharing/support	Regional, long-term benefits	High aesthetic value
PRIORITY 1 PROJECTS																
WF-3	Pacific Dr. and Sunrise Dr.	180	90				270.0	$275,964	$275,964	$11,850	$287,814	0.94				
WF-4	Westside Dr. and Lacy Ln.	900	90		10		1000.0	$2,857,840	$3,133,803	$85,425	$2,943,265	0.34	W			
OC-1	Hight Ave. and Bryan Way	300	112.5	60			472.5	$1,599,312	$4,733,115	$0	$1,599,312	0.30				
WF-1	Sunset Ln. and N Hillcrest Dr.	540	90	30			660.0	$2,302,790	$7,035,905	$18,825	$2,321,615	0.28	W			
WF-2	Sunrise Dr. and Buena Vista Dr.	120	45				165.0	$692,505	$7,728,410	$2,150	$694,655	0.24	W			
OC-2 - B	Valentine Ave. and 162nd St.	360	75				435.0	$2,071,083	$9,799,493	$0	$2,071,083	0.21	T			Y
Markey Lake	South of US 71 and Hwy. Y	24	7	2		20	53.0	$1,117,749	$10,917,242	$450,000	$1,567,749	0.03	P	Y	Y	Y
Total Construction Costs - Priority 1 Group								**$10,917,242**								
PRIORITY 2 PROJECTS																
OC-3	Richmond Ave. and E 160th St.	120	60				180.0	$73,128	$73,128	$1,125	$74,253	2.42				
WF-13	Walnut St. and Scott Ave.	60					60.0	$29,124	$102,252	$500	$29,624	2.03				
OC-7	Terry Ave. and 161st Ter.	180					180.0	$115,232	$217,484	$9,800	$125,032	1.44				
OC-2 - A	Valentine Ave. and 162nd St.	120					120.0	$182,594	$400,078	$0	$182,594	0.66				
OC-9	South of Bel-Ray Blvd. and Middleto	60	150				210.0	$373,223	$773,300	$3,575	$376,798	0.56				
WF-10	South of Margaret Ln. and South Av	40	90				130.0	$255,388	$1,028,688	$5,475	$260,863	0.50	R			
WF-6	Cherry Hill Rd. and Orchard Dr.	60				40	100.0	$154,033	$1,182,721	$52,550	$206,583	0.48	R			
WF-11	Baldwon St. and Lynn St.	180	90				270.0	$726,329	$1,909,050	$6,225	$732,554	0.37				
OC-5	North of Slater Ave. and E 160th Ter	40					40.0	$146,320	$2,055,370	$9,500	$155,820	0.26				
WF-5	N Cleveland Ave. and Tervis Ave.		90	30			120.0	$852,529	$2,907,899	$38,275	$890,804	0.13	W			
Total Construction Costs - Priority 2 Group								**$2,907,899**								
PRIORITY 3 PROJECTS																
WF-19	East of Brian Ave. and S Scott Ave.		72	30			102.0	$28,650	$28,650	$0	$28,650	3.56	W			
OC-6	162nd St. and Slater Ave.	120					120.0	$45,056	$73,706	$2,175	$47,231	2.54				
OC-8	Kay Ave. and 158th Ter.	60					60.0	$28,240	$101,946	$0	$28,240	2.12				
WF-18	Black Cherry Ct.	60					60.0	$29,600	$131,546	$0	$29,600	2.03				
WF-16	Plaza Acres Ct.	40					40.0	$38,524	$170,070	$2,200	$40,724	0.98				
WF-7	South of Pawnee Ln. and W Cambridge Rd.			90			90.0	$135,000	$305,070	$0	$135,000	0.67				
WF-12	Kent Dr. and Brentwood Dr.	120					120.0	$266,120	$571,190	$8,750	$274,870	0.44	W			
WF-14	East of S Cedar St. and E Cambridge Rd.			30			30.0	$88,000	$659,190	$0	$88,000	0.34				
WF-15	West of S Cedar St. and W Cambridge Rd.			60			60.0	$201,100	$860,290	$0	$201,100	0.30				
WF-9	North end of Kendi Ln.			30	25		55.0	$217,500	$1,077,790	$0	$217,500	0.25	P			
OC-4	Terry Ave. and Valentine St.	60					60.0	$242,543	$1,320,333	$0	$242,543	0.25	T			
WF-20	Hollywood Blvd. and S Scott Ave.		90				90.0	$458,250	$1,778,583	$500	$430,250	0.21	W			
WF-8	South of Cherry Hill Dr. and E 171st St.			55	40		95.0	$492,000	$2,270,583	$0	$492,000	0.19	P			
WF-17	181st Ter. and Mary Way	40					40.0	$376,394	$2,646,977	$0	$376,394	0.11				
Total Construction Costs - Priority 3 Group								**$2,646,977**								

** Project to move forward only if majority of project is funded through private-public benefit district*
*** S-Sanitary, W-Water, R-Roadway, T-Trails, P-Preventative*

Figure B1: Recommended Project Locations



Legend

Watersheds

Sub Watersheds

Stream Centerline

Project Areas

City Limits

1 inch = 2,500 feet

N

OLSSON ASSOCIATES

10/09/2012

B-2.3. Project Descriptions, Maps and Estimates

B-2.3.1 West Fork East Creek Watershed

Improvement Project WF-1 (Hargis Lake)

Problem Description

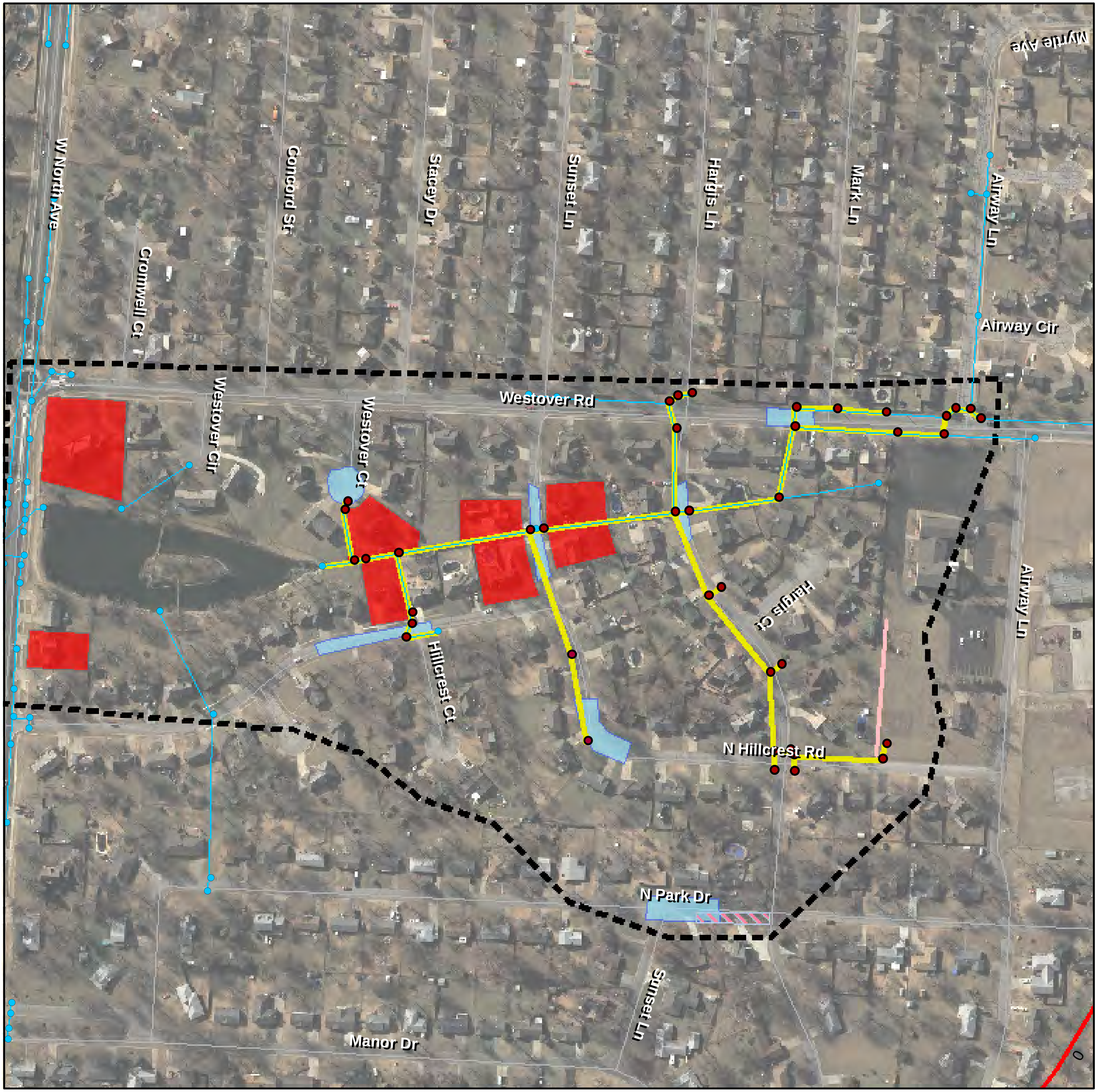
The problem consists of 14 residential complaints regarding stormwater flooding, sanitary sewer backup, street flooding, and erosion. The storm sewer main line is corrugated metal pipe that ranges from 3 to 4 feet in diameter that is in poor condition and significantly undersized throughout most of the system. Furthermore, a significant amount of bypass flow from the upper portion of the watershed accumulates in the sump regions where there are too few inlets to capture it. When the system capacity is reached, ponding occurs at the inlets on Hargis Lane, Sunset Lane, Westover Court, and North Hillcrest Road which floods nearby houses and eventually overflows and continues downstream. The street is in poor condition along Sunset Lane and North Hillcrest Road because of the excess and fast moving stormwater. Overflow swales in the region are insufficient to protect houses from significant storm events. During the 10 year storm, 70% of the peak flow bypasses the inlets on Sunset Lane and travels above ground toward Hargis Lake. The excessive amount of stormwater in the area is also partially responsible for surcharging the sanitary sewer system and causing backup in houses.

Conceptual Improvement

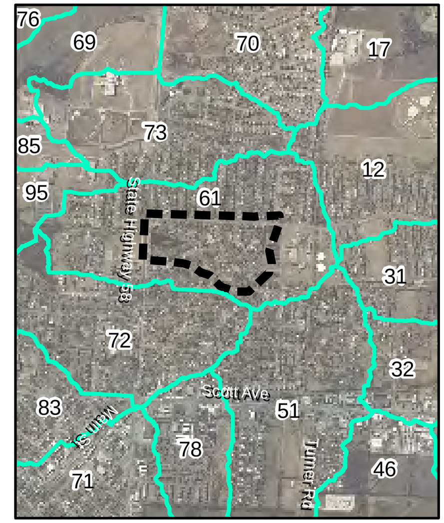
Because of the repeated problems in this area, a detailed analysis of the region was performed to determine the necessary system improvements for the system to reach a 100 year capacity. The proposed improvements extend the storm sewer on Hargis Lane east to the intersection with North Hillcrest Road. Intercepting flow at this intersection will help eliminate the ponding that occurs at the low spots on both Hargis Lane and Sunset Lane. The existing main line 4 foot CMP will be replaced with 450 feet of 10' x 5' concrete box culvert and 340 feet of 8' x 4' concrete box culvert. Ten storm inlets will be added in new locations and 18 of the existing storm inlets will be replaced with new, more efficient inlets. Detention on upstream property was evaluated as an option to reduce peak flows, but it was determined to be ineffective in this area.   Although it was not included in this estimate, it is recommended that Sunset Lane and North Hillcrest Road be resurfaced since the pavement is in poor condition and the stormwater problems will be resolved with this project.

The conceptual improvements for the Hargis Lake area meet the criteria for the 10 year design storm, while the main line downstream of Hargis Lane meets the criteria for the 100 year design storm.

Improvement Project WF-1



Project Drainage Basin Map



Legend

- Existing Storm Structure
- Existing Storm Pipe
- Proposed Structure
- Proposed Berm
- Project Boundary
- Proposed Sewer Upgrade
- Street Rehabilitation
- Street Flooding

Complaints

- Localized Improvements
- Major System Improvements
- Belton Roads

1 inch = 300 feet

WF-1 (Hargis Lake) - Belton, MO					
Item No.	**Item Description**	**Quantity**	**Qty. Units**	**Unit Cost**	**Total Cost**
1	Pavement Removal	2100	SY	$15	$31,500
2	Erosion Control	1	LS	$20,000	$20,000
3	Traffic Control	1	LS	$20,000	$20,000
4	Overflow Swale Earthwork	1010	SY	$30	$30,300
4	Storm Inlets	29	EA	$4,000	$116,000
5	Std. Manhole w/lid	12	EA	$3,500	$42,000
6	Storm Sewer (15" RCP)	200	LF	$70	$14,000
7	Storm Sewer (18" RCP)	160	LF	$75	$12,000
8	Storm Sewer (24" RCP)	400	LF	$80	$32,000
9	Storm Sewer (30" RCP)	220	LF	$120	$26,400
10	Storm Sewer (36" RCP)	950	LF	$135	$128,250
11	Storm Sewer (42" RCP)	560	LF	$150	$84,000
12	Storm Sewer (48" RCP)	667	LF	$180	$120,060
13	Precast Concrete Box Culvert (8x4)	345	LF	$520	$179,400
14	Precast Concrete Box Culvert (10x5)	450	LF	$700	$315,000
15	Junction Box for 8x4 RCB	4	EA	$10,000	$40,000
16	Concrete Apron and Wingwalls for 8x4 RCB	1	LF	$12,000	$12,000
17	Curb and Gutter	1200	LF	$25	$30,000
18	Driveway Apron, Residential	290	SY	$65	$18,850
19	Concrete Sidewalk Construction	1700	SF	$9	$15,300
20	Stone Riprap (D50 24")	1000	SY	$45	$45,000
21	Asphaltic Concrete, Base (Street)	2100	SY	$45	$94,500
22	Asphaltic Concrete, Surface (Street - Residential)	2100	SY	$45	$94,500
23	Fencing (Chain Link)	625	LF	$35	$21,875
24	Sodding	3100	SY	$5	$15,500
				Construction Sub-Total	$1,558,435
				Construction Contingency	$389,609
				Engineering	$200,000
				Land Rights and Administration (10%)	$155,844
				Utility Contingency (10%)	$155,844
				Probable Project Costs	$2,459,731

Improvement Project WF-2 (Buena Vista Drive)

Problem Description

The problem in this area consists of potential building flooding in at least 7 residences as well as flash flooding of streets. The culvert on West Sunrise Drive overflows and spills into the street during the 1 year event. Because of the grade in this area, the water that overflows the culvert flows toward the east and then south on Buena Vista Drive. The street and storm sewers in this area were not designed for this amount of flow and, therefore, houses on Buena Vista also experience flooding from the street. Additionally, the storm inlets on West Sunrise Street have insufficient capacity due to high tailwater caused by the culvert. These inlets discharge into the culvert on West Sunrise that is undersized. The culvert at the downstream end of the neighborhood on Park Avenue is also undersized. This culvert overflows in the 2 year storm event and, in the process, backs up water into the yards on the upstream side of the culvert. In the 100 year event, these houses will also flood.

The storm sewer system near Buena Vista Court is inadequate for the 10 year storm and the excess flow from the culvert on West Sunrise exacerbates this problem. Two residences at 508 and 510 West Sunrise experience flooding in their backyards as a result of inadequate drainage from the field to the north.

The open channel located between the houses on Buena Vista Drive and the houses on Valle Drive is vertically and laterally constrained by bedrock and, therefore, provides a low risk to infrastructure.

Conceptual Improvement

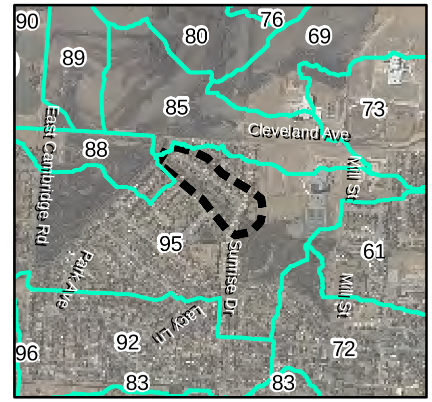
The existing twin 5’ x 1.5’ box culverts at West Sunrise Drive should be replaced with twin 6’ x 5.5’ box culverts in the base of the channel and one 4’ x 3.5’ box culverts elevated and outside of the larger boxes. This design will allow the 2 year storm to pass through the culvert. Without major changes to the elevation of the road, it will be difficult to convey the 10 year event in this location.

The existing twin 6’ x 4’ box culverts at Park Avenue should be replaced with twin 7’ x 6’ box culverts. This design will allow for the 2 year storm to pass through the culvert and will reduce backwater and overflow in the less frequent storms. Once again, cover and width constraints limit the ability to upgrade the culvert to 10 year capacity.

The existing storm sewer system at Buena Vista Court has a 5 year capacity, but because of the excess water overflowing West Sunrise St, additional capacity is needed. This area should be upgraded to prevent the adjacent houses from flooding. Also, additional inlets should be added on West Sunrise Drive to catch water before it is able to overtop the crown of the street and flow down Buena Vista Drive. The outlet of the storm sewer system at West Sunrise Drive should be redirected to discharge at the downstream end of the culvert at West Sunrise Drive. Finally, the drainage ditch north of 510 West Sunrise should be increased in size to a trapezoidal channel with 9 feet flat bottom with 4:1 side slopes that is about 2 feet deep. Although it was not included in this estimate, it is recommended that Buena Vista Drive and North Park Avenue be resurfaced since the pavement is in poor condition and the stormwater problems will be resolved with this project.

Improvement Project WF-2

Project Drainage Basin Map



Legend

- Existing Storm Structure
- Existing Storm Pipe
- Proposed Structure
- Proposed Berm
- Project Boundary
- Proposed Sewer Upgrade
- Street Rehabilitation
- Streed Flooding

Complaints

- Localized Improvements
- Major System Improvements

Stream Assessment

- High
- Med
- Low
- Belton Roads

1 inch = 200 feet

WF-2 (Buena Vista) - Belton, MO					
Item No.	***Item Description***	***Quantity***	***Qty. Units***	***Unit Cost***	***Total Cost***
1	Removal of Existing Structures	1	LS	$50,000	$50,000
2	Erosion Control	1	LS	$2,000	$2,000
3	Traffic Control	1	LS	$2,000	$2,000
4	Storm Inlets (4' x 6')	4	EA	$4,000	$16,000
6	Storm Sewer (24" RCP)	300	LF	$80	$16,000
6	Storm Sewer (30" RCP)	130	LF	$120	$15,600
7	End Section (30" RCP)	1	EA	$1,250	$1,250
8	Sodding	100	SY	$5	$500
9	Asphaltic Concrete (Street - Residential)	2250	SY	$90	$202,500
10	Fencing, Chain Link	70	LF	$35	$2,450
11	Curb and Gutter	200	LF	$25	$5,000
12	Concrete Sidewalk Construction	100	SF	$9	$900
13	Precast Concrete Box Culvert (7x6)	72	LF	$600	$43,200
14	Precast Concrete Box Culvert (6x5.5)	100	LF	$520	$52,000
15	Precast Concrete Box Culvert (4x3.5)	100	LF	$400	$40,000
				Construction Sub-Total	$456,900
				Construction Contingency	$114,225
				Engineering	$30,000
				Land Rights and Administration (10%)	$45,690
				Utility Contingency (10%)	$45,690
				Probable Project Costs	$692,505

Improvement Project WF-3 (E Pacific Drive)

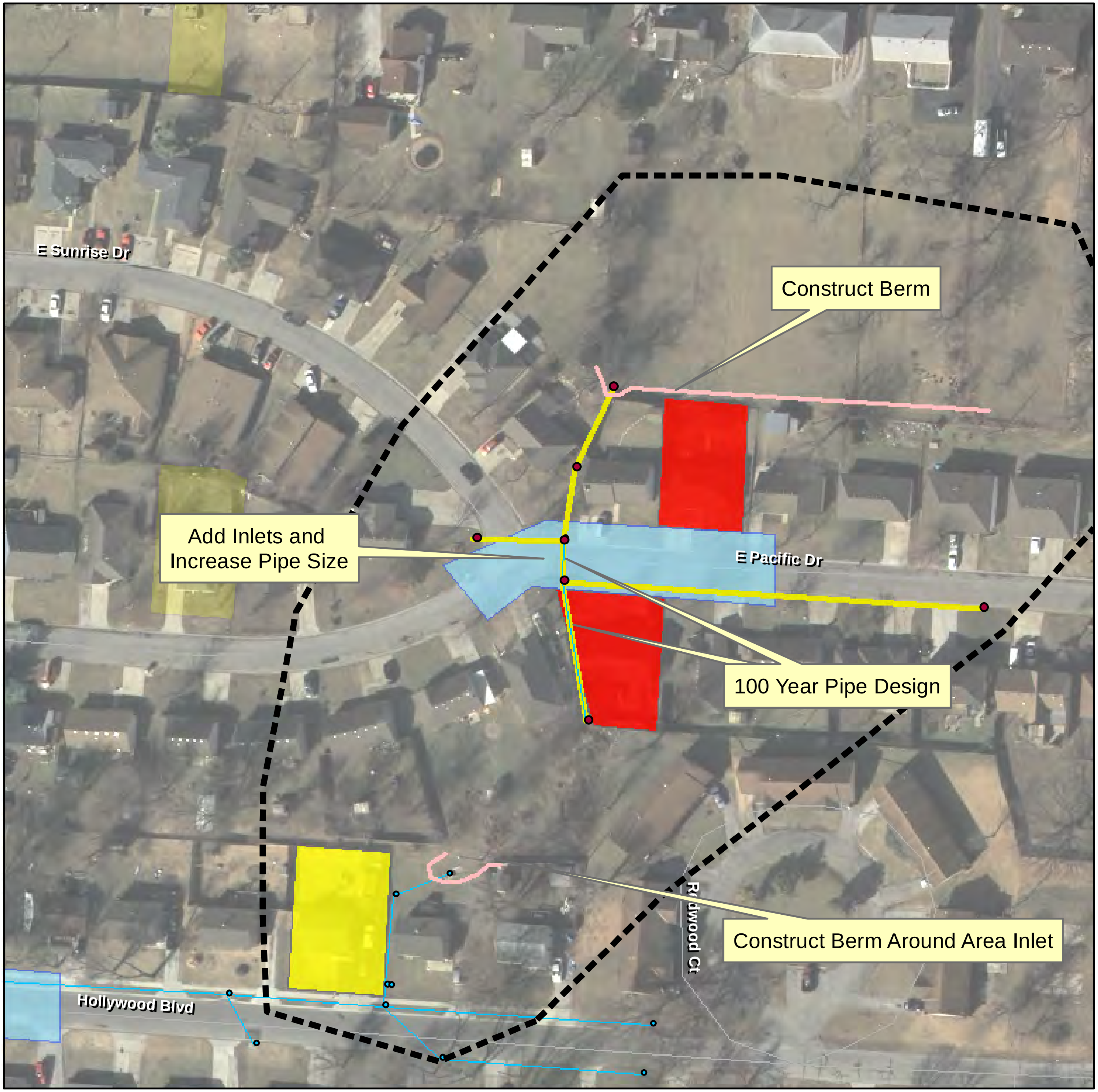
Problem Description

The problem consists of residential and street flooding caused by excessive amounts of water draining from the area north of 206 East Pacific Drive. The storm inlets and pipes on East Pacific Drive are undersized and unable to prevent the street from flooding. The residence at 112 East Hollywood Boulevard experiences flooding from flows that bypass the backyard inlet.

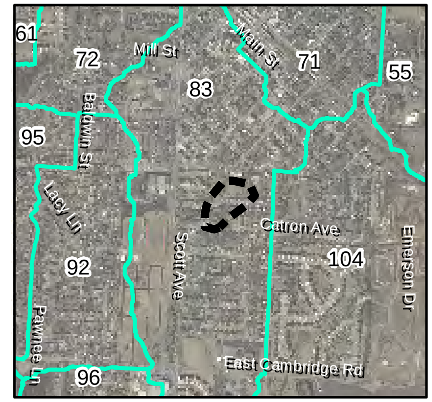
Conceptual Improvement

A berm should be constructed behind the houses on the north side of East Pacific Drive that will catch flows headed toward these houses and direct them to an area inlet behind 206 East Pacific Drive. The storm sewer system will still need to be upgraded to convey the flows from the low spot on East Pacific Drive. Inlets will be added to the east and west of the current inlets on East Pacific Drive to catch drainage before it ponds in the low spot, and the inlets at the sump will be replaced with more efficient inlets. The storm sewer pipes will be upgraded to 10 year capacity with the exception of the pipes which carry water south from the low spot on East Pacific Drive. There is not an adequate overflow route for storms in excess of the 10 year event. It is recommended that a 100 year pipe design be completed for the route downstream. Additional earthwork around the area inlet on private property at 112 East Hollywood Boulevard will be necessary to prevent future flooding.

Improvement Project WF-3



Project Drainage Basin Map



Legend

- Existing Storm Structure
- Existing Storm Pipe
- Proposed Structure
- Proposed Berm
- Project Boundary
- Proposed Sewer Upgrade
- Street Rehabilitation
- Streed Flooding

Complaints

- Localized Improvements
- Major System Improvements

Stream Assessment

- High
- Med
- Low
- Belton Roads

1 inch = 150 feet

N W E S

WF-3 (E. Pacific Dr.) - Belton, MO					
Item No.	**Item Description**	**Quantity**	**Qty. Units**	**Unit Cost**	**Total Cost**
1	Removal of Existing Structures	1	LS	$30,000	$30,000
2	Erosion Control	1	LS	$15,000	$15,000
3	Traffic Control	1	LS	$15,000	$15,000
4	Storm Inlets (4' x 6')	4	EA	$4,500	$18,000
5	Storm Sewer Junction Box	1	EA	$3,500	$3,500
6	Storm Sewer (15" RCP)	175	LF	$70	$12,250
7	Storm Sewer (18" RCP)	30	LF	$75	$2,250
8	Storm Sewer (24" RCP)	299	LF	$80	$23,920
9	Storm Sewer (36" RCP)	130	LF	$135	$17,550
10	End Section (30" RCP)	1	EA	$1,250	$1,250
11	Driveway Apron, Residential	60	SY	$65	$3,900
12	Sodding	300	SY	$5	$1,500
13	Earthwork	70	CY	$18	$1,260
14	Asphaltic Concrete, Surface (Street - Residential)	225	SY	$90	$20,250
15	Fencing, Decorative	80	LF	$50	$4,000
				Construction Sub-Total	$169,630
				Construction Contingency	$42,408
				Engineering	$30,000
				Land Rights and Administration (10%)	$16,963
				Utility Contingency (10%)	$16,963
				Probable Project Costs	$275,964

Improvement Project WF-4 (Lacy Estates)

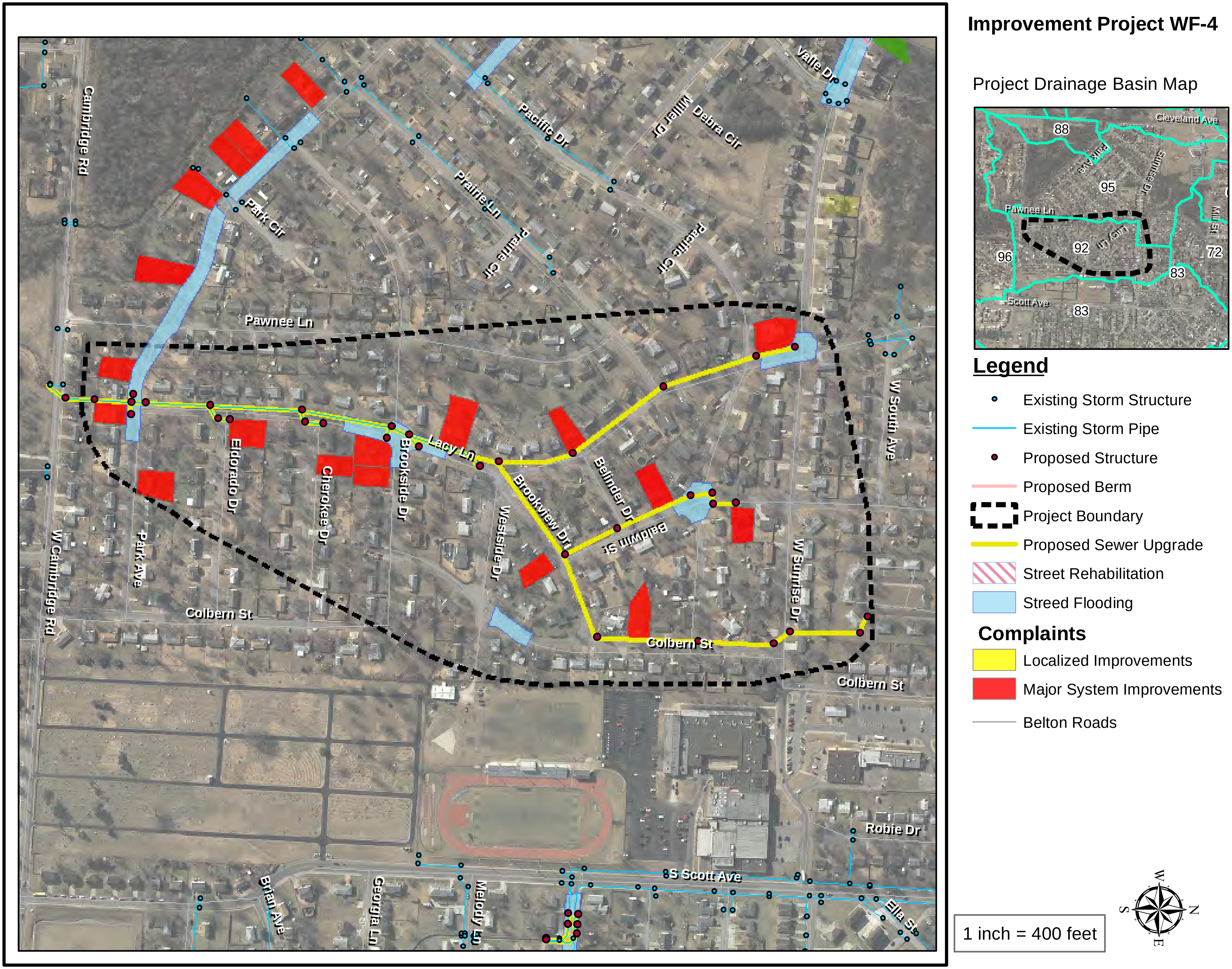
Problem Description

The problem consists of numerous flooding complaints throughout the Lacy Estates subdivision. The upper end of the subdivision is currently without an underground storm sewer system and, consequently, suffers from street flooding, residence flooding, and crumbling pavement. The poor condition of the pavement appears to be caused by a loss of subgrade strength due to saturation. The existing storm sewer in Lacy Estates is undersized and incapable of removing fast flowing water from the street, and therefore, flooding problems are also an issue in the southern part of the neighborhood.

Conceptual Improvement

A detailed analysis of the system was performed in order to resize the system to convey the 10 year event. The system was extended to the north along Lacy Lane, Baldwin Street and Colbern Street to address flooding and erosion concerns in these areas. The proposed system is significantly larger than the existing system and also has several additional inlets. At the downstream end of the system, the pipe size will increase from a 42" RCP to a 72" RCP in order to meet design criteria for the 10 year storm. Since significant pavement will have to be replaced to install the storm sewer pipes, it may be beneficial to consider resurfacing all pavement north of Brookside Drive as it is in poor condition.

Improvement Project WF-4



Project Drainage Basin Map

Legend

- Existing Storm Structure
- Existing Storm Pipe
- Proposed Structure
- Proposed Berm
- Project Boundary
- Proposed Sewer Upgrade
- Street Rehabilitation
- Streed Flooding

Complaints

- Localized Improvements
- Major System Improvements
- Belton Roads

1 inch = 400 feet

WF-4 (Lacy Estates) - Belton, MO					
Item No.	***Item Description***	***Quantity***	***Qty. Units***	***Unit Cost***	***Total Cost***
1	Removal of Existing Structures	1	LS	$75,000	$75,000
2	Erosion Control	1	LS	$30,000	$30,000
3	Traffic Control	1	LS	$50,000	$50,000
4	Storm Inlets (4' x 6')	30	EA	$4,000	$120,000
5	Storm Sewer Junction Box	2	EA	$3,500	$7,000
5	Storm Sewer (15" RCP)	36	LF	$70	$2,520
6	Storm Sewer (18" RCP)	600	LF	$75	$45,000
7	Storm Sewer (24" RCP)	1750	LF	$80	$140,000
8	Storm Sewer (36" RCP)	900	LF	$135	$121,500
9	Storm Sewer (42" RCP)	385	LF	$150	$57,750
10	Storm Sewer (48" RCP)	100	LF	$180	$18,000
11	Storm Sewer (54" RCP)	600	LF	$230	$138,000
12	Storm Sewer (60" RCP)	310	LF	$250	$77,500
13	Storm Sewer (66" RCP)	265	LF	$260	$68,900
14	Storm Sewer (72" RCP)	300	LF	$265	$79,500
15	Driveway Apron, Residential	450	SY	$65	$29,250
16	Curb and Gutter	4500	LF	$25	$112,500
16	Sodding	1920	SY	$5	$9,600
17	Asphaltic Concrete (Street - Residential)	5500	SY	$90	$495,000
18	Fencing, Chain Link	100	LF	$35	$3,500
19	Curb and Gutter	4500	LF	$25	$112,500
20	Earthwork	305	CY	$18	$5,490
				Construction Sub-Total	$1,798,510
				Construction Contingency	$449,628
				Engineering	$250,000
				Land Rights and Administration (10%)	$179,851
				Utility Contingency (10%)	$179,851
				Probable Project Costs	$2,857,840

Improvement Project WF-5 (Valley High)

Problem Description

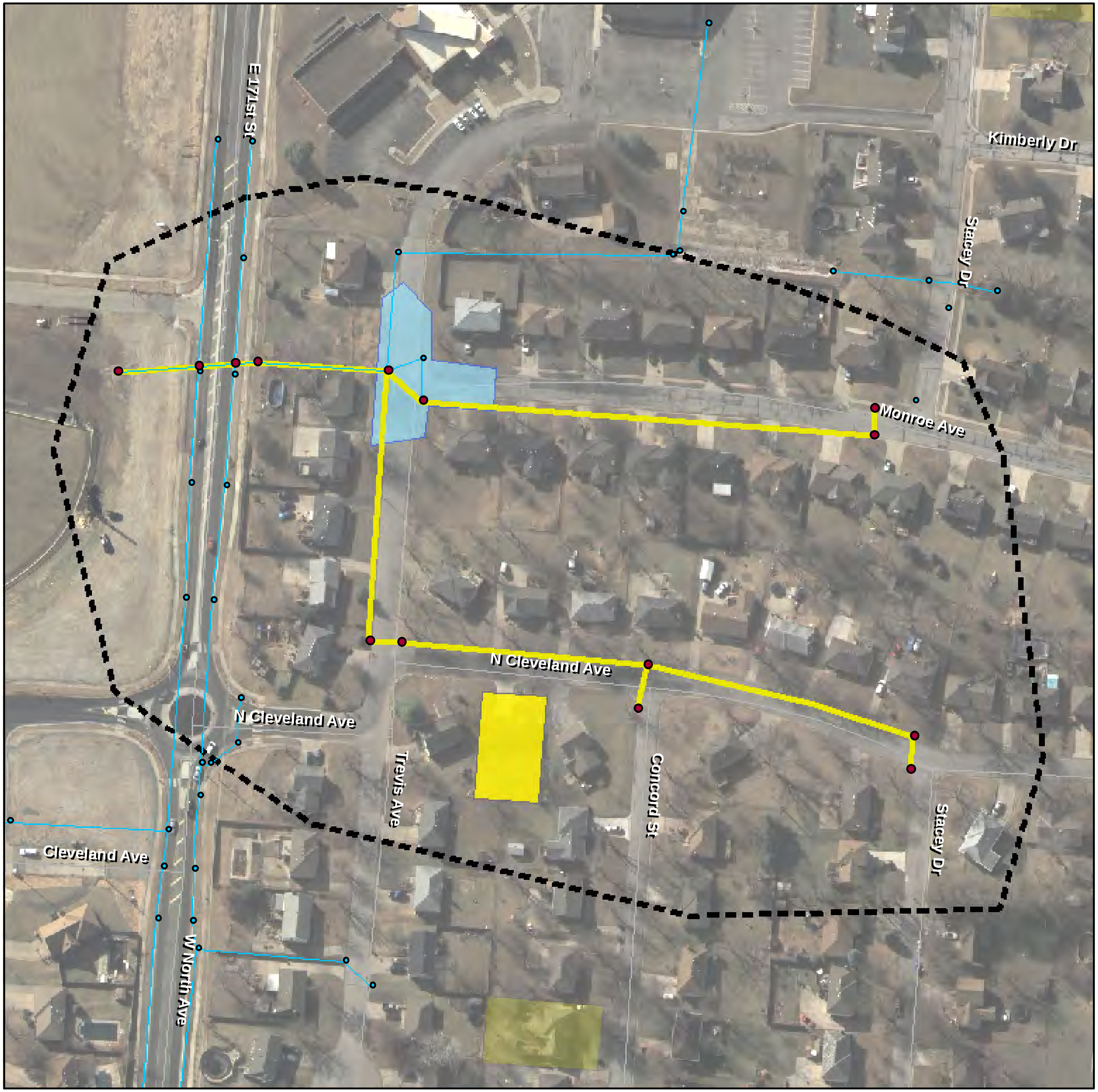
The problem consists of street flooding on Trevis Avenue at the intersections with Monroe Avenue and North Cleveland Avenue. Currently, there is no storm sewer upstream on Monroe Avenue or North Cleveland Avenue. Water flows downhill in a curb and gutter at high velocities causing pavement erosion until it reaches Trevis Avenue. The system downstream of Trevis Avenue is undersized, which causes the water to remain in the low spot for extended periods of time.

Conceptual Improvement

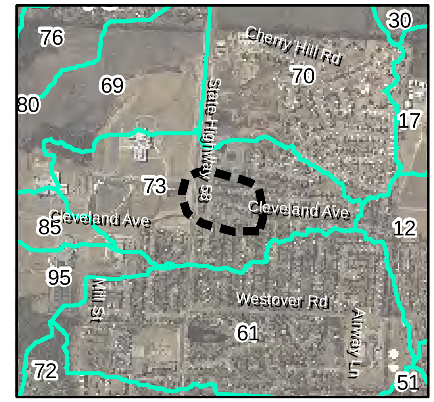
A detailed analysis was performed to design a storm sewer system for this region that would not only have the capacity to drain the 10 year storm in the low spot, but also capture runoff upstream and prevent damage to pavement. The proposed improvements add inlets and extend the system 2 blocks north on Monroe Avenue and North Cleveland Avenue. The pipes downstream of Trevis Avenue will be upgraded from 42” RCP to 54” RCP. Lastly, significant pavement will have to be replaced to install the storm sewer pipes so it may be beneficial to consider resurfacing all of the pavement on North Cleveland Ave, Monroe Ave, and Trevis Avenue that is in poor shape because of erosion or cracking due to saturated subgrade.

A detailed analysis was not completed on the downstream system due to the fact that the system is located on private property.

Improvement Project WF-5



Project Drainage Basin Map



Legend

- Existing Storm Structure
- Existing Storm Pipe
- Proposed Structure
- Proposed Berm
- Project Boundary
- Proposed Sewer Upgrade
- Street Rehabilitation
- Streed Flooding

Complaints

- Localized Improvements
- Major System Improvements
- Belton Roads

1 inch = 150 feet

WF-5 (Valley High.) - Belton, MO					
Item No.	***Item Description***	***Quantity***	***Qty. Units***	***Unit Cost***	***Total Cost***
1	Removal of Existing Structures	1	LS	$75,000	$75,000
2	Erosion Control	1	LS	$30,000	$30,000
3	Traffic Control	1	LS	$50,000	$50,000
4	Storm Inlets (4' x 6')	10	EA	$4,000	$40,000
5	Storm Sewer Junction Box	4	EA	$3,500	$14,000
6	Storm Sewer (15" RCP)	575	LF	$70	$40,250
7	Storm Sewer (24" RCP)	430	LF	$80	$34,400
8	Storm Sewer (30" RCP)	290	LF	$120	$34,800
9	Storm Sewer (54" RCP)	165	LF	$230	$37,950
10	Driveway Apron, Residential	227	SY	$65	$14,755
11	Sodding	737	SY	$5	$3,685
12	Asphaltic Concrete (Street - Residential)	1500	SY	$90	$135,000
13	Curb and Gutter	1400	LF	$25	$35,000
14	Fencing, Chain Link	105	LF	$35	$3,675
15	Fencing, Decorative	25	LF	$50	$1,250
16	Concrete Sidewalk Construction	3400	SF	$9	$30,600
				Construction Sub-Total	$580,365
				Construction Contingency	$145,091
				Engineering	$11,000
				Land Rights and Administration (10%)	$58,037
				Utility Contingency (10%)	$58,037
				Probable Project Costs	$852,529

Improvement Project WF-6 (Orchard Drive)

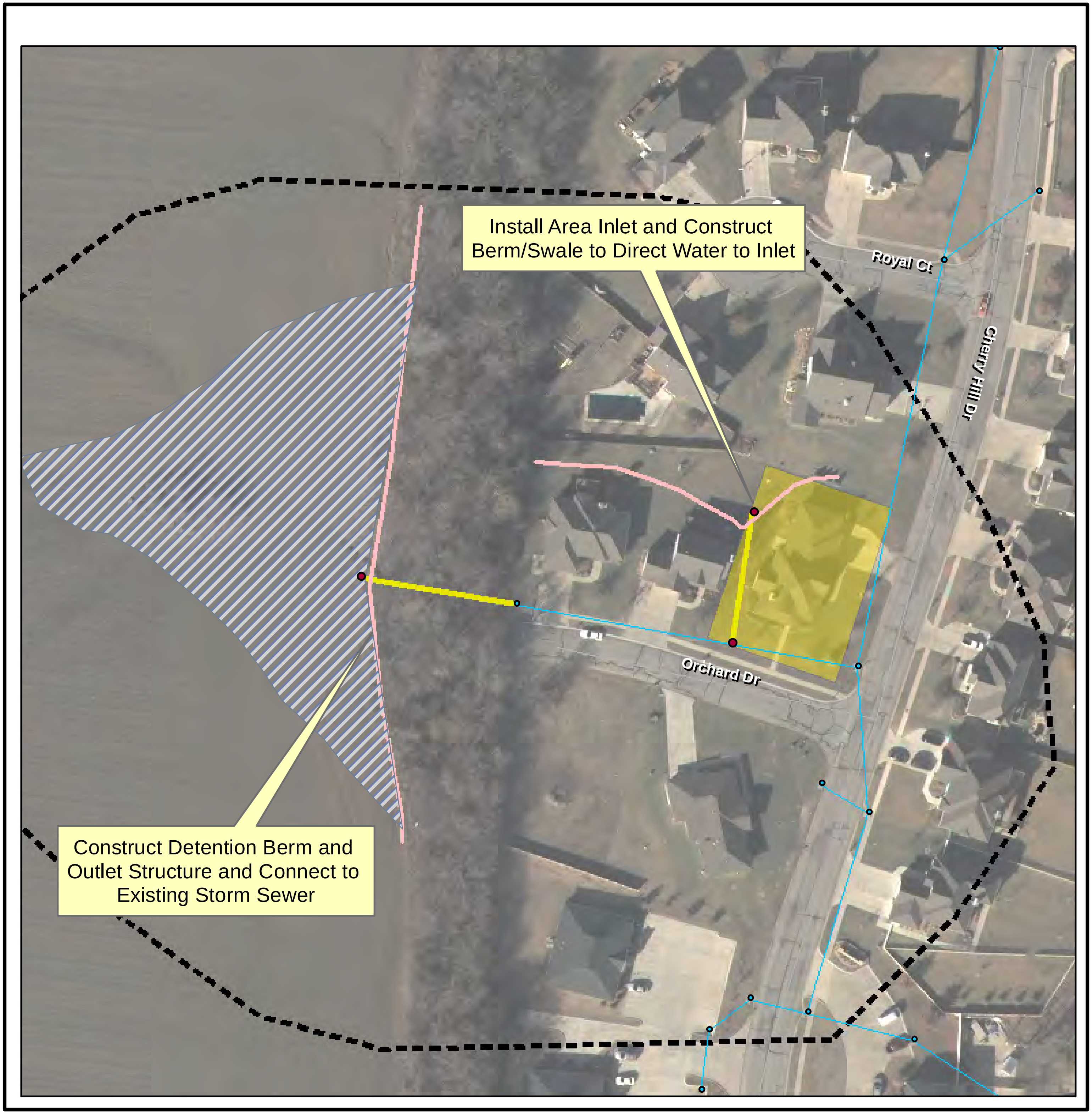
Problem Description

The problem consists of excess flows coming from the field to the west of Cherry Hill Drive that are directed into the backyards of the houses on Orchard Drive. The house at 1004 Orchard Drive experiences flooding as this water runs into the back of the house and continues to pond in the backyard.

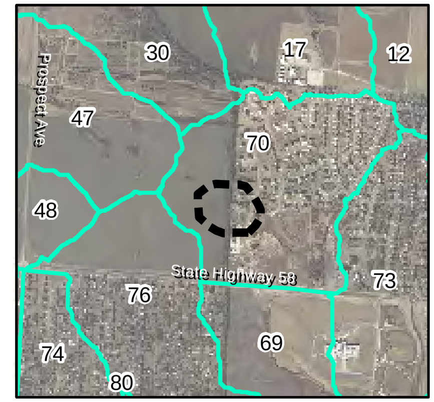
Conceptual Improvement

A detailed analysis of this area showed that constructing a berm in the field to the west of the flooding complaints will help to catch errant water that flows into the backyards of the houses on Orchard Drive rather than to the inlet at the west end of Orchard Drive as was intended. Construction of a berm to the west may also provide storm water detention and, therefore, reduce the peak flow rate that must be conveyed in the storm sewer at Orchard Drive. The outlet structure for the berm will be connected to the 30” CMP pipe at the west end of Orchard Drive with an 18” reinforced concrete pipe. It may also be necessary to construct a small swale and area inlet in the backyard of 1004 Orchard to collect water running through the backyard and redirect it to the storm sewer on Orchard Drive.

Improvement Project WF-6



Project Drainage Basin Map



Legend

- Existing Storm Structure
- Existing Storm Pipe
- Proposed Structure
- Proposed Berm
- Project Boundary
- Proposed Sewer Upgrade
- Street Rehabilitation
- Streed Flooding

Complaints

- Localized Improvements
- Major System Improvements
- Belton Roads

1 inch = 100 feet

N W E S

WF-6 (Orchard Dr.) - Belton, MO					
Item No.	***Item Description***	***Quantity***	***Qty. Units***	***Unit Cost***	***Total Cost***
1	Erosion Control	1	LS	$30,000	$30,000
2	Clearing and Grubbing	1	LS	$10,000	$10,000
3	Storm Sewer (18" RCP)	207	LF	$75	$15,525
4	Earthwork	1000	CY	$18	$18,000
5	Drainage Pipe (12" HDPE)	100	LF	$35	$3,500
6	18" Nyloplast Drain Basin	1	LS	$1,500	$1,500
7	Detention Land Acquisition	1.15	AC	$20,000	$23,000
8	Detention Outlet Structure (4' x 4')	1	LS	$5,000	$5,000
9	Storm Sewer Junction Box	1	EA	$3,500	$3,500
				Construction Sub-Total	$110,025
				Construction Contingency	$27,506
				Engineering	$11,000
				Utility Contingency (5%)	$5,501
				Probable Project Costs	$154,033

Improvement Project WF-7

Problem Description

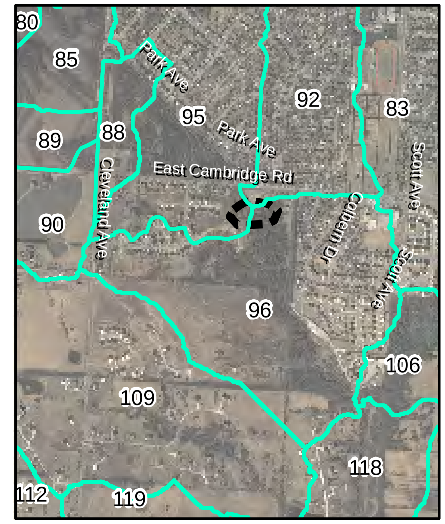
The stream has meander migration problems and there is a hairpin corner just south of the existing detention pond on West Cambridge Road. The alluvial banks appear to be silty clay that is prone to additional erosion. As migration continues, either the pond embankment will fail or the peninsula at the hairpin corner will be cut (oxbow creation).

Conceptual Improvement

Stream stabilization options include placing rock rip rap to stabilize the outside bend or excavating the peninsula to accelerate the oxbow creation. The peninsula excavation should be performed down to, but not below, the ordinary high water mark.

Improvement Project WF-7

Project Drainage Basin Map



Legend

Project Boundary

Stream Assessment

Risk to Infrastructure

- Low
- Med
- High

N E S W

1 inch = 100 feet

Project WF-7

Item No.	Item Description	Quantity	Qty. Units	Unit Cost	Total Cost
1	Stream Bank Improvements	300	LF	$300	$90,000
				Construction Sub-Total	$90,000
				Construction Contingency	$22,500
				Engineering	$13,500
				Land Rights and Administration (10%)	$9,000
				Probable Project Costs	$135,000

Improvement Project WF-8

Problem Description

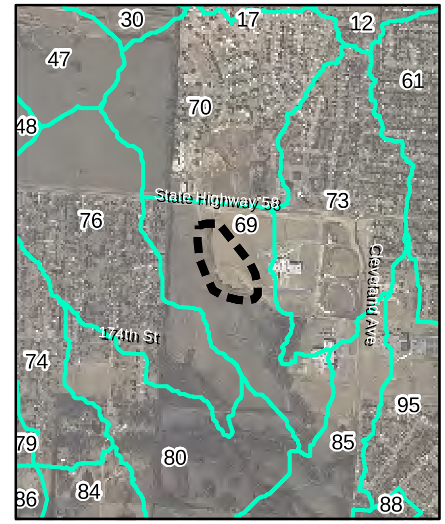
Surface drainage is allowed to cascade over the top of the stream banks. The alluvial banks appear to be silty clay that is prone to additional erosion. Significant erosion is occurring now and will continue into the future. Sediment generation is an issue since this stream drains to the proposed Cleveland Lake. There is a low risk of the stream threatening public infrastructure.

Conceptual Improvement

Installing a buffer along the stream edge to prevent erosion from lateral sheet flows entering the channel will help prevent bank erosion. At locations of concentrated flow, an area inlet and pipe outlet should be used. The pipe flow line should be near the bottom of the channel, have a slope less than 1%, and adequate energy dissipation at the outlet.

Impovement Project WF-8

Project Drainage Basin Map



Legend

Project Boundary

Stream Assessment

Risk to Infrastructure

Low

Med

High

N
W E
S

1 inch = 150 feet

Project WF-8

Item No.	Item Description	Quantity	Qty. Units	Unit Cost	Total Cost
1	Stream Bank Improvements	1100	LF	$300	$330,000
				Construction Sub-Total	$330,000
				Construction Contingency	$82,500
				Engineering	$30,000
				Land Rights and Administration (10%)	$33,000
				Construction Sub-Total	$16,500
				Probable Project Costs	$492,000

Improvement Project WF-9

Problem Description

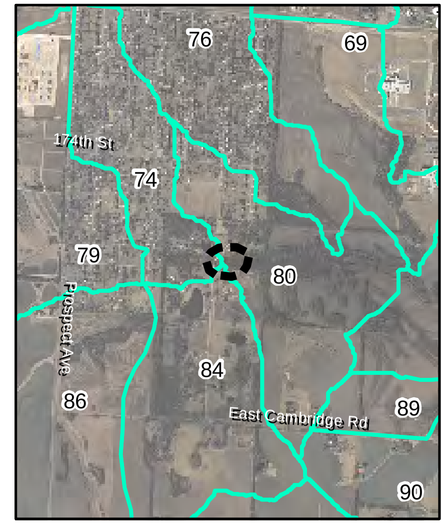
The stream shows flow line scour, bank widening, and meander migration. The alluvial banks are 6' to 8' tall and appear to be silty clay. Sediment generation is a concern as the stream flows into the proposed Cleveland Lake. Large trees (36" to 60" diameter trunks) have been undermined and are lying across the stream. Access to the woody debris is a problem. A suitable riparian buffer exists through much of this reach. Presents low risk to infrastructure, however sediment flowing into Cleveland Lake is a concern.

Conceptual Improvement

The conceptual improvement for this area includes removing woody debris that is lying in the creek, removing distressed woody material at the top of the bank to prevent debris generation, and performing a fluvial geomorphic assessment to determine appropriate stream geometry for this reach.

Impovement Project WF-9

Project Drainage Basin Map



Legend

Project Boundary

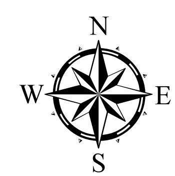
Stream Assessment

Risk to Infrastructure

Low

Med

High



1 inch = 100 feet

WF-9 - Belton, MO					
Item No.	***Item Description***	***Quantity***	***Qty. Units***	***Unit Cost***	***Total Cost***
1	Stream Bank Improvements	500	LF	$300	$150,000
				Construction Sub-Total	$150,000
				Construction Contingency	$37,500
				Engineering	$15,000
				Land Rights and Administration (10%)	$15,000
				Probable Project Costs	$217,500

Improvement Project WF-10 (Margaret Lane)

Problem Description

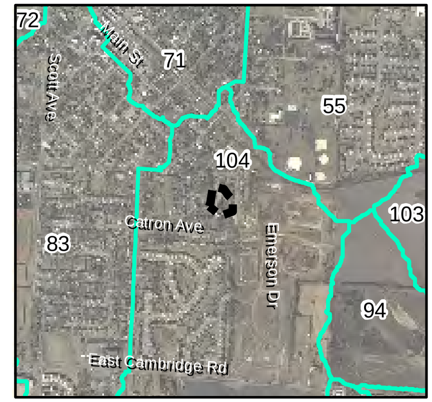
The problem consists of roughly 25 acres of residential land draining to 2 inlets on Margaret Lane. The current inlets are also very small and inefficient. The 15” CMP that drains the low spot on Margaret Lane is only capable of carrying 5% of the 77 cfs, 10 year peak flow.

Conceptual Improvement

A detailed analysis was performed to determine the number of new inlets that would be required in this area as well as the necessary pipe sizes to carry the 10 year flow. Because of limited cover and a flat terrain, a 5’ x 2’ concrete box culvert was chosen to replace the 15” CMP that flows east from Margaret Lane. The two, existing inlets will be replaced with newer, more efficient inlets. Two additional inlets will be placed in the low spot on Margaret Lane, and two more inlets will be placed to the North on Margaret Lane to catch water before it reaches the low spot.

Improvement Project WF-10

Project Drainage Basin Map



Legend

- Existing Storm Structure
- Existing Storm Pipe
- Proposed Structure
- Proposed Berm
- Project Boundary
- Proposed Sewer Upgrade
- Street Rehabilitation
- Streed Flooding

Complaints

- Localized Improvements
- Major System Improvements
- Belton Roads

1 inch = 50 feet

WF-10 (Margaret Ln.) - Belton, MO					
Item No.	***Item Description***	***Quantity***	***Qty. Units***	***Unit Cost***	***Total Cost***
1	Removal of Existing Structures	1	LS	$5,000	$5,000
2	Erosion Control	1	LS	$5,000	$5,000
3	Traffic Control	1	LS	$5,000	$5,000
4	Storm Sewer Junction Box	1	EA	$3,500	$3,500
5	Storm Inlets (4' x 6')	2	EA	$4,000	$8,000
5	Storm Inlets (4' x 8')	3	EA	$4,500	$13,500
6	Storm Inlets (6' x 8')	1	EA	$5,000	$5,000
7	Storm Sewer Junction Box	1	EA	$3,500	$3,500
8	Storm Sewer (15" RCP)	27	LF	$70	$1,890
9	Storm Sewer (18" RCP)	50	LF	$75	$3,750
10	Storm Sewer (24" RCP)	170	LF	$80	$13,600
11	Precast Concrete Box Culvert (5x2)	215	LF	$280	$60,200
12	Rip Rap Apron and Wingwalls for 5x2 RCB	1	LS	$4,000	$4,000
13	Curb and Gutter	190	LF	$25	$4,750
14	Driveway Apron, Residential	30	SY	$65	$1,950
15	Sodding	300	SY	$5	$1,500
16	Asphaltic Concrete (Street - Residential)	170	SY	$90	$15,300
				Construction Sub-Total	$155,440
				Construction Contingency	$38,860
				Engineering	$30,000
				Land Rights and Administration (10%)	$15,544
				Utility Contingency (10%)	$15,544
				Probable Project Costs	$255,388

Improvement Project WF-11 (Highway 58 and Baldwin Street)

Problem Description

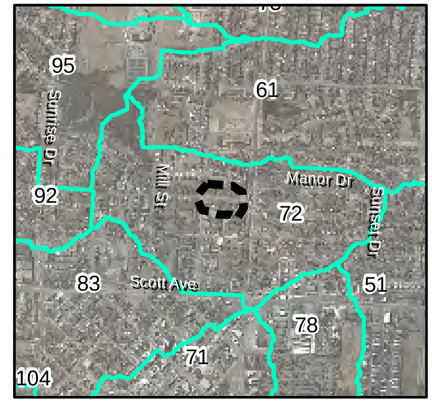
The problem on Baldwin Street consists of two houses that regularly experience stormwater flooding. The house at 103 Baldwin is located at the bottom of a hill with the runoff from the hill sheeting directly into the house. The house at 107 Baldwin suffers from an inadequate drainage ditch on the north side of the property and a drive way that slopes down toward the garage on the west side of the property. Lastly, the concrete channel near 200 Baldwin Street does not have adequate energy dissipation at its outfall and the banks are eroding close to houses.

Conceptual Improvement

A detailed analysis was performed and concluded that a berm should be built on the north side of 107 Baldwin to protect the north side of the house and direct water to an area inlet. An 18" concrete culvert should be added to collect flows from the north and from the east. The area inlet at the corner of Lynn and Baldwin Street will connect to the existing 52" RCP on the west side of Baldwin Street. A berm should also be placed behind 103 Baldwin to direct flows to Lynn Street. Energy dissipation and bank armoring should be installed at the outlet of the concrete channel near 200 Baldwin Street.

Improvement Project WF-11

Project Drainage Basin Map



Legend

- Existing Storm Structure
- Existing Storm Pipe
- Proposed Structure
- Proposed Berm
- Project Boundary
- Proposed Sewer Upgrade
- Street Rehabilitation
- Streed Flooding

Complaints

- Localized Improvements
- Major System Improvements
- Belton Roads

1 inch = 100 feet

WF-11 (Highway 58 and Baldwin) - Belton, MO					
Item No.	***Item Description***	***Quantity***	***Qty. Units***	***Unit Cost***	***Total Cost***
1	Erosion Control	1	LS	$5,000	$8,000
2	Traffic Control	1	LS	$5,000	$5,000
3	Storm Sewer Junction Box	1	EA	$3,500	$3,500
4	Area Inlet (4' x 6')	1	EA	$4,000	$4,000
5	Storm Sewer (18" RCP)	170	LF	$75	$12,750
6	Sodding	550	SY	$5	$2,750
7	Asphaltic Concrete (Street - Residential)	80	SY	$90	$7,200
8	Earthwork	250	CY	$18	$4,500
9	Stone Riprap(D50 24")	45	SY	$45	$2,025
10	Storm Inlets (4' x 6')	1	EA	$4,000	$4,000
11	Driveway Apron, Residential	50	SY	$65	$3,250
				Construction Sub-Total	$56,975
				Construction Contingency	$14,244
				Engineering	$9,000
				Land Rights and Administration (10%)	$5,698
				Utility Contingency (10%)	$5,698
				Probable Project Costs	$91,614

Improvement Project WF-12 (Brentwood Manor)

Problem Description

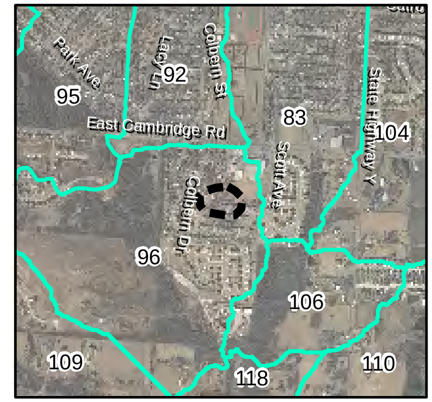
The problem consists of runoff from the field to the northeast that flows down the hill and floods homes from behind. Brentwood Drive is also in poor condition because of stormwater traveling down the street. Although there were no complaints downstream, the entire storm sewer downstream does not have capacity to convey the 2 year storm.

Conceptual Improvement

The proposed improvement involves building a berm on top of the hill in the field to the northeast to prevent runoff from rushing down the hill and into houses. An area inlet will be placed in top of the hill to collect the stormwater and pipe it into the existing system on Kent Drive. Two additional storm inlets were added to collect runoff from Brentwood Drive. Flows on the south side of Brentwood Drive are currently not collected at the intersection with Kent Drive because the inlets are only on the north side of the intersection. As previously stated the downstream system is undersized. However, since no houses experience flooding and the only negative consequence is damage to the street, no improvements were shown in this area.

Improvement Project WF-12

Project Drainage Basin Map



Legend

- Existing Storm Structure
- Existing Storm Pipe
- Proposed Structure
- Proposed Berm
- Project Boundary
- Proposed Sewer Upgrade
- Street Rehabilitation
- Streed Flooding

Complaints

- Localized Improvements
- Major System Improvements
- Belton Roads

1 inch = 100 feet

N W E S

WF-12 (Brentwood Manor) - Belton, MO					
Item No.	***Item Description***	***Quantity***	***Qty. Units***	***Unit Cost***	***Total Cost***
1	Removal of Existing Structures	1	LS	$10,000	$10,000
2	Erosion Control	1	LS	$10,000	$10,000
3	Traffic Control	1	LS	$2,500	$2,500
4	Storm Inlets (4' x 6')	3	EA	$4,000	$12,000
5	Storm Sewer Junction Box	1	EA	$3,500	$3,500
6	Storm Sewer (18" RCP)	350	LF	$75	$26,250
7	Detention Land Acquisition	0.25	AC	$20,000	$5,000
8	Asphaltic Concrete (Street - Residential)	70	SY	$90	$6,300
9	Sodding	700	SY	$5	$3,500
10	Fencing, Chain Link	150	LF	$35	$5,250
11	Earthwork	200	CY	$18	$3,600
	Total				$87,900

Construction Sub-Total	$175,800
Construction Contingency	$43,950
Engineering	$20,000
Land Rights and Administration (10%)	$17,580
Utility Contingency (5%)	$8,790
Probable Project Costs	$266,120

Improvement Project WF-13

Problem Description

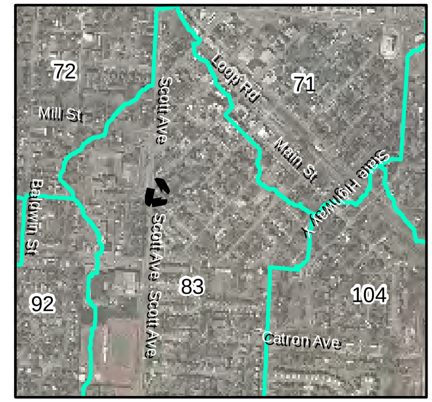
The house at 903 East Walnut Street experiences stormwater flooding and sanitary sewer back up several times each year. The problem appears to be due to runoff that has bypassed inlets upstream and overtopped the curb or from sheet flow directly from the northeast. The street to the northeast does not have curb and gutter so runoff is able to flow directly across it. Scott Avenue is higher than the surrounding area so runoff ponds up against the east side of Scott Avenue.

Conceptual Improvement

Building a berm on the north side of 903 East Walnut Street will direct water into the proposed area inlet. This will collect excess flows from Walnut Street and Scott Avenue that may overtop the curb. Connect to the inlet on South Scott Avenue with a 24” RCP.

Improvement Project WF-13

Project Drainage Basin Map



Legend

- Existing Storm Structure
- Existing Storm Pipe
- Proposed Structure
- Proposed Berm
- Project Boundary
- Proposed Sewer Upgrade
- Street Rehabilitation
- Streed Flooding

Complaints

- Localized Improvements
- Major System Improvements
- Belton Roads

1 inch = 50 feet

WF-13 (903 E Walnut) - Belton, MO					
Item No.	***Item Description***	***Quantity***	***Qty. Units***	***Unit Cost***	***Total Cost***
1	Removal of Existing Structures	1	LS	$5,000	$5,000
2	Erosion Control	1	LS	$5,000	$2,500
3	Area Inlet (4' x 4')	1	EA	$3,500	$3,500
4	Storm Sewer Junction Box	1	EA	$3,500	$3,500
5	Storm Sewer (24" RCP)	20	LF	$80	$1,600
6	Sodding	80	SY	$5	$400
7	Earthwork	120	CY	$18	$2,160
				Construction Sub-Total	$18,660
				Construction Contingency	$4,665
				Engineering	$3,000
				Land Rights and Administration (10%)	$1,866
				Utility Contingency (5%)	$933
				Probable Project Costs	$29,124

Improvement Project WF-14

Problem Description

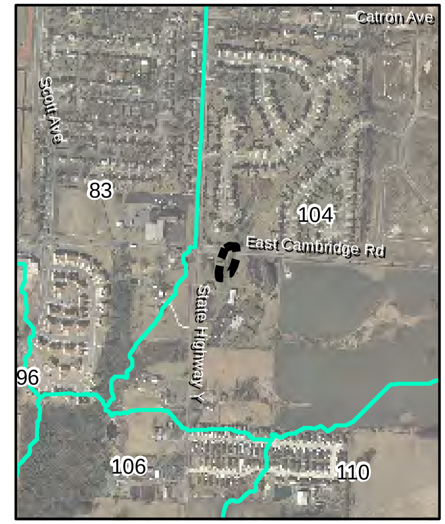
The stream shows prior down cut, and meander migration is in progress. The stream has already taken out a fence at 903 East Cedar Street. No buffer for the stream is present. Stream has 4 to 5 foot tall dirt banks which is a sign of instability

Conceptual Improvement

Laying back the banks and stabilizing the toe will fervent further lateral movement. Also planting a buffer will reduce erosion caused by lateral incoming flows.

Impovement Project WF-14

Project Drainage Basin Map



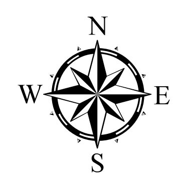
Legend

Project Boundary

Stream Assessment

Risk to Infrastructure

- Low
- Med
- High



1 inch = 100 feet

WF-14- Belton, MO					
Item No.	***Item Description***	***Quantity***	***Qty. Units***	***Unit Cost***	***Total Cost***
1	Stream Bank Improvements	200	LF	$300	$60,000
				Construction Sub-Total	$60,000
				Construction Contingency	$10,000
				Engineering	$9,000
				Land Rights and Administration (10%)	$6,000
				Utility Contingency (5%)	$3,000
				Probable Project Costs	$88,000

Improvement Project WF-15

Problem Description

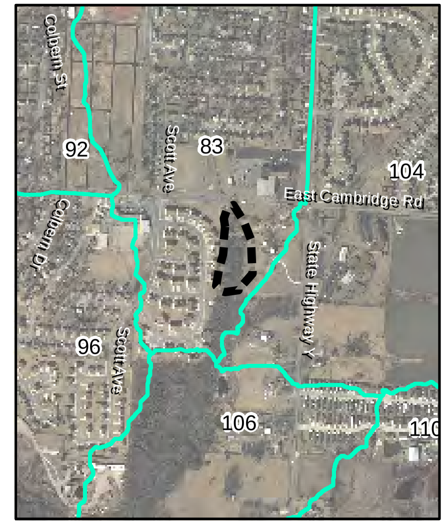
The channel in this area has experienced some flow line scour and has alluvial banks that are 4 to 5 feet tall which is a sign of bank instability. The upstream system is a concrete open channel. An outside bend is very close to quadplex and is likely to continue moving towards the quadplex. The channel contains a significant amount of urban trash.

Conceptual Improvement

Stabilize the tow of the channel with large diameter rock. The trash, wood and old steel bridge should be removed before they create a jam and cause water to back up which could flood the quadplex. A geomorphic evaluation should be performed to determine the appropriate channel dimensions.

Improvement Project WF-15

Project Drainage Basin Map



Legend

Project Boundary

Stream Assessment

Risk to Infrastructure

- Low
- Med
- High

N W E S

1 inch = 100 feet

WF-15 - Belton, MO					
Item No.	***Item Description***	***Quantity***	***Qty. Units***	***Unit Cost***	***Total Cost***
1	Stream Bank Improvements	490	LF	$300	$147,000
				Construction Sub-Total	$147,000
				Construction Contingency	$10,000
				Engineering	$22,050
				Land Rights and Administration (10%)	$14,700
				Utility Contingency (5%)	$7,350
				Probable Project Costs	$201,100

Improvement Project WF-16 (414 Mill Road)

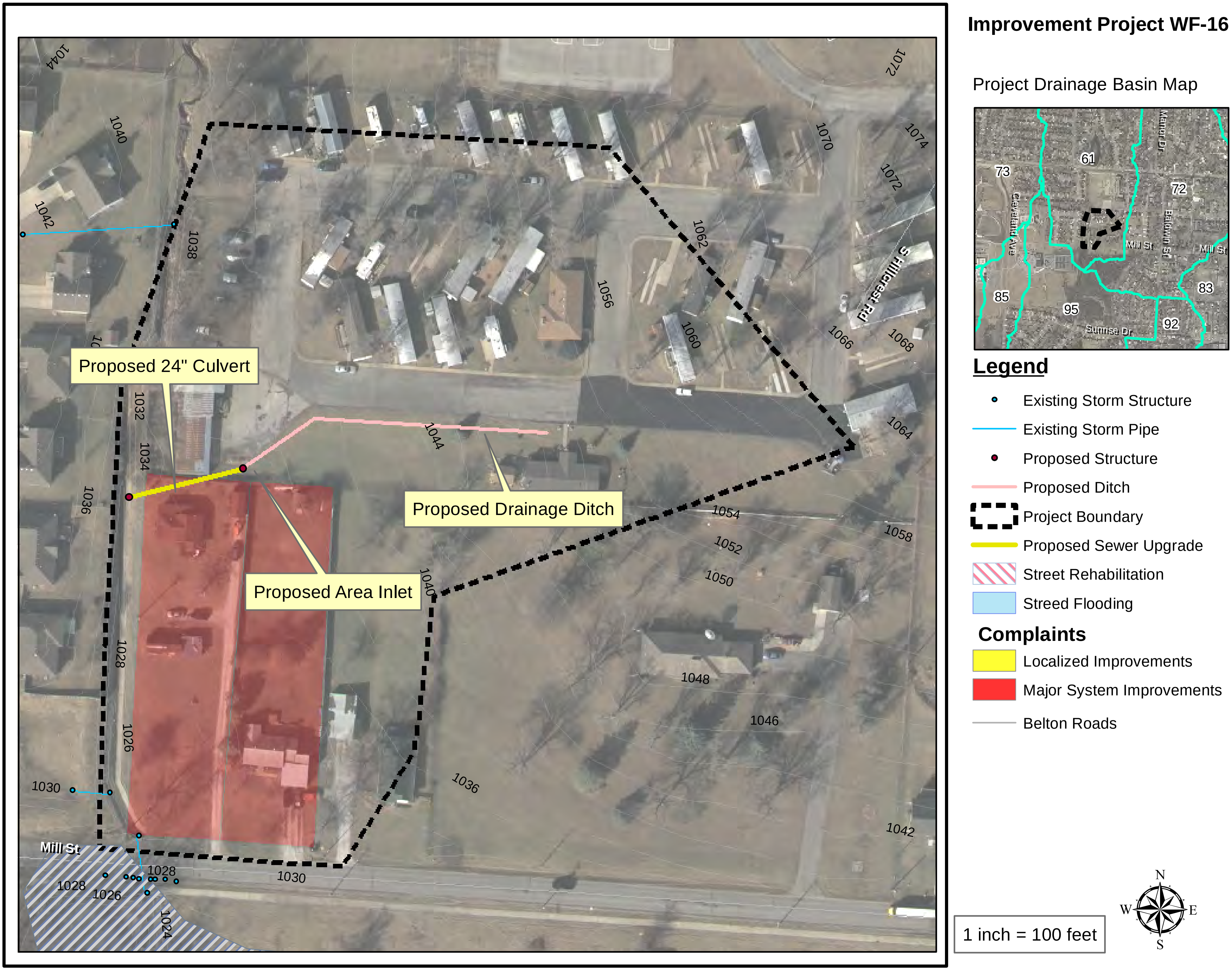
Problem Description

The problem consists of two houses that flood next to a tributary of West Fork East Creek. Backup in basement drains due to high groundwater caused by the nearby stream is part of the problem. Runoff from the mobile home park to the north, which is not captured by a storm sewer system runs through the yard at 414 Mill Road causing erosion and entering the house.

Conceptual Improvement

The existing channel to the west is concrete lined and it would not be practical to modify this channel. The excess runoff from the northeast may be addressed by installing a storm sewer system in the mobile home park. This system will collect stormwater underground and discharge to the concrete channel just west of 414 Mill Road.

Improvement Project WF-16



WF-16 (414 Mill Road) - Belton, MO					
Item No.	***Item Description***	***Quantity***	***Qty. Units***	***Unit Cost***	***Total Cost***
1	Erosion Control	1	LS	$5,000	$5,000
2	Area Inlet (4' x 6')	1	EA	$4,000	$4,000
3	Storm Sewer (24" RCP)	88	LF	$80	$7,040
4	End Section (24" RCP)	1	EA	$1,000	$1,000
5	Sodding	290	SY	$5	$1,450
6	Earthwork	65	CY	$18	$1,170
7	Fencing, Decorative	100	LF	$50	$5,000
				Construction Sub-Total	$24,660
				Construction Contingency	$6,165
				Engineering	$4,000
				Land Rights and Administration (10%)	$2,466
				Utility Contingency (5%)	$1,233
				Probable Project Costs	$38,524

Improvement Project WF-17 (201 Mary Way)

Problem Description

The problem consists of several houses that are located in the floodplain of West Fork East Creek. While several residences have experienced flooding in their back yard, only the residence at 201 Mary Way has experienced flooding inside the home.

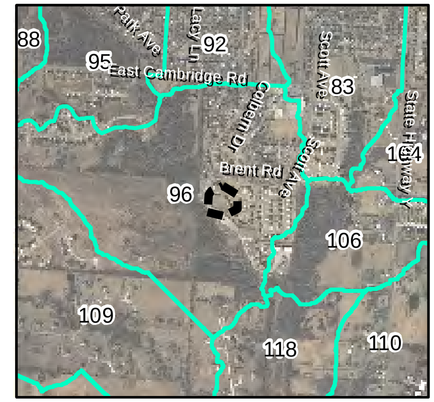
Conceptual Improvement

An analysis was performed and concluded that improving the channel and overbank would not reduce the water surface significantly enough to alleviate building flooding at 201 Mary Way. Therefore, the most practical solution for eliminating building flooding is to acquire the floodplain property.

The existing grading potentially allows floodwaters to impact these houses during the 10 year storm event. Further analysis, including a survey showing finished floor elevations of the houses, is needed to determine if grading around the houses can be performed to protect them from the smaller storm events.

Improvement Project WF-17

Project Drainage Basin Map



Legend

- Existing Storm Structure
- Existing Storm Pipe
- Proposed Structure
- Proposed Berm
- Project Boundary
- Proposed Sewer Upgrade
- Street Rehabilitation
- Olsson 100 Year Floodplain

Complaints

- Localized Improvements
- Major System Improvements
- Belton Roads

1 inch = 150 feet

WF-17 (Mary Way) - Belton, MO					
Item No.	***Item Description***	***Quantity***	***Qty. Units***	***Unit Cost***	***Total Cost***
1	Property Buyout	1	LS	$278,810	$278,810
				Construction Costs	$97,584
				Probable Project Costs	$376,394

Improvement Project WF-18 (905 Black Cherry Court)

Problem Description

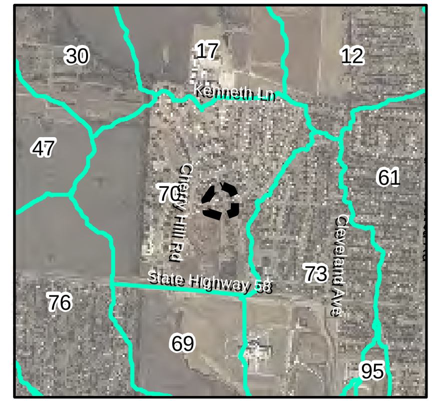
The problem consists of one residence at 905 Black Cherry Court that has repeatedly experienced water entering the house and ponding in the yard. The runoff flows laterally to the channel, which conveys the water to the area inlet to the north. The area inlet has sufficient capacity for the 10 year event. The problem appears to be the grading around the southern and eastern sides of 905 Black Cherry Court.

Conceptual Improvement

The proposed solution is to perform grading around the house to protect it from runoff. The ditch should be re-routed closer to the back of the yard and fill should be added to the back of the house if possible.

Improvement Project WF-18

Project Drainage Basin Map



Legend

- Existing Storm Structure
- Existing Storm Pipe
- Proposed Structure
- Proposed Ditch
- Project Boundary
- Proposed Sewer Upgrade
- Street Rehabilitation
- Streed Flooding

Complaints

- Localized Improvements
- Major System Improvements
- Belton Roads

1 inch = 50 feet

WF-18 - Belton, MO					
Item No.	***Item Description***	***Quantity***	***Qty. Units***	***Unit Cost***	***Total Cost***
1	Erosion Control	1	LS	$30,000	$2,500
2	Earthwork	70	CY	$18	$5,490
				Construction Sub-Total	$7,990
				Construction Contingency	$1,998
				Engineering	$2,000
				Land Rights and Administration (10%)	$799
				Utility Contingency (5%)	$400
				Probable Project Costs	$13,186

Improvement Project WF-19 (108 Brian Avenue)

Problem Description

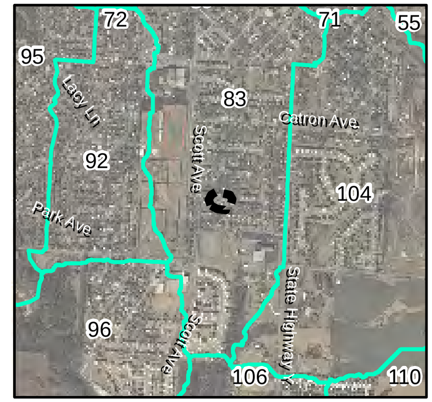
The problem consists of yearly flooding in the low spot next to 108 Brian Road. The existing system is two curb inlets in the sump that discharge directly into the culvert that goes underneath Brian Road. Water has not entered into any houses but ponding has backed up onto the driveway at 108 Brian Road and covered the street. The model shows that tail water in the concrete channel does not create a problem and pipe conveyance is adequate. The inlets have roughly a 5 year capacity. There may be an issue with partially blocked pipes or inlets.

Conceptual Improvement

Check pipes for clogging. Add an additional 6' curb inlet on the north and south side of Brian Avenue.

Improvement Project WF-19

Project Drainage Basin Map



Legend

- Existing Storm Structure
- Existing Storm Pipe
- Proposed Structure
- Proposed Berm
- Project Boundary
- Proposed Sewer Upgrade
- Street Rehabilitation
- Streed Flooding

Complaints

- Localized Improvements
- Major System Improvements
- Belton Roads

1 inch = 50 feet

WF-19 - Belton, MO					
Item No.	***Item Description***	***Quantity***	***Qty. Units***	***Unit Cost***	***Total Cost***
1	Erosion Control	1	LS	$30,000	$3,000
4	Storm Inlets (4' x 6')	2	EA	$4,000	$16,000
				Construction Sub-Total	$19,000
				Construction Contingency	$4,750
				Engineering	$3,000
				Land Rights and Administration (10%)	$1,900
				Utility Contingency (5%)	$950
				Probable Project Costs	$29,600

Improvement Project WF-20 (Hollywood Boulevard)

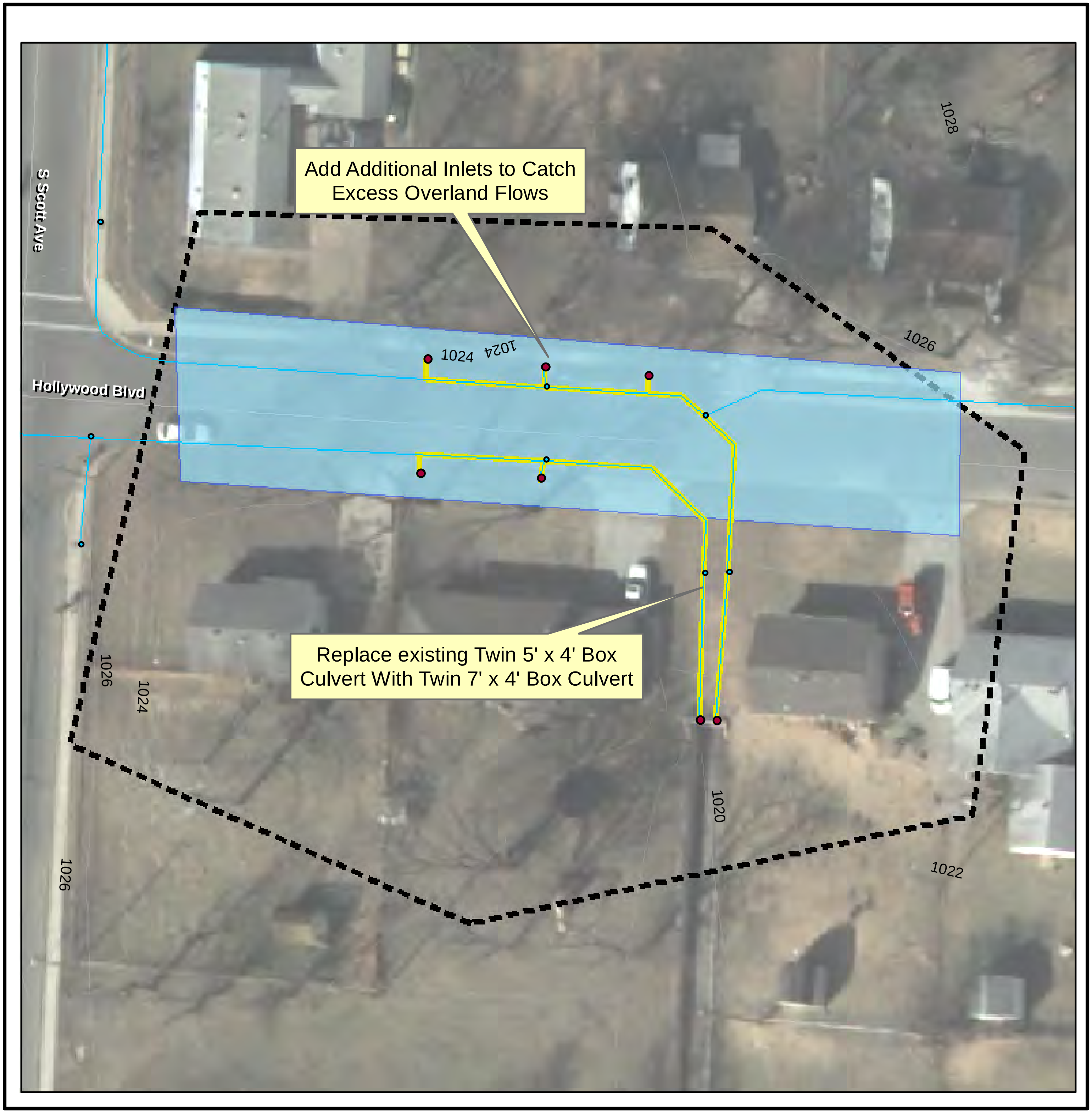
Problem Description

The problem consists of street flooding in the low spot on Hollywood Boulevard. The existing system has a 4' curb inlet on the north and south side of the street which each outlet to a 5' x 4' concrete box culvert. Because of the flat terrain the box culverts are extremely flat between the curb inlets on Hollywood Boulevard and the outlet to the concrete open channel.

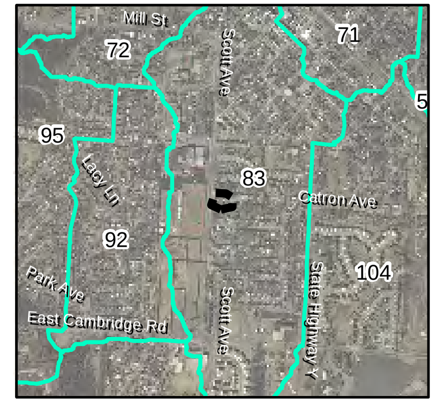
Conceptual Improvement

Detailed analysis shows that a 7' x 4' concrete box culvert will have sufficient capacity to maintain the HGL below the crown of the box for the 10 year peak flowrate. Additional inlets will be required to catch the flow traveling above ground on Hollywood Boulevard and Scott Avenue. Analysis shows that 5 curb inlets with 7' openings will be required to eliminate ponding during the 10 year event.

Improvement Project WF-20



Project Drainage Basin Map



WF-20 (Hollywood Blvd) - Belton, MO					
Item No.	***Item Description***	***Quantity***	***Qty. Units***	***Unit Cost***	***Total Cost***
1	Removal of Existing Structures	1	LS	$10,000	$10,000
2	Erosion Control	1	LS	$10,000	$10,000
3	Traffic Control	1	LS	$5,000	$5,000
4	Storm Inlets (8' x 8')	5	EA	$5,000	$25,000
5	Storm Sewer (12" RCP)	30	LF	$70	$2,100
6	Precast Concrete Box Culvert (7x4)	335	LF	$500	$167,500
7	Junction Box for 7x4 RCB	2	EA	$10,000	$20,000
8	Concrete Apron and Wingwalls for Dual 7x4 RCB	1	LF	$12,000	$12,000
9	Curb and Gutter	40	SY	$25	$1,000
10	Driveway Apron, Residential	40	SY	$65	$2,600
11	Concrete Sidewalk Construction	250	SF	$9	$2,250
12	Asphaltic Concrete (Street - Residential)	300	SY	$90	$27,000
13	Sodding	110	SY	$5	$550

Construction Sub-Total	$285,000
Construction Contingency	$71,250
Engineering	$45,000
Land Rights and Administration (10%)	$28,500
Utility Contingency (10%)	$28,500
Probable Project Costs	$458,250

B-2.3.2 Oil Creek and Little Blue River Watershed Projects

Improvement Project OC-1 (Hight Avenue and McKinley Street)

Problem Description

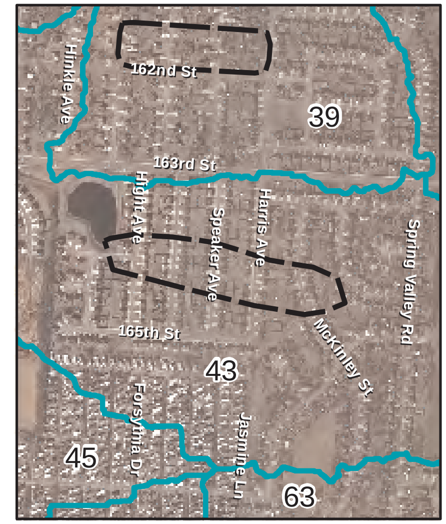
The problem consists of reported building flooding in two locations as well as street flooding in five locations. The existing enclosed system outlet begins at the outlet to Somerset Park Lake the 5 foot to 5.5 foot Corrugated Metal Pipe travels to the east between houses. The main line of the system continues east and drainage from the north and south connect into the system. The main trunk system continues to the east and reduces in size to a 4.5 foot Corrugated Metal Pipe. East of McKinley Street the system splits into two branches with the main branch continuing to the southeast. The entire system lacks the capacity for the 5-year storm which creates building and street flooding problems. Many of the houses adjacent to the enclosed system and the overflow path above the pipe are in danger of flooding in frequent events. The undersized system also causes street flooding over 7 inches along the main trunk line. The storm event on May 25, 2012 caused numerous complaints in this project area and collapsed fences and caused erosion in properties along the drainage path.

Conceptual Improvement

The conceptual improvement for this area includes replacing the entire main line system from the outlet of the system at Somerset Park Lake to east of McKinley Street. While the line is being replaced an overflow path should be graded over the top of the pipe to carry the water for storms more frequent than the 10-year event. The improved line will have capacity for the 10-year event and will follow the same alignment as the existing line. The improved line will begin with a 5’x7’ Reinforced Concrete Box on the downstream end that will decrease in size to a 5’x6’ Reinforced Concrete Box on the east side of Hight Avenue. The RCB will continue along the existing alignment and will reduce in size to a 5’x5’ Reinforced Concrete Box between Slater Avenue and Speaker Avenue. The 5’x5’ Reinforced Concrete Box will continue to the east side of Harris Avenue east of Harris Avenue the pipe will change to a 4.5’ diameter Reinforced Concrete Pipe (RCP). East of McKinley Street the pipe will reduce in size to a 4’ diameter Reinforced Concrete Box. The pipe will continue to the junction of the two branches of the system. The improved system will have the capacity for the 10-year event. An overflow path will be provided for storms greater than the 10-year event.

Improvement Project OC-1

Project Drainage Basin Map



Legend

- Existing Storm Structure
- Existing Storm Pipe
- Proposed Structure
- Proposed Berm
- Project Boundary
- Proposed Sewer Upgrade
- Street Rehabilitation
- Street Flooding

Complaints

- Not Applicable
- Localized Improvements
- Major System Improvements
- Street Flooding Only
- Watershed Boundary
- Belton Roads

1 inch = 250 feet

OC-1 (Hight Ave and McKinley St) - Belton, MO

Item No.	Item Description	Quantity	Qty. Units	Unit Cost	Total Cost
1	Removal of Existing Structures	1	LS	$75,000	$75,000
2	Erosion Control	1	LS	$50,000	$50,000
3	Traffic Control	1	LS	$20,000	$20,000
4	Storm Inlets (4' x 6')	15	EA	$4,500	$67,500
5	Storm Sewer (48" RCP)	150	LF	$180	$27,000
5	Storm Sewer (54" RCP)	316	LF	$230	$72,680
6	Storm Sewer (60" RCP)	60	LF	$250	$15,000
7	Storm Sewer (5' x 5' Box)	450	LF	$450	$202,500
8	Storm Sewer (6' x 5' Box)	670	LF	$600	$402,000
9	Driveway Apron, Residential	40	SY	$65	$2,600
10	Sodding	2500	SY	$5	$12,500
11	Asphaltic Concrete, Surface (Street - Residential)	250	SY	$90	$22,500
				Construction Sub-Total	$969,280
				Construction Contingency (25%)	$242,320
				Survey, Design, and Permitting (20%)	$193,856
				Land Rights and Administration (10%)	$96,928
				Utility Contingency (10%)	$96,928
				Probable Project Cost	**$1,599,312**

Improvement Project OC-2 –Option A (Valentine Avenue and 162nd Street)

Problem Description

The problems in this area consist of flooding from open channels and roadway drainage. The natural channels in this area cause reported flooding at one house and street flooding on 162nd Street in large events. The flooding in the natural channel is caused by lack of channel capacity and the culvert at 162nd Street. The home at 7111 E. 162nd Street experiences flooding from the stormwater flowing down 162nd Street to the west and the adjacent channel to the south of the home. An existing grate inlet is in place on the east side of the driveway to 7111 E. 162nd Street. This grate inlet can easily become clogged and could cause flooding at 7111 E. 162nd Street. 16105 Valentine Avenue has reported flooding 6 times in 4 years from the creek to the east of the home. Modeling for the area also shows that 162nd Street overtops in the 10-year event.

Conceptual Improvement

The improvement for this area will utilize several strategies to alleviate flooding problems. The first strategy that will be utilized is the use of berms and improved ditches around 7111 162nd Street. This will allow the stormwater to be conveyed around the home. The berm to the south of the home will also prevent the creek from overtopping and flooding the home. The culvert under 162nd Street will need to have sediment removed to improve conveyance. To prevent sediment buildup from reoccurring a small wall should be installed on the upstream side of two of the cells to force the base flow carrying sediment through one cell. The base flow flowing through one cell will maintain the water velocity and will prevent sediment drop out. The flooding at 16105 Valentine Avenue is caused by Oil Creek to the east of the house. Based on modeling the home is located in the 100-yr floodplain by approximately two feet. To remove the home from the floodplain would require extensive grading to the main channel of Oil Creek. The costs of the alterations of the channel are cost prohibitive to prevent flooding at one house. A quality wooded buffer also exists on the east side of the channel that would have to be mostly removed to expand the capacity of the channel and provide flood protection for 16150 Valentine Avenue described in Option B. Option A is therefore recommended as a significantly lower cost alternative providing a slightly lower, but still highly improved level of service.

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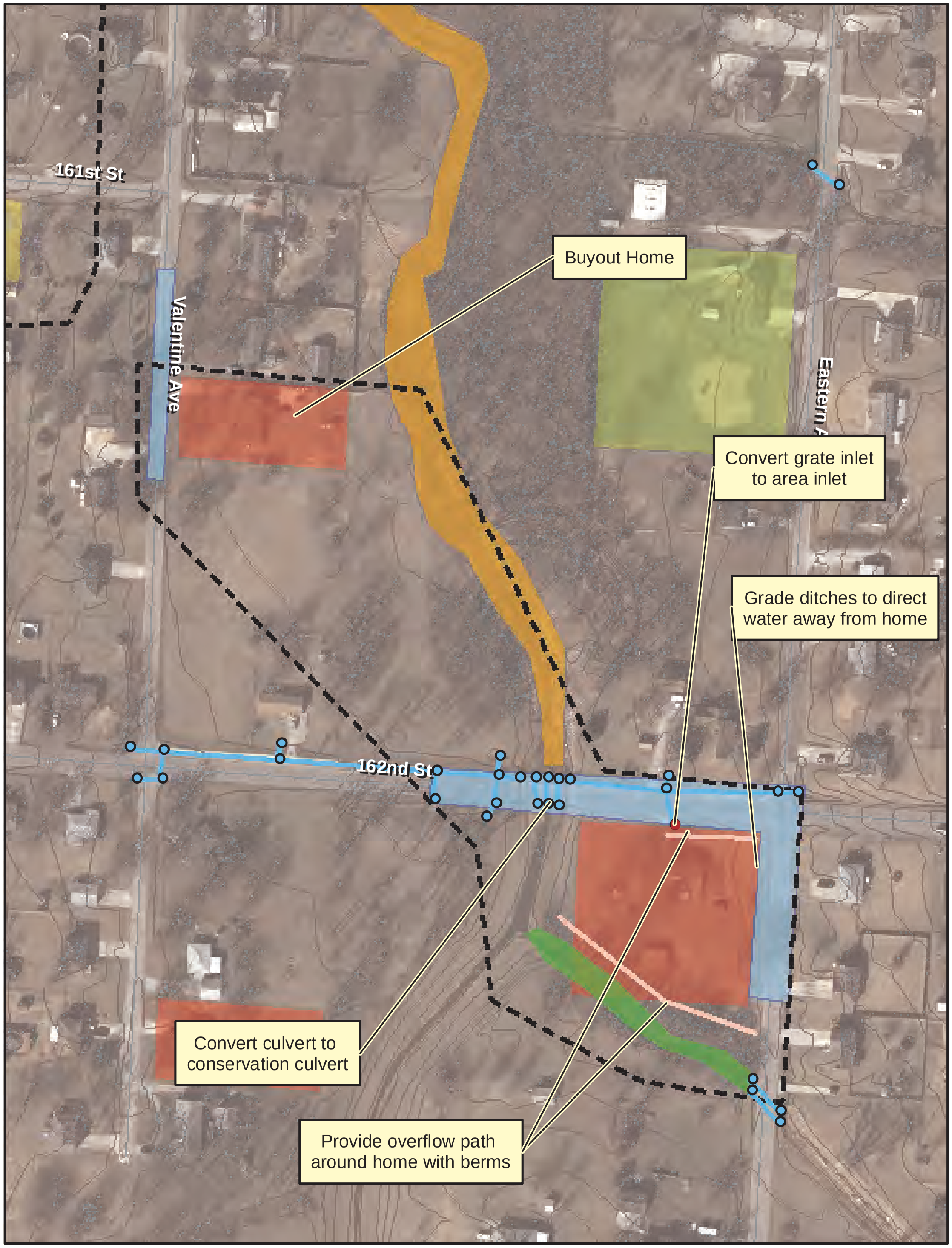
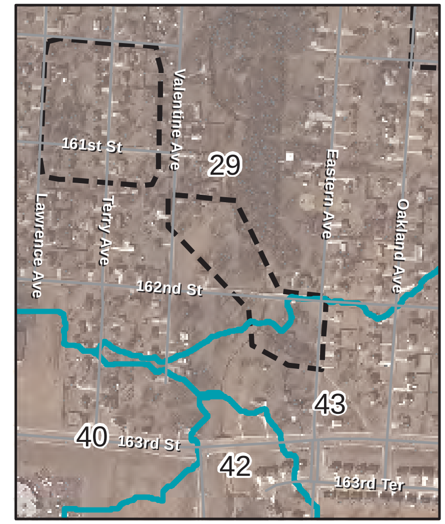
Improvement Project OC-2
Option A



Project Drainage Basin Map



Legend

Stream Assessment

Risk to Infrastructure

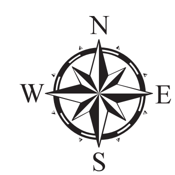
- Low
- Med
- High

Complaints

- Not Applicable
- Localized Improvements
- Major System Improvements
- Street Flooding Only
- Watershed Boundary
- Belton Roads

- Existing Storm Structure
- Existing Storm Pipe
- Proposed Structure
- Proposed Berm
- Project Boundary
- Proposed Sewer Upgrade
- Street Rehabilitation
- Street Flooding

1 inch = 200 feet



OC-2 - Option A (Valentine Ave and 162nd St) - Belton, MO					
Item No.	**Item Description**	**Quantity**	**Qty. Units**	**Unit Cost**	**Total Cost**
1	Erosion Control	1	LS	$2,500	$2,500
2	Traffic Control	1	LS	$1,000	$1,000
3	Buyout of 16105 Valentine	1.30	LS	$61,080	$79,404
4	Storm Inlets (4' x 6')	1	EA	$4,500	$4,500
5	Sodding	170	SY	$5	$850
6	Rip-Rap	280	SY	$70	$19,600
7	Culvert Walls	3	SY	$850	$2,550
8	Earthwork	413	CY	$9	$3,717
				Construction Sub-Total	$114,121
				Construction Contingency	$28,530
				Survey, Design, and Permitting (20%)	$22,824
				Land Rights and Administration (10%)	$11,412
				Utility Contingency (5%)	$5,706
				Probable Project Cost	**$182,594**

Improvement Project OC-2 - Option B (Valentine Avenue and 162nd Street)

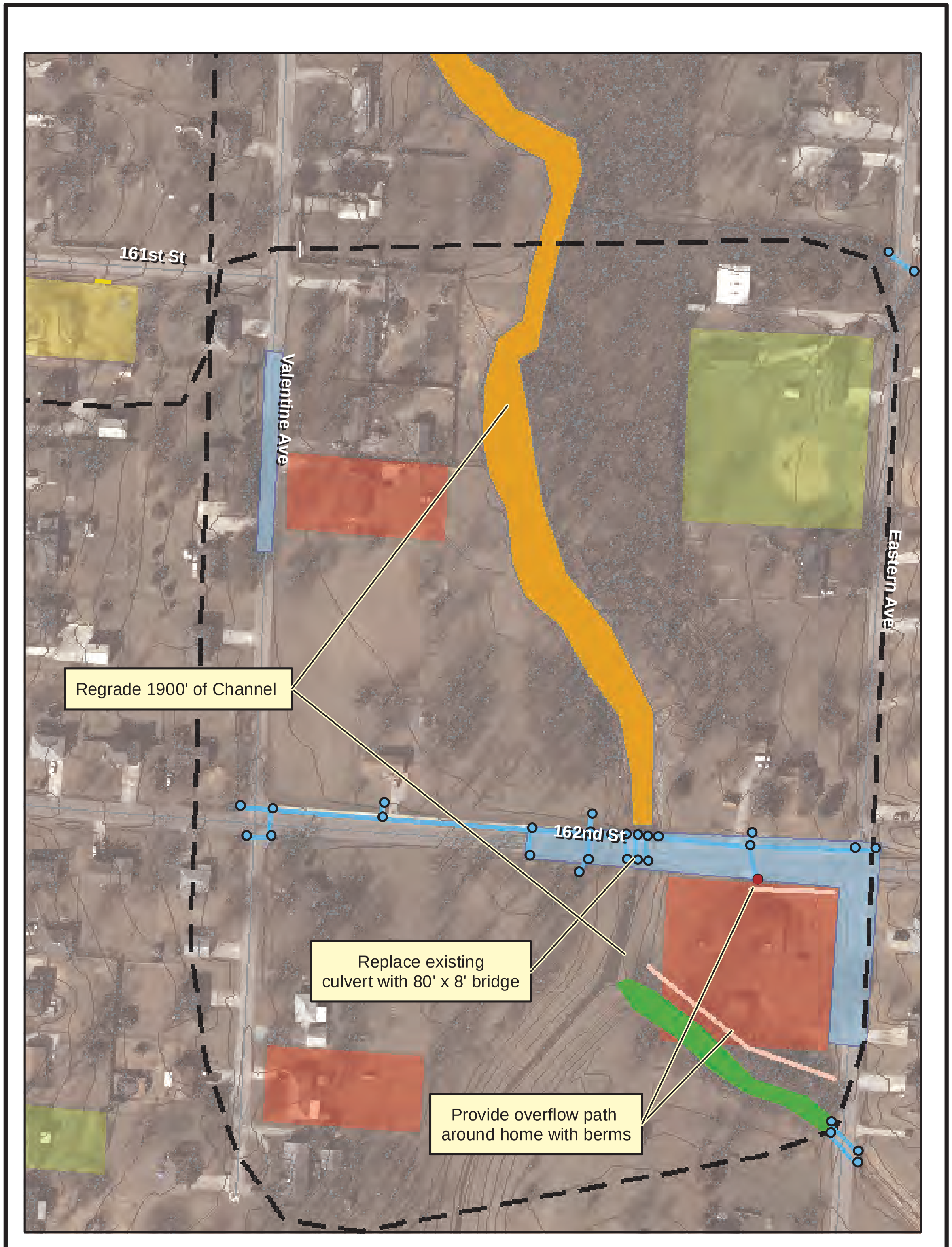
Problem Description

The problems in this area consist of flooding from open channels. The natural channels in this area cause reported flooding at three houses and street flooding on 162nd Street in large events. The flooding in the natural channel is caused by lack of channel capacity and the culvert at 162nd Street. In large events the capacity in the channel is too small and the houses adjacent to the channel are flooded. The house at 7111 E. 162nd Street also experiences flooding from the stormwater flowing down 162nd Street to the west. An existing grate inlet is in place on the east side of the driveway to 7111 E. 162nd Street. This grate inlet can easily become clogged and could cause flooding at 7111 E. 162nd Street. 16105 Valentine Avenue has reported flooding 6 times in 4 years from the creek to the east of the home. Modeling for the area also shows that 162nd Street overtops in the 10-year event.

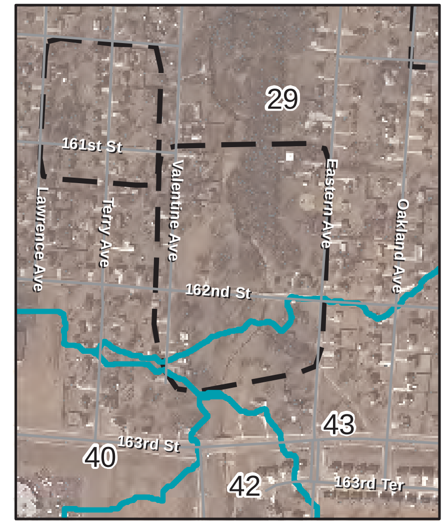
Conceptual Improvement

The improvement for this area will utilize several strategies to alleviate flooding problems. The first strategy that will be utilized is the use of berms and improved ditches around 7111 162nd Street. This will allow the stormwater to be conveyed around the house. The next portion of the solution is to grade the channel to allow greater conveyance. This will expand the natural channel and allow multiple houses to be removed from the flood plain. It will also give the City the opportunity to incorporate trail improvements in accordance with the trail master plan. To prevent the culvert at 162nd Street to have less than 7 inches of overtopping in the 100-year event an 80’ by 8 foot bridge will be required. The channel downstream and upstream of the road will need to be altered to allow for greater conveyance.

Improvement Project OC-2
Option B



Project Drainage Basin Map



Legend

Stream Assessment

Risk to Infrastructure

- Low
- Med
- High

Complaints

- Not Applicable
- Localized Improvements
- Major System Improvements
- Street Flooding Only
- Watershed Boundary
- Belton Roads

- Existing Storm Structure
- Existing Storm Pipe
- Proposed Structure
- Proposed Berm
- Project Boundary
- Proposed Sewer Upgrade
- Street Rehabilitation
- Street Flooding

1 inch = 200 feet

OC-2 - Option B (Valentine Ave and 162nd St) - Belton, MO					
Item No.	***Item Description***	***Quantity***	***Qty. Units***	***Unit Cost***	***Total Cost***
1	Removal of Existing Structures	1	LS	$5,000	$5,000
2	Erosion Control	1	LS	$5,000	$5,000
3	Traffic Control	1	LS	$5,000	$5,000
4	Storm Inlets (4' x 6')	1	EA	$4,500	$4,500
5	Sodding	170	SY	$5	$850
6	Rip-Rap	500	SY	$70	$35,000
7	80' x 30' bridge	1	LS	$305,000	$305,000
8	Earthwork	49714	CY	$18	$894,852
				Construction Sub-Total	$1,255,202
				Construction Contingency	$313,801
				Survey, Design, and Permitting (20%)	$251,040
				Land Rights and Administration (10%)	$125,520
				Utility Contingency (10%)	$125,520
				Probable Project Cost	**$2,071,083**

Improvement Project OC-3 (Hight Avenue and 161st Street)

Problem Description

The flooding problems in this area are caused by poor driveway culverts and inadequate ditch capacity. The stormwater flows from the east and south. At 16002 and 16004 Hight Avenue the stormwater flows from the east and over Hight Avenue and into houses. Stormwater also flows from the south and over 161st Street and into the house at 16005 Hinkle Avenue. The lack of adequate ditching and a low portion of the road allow the water to flow over 161st Street. Along 160th Terrace the ditching is adequate causing flooding of the street and one house at 16001 Oakland Avenue. The houses on Oakland Avenue north of 160th Terrace have also experienced flooding problems due to inadequate ditching and degraded pipe end sections.

Conceptual Improvement

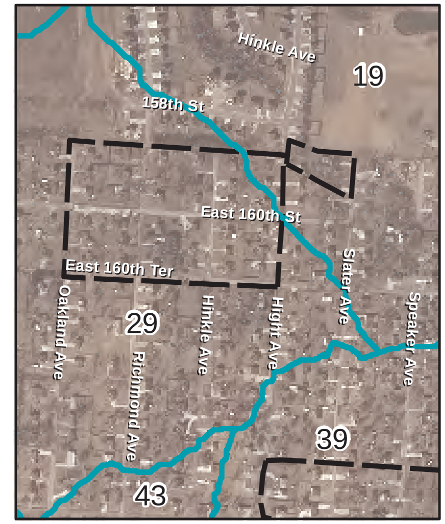
The improvement for this area will utilize berming and new driveway culverts to divert the stormwater into the existing improved ditches. New driveway culverts will be installed on Hight Avenue to direct the water to the south and parallel to 161st Street. The water will then flow parallel to 161st Street and will turn north and flow parallel to Hinkle Avenue. A new cross road culvert will be placed across 161st Street on the east of Hinkle Avenue to prevent flows from overtopping 161st Street. A berm and improved ditch will also be installed on the south portion of lot of 16005 Hinkle Avenue to prevent water from flowing into 16005 Hinkle Avenue. The ditching along Oakland Avenue north of E 160th Terrace will be altered to improve conveyance and prevent stormwater from entering the houses and causing erosion on Oakland Avenue. New driveway culvert end sections will also be installed to allow the stormwater to move through the system more efficiently.

It was discovered after further field investigation that the homeowner at 16001 Oakland Avenue has made significant improvements to their driveway and culverts. These improvements should have improved the drainage issue for 16001 Oakland Avenue.

This area is a potential candidate for Green Neighborhood improvements as described in Section D-3.

Improvement Project OC-3

Project Drainage Basin Map



Legend

- Existing Storm Structure
- Existing Storm Pipe
- Proposed Structure
- Proposed Berm
- Project Boundary
- Proposed Sewer Upgrade
- Street Rehabilitation
- Street Flooding

Complaints

- Not Applicable
- Localized Improvements
- Major System Improvements
- Street Flooding Only
- Watershed Boundary
- Belton Roads

1 inch = 200 feet

OC-3 (Hight Ave and 161st St) - Belton, MO					
Item No.	***Item Description***	***Quantity***	***Qty. Units***	***Unit Cost***	***Total Cost***
1	Erosion Control	1	LS	$10,000	$10,000
2	Traffic Control	1	LS	$5,000	$5,000
3	Storm Sewer (24" RCP)	85	LF	$80	$6,800
4	Earthwork	225	CY	$18	$4,050
5	Driveway Apron, Residential	25	SY	$65	$1,625
6	End Sections	3	EA	$1,000	$3,000
7	Channel Improvements	278	LF	$35	$9,730
8	Sodding	650	SY	$5	$3,250
9	Asphaltic Concrete, Surface (Street - Residential)	25	SY	$90	$2,250
				Construction Sub-Total	$45,705
				Construction Contingency (25%)	$11,426
				Survey, Design, and Permitting (20%)	$9,141
				Land Rights and Administration (10%)	$4,571
				Utility Contingency (5%)	$2,285
				Probable Project Cost	**$73,128**

Improvement Project OC-4 (15803 Terry Avenue)

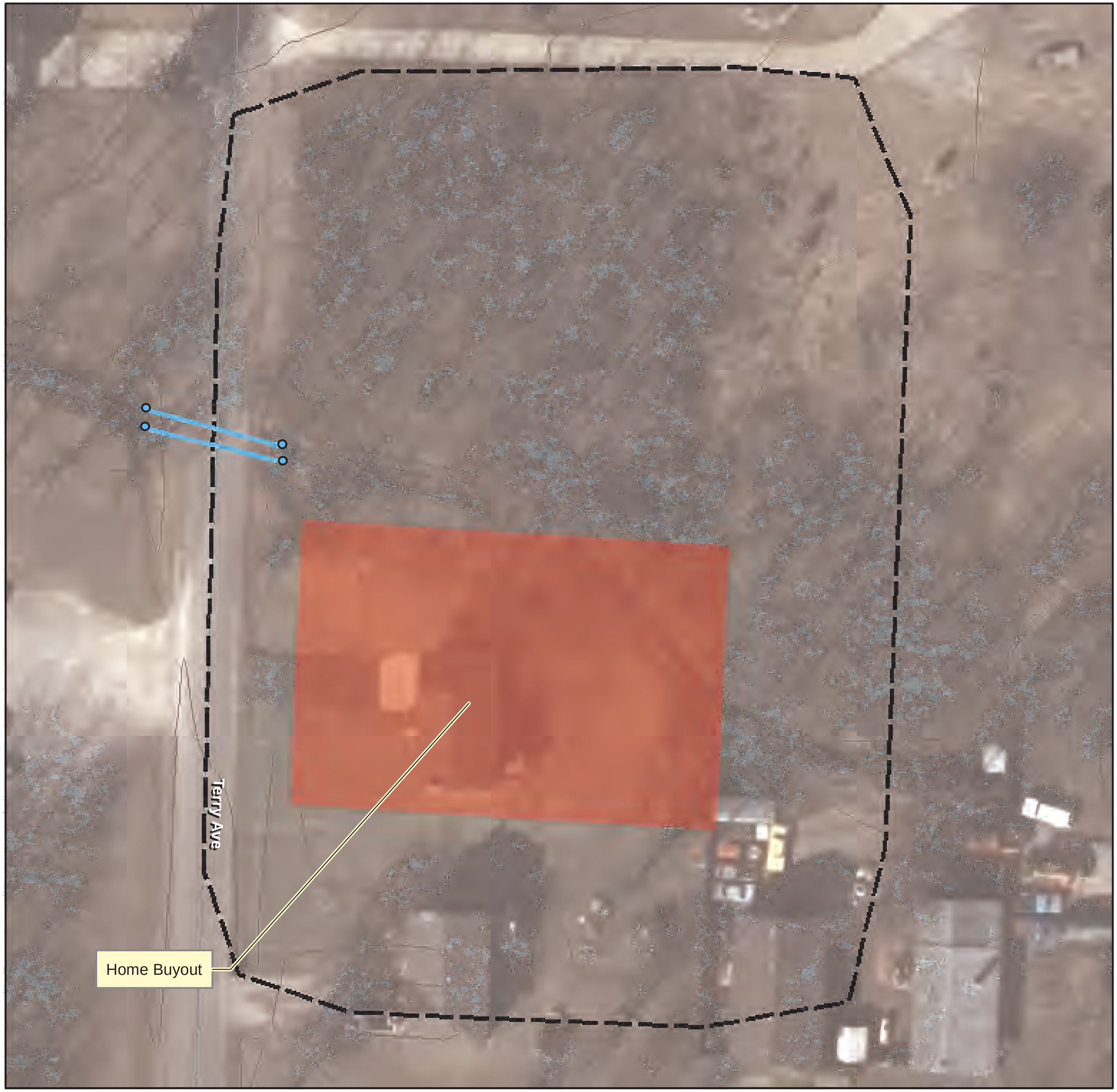
Problem Description

The flooding problems at 15803 Terry Avenue are caused by a stream to the north of the property. During significant storm events the creek causes flooding due the proximity of the house to the creek.

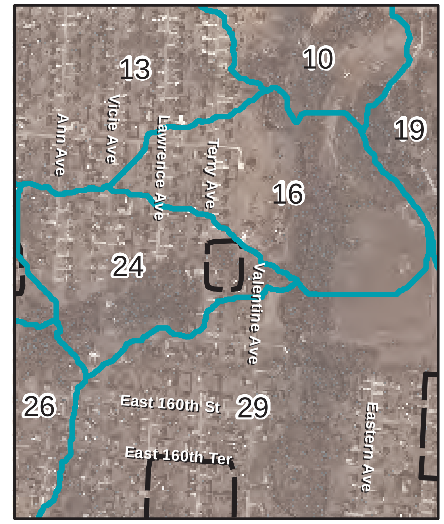
Conceptual Improvement

Engineered channel improvements are too significant and costly, exceeding the value of the home. Therefore, the conceptual improvement for this area includes buying out and demolishing the house and using the area for a trail head and park land.

Improvement Project OC-4



Project Drainage Basin Map



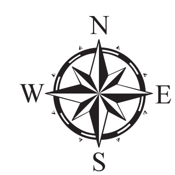
Legend

- Existing Storm Structure
- Existing Storm Pipe
- Proposed Structure
- Proposed Berm
- Project Boundary
- Proposed Sewer Upgrade
- Street Rehabilitation
- Street Flooding

Complaints

- Not Applicable
- Localized Improvements
- Major System Improvements
- Street Flooding Only
- Watershed Boundary
- Belton Roads

1 inch = 50 feet



OC-4 (15803 Terry) - Belton, MO					
Item No.	***Item Description***	***Quantity***	***Qty. Units***	***Unit Cost***	***Total Cost***
1	Removal of Existing Structures	1	LS	$10,000	$10,000
2	Erosion Control	1	LS	$5,000	$5,000
3	Traffic Control	1	LS	$2,500	$2,500
4	Buyout 15803 Terry	1.5	EA	$103,830	$155,745
				Construction Sub-Total	$173,245
				Construction Contingency (25%)	$43,311
				Survey, Design, and Permitting (5%)	$8,662
				Land Rights and Administration (10%)	$17,325
				Probable Project Cost	**$242,543**

Improvement Project OC-5 (115900 Slater Avenue)

Problem Description

The flooding problems at 115900 Slater Avenue are caused by a stream to the southwest of the property. During significant storm events the creek causes flooding in the rear of the house due to the proximity of the house to the creek.

Conceptual Improvement

The conceptual improvement for this area will consist of widening the drainage channel from Slater Avenue to Hight Avenue. The channel will also need rock rip-rap to prevent erosion. The improved hydraulics of the channel will lower the water surface elevation and prevent the house from flooding.

Improvement Project OC-5

Project Drainage Basin Map

Legend

- Existing Storm Structure
- Existing Storm Pipe
- Proposed Structure
- Proposed Berm
- Project Boundary
- Proposed Sewer Upgrade
- Street Rehabilitation
- Street Flooding
- Proposed Channel Stabilization

Complaints

- Not Applicable
- Localized Improvements
- Major System Improvements
- Street Flooding Only
- Watershed Boundary
- Belton Roads

N W E S

1 inch = 100 feet

OC-5 (115900 Slater Ave) - Belton, MO					
Item No.	***Item Description***	***Quantity***	***Qty. Units***	***Unit Cost***	***Total Cost***
1	Erosion Control	1	LS	$25,000	$25,000
2	Traffic Control	1	LS	$5,000	$5,000
3	Earthwork	150	CY	$18	$2,700
4	Stone Rip-Rap (D50 6")	1100	SY	$45	$49,500
5	Sodding	850	SY	$5	$4,250
6	Landscaping	1	LS	$5,000	$5,000
				Construction Sub-Total	$91,450
				Construction Contingency (25%)	$22,863
				Survey, Design, and Permitting (20%)	$18,290
				Land Rights and Administration (10%)	$9,145
				Utility Contingency (5%)	$4,573
				Probable Project Cost	**$146,320**

Improvement Project OC-6 (Slater Avenue and 162nd Street)

Problem Description

The flooding problems in area OC-6 are related to inadequate driveway culverts and topography that allows overland flow to enter houses. Overland water flows from the north to the south between Speaker Avenue and Harris Avenue. The water lacks a defined drainage path north of 16111 Speaker Avenue and turns to the west and flows into the house at 16111 Speaker Avenue. The water then continues in a roadside ditch to the south.

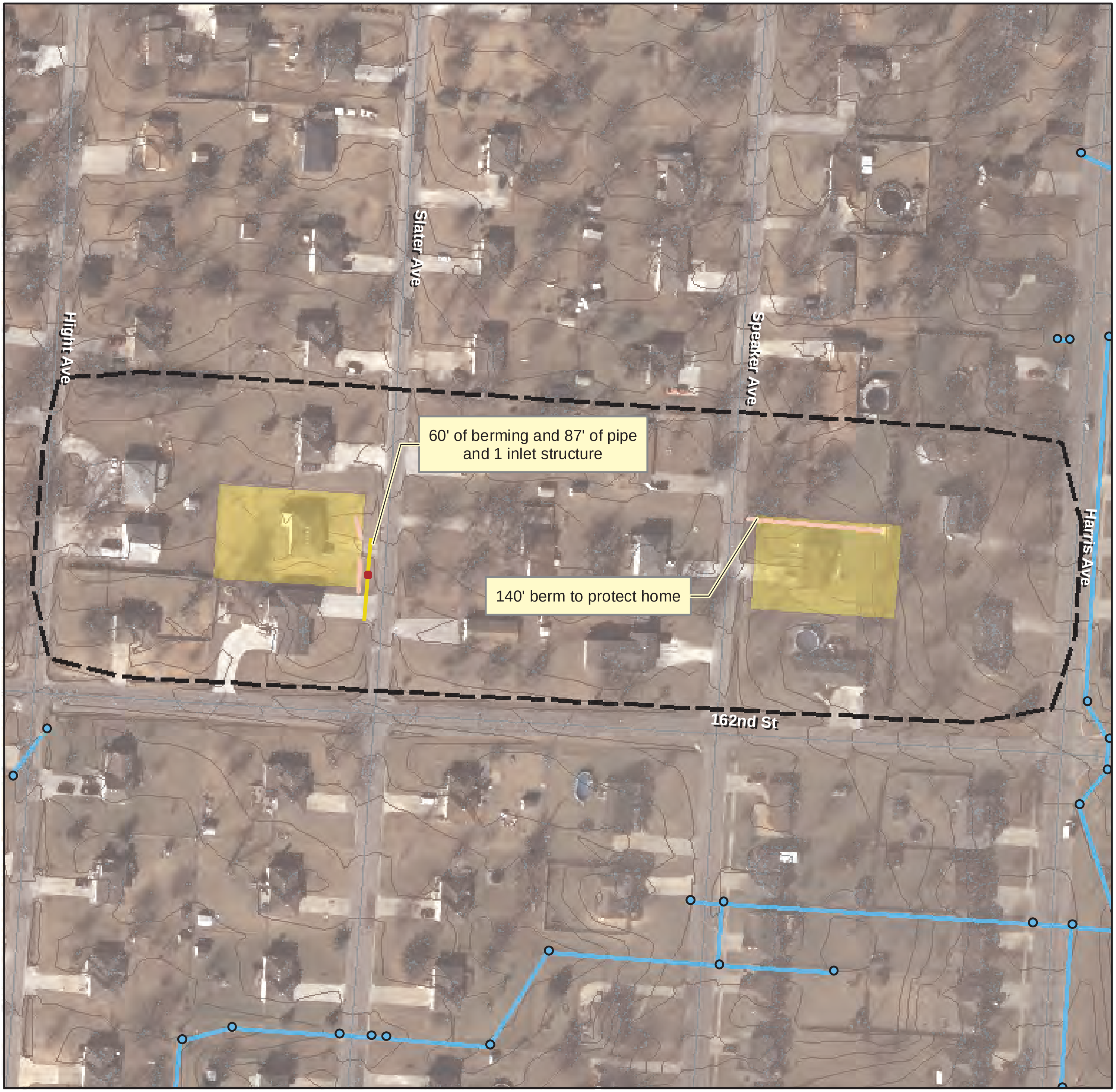
Along Slater Avenue water enters a road side ditch and flows to the south. Near 16110 Slater Avenue the roadside ditch becomes less defined. The lack of adequate ditching combined with the inadequate driveway pipe, for 16110 Slater Avenue, and the downward gradient of the driveway allow water to enter 16110 Slater Avenue. The water that does not enter the home continues to the southeast and flows through the backyard of 16112 Slater Avenue. The water then enters a roadside ditch on 162nd Street.

Conceptual Improvement

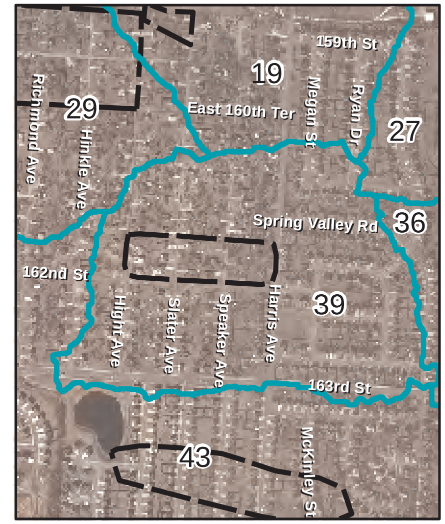
The improvement for this area consists of constructing berms and a limited amount of piping. One berm will be constructed on the north lot line of 16111 Speaker Avenue. This berm will direct water from the rear of the lot to the roadside ditch on Speaker Avenue.

On Slater Avenue the roadside ditch will be improved on the west side of Slater Avenue. A new pipe will be placed on the north side of the driveway for 16110 Slater Avenue, the pipe will continue to the south side of 16112 Slater Avenue. This will allow the stormwater to travel past 16110 Slater Avenue and will prevent the water from flowing down the driveway and into the house. A berm will also be constructed between the driveways of 16110 and 16112 Slater Avenue. This berm will prevent runoff from the street flowing down the driveway and into 16110 Slater Avenue. A new inlet will also be added to catch any additional drainage that flows down the west side of Slater Avenue.

Improvement Project OC-6



Project Drainage Basin Map

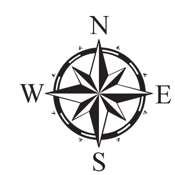


Legend

- Existing Storm Structure
- Existing Storm Pipe
- Proposed Structure
- Proposed Berm
- Project Boundary
- Proposed Sewer Upgrade
- Street Rehabilitation
- Street Flooding

Complaints

- Not Applicable
- Localized Improvements
- Major System Improvements
- Street Flooding Only
- Watershed Boundary
- Belton Roads



1 inch = 150 feet

OC-6 (Slater Ave and 162 St) - Belton, MO					
Item No.	***Item Description***	***Quantity***	***Qty. Units***	***Unit Cost***	***Total Cost***
1	Erosion Control	1	LS	$5,000	$5,000
2	Traffic Control	1	LS	$5,000	$5,000
3	Storm Inlets (4' x 4')	1	EA	$4,000	$4,000
4	Storm Sewer (24" RCP)	87	LF	$80	$6,960
5	Driveway Apron, Residential	30	SY	$75	$2,250
6	Sodding	450	SY	$5	$2,250
7	Earthwork	135	CY	$20	$2,700
				Construction Sub-Total	$28,160
				Construction Contingency (25%)	$7,040
				Survey, Design, and Permitting (20%)	$5,632
				Land Rights and Administration (10%)	$2,816
				Utility Contingency (5%)	$1,408
				Probable Project Cost	**$45,056**

Improvement Project OC-7 (Terry Avenue & 161st Terrace)

Problem Description

The flooding problems near Terry Avenue and 161st Terrace are due to the lack of adequate overflow paths. Two houses in this area flood as a result of this problem. 16009 Terry Avenue is one house that floods as a result of inadequate overflow paths. In storm events water flows from the north and south in roadside ditches to the south lot line of 16009 Terry. The water then turns and flows east. As the water flows east the drainage ditch is inadequate which causes water to flow into the attached garage and walls of 16009 Terry.

Flooding at 16101 Terry Avenue is caused by inadequate ditches and an undersized driveway culvert. The water flows from the west and under Terry Avenue and continues to the east. As the stormwater is traveling east it overwhelms the roadside ditch and flows into the rear walkout basement of 16101 Terry Avenue. The problem is amplified by the undersized driveway culvert. This culvert stops the water and pushes it towards 16101 Terry Avenue.

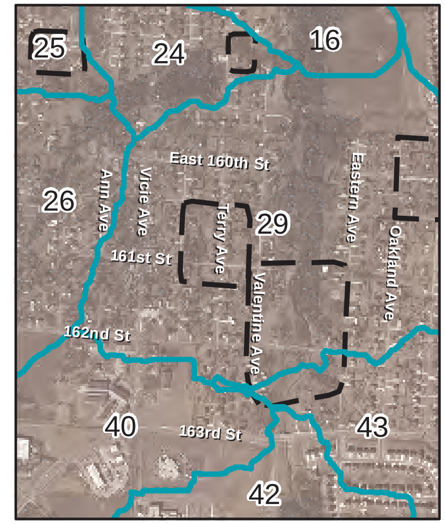
Conceptual Improvement

The conceptual improvements in this improvement project area involve improved ditches and driveway culverts. The first portion of the improvements will take place along 161st Terrace. Improvements in this area will include improving the roadside ditching along Terry Avenue and 161st Terrace and replacing the undersized driveway culvert to 16101 Terry Avenue. These improvements will provide a flow path for the water and will prevent the water from flowing into the rear of 16101 Terry Avenue.

The second portion of the improvements involve a piping system. The 18” pipe will travel along the south lot line of 16009 Terry Avenue. The pipe will then turn to the north and will connect into the existing drainage ditch on the south side of 161st Street. An area inlet will be added where the pipe turns north to receive any overland drainage. The pipe will allow the water to pass by 16009 Terry Avenue without flooding the attached garage. The piping system will also help alleviate street flooding on Terry Avenue.

Improvement Project OC-7

Project Drainage Basin Map



Legend

- Existing Storm Structure
- Existing Storm Pipe
- Proposed Structure
- Proposed Berm
- Project Boundary
- Proposed Sewer Upgrade
- Street Rehabilitation
- Street Flooding

Complaints

- Not Applicable
- Localized Improvements
- Major System Improvements
- Street Flooding Only
- Watershed Boundary
- Belton Roads

1 inch = 100 feet

N W E S

OC-7 (Terry Ave and 161st Terr) - Belton, MO					
Item No.	***Item Description***	***Quantity***	***Qty. Units***	***Unit Cost***	***Total Cost***
1	Erosion Control	1	LS	$7,500	$7,500
2	Traffic Control	1	LS	$2,500	$2,500
3	Storm Inlets (4' x 4')	1	EA	$4,000	$4,000
4	Ditch Rehabilitation	261	LF	$75	$19,575
5	Sodding	1025	SY	$5	$5,125
6	Storm Sewer (18" RCP)	392	LF	$85	$33,320
				Construction Sub-Total	$72,020
				Construction Contingency (25%)	$18,005
				Survey, Design, and Permitting (20%)	$14,404
				Land Rights and Administration (10%)	$7,202
				Utility Contingency (5%)	$3,601
				Probable Project Cost	**$115,232**

Improvement Project OC-8 (6800 158th Terrace)

Problem Description

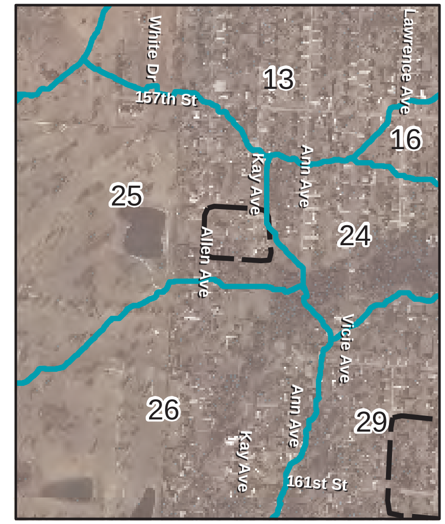
The flooding problems at 6800 158th Terrace are caused by inadequate ditching. This area also has potential for flooding due to houses close to a drainage ditch. The house at 6800 158th Terrace lacks adequate ditching to prevent water from flowing into the attached garage and into the home. Water flows from the north along the east side of Allen Avenue and turns to the east into a roadside ditch along 158th Terrace. The ditch on the north side of 158th Terrace is undersized and lacks adequate slope to convey the water to the east. The lack of adequate ditching allows water to enter the attached driveway of 6800 158th Terrace. Also of concern in the project area is the home at 15809 Allen Avenue. A drainage channel is in close proximity to the house. The low opening of the house is also near the top of bank of the channel that runs adjacent to the home.

Conceptual Improvement

The conceptual improvement for this area involves improving ditching along 158th Terrace and replacing the driveway culvert for 6800 158th Terrace. This improvement will allow the stormwater from the north to turn to the east and travel along 158th Terrace without flowing into the house at 6800 158th Terrace. The house at 15809 Allen Avenue has not reported flooding problems in the most recent survey. However if future development occurs upstream it could have a negative impact on this property. Restrictive detention is recommended for the property west of Allen Avenue to prevent increased flow downstream and potential flooding at 15809 Allen Avenue.

Improvement Project OC-8

Project Drainage Basin Map



Legend

- Existing Storm Structure
- Existing Storm Pipe
- Proposed Structure
- Proposed Berm
- Project Boundary
- Proposed Sewer Upgrade
- Street Rehabilitation
- Street Flooding

Complaints

- Not Applicable
- Localized Improvements
- Major System Improvements
- Street Flooding Only
- Watershed Boundary
- Belton Roads

1 inch = 100 feet

N W E S

OC-8 (6800 158th Terr) - Belton, MO					
Item No.	***Item Description***	***Quantity***	***Qty. Units***	***Unit Cost***	***Total Cost***
1	Erosion Control	1	LS	$2,500	$2,500
2	Traffic Control	1	LS	$2,500	$2,500
3	Ditch Rehabilitation	152	LF	$75	$11,400
4	Sodding	250	SY	$5	$1,250
				Construction Sub-Total	$17,650
				Construction Contingency (25%)	$4,413
				Survey, Design, and Permitting (20%)	$3,530
				Land Rights and Administration (10%)	$1,765
				Utility Contingency (5%)	$883
				Probable Project Cost	**$28,240**

Improvement Project OC-9 (16721 Bel Ray Boulevard)

Problem Description

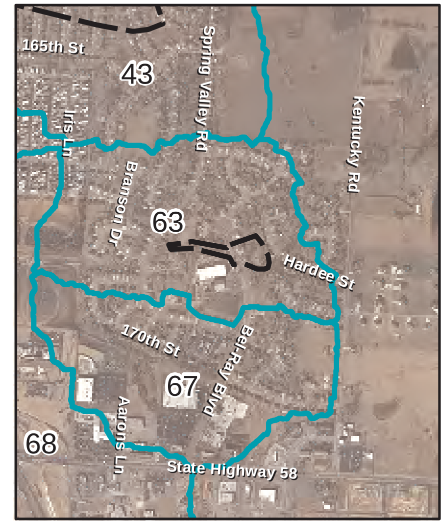
Stormwater flows from the south overland and into an existing storm system. The system turns to the west and flows on the north side of 16721 Bel Ray Boulevard, crosses Bel Ray Boulevard and continues to the west. The current system is undersized for the 10-year event. The undersized system also causes water to back up on Bel Ray Boulevard and water to enter the attached garage of 16821 Bel Ray Boulevard.

Conceptual Improvement

The conceptual improvement for this area includes the addition of pipe and stormwater inlets. The new pipe system would begin to the east of 16729 Bel Ray Boulevard. The new system would travel to the northwest and be placed on the south side of 16721 Bel Ray. The system would then begin replacing the existing system and would follow the existing alignment. The replacement system would travel under Bel Ray Boulevard to the northwest where it will join the existing system west of Bel Ray Court.

Improvement Project OC-9

Project Drainage Basin Map



Legend

- Existing Storm Structure
- Existing Storm Pipe
- Proposed Structure
- Proposed Berm
- Project Boundary
- Proposed Sewer Upgrade
- Street Rehabilitation
- Street Flooding

Complaints

- Not Applicable
- Localized Improvements
- Major System Improvements
- Street Flooding Only
- Watershed Boundary
- Belton Roads

1 inch = 150 feet

OC-9 (16719-21 Bel-Ray) - Belton, MO					
Item No.	***Item Description***	***Quantity***	***Qty. Units***	***Unit Cost***	***Total Cost***
1	Removal of Existing Structures	1	LS	$30,000	$30,000
2	Erosion Control	1	LS	$10,000	$10,000
3	Traffic Control	1	LS	$10,000	$10,000
4	Storm Inlets (4' x 6')	4	EA	$4,500	$18,000
5	Storm Sewer Junction Box	1	EA	$3,500	$3,500
5	Storm Sewer (24" RCP)	285	LF	$80	$22,800
6	Storm Sewer (36" RCP)	75	LF	$120	$9,000
7	Storm Sewer (42" RCP)	405	LF	$150	$60,750
8	Storm Sewer (48" RCP)	190	LF	$170	$32,300
9	Driveway Apron, Residential	36	SY	$65	$2,311
10	Sidewalk	9	SY	$72	$648
11	Earthwork	40	CY	$15	$600
12	Sodding	1163	SY	$5	$5,815
13	Asphaltic Concrete, Surface (Street - Residential) & Parking lot	306	SY	$90	$27,540

Construction Sub-Total	$233,264
Construction Contingency (25%)	$58,316
Survey, Design, and Permitting (20%)	$46,653
Land Rights and Administration (10%)	$23,326
Utility Contingency (5%)	$11,663
Probable Project Cost	**$373,223**

B-3. MAINTENANCE ACTIONS

This section outlines recommended immediate and long-term maintenance actions and repairs to the storm drainage system. This section provides a summary of all storm sewer structures found to be in poor condition through Olsson's system inventory. System inspections performed consisted of a visual inspection of storm structures (inlets, manholes, junction boxes and outfalls) for visible deterioration, clogging and structure failures; underground pipe video inspections were not performed under the scope of this Master Plan, but could be as a follow-up action to this effort.

B-3.1. Immediate Repairs Needed

Several areas in the City are in need of immediate repair. Many of the areas have been identified through the citizen stormwater survey and complaints and through staff observations. Most of the immediate repair actions can be completed by City staff and are therefore noted here rather than in the Capital Projects section. The solutions to immediate repairs throughout the City vary by location; typical repair actions include:

- Pipe and inlet cleaning
- Small concrete repairs
- Ditch and other minor grading
- Rip-rap placement
- Driveway culvert replacement and clean-out
- Erosion control in sensitive areas
- Vegetation establishment in upland areas

By using the above practices the City will be able to maintain and immediately address minor problems before they escalate into major problems. The structures that were inspected as part of the stormwater system inventory and were rated as poor are listed below with a recommend repair action.

Table B-2
Recommended Immediate Maintenance Locations

Structure ID	Structure Type	Location	Recommended Repair Action
1058	Curb Inlet	201 Brent Rd	Patch/repair throat. Remove silt and debris.
1061	Curb Inlet	922 Kent Dr	Patch/repair throat. Remove silt.
1070	Grate Inlet	213 W Cambridge Rd	Remove silt.
1251	Area Inlet	823 Heather Dr - Backyard	Backfill eroded area with topsoil. Plant grass seed and install erosion control blanket.
1378	Grate Inlet	415 Cherry St	Replace grate lid.
1480	Grate Inlet	610 Ella St	Remove silt and debris.
1482	Grate Inlet	610 Ella St	Remove silt, debris and vegetation.
1483	Grate Inlet	610 Ella St	Remove silt and debris.
1484	Grate Inlet	610 Ella St	Remove silt and debris.
1485	Grate Inlet	610 Ella St	Remove silt and debris.
1614	Area Inlet	208 Redbud Ave	Remove silt.

Structure ID	Structure Type	Location	Recommended Repair Action
1725	Curb Inlet	358 S Cleveland Ave	None - Private structure on school property.
1828	Curb Inlet	209 Monroe Ave	Monitor
1883	Curb Inlet	200 Bienbille St	Remove silt.
1960	Curb Inlet	1510 E 173rd St	Remove silt.
1961	Curb Inlet	1510 E 173rd St	Remove silt.
2038	Pipe Inlet	104 S Circle Dr	Remove silt and vegetation.
2039	Pipe Outfall	104 S Circle Dr	Remove silt and vegetation.
3021	Grate Inlet	414 Robie Dr	Remove silt and debris.
3022	Grate Inlet	415 Robie Dr	Remove silt and debris.
4118	Curb Inlet	6901 Chapel Dr	None - Private structure within apartment complex.
4210	Curb Inlet	16209 Vicie Ave	Level and re-attach top.
4214	Curb Inlet	16209 Vicie Ave	Remove silt and standing water.
4216	Curb Inlet	16203 Vicie Ave	Remove silt. Re-align top of structure.
4656	Curb Inlet	16812 Spring Valley Rd	Replace top of structure. Remove trash.
4964	Curb Inlet	403 J R Ave	Replace top of structure.
5130	Curb Inlet	356 John Ross Rd	Replace top of structure.
5131	Curb Inlet	359 John Ross Rd	Monitor
5149	Curb Inlet	109 Locust Hill Rd	Monitor
5150	Curb Inlet	109 Locust Hill Rd	Monitor
5151	Curb Inlet	115 Locust Hill Rd	Monitor
5177	Grate Inlet	1400 N Scott Ave	Monitor
6025	Curb Inlet	8107 Bel Ray Dr	Monitor
6026	Curb Inlet	8107 Bel Ray Dr	Monitor
6080	Curb Inlet	16415 Mckinley St	Monitor
11306	Grate Inlet	300 W Cambridge Rd	Repair broken portion of RCP.
15114	Junction Box	313 W South Ave	Could not locate junction box at this location. Poor rating given to note that a camera inspection is needed.
15130	Grate Inlet	508 Margaret Ln	Remove silt and debris.
55064	Curb Inlet	340 John Ross Rd	Remove silt.
55065	Curb Inlet	341 John Ross Rd	Remove silt.

B-3.2. Long-term Maintenance

The long term maintenance plan for the stormwater system in Belton utilizes several strategies to provide an efficient maintenance plan. The inlets and junction structures throughout the City were inspected as a part of the stormwater master plan, and the next step should be detailed pipe inspections via closed circuit video inspection for pipe segments running to and from the structures noted above in Table B-2. The pipe should then be assessed based on the condition of the pipe. Once the pipe has been assessed a ranking system should be established to begin replacement of the poorest sections of pipe as funds are available. The video inspection of the pipe should be completed every three to five years to track the degradation of the pipe. The amount of degradation of the pipe will also allow the City to determine how quickly repairs need to be made based on the condition of the pipe.

Another strategy to help the City determine the long term maintenance of the stormwater system is the use of resident questionnaires to help identify maintenance and flooding problems. Questionnaires should be completed every 5 years to gather information from residents regarding maintenance issues that are not apparent from pipe and inlet inspections.

Ditch inspections should also be completed in portions of the City where roadside ditches are a main source of conveyance. The ditches should be inspected to ensure that blockages are not present and that the ditches continue to provide adequate conveyance. This is a relatively quick and easy “windshield” inspection that can be done annually. Roadside ditches often collect sediment and may need to be cleared periodically to provide adequate conveyance.

Figure B2:
System Structure Conditions &
Recommended Maintenance (north)

Legend

Storm Structures

- Poor Condition
- Fair Condition
- Good Condition

- Storm Sewer Pipes
- Streams
- Watershed Boundary
- Potential Project Areas

0 625 1,250 2,500 Feet

N

OLSSON ASSOCIATES
10/09/2012

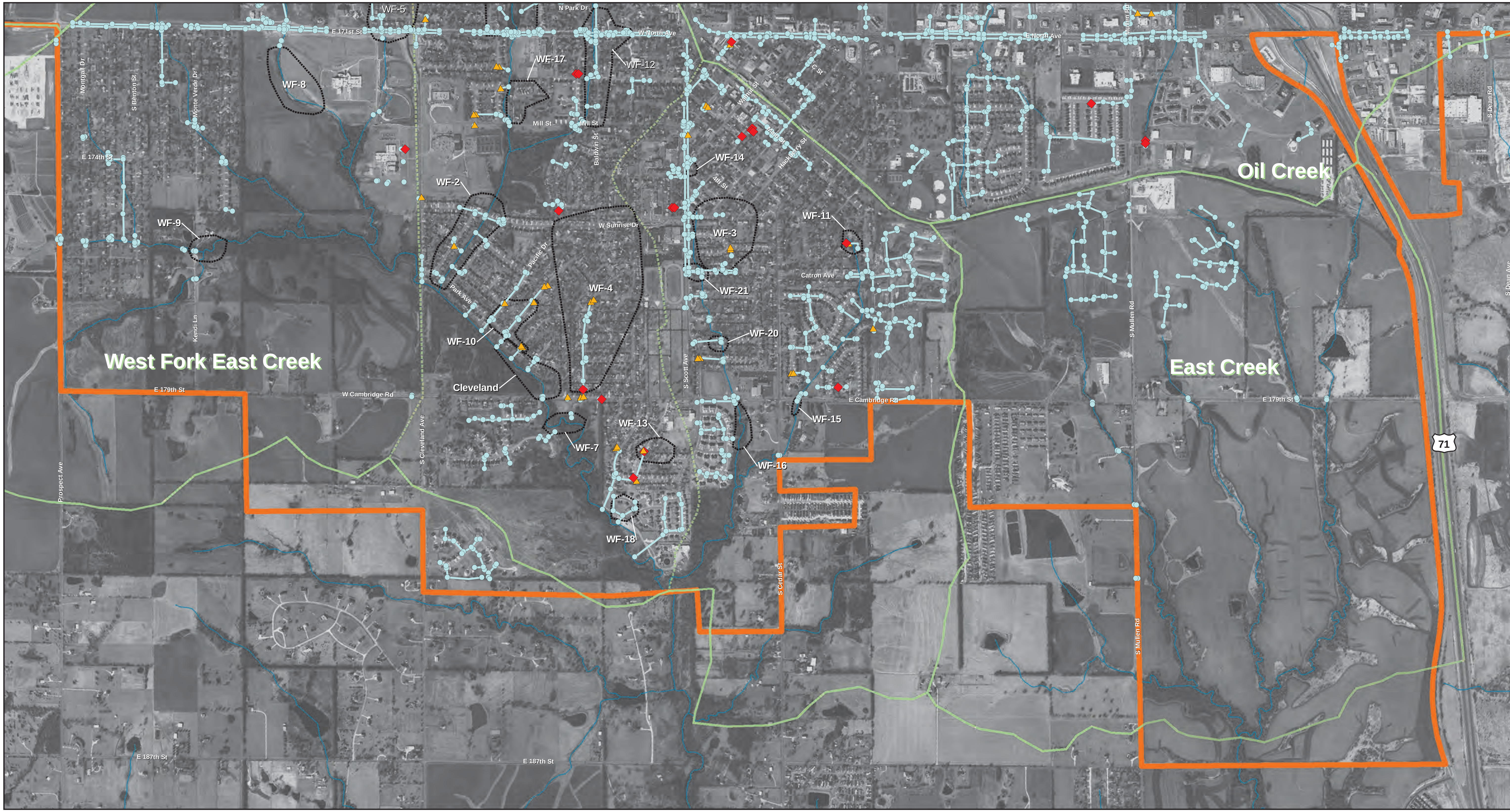


Figure B3:
System Structure Conditions &
Recommended Maintenance

Legend

Storm Structures

- Poor Condition
- Fair Condition
- Good Condition
- Storm Sewer Pipes
- Watershed Boundary
- Streams
- Potential Project Areas

0 625 1,250 2,500 Feet

N

OLSSON ASSOCIATES
10/09/2012

B-4. FUNDING NEEDS AND MECHANISMS

The City of Belton does not currently have a dedicated source of revenue for maintenance of or improvements to the drainage system. Based on per-foot pipe maintenance costs gathered from other local municipalities, the estimated cost for maintenance of the stormwater system for Belton is $500,000 per year. Stormwater maintenance and improvement costs are likely to increase due to inflation, infrastructure degradation that increases with age, and expanding state and federal stormwater program requirements. The present value estimated costs of needed improvements and ongoing maintenance outlined above are summarized below:

- ❑ Priority 1 capital improvements: $10.4M
- ❑ Priority 2 and 3 capital improvements: $5.2M
- ❑ Ongoing annual maintenance costs: $500,000

Due to the variety of needed stormwater management expenditures, a variety of funding mechanisms should be explored to maintain and improve the level of stormwater management service to the citizens, primarily:

- General Obligation (GO) Bonds
- Stormwater Utility
- Sales Tax

Each mechanism has been used by numerous municipalities both locally and across the country in order to fund stormwater improvements and maintenance. There is no one-size-fits-all approach, as each option carries its share of advantages and disadvantages, and proper application depends ultimately on the community's goals, needs and financial position. The table below briefly summarizes each option. Please note the estimated citizen impact costs below are approximate and would need to be calculated in full detail when a funding method is chosen for implementation.

Table B-3
Summary of Potential Stormwater Program Funding Mechanisms

Funding Option	Basic Structure	Recommended Application	Fund Generation, City & Citizen Impact	Advantages	Disadvantages or Limitations
GO Bonds	Low interest debt instrument typically used by cities to fund public infrastructure (same as Belton's 2006 bond issue)	Funding of initial Priority 1 capital projects estimated at $10.4M.	Funding amount limited by City's bonding capacity. City obligated to repay bond holders at specified rate.	+ Large amount of funds available up front to address most severe problems quickly + Low interest + Belton is familiar with the bonding process	- City pays interest - Not practical for multiple small cost repairs
Utility	Property owners are charged a fixed monthly fee to fund the stormwater program, typically based on an Equivalent Residential Unit (ERU) (1)	1. Fund annual maintenance of the existing system at $500k/yr. 2. Fund smaller Priority 2 and 3 capital projects, $5.2M over 10 years.	1. Cost per ERU estimated at $4.00/mo. to cover annual maintenance. 2. Cost per ERU estimated at approximately $8.00/mo. to fund annual maintenance and Priority Group 2 and 3 capital projects	+ Steady, predictable annual funding stream + Fee structure to citizens is equitable, based on runoff generation + Provides built-in incentive to reduce impervious area on properties	- Takes time to build funds; not ideal for completing urgent capital projects
Sales Tax	A dedicated amount of local sales tax is authorized for public improvements and maintenance.	1. Fund annual maintenance of the existing system at $500k/yr. 2. Fund smaller Priority 2 and 3 capital projects, $5.2M over 10 years.	1/4-cent sales tax would be needed to generate $500,000/yr covering annual maintenance. Additional 1/4cent could be added for 10 years to fund Priority 2 & 3 projects.	+ Part of the revenue is generated by out-of-town visitors + Stormwater can be combined with Parks program, which has been successful and voter-supported in many other cities	- Revenue can fluctuate greatly from year to year - Takes time to build funds; not ideal for completing urgent capital projects

(1) *Equivalent Residential Unit is a common stormwater utility measuring unit that is calculated based on the average impervious area (rooftop, driveway, etc.) on a typical single family lot. The ERU can be applied to commercial, industrial, school, church and other non-residential properties, which are then charged a fee for multiple ERUs as determined by the impervious area on the property.*

A property tax is another revenue generation option, but is less common and not recommended over the above options due to the fact the rate charged is based upon property value and not runoff generation or watershed impact. The average rate per parcel that would need to be charged across all parcels in Belton – residential, commercial, industrial and undeveloped areas – is approximately $5-$6/month for annual maintenance, and an additional $5/month to cover Priority 2 and 3 project costs, if desired. This is an approximation based on the total number of parcels currently in Belton. Actual rates will vary widely depending on land use and value, and would need to be calculated using specific property values for more exact revenue forecasting.

Based on Olsson's initial analysis and research, it is recommended the City explore utilizing a combination of general obligation bonds for initial Priority 1 Group Project implementation and a Stormwater Utility to fund annual ongoing maintenance.

B-5. PLANNING AND PREVENTION MEASURES

B-5.1 Water Quality Management

Belton is developing and growing on the periphery of the greater Kansas City metropolitan area, stormwater runoff reflects both the built environment as well as nearby agricultural lands. These dramatically impact water quality in our streams lakes, and parks. Primary pollutants affecting Belton's water quality include:

- Nutrients from fertilizers such as nitrogen and phosphorus
- Sediments from streets, parking lots, and disturbed ground
- Bacteria from pet wastes and other animal droppings
- Pesticides from weed and insect control chemicals

To reduce stormwater pollution, stormwater best management practices (BMPs) are required under the City's Municipal Separate Storm Sewer System (MS4) permit through the Missouri Department of Natural Resources (MDNR). A comprehensive stormwater management strategy for the City of Belton should combine structural and non-structural best management practices (BMPs) at a local site and regional level for surface water quality protection. Structural BMPs are constructed facilities that physically treat and manage runoff from specific targeted sites or areas; they do not reduce the amount of pollutants generated, but rather act to remove pollutants from runoff. Non-structural BMPs are designed to reduce or prevent pollution at the source through efforts such as land conservation, protective overlay zoning, stream buffers, and public education and outreach.
The MDNR MS4 requirements include six areas of compliance:

1. Public Outreach and Education
2. Public Involvement and Participation
3. Illicit Discharge Detection and Elimination
4. Construction Site Runoff Control
5. Post-Construction Runoff Control
6. Pollution Prevention and Good Houskeeping in Municipal Operations

Based on the known conditions within the City's watersheds, including land use and development practices, management strategies to achieve compliance with the MS4 requirements are recommended in this section. These recommendations combine primarily preventative actions, proactive planning efforts, public outreach programs, and structural BMPs for corrective actions in select areas.

1. Public Outreach and Education

The City will continue its program of informing and educating the watershed community as a key management tool. Water quality and quantity problems are often associated with the individual actions of residents and business owners, and the solutions are often voluntary practices by the same people. To accomplish public outreach and education goals, the following practices will be continued or are recommended for implementation:

A. Develop informational mailers and flyers for residents on best management practices they can practice at home. Examples of educational materials include:
   - Balanced maintenance of urbanized lawns and use of phosphorus-free fertilizers;
   - Packets for home owners on property maintenance and care;
   - Descriptions of the local watershed and conservation practices; and
   - Activities within the watershed and how residents can get involved.

B. Issue regular press releases about yard maintenance, waste management, and stormwater quality.
C. Maintain a relationship with area schools: visit classrooms, facilitate field trips, distribute informational materials, and organize student stream clean-ups.
D. Continue the storm drain stenciling program throughout the city that informs residents "DRAINS TO STREAM – DO NOT DUMP WASTE".
E. Develop and maintain a stormwater management web page for informational and public input purposes.

The City will document all public outreach and education programs and their outcomes.

2. Public Involvement and Participation
The City will continue its program of public involvement and participation in stormwater management and pollution control. Records of public participation events and their outcomes will be maintained as a requirement of the MS4 permit compliance.

3. Illicit Discharge Detection and Elimination
The City of Belton will develop an ordinance for monitoring, detecting, and managing illicit discharges into and out of the stormwater sewer system. The enacted ordinance will include a program with measures for monitoring the more than 200 stormwater outfalls in the City, tracking illicit discharges, including citizen complaints and monitoring reporting, and enforcement of illicit discharge ordinances. A model illicit discharge ordinance was provided to the City and is planned for adoption in 2012. Additional actions include:

- Identify and map known point pollution sources (filling stations, industrial areas, etc)
- Develop and implement screening/detection protocols
- Evaluate staff availability and authorization to check into potential ID's

4. Construction Site Runoff Control
The City of Belton will continue its program of construction site stormwater control through the following actions:

- Preparation and submittal of a stormwater pollution prevention plan (SWPPP) with each new development or construction site that disturbs more than one acre.
- Requirement for erosion and sediment control BMPs on all construction sites.
- Monitoring and enforcement of all construction site SWPPPs, with provisions of

penalties for non-compliance.

- Repair or replacement of damaged or ineffective sediment control BMPs within seven days.
- Elimination of construction site illicit discharges.

5. Post-Construction Runoff Management

The City will establish a Post-Construction Runoff Control Program through the development of ordinance and policy for stormwater management, and the implementation of specific water quality projects that comply with this requirement of the MS4 permit. The following actions are recommended.

Action No. 1: Adopt a Stormwater Quality Ordinance and Design Criteria for New Development

As required by MDNR, the City of Belton is working on the development of a Stormwater Quality Ordinance and design criteria for adoption by City Council. The ordinance would require that all new development and redevelopment that increases impervious area on a given site must incorporate Best Management Practices (BMPs) for water quality. Furthermore, the ordinance sets forth maintenance requirements, enforcement and penalties, plan review procedures, bonding requirements, inspections, and other key elements required for long-term implementation and performance of BMPs in new development. An example ordinance is provided in Appendix F.

The recommended design criteria for stormwater management and BMPs are current editions of:

Standard Specifications and Design Criteria, Seciton 5600
Kansas City Metropolitan Chapter American Public Works Association

Manual of Best Management Practices for STormwater Quality
Mid-America Regional Council

The criteria and requirements set forth in these documents are the generally accepted criteria manuals for the Kansas City Metropolitan Area, but they are not absolute for all communities or in all instances. It is recommended the City of Belton adopt the majority of these manuals, with some supplements and exceptions that would ultimately be discussed and thought through by City staff. Generally, these manuals provide good guidance for BMPs on new development, exceptions for new development, and a varying stormwater detention strategy by watershed that is recommended in Section B-5.3 of this Plan. The primary recommended exceptions to these criteria involve trimming down the list of BMPs that would be used on developments and providing developers a guide matrix on where to apply certain BMPs based on the development type. Below is an example of such a matrix followed by brief descriptions of recommended BMP types for application in Belton that address the key pollutants described above.

Table B-4
Local and Private BMP Applicability

Land Use	Rain Gardens & Bioretention	Native Landscapes	Vegetated Swales	Pervious Pavement	Wet & Dry Detention, Wetlands
Commercial & Industrial	0	-	-	+	+
High Density Residential	+	0	0	0	+
Low Density Residential	0	+	+	-	+

Legend
- **-** Not Recommended
- **0** Somewhat Applicable
- **+** Highly Applicable

Rain Garden and Bioretention Gardens: A rain garden is a small residential depression planted with native wetland and prairie vegetation (rather than a turfgrass lawn) where sheet flow runoff collects and infiltrates. Typical sites for rain gardens include residential yards and community common areas. Bioretention gardens are similar to very large rain gardens that are often used to collect runoff from large areas, such as parking lots. Bioretention gardens promote infiltration of runoff, and include underdrain systems that help drain the bioretention cell in low-permeability soil applications.

Application of a Bioretention Garden in a Suburban Neighborhood

Vegetated Swales: Vegetated swales are typically drainage swales that are planted with native vegetation. Swales have gently sloping sides and are used to convey the overland flow of stormwater down a subtle gradient. Swales accomplish many of the same functions provided by filter strips (slowing and cleaning water, encouraging infiltration, etc.), while also providing directed conveyance. This conveyance function is particularly important when managing concentrated flows and during severe storm events when stormwater needs to be directed to a destination, such as a wetland.

Pervious Pavement: Pervious pavement is a porous, solid road, parking lot, or walking surface that allows precipitation to infiltrate through pore spaces in the paving material. Materials used for pervious pavements include brick, concrete, asphalt, plastic, rock, and gravel. Pervious pavement is suitable at a variety of scales, including individual driveways, trails, overflow parking lots, and light traffic roadways.

Native Landscapes: Undisturbed or native landscaped areas can serve many BMP functions. They can help reduce erosion by protecting the underlying soil from splash erosion and slowing velocity of runoff. They can reduce off-site runoff by providing infiltration. They can filter sediment and other pollutants from stormwater runoff. They can also provide wildlife habitat and aesthetic values for the public.

Dry and Wet Detention: Wet detention is typically a constructed pond or lake. They are generally considered "end-of-the-pipe" BMPs. Dry detention basins are stormwater basins that are designed to intercept a volume of stormwater runoff and temporarily impound the water for gradual release to the receiving stream or stormwater system. They are effective at capturing and storing runoff, and allowing many pollutants to settle to the bottom, or organic pollutants to decompose.

Wetlands: Treatment wetlands are typically shallow stormwater detention systems that facilitate flow of water through wetland vegetation to filter pollutants from stormwater while also detaining and slowing runoff velocity. Treatment wetlands are very effective for removing most pollutants and protecting streams and lakes.

Action No. 2: Post-Construction Runoff Management - Regional and Public BMPs

Stormwater BMPs that can be implemented on a larger, regional scale include both wet and dry detention basins, as well as treatment wetlands. An example of such a BMP includes the proposed Cleveland Lake, located on the west side of Belton being constructed for flood control and recreation, but also serves to improving water quality by capturing sediments, filtering nutrients and pesticides, and removing metals from stormwater that flows to the wetland and lake complex.

Recommended applications of regional and public BMPs that improve water quality in Belton include:

1. A wet retention pond, planned as Markey Lake, located along an unnamed tributary of Oil Creek east of Highway Y, north of the Price Chopper shopping complex. This wet retention pond will aid in flood control as this area is developed while also capturing sediments, nutrients, and metal pollutants emanating from areas west of Highway Y, particularly as new development occurs.
2. Dry detention basin at Cherry Hills Drive, north of East 171st Street, and the interface of undeveloped farmland and residential community (Project WF-6). This dry detention will serve to remove sediments, nutrients, and pesticides eroding from farm field runoff that flow south toward Cleveland Lake. Removal of these pollutants will increase the water quality and lifespan, as well as reduce the maintenance, of Cleveland Lake.
3. Wet detention pond near Prospect Avenue, north of Cambridge Street (Project WF-9). Wet detention will serve to capture sediments from this currently undeveloped area that may be developed in the future. This pond will protect and cleanse water and protect Cleveland Lake.
4. Bioretention and rain gardens in the mid-town area, along South Scott Avenue, north of Cambridge Street (Projects WF-14 and WF-21). Bioretention gardens can be well-applied in public areas such as school grounds and parks, as well as adjacent to parking lots near

shops and churches. Rain gardens can be planned with local residents to reduce flow and improve water quality from private residential lots. These actions will primarily remove oils and greases, nutrients, and pesticides from stormwater runoff flowing south.

6. Pollution Prevention and Good Houskeeping in Municipal Operations

The City will inspect all public maintenance facilities to monitor pollution prevention and good housekeeping procedures, and to inspect for controls to contain and treat polluted stormwater runoff. The City will also develop and implement program documentation that includes the following:

1. Develop an inventory of all municipal facilities and operations and develop a stormwater pollution plan template that can be applied to all facilities.
2. Listing of Standard Operating Procedures, such as annual inspections, for pollution prevention and good housekeeping practices.
3. Documentation of good housekeeping/maintenance practices.
4. Employee training program, including documentation of training.

B-5.2. Stream Buffers

The City of Belton stormwater regulations currently require a minimum stream buffer width of 80 feet, or the floodplain limits as shown on the Flood Insurance Rate Map (FIRM) and Flood Boundary and Floodway Map (FBFM), whichever is greater. Through discussions with City staff, it may be desirable to set forth minimal buffer widths based solely on protecting properties from active lateral stream migration, then provide incentives to widen the buffer in order to meet water quality and open space requirements. As part of the city-wide geomorphic analysis, aerial photography was used to assist in determining a suitable stream buffer width for streams located in Belton. The meander belt width (generally the corridor within which a stream has and is expected to meander or migrate over time) was calculated as a function of the drainage area for each stream using geomorphic relationships developed by the NRCS for the Osage Plains region. The buffer width is measured outwardly from the high water mark and the calculated meander belt width shown below is measured outwardly from the valley center line. The calculated meander belt width was drawn and compared to the APWA Section 5605 stream buffers standard as well as a constant 80 foot stream buffer in order to determine the stream buffer that Belton should implement moving forward. Table B-5 on the following page shows the buffers and meander belt width as a function of the drainage area.

Table B-5
Stream Buffers and Meander Belt Width

DA (acres)	Constant 80 ft Buffer	APWA Standard	Calculated Meander Belt Width
10	80	40	19
20	80	40	24
30	80	40	28
40	80	40	31
50	80	60	33
60	80	60	35
70	80	60	37
80	80	60	39
90	80	60	40
100	80	60	42
120	80	60	45
140	80	60	47
160	80	100	49
180	80	100	51
200	80	100	53
400	80	100	67
800	80	100	84
1600	80	100	106
3200	80	100	133

The analysis showed that the APWA standard for stream buffers will contain the meander belt width. For smaller drainage areas both the constant 80 ft buffer and the APWA standard are conservative. For drainage areas greater than 800 acres the constant 80 ft buffer is inadequate while APWA is still sufficient. The APWA standard appears to be the most suitable stream buffer for Belton and is recommended for adoption and use in Belton, but adjustments may be made to avoid unnecessary buffer in smaller drainage areas.

Figure B4:
Stream Buffer Comparisons (northwest)

Legend

- APWA Buffer
- Current City Buffer
- Streams
- Watershed Boundary
- Potential Project Areas
- City Limits

0 625 1,250 2,500 Feet

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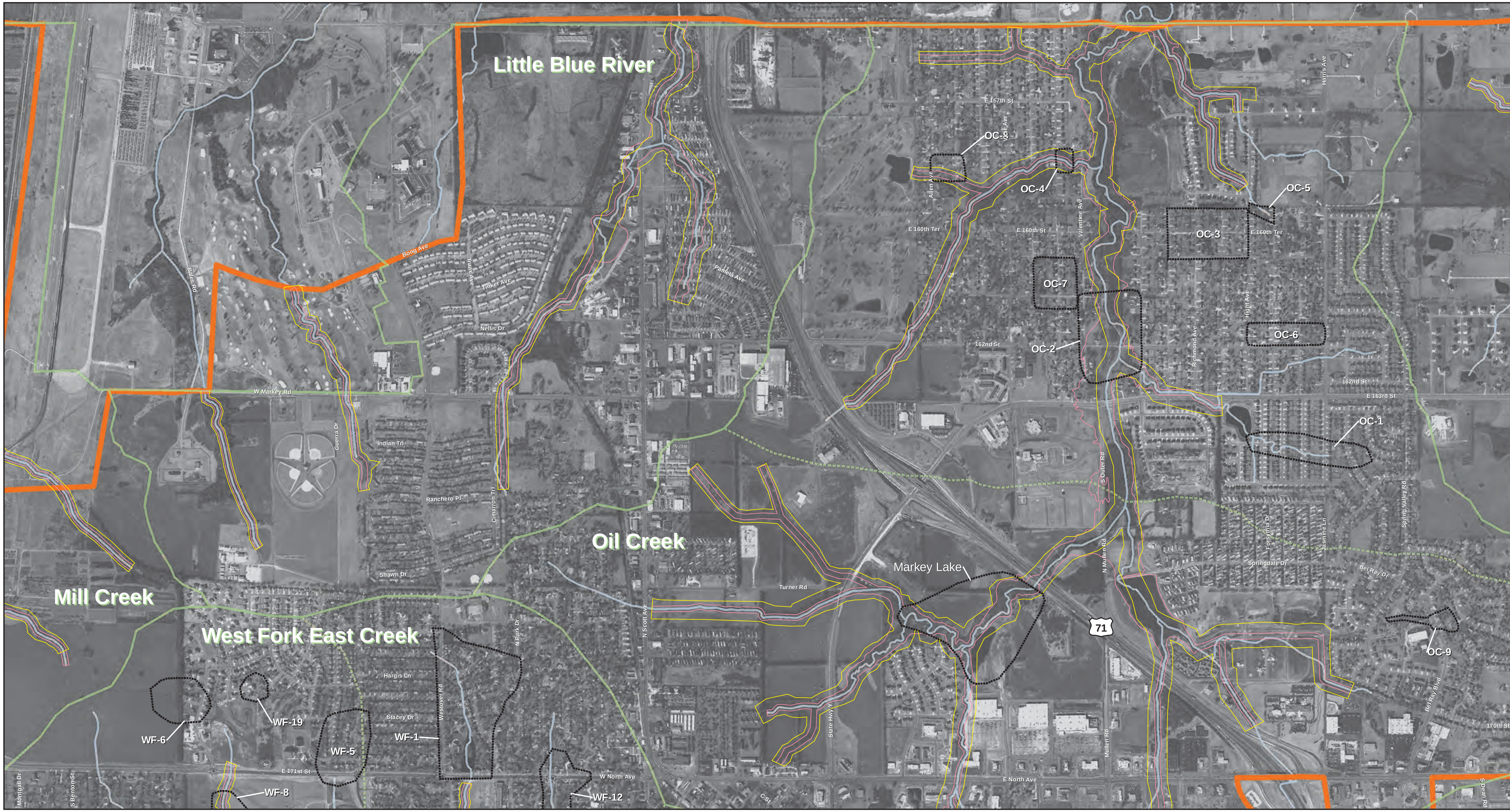

Figure B5:
Stream Buffer Comparisons (northeast)

Legend

- APWA Buffer
- Current City Buffer
- Streams
- Watershed Boundary
- City Limits
- Potential Project Areas

0 625 1,250 2,500 Feet

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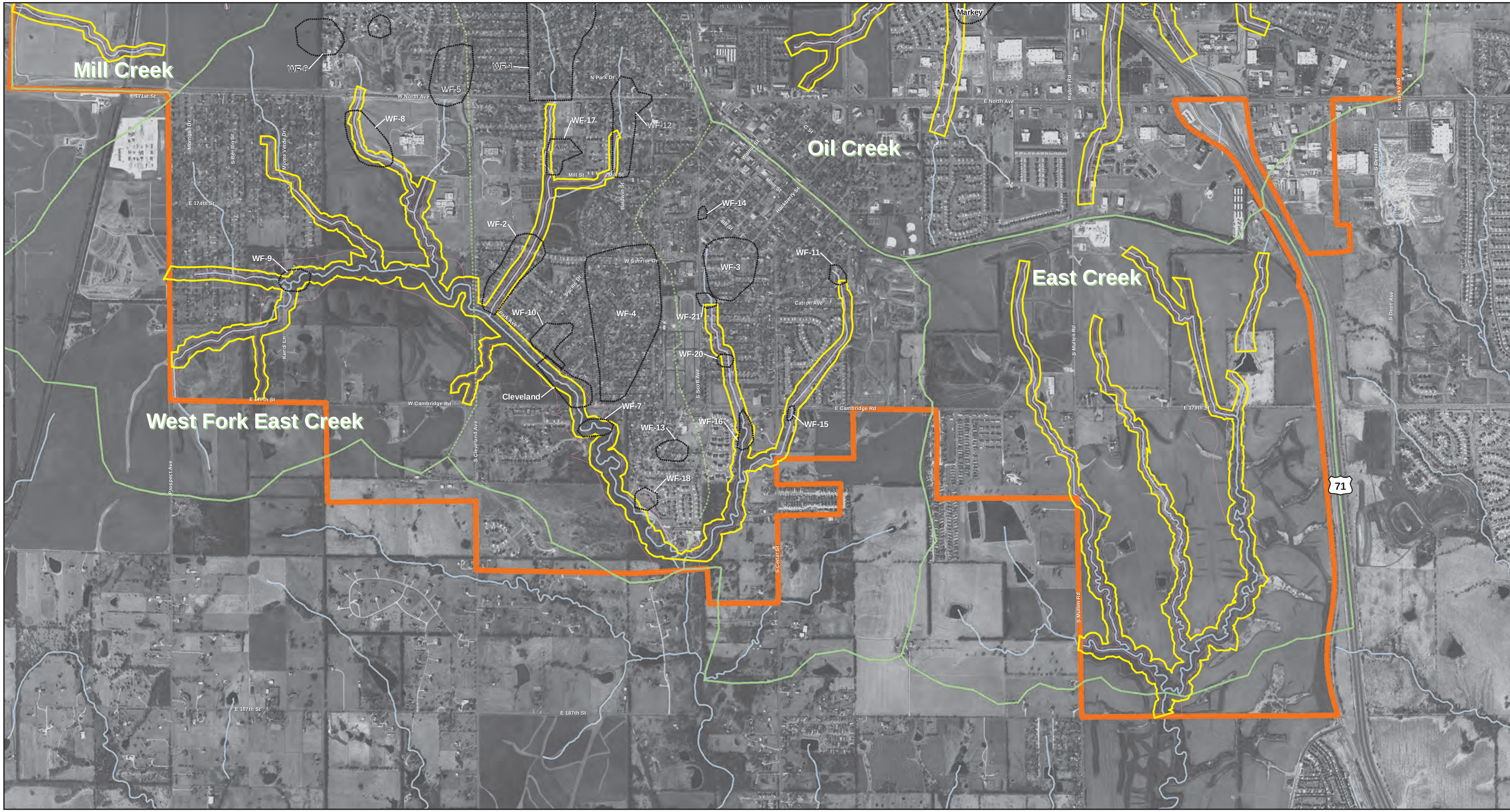

Figure B6:
Stream Buffer Comparisons (south)

Legend

- APWA Buffer
- Current City Buffer
- Streams
- Watershed Boundary
- Potential Project Areas
- City Limits

0 625 1,250 2,500 Feet

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B-5.3. Private Development Detention Strategies by Watershed

The City of Belton is in various stages of development throughout the City, and as such, flooding problems differ throughout the City. Four different detention strategies were developed and recommended to provide customized stormwater management for various watershed conditions. Several factors were considered for each section of the City when determining the appropriate detention strategy. Some of the major factors considered were runoff from a site may be limited by the need to minimize downstream flood damage, prevent erosion, and/or minimize impacts to the ecology and water quality of the downstream drainage system. For detention controls to be effective they must be applied across a watershed. The following four strategies are recommended for application on new developments in the areas illustrated in Fig. B-7.

Comprehensive – This is the default strategy and covers the majority, approximately 74%, of the City. This strategy provides peak runoff control for the 1%, 10% and 50% chance storms and volumetric and/or extended detention control of the 90% mean annual event storm for broad protection of the receiving system, including channel erosion protection and flood peak reductions over a range of return periods. This strategy should also be utilized for new land annexations to the City.

Frequent - This strategy provides runoff control for the 10% and 50% chance storms and volumetric and/or extended detention control of the 90% mean annual event storm in order to protect downstream channels from erosion. This strategy is appropriate for largely undeveloped watersheds containing natural streams where downstream flooding of existing structures is not present and would not occur under future upstream full-development conditions. This strategy covers approximately 5% of the City.

Extreme - Under this strategy, detention is provided solely to reduce peak runoff rates for the 10% and 1% storm events. Over-detention of the peak release rates at the discharge point (i.e. requiring the post-development rate to be less than the pre-development rate) is used to ensure a cumulative benefit for a reasonable distance downstream. This strategy is not effective at protecting stream channels and banks from erosion. It is most applicable in certain redevelopment and in-fill situations where flooding problems are known, existing downstream stream conditions are already poor, and economic barriers to redevelopment preclude more extensive control. This strategy covers approximately 16% of the City.

Special – Two areas in Belton are designated as special detention areas. These areas are designated for alternative strategies that are tailored to specific circumstances of the watersheds. The first special detention area is located west of US Highway 71 and west and east of Sate Highway Y. This area is designated as special because detention for development in this area should be provided regionally by the planned Markey Lake that will be built in conjunction with Markey Parkway. Development in the contributing drainage area will pay a fee to forgo detention on their property. The collected fees will allow detention to be provided regionally while providing a public amenity. The second special detention area will be located on the former golf course north of 162nd Street and west of Allen Avenue. This area is designated as a special detention area because the downstream area has several homes that are adjacent to a natural channel that could be flooded if runoff increases. Over-detention should be utilized in this area to prevent any adverse effects on the downstream channel and impacts to adjacent homes.

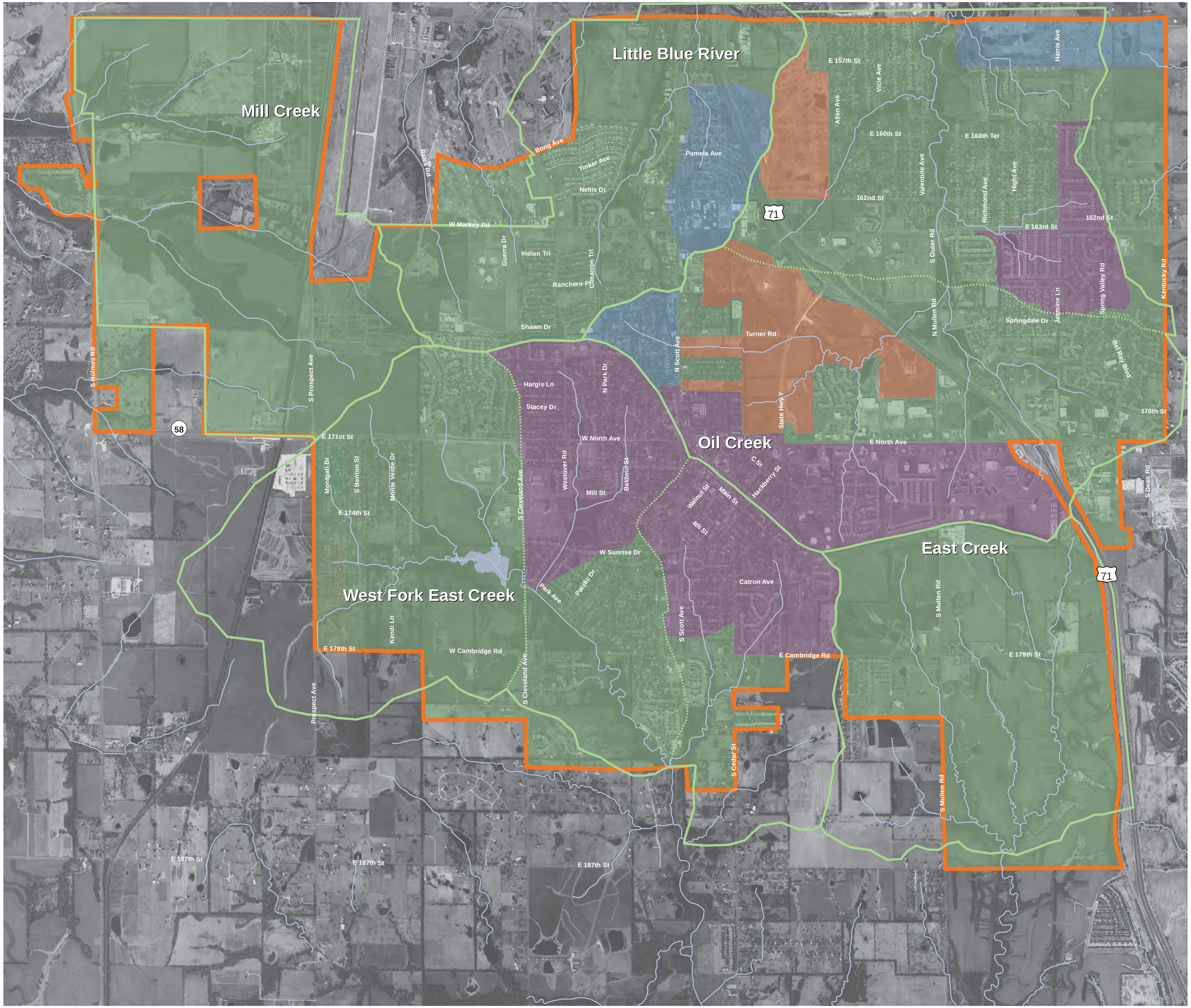

Figure B7:
Detention Strategies by Watershed

Legend

Det Zone Strategy

- Comprehensive
- Extreme
- Frequent
- Special

- Stream Centerline
- Watersheds
- Sub Watersheds
- City Limits

1 inch = 2,500 feet

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B-5.4 Floodplain Management Policies

Effective floodplain management policies and procedures within the City can significantly reduce risk of future flood damage to new development, reduce residual risk to existing development within and adjacent to the floodplain, and minimize risk to public infrastructure. Traditional flood reduction strategies and risk management often focused on structural improvements such as fills in the floodplain, levees or dikes, rerouting streams, or other projects to alter the natural stream and control flooding. While many of these projects met their original design purpose, some of these flood control projects were based on then existing hydrology and were not necessarily designed to a 1% annual chance flood protection level. There is currently a much better understanding of flood damage risk and managing this risk in and near floodplains, and design guidance and recommendations have been updated to reflect this better understanding of flood risk management.

The City of Belton participates in the National Flood Insurance Program (NFIP), a federal program originally enacted by Congress 1968, which provides subsidized flood insurance to residents in communities where certain minimum floodplain development regulations are enacted. The City's current floodplain development code covers development in and adjacent to the 1% annual chance floodplain identified in the Flood Insurance Studies and on the Flood Insurance Rate Maps promulgated by FEMA, with some exceptions. It requires habitable structures to be built or flood proofed to the base flood elevation (1% chance flood elevation) or 1 foot above the base flood elevation. The ordinance also requires a stream buffer the width of the existing floodplain in areas where the FEMA floodplain is identified and in areas subject to flooding in a 100-yr event. The code identifies certain activities that are allowed within the stream buffer, and it appears that habitable building construction is not one of the allowed activities. The code does not allow platted lots to include any land shown in the FEMA floodplain or include areas subject to flooding in a 100-yr storm. The FEMA floodplain mapping is currently being updated by FEMA and its contractors, and new maps may become effective in 2013.

The City's existing floodplain regulations, including buffer requirements, provide a good basis for reducing future flood risk to development and public infrastructure along streams and floodplains. It is recommended that these codes continue to be uniformly applied throughout the City to allow continued development along streams while minimizing the risk of future flooding. In addition, recommended enhancements to these codes and policies to reduce future flood risk include:

- Require all residential and non-residential construction adjacent to an open channel to have a finish floor or low opening a minimum of 1 foot above the ultimate (developed) conditions 1% annual chance flood elevation.
- Complete Letter of Map Revision (LOMR) in a timely manner for all changes in the FEMA floodplain, including fill, roadway structures, and other enhancements.

B-5.5. Public Education and Outreach Practices

Continuing to inform and educate the citizens and watershed community as a whole is recommended as a key management tool for the City of Belton. Water quality and quantity problems are often associated with the individual actions of residents and business owners, and the solutions are often voluntary practices by the same people. Effective public involvement and education help promote the adoption of management practices. To accomplish public outreach and education goals, the following practices outlined in Section B-5.1 are outlined below along with critical actions and budgetary costs:

A. Develop informational mailers and flyers for residents on best management practices they can practice at home. Approx. 5,000 count: budget $7,000 annually

B. Maintain a relationship with area schools: visit classrooms, facilitate field trips, distribute informational materials, and organize student stream clean-ups. Budget: $1,000-$2,000 annually.

C. Continue the storm drain stenciling program throughout the city that informs residents "DRAINS TO STREAM – DO NOT DUMP WASTE". Budget $1,000-$2,000 annually.

D. Develop and maintain a stormwater management web page for informational and public input purposes.

B-5.6. Conservation Overlay Zoning Districts Recommendations Overview

This section recommends the creation of a new Conservation Overlay District (COD) zone to apply to areas mapped on the Storm water Master Plan, Figure B-4.2.1. The COD applies as an overlay, regardless of the underlying zoning, with the intent to protect the water quality of key water resources.

The COD would apply to all new projects in the mapped areas. It would have four categories of Standards for review:

1. Site Planning. This is a review of the overall site planning criteria for projects. It would include street and subdivision layout, location of buildings, and location of key engineering features.
2. Landscape Design. Landscape design is a detailed review of the particular sites, including species of plants, locations and quantities.
3. Erosion Control. This item is a review of all of the erosion control measures that will be taken to during and after construction.
4. Storm water Management. A detailed review of all design features that are intended to control and/or direct storm water, including Best Management Practices (BMP's).

For each category of standards, a list of suggested design and management techniques would be provided. Those techniques each would carry a corresponding series of weighted points. The idea is that any application must meet a certain number of points in order to be approved, but that those techniques can be drawn from each of the four categories as they choose.

The point chart would be further divided into three categories:

1. Minimum requirement for approval
2. Green incentive level
3. Gold incentive level

The incentive levels are set up to encourage applicants to go above and beyond the base requirements. In essence, this is a carrot and stick approach to encourage better-designed projects, while still providing a minimum that protects the resources. Incentives can include:

1. Municipal Fee Waivers (TBD)
2. Density bonuses
3. Alternate Street Standards – allow construction of narrower streets, lower cost road/sewer infrastructure
4. Expedited approval process

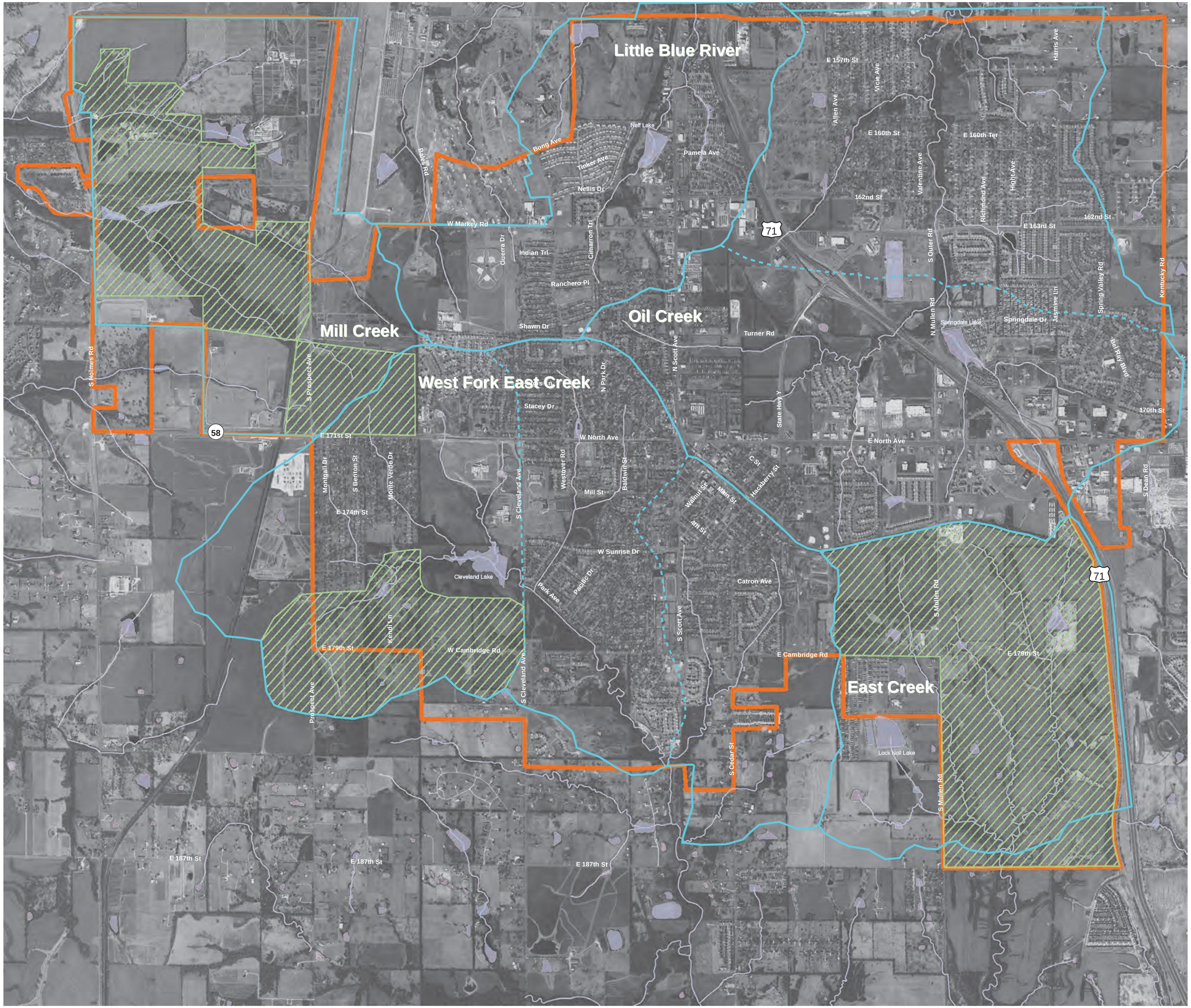
The incentives would have limitations, so that they cannot be abused, or cause harm to the City. For example:

1. Fees can't be waived beyond a certain level
2. Still have maximum densities, based on the underlying zoning (but higher than typically allowed)
3. Still have certain minimum infrastructure requirements
4. Approval process still has to meet state requirements

Below is a list of some suggested base requirements for each of the 4 categories, which would ultimately need to be discussed and finalized among City staff, and rated accordingly:

1. Site planning to minimize infrastructure (minimizing runoff)
    a. Limited pavement area – no cul-de-sacs or driveways longer than 40'
    b. No one-sided streets
    c. Provide park and public spaces, with 25% set-aside. Public spaces must contain useful public amenities – trails, playgrounds or fields.
    d. Cluster lots at ¼ acre maximum, with 50% set-aside for public space
    e. All lots are over 10 acres
2. Landscape Design
    a. Use of Landscape Design BMP's (use of native species, plants good for water quality, etc)
    b. Provide X trees per lot outside of ROW
    c. Provide street trees at X spacing in ROW
3. Erosion Control
    a. Specific erosion control measures during construction
    b. Specific erosion control measures post-construction
4. Stormwater Management
    a. Use of BMP's - refer to most updated version of MARC/APWA Manual

Figure B8: Recommended Conservation Overlay Districts



Legend

- Watersheds
- Sub Watersheds
- Stream Centerline
- Recommended Conservation Overlay Districts
- Lakes
- City Limits

1 inch = 2,500 feet

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B-5.7. Benefit Districts for Regional Detention and BMPs

Within Belton several opportunities exist for the placement of regional Best Management Practices (BMPs) and detention facilities. The regional facilities allow the development to occur in upland areas and the treatment or detention to occur further downstream in the watershed. Regional facilities can also be built to protect homes or property downstream that have flooding issues. Regional BMPs can also be constructed to protect a sensitive environmental location or water body that is downstream of development, or a combination facility could be constructed. A regional facility can also provide water quality benefits and detention benefits that would not be feasible on a small scale. Regional facilities are also beneficial because they can provide a public benefit in terms of recreation and education.

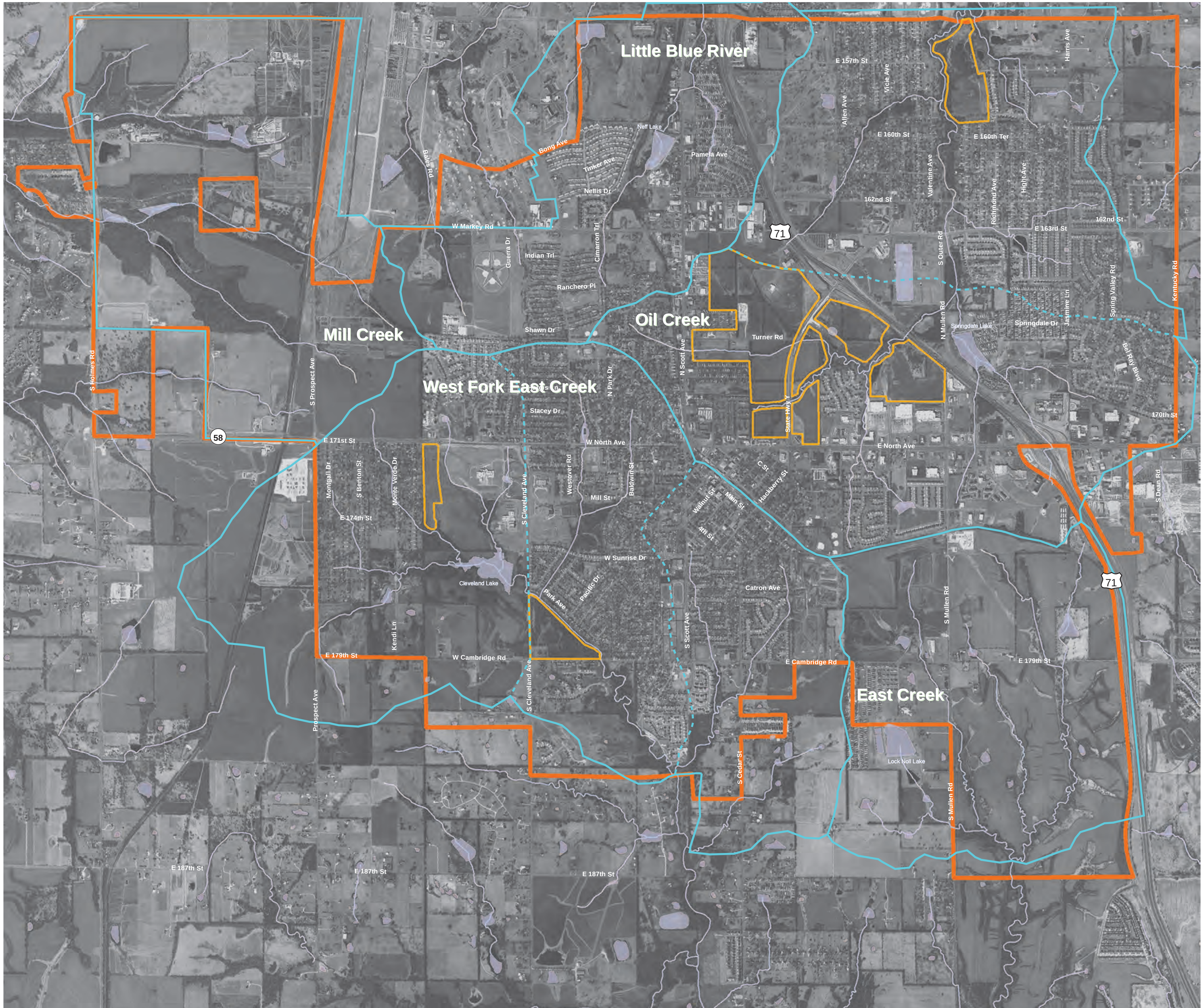
In order to fund these regional facilities developers would be asked to contribute to fund the regional facility to be able to forgo detention on their property. A case study was completed to explore the costs associated with providing regional detention for various types of developments. Several assumptions were made to compute the approximate costs for detention. It was assumed the slope of the site did not change and that storage would need to be provided for the 100-year difference in volume between proposed and existing conditions. The costs of the detention basin outlet and piping were assumed to be equal for all types of development. The approximate costs for detention can be seen in the following table.

Table B-6
Typical Detention Costs per Acre of Development

Development Size	Percent Impervious		
	<40%	40-70%	>70%
less than 25 ac	$1,004	$1,287	$1,717
greater than 25 ac	$501	$785	$1,215

As can be seen in the previous table the costs for development approach each other for developments of less than and greater than 25 acres. If a regional facility was developed the City could have developers pay a fee based on the above table to provide detention in a regional facility. Further analysis would need to be conducted to account for land prices in the watershed area.

Figure B9: Future High Growth Areas



Legend

- Watersheds
- Sub Watersheds
- Stream Centerline
- Future High Growth Areas
- Lakes
- City Limits

1 inch = 2,500 feet

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C-1 Citizen Stormwater Survey Response

The citizens of Belton were engaged in many ways throughout the stormwater master plan process. One of the first steps in communicating with residents as part of the stormwater master plan was sending out a questionnaire to the residents. The questionnaire was sent to all Belton households in May 2011 with the monthly water bill. On the questionnaire residents reported home and street stormwater flooding, sanitary sewer backups, and erosion caused by stormwater. The complete form can be seen in the Appendix. Out of the estimated total of approximately 5,000 addresses, 543 households responded for a return rate of roughly 11%. Several public meetings were also held to gather public comment and opinion. The public meetings held are listed below:

- December 15, 2011 – Gladden Elementary School
- May 10, 2012 - Belton Citizen Appreciation Fair – Wallace Park
- May 2, 2012 – Mill Creek Elementary School
- May 14, 2012 – High Blue Wellness Center

At the public meetings residents were presented with maps of the City with identified problem areas and potential solutions. The residents then spoke with Olsson and City staff about the problems and potential solutions. Residents present at the public meetings were encouraged to complete stormwater questionnaires. The results of the stormwater questionnaires can be seen in Figure C1.

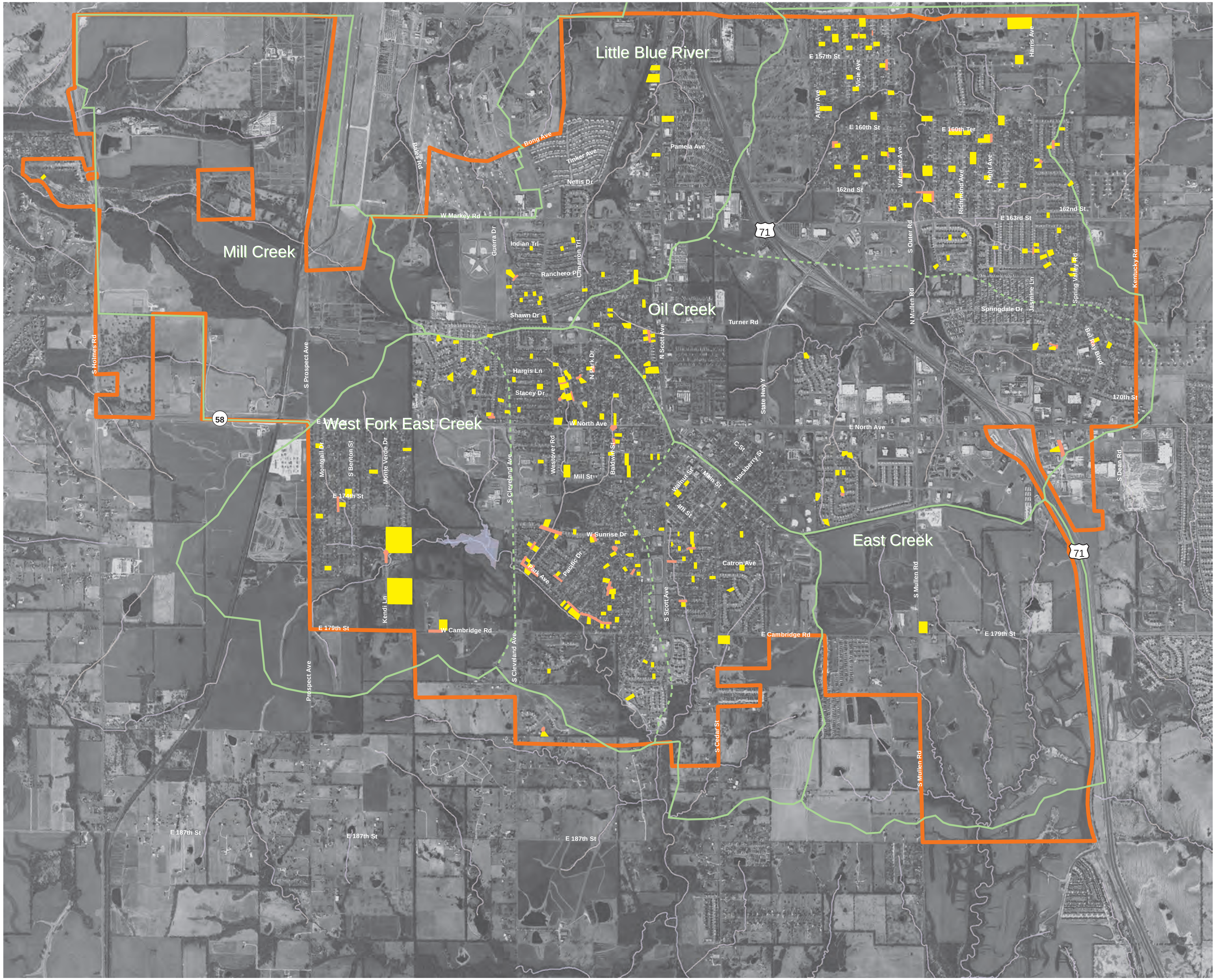

Figure C1:
Citizen Survey Response Map

Legend

- Watersheds
- Sub Watersheds
- Stream Centerline
- Reported Flooding
- Street Flooding
- City Limits

1 inch = 2,500 feet

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C-2 Storm Drainage System Inventory

A storm sewer system survey and inventory was completed for the City of Belton storm sewer system. The system inventory consisted of several actions, including:

- Locating existing visible storm sewer outfalls along major stream and visible storm sewer system structures.
- Providing a horizontal location, top elevation, structure invert elevation, and size, type and direction of incoming and outgoing pipes 12" and larger.
- Identifying detention basins whose outfalls lie on the storm sewer system.
- Completing a structure condition assessment of inventoried structures. The assessment included a visual evaluation of the invert, walls, sides, and top of inlet and the inlet opening. The structure was given a score of new, good, fair, or poor.
- Inputting the inventoried pipes and structures into a GIS database.

A total of 2,882 storm structures were identified during the inventory and 2,453 pipe segments were identified. The distribution of the structures condition can be seen in the following table:

Table C1
Summary of Belton Storm Sewer Conditions

Structure Condition	Number of Structures	Percentage
New	72	2.5%
Good	2,563	88.9%
Fair	69	2.4%
Poor	40	1.4%
Inaccessible	138	4.8%

The inaccessible structures could not be accessed primarily due to the structures location underground. Video recording of the storm sewer not completed as part of this project. The condition survey of the pipe segments was completed from a visual inspection at the end of the pipe if possible. A complete GIS database was developed and included with this Master Plan for future use and system management by the City. Recommended maintenance actions are outlined in Part B of this report.

C-3. Hydrology & Hydraulics Methodology

C-3.1 Watershed Modeling

<u>Open Channel Modeling</u>

The Corps of Engineers HEC-HMS computer program was used to calculate the open channel flow rates at desired locations in the watershed. The HEC-HMS computer program simulates rainfall and generates runoff hydrographs for each sub-area within a watershed. The program then routes the runoff hydrographs through the various drainage system components of the watershed, including pipes, open channels, and reservoirs. Runoff and stream flow is simulated based on the specific input parameters used for each component of the overall drainage system. The SCS Curve Number option within HEC-HMS was used to determine the existing and future conditions runoff rates. The hypothetical design storms used for the watershed model were generated using the 10%, 2%, 1%, and 0.2% probability 24-hr rainfall amounts (10, 50, 100, and 500 year return interval) for Cass County and the SCS Type II, 24-Hour rainfall distribution. The Muskingum-Cunge 8-point channel routing option was used to route the flow through the watershed. The channel shape was estimated based on 2-foot contour interval topographic mapping provided by the City of Belton..

The Corps of Engineers HEC-RAS computer program was used to model and generate the water surface profiles for open channels in Belton using the peak flows generated by the HEC-HMS program described above. Cross-sections used for modeling flows in open channels were generated from 2-foot contour interval topographic mapping using the Corps of Engineers HEC-GeoRAS computer program.

Enclosed System Modeling

The XP-SWMM computer program was used to develop and route flows in the enclosed stormwater system. XP-SWMM simulates rainfall-runoff processes and generates runoff hydrographs for each sub-area in the watershed. The program then routes the hydrograph through various drainage system components of the watershed, including pipes, open channels, and detention ponds. Runoff and enclosed system flow is simulated based on input parameters for each component for the drainage system. The SCS Curve Number method was used to determine the existing and future condition runoff for the sub-areas for the 50%, 20%, 10%, and 1% probability design storms. The hydraulic routing in XP-SWMM is achieved by the use of a dynamic wave routing procedure. The hypothetical design storms used for the watershed model were generated using the statistical 24-hr rainfall amounts for Cass County and the SCS Type II, 24-Hour rainfall distribution. Cross-sections used for modeling flows in open channels were generated from 2-foot contour interval topographic mapping.

Model Development

Hydrology was modeled using the HEC-HMS program to determine flows at approximately 120 locations within the corporate limits of the City of Belton. Hydraulics were modeled using the HEC-RAS program to calculate water surface profiles in the watershed’s major drainage channels and model hydraulic structures for the peak flows calculated by HEC-HMS.

The hydrologic analysis was performed by dividing sections of the City of Belton into watersheds and into sub-areas for runoff determination. The Soil Conservation Service, (SCS) Curve Number option within HEC-HMS and XPSWMM computer programs were used to calculate the runoff in each sub-area. The SCS Curve Number Method takes into account such factors as the size of the drainage area, slope of the ground surface, nature of the soil, and type of ground cover. The method requires the determination of a Lag-Time (L_t) and a curve number (CN) for each sub-area under consideration. The Lag Time is defined as the time interval between the time of the peak rainfall and the time of peak runoff in the sub-area, and is dependent on the length and slope of the drainage path and the Curve Number. In general, developed areas will have shorter Lag Times than undeveloped sub-areas of equal size and shape. The Curve Number is a measure of the nature and imperviousness of the ground surface, and in general will be higher for developed areas than for undeveloped areas.

The hydraulic analysis of open channel systems greater than 160 acres was performed by dividing the conveyance system into sub-reaches defining the cross-section, slope, length, and other hydraulic properties of the watershed’s various open channels, culverts, and pipe systems. HEC-GeoRAS computer program was used to delineate cross-sections of the open channels and other geometric data required by the HEC-RAS program such as stream bank locations and distance between cross sections. The HEC-GeoRAS program, allows geometric data to be entered directly into HEC-RAS from a 3-dimensional terrain model which was developed from the 2-foot contour topographic mapping, using the ARCVIEW GIS computer program. The HEC-RAS computer program was then used to model the flows and calculate water surface elevations in open channels and culverts. The XPSWMM computer program was used to model flows in the pipes and inlets of enclosed drainage systems within the watershed.

XPSWMM is an enhanced version of the SWMM computer program that was originally developed for the EPA in the early 1970s for modeling flow in closed pipe systems. XPSWMM incorporates a CAD-style graphics interface into the EPA SWMM program that facilitates creating and visualizing the storm water system network. Input data is entered or displayed and modified using graphic dialog boxes. The program performs data checking prior to calculation to reduce data entry errors. XPSWMM is a modular program that allows the user to choose which analysis package or packages are to be used for a particular conveyance system model. For the Belton master plan study, the conveyance system was evaluated using the EXTRAN Block of the XP-SWMM program. The dynamic routing methodology used by the EXTRAN Block routes the complete runoff hydrographs through the system and includes modeling of backwater effects, flow reversal, surcharging conduits, looped connections, pressure flow, outfalls, and interconnected ponds.

The hydraulic modeling results for the 10%, 2%, 1%, and 0.2% probability rainfall events (10, 50, 100, and 500 year return interval) for existing and future conditions for each watershed sub-area are included in Appendix A to this report. Because of the differences in the dynamic routing method used by the EXTRAN Block, and the steady state routing method used by HEC-RAS, some variations in the flows may occur. These differences are generally small and the resulting peak flow values and water surface elevations should accurately reflect the hydraulic performance of the various conveyance system components.

Hydrologic Model Structure

The City of Belton was subdivided into 5 major watersheds: Little Blue River, Oil Creek, West Fork East Creek, East Creek, and Mill Creek as shown in Figure II-1. The Oil Creek, Little Blue River and West Fork East Creek watersheds are the most heavily developed and include most of the commercial and residential development. Land use in the Mill Creek and East Creek watersheds is characterized by large undeveloped tracts and multi-acre residential development. Each watershed was further subdivided into sub-areas to define flood flows at points of interest within the watershed. A total of 78 such tributary sub-watersheds, varying in size from 17 to 331 acres, were used to develop the watershed models. Sub-watersheds were further combined or subdivided, as required, to define land use and soil types, for the determination of composite runoff parameters.

A separate HEC-RAS hydraulic and HEC-HMS hydrologic model was developed for each of the 5 major watersheds for modeling open channel elements downstream of the enclosed storm sewer system. One set of models was developed for existing conditions and one for future conditions. The Mill Creek major watershed is composed of several separate tributaries that do not have their confluence within the corporate limits for the City of Belton. Therefore, each tributary was modeled separately. Updated, existing conditions Mill Creek models had already been developed for the FEMA county-wide mapping process for Cass County. The FEMA models were used, with some modifications and revisions for the Mill Creek tributaries.

Sub-watershed Numbering System

The typical GeoHMS nomenclature convention was used to uniquely label each sub-watershed with a HydroID identifier. The sub-watersheds are numbered 1 through 125 for the HydroID. Some of the sub-watersheds were later merged for convenience. Figure II–1 shows the sub-watershed and sub-area boundaries and the sub-area naming convention used in the model. Sub-watersheds for the enclosed system were given the same name as the structure that they drain to. The sub-areas modeled using XP-SWMM, are generally located in the developed areas in the upper portion of the watershed and are shown in Fig II-2.

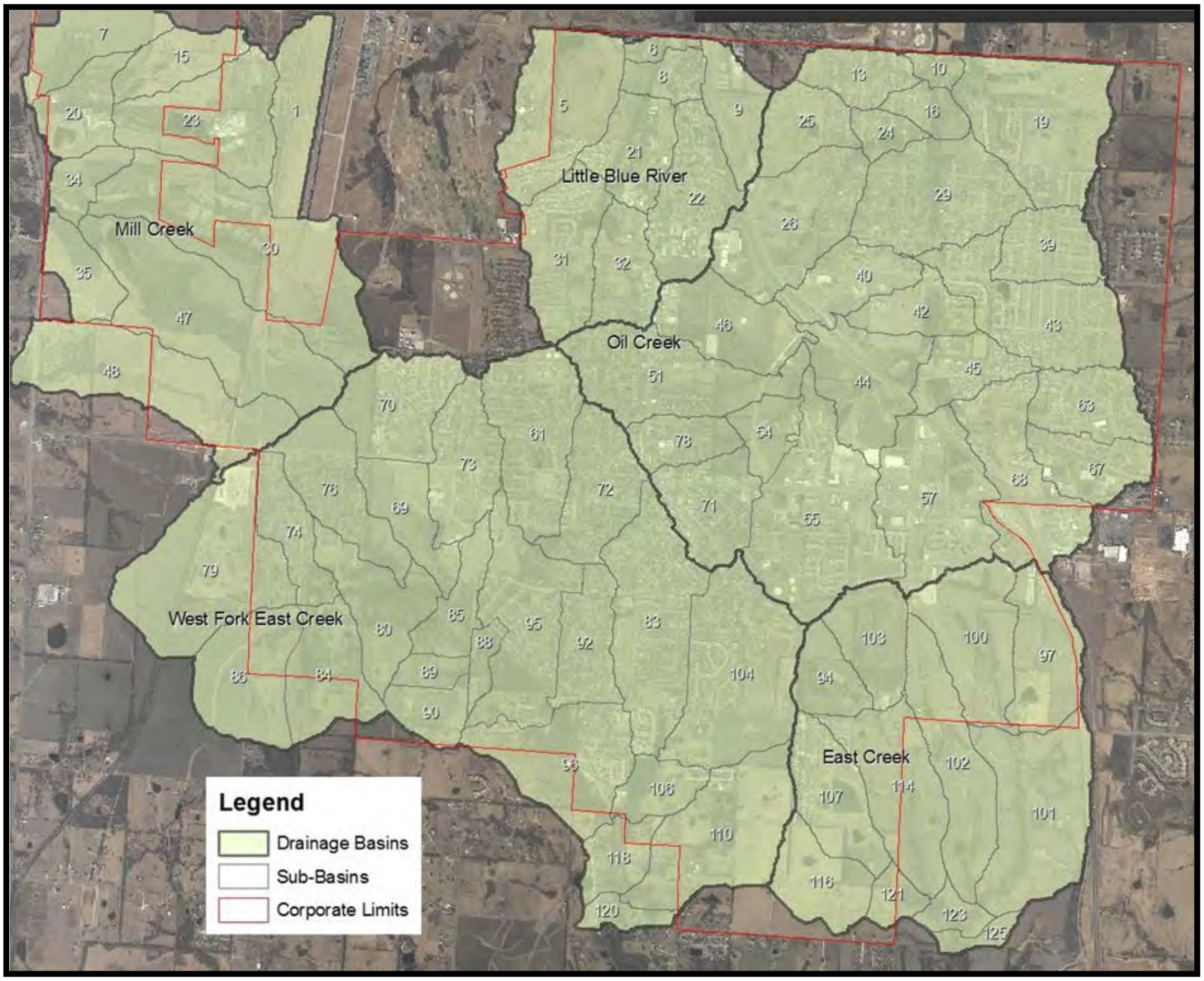


Figure C1: Sub Watershed Map

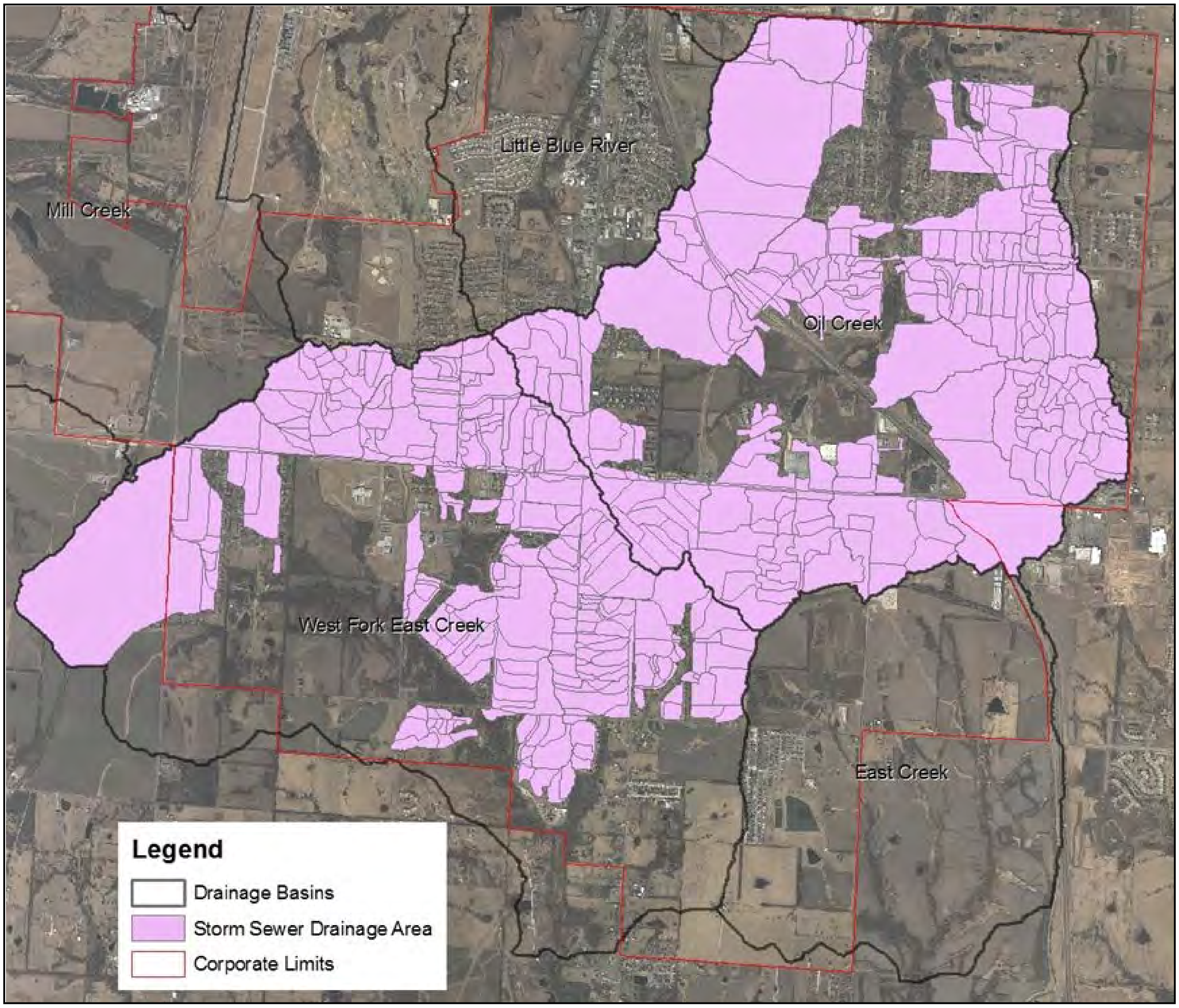


Figure C2: Storm Sewer Drainage Areas Overview *(see GIS data file for detailed delineations)*

Tributary Numbering System

The stream reaches for each of the major watersheds were numbered sequentially from downstream to upstream, beginning at the downstream limit of the main channel model (either the mouth of the stream or the corporate limits of the City of Belton). The tributaries were also numbered sequentially from downstream to upstream. For example, the downstream-most reach of the West Fork East Creek is labeled Main 1. The first major tributary to the West Fork East Creek is labeled Tributary 1. The next upstream tributary is labeled Tributary 2. The tributary numbers used in the watershed model are shown in the following Figures.

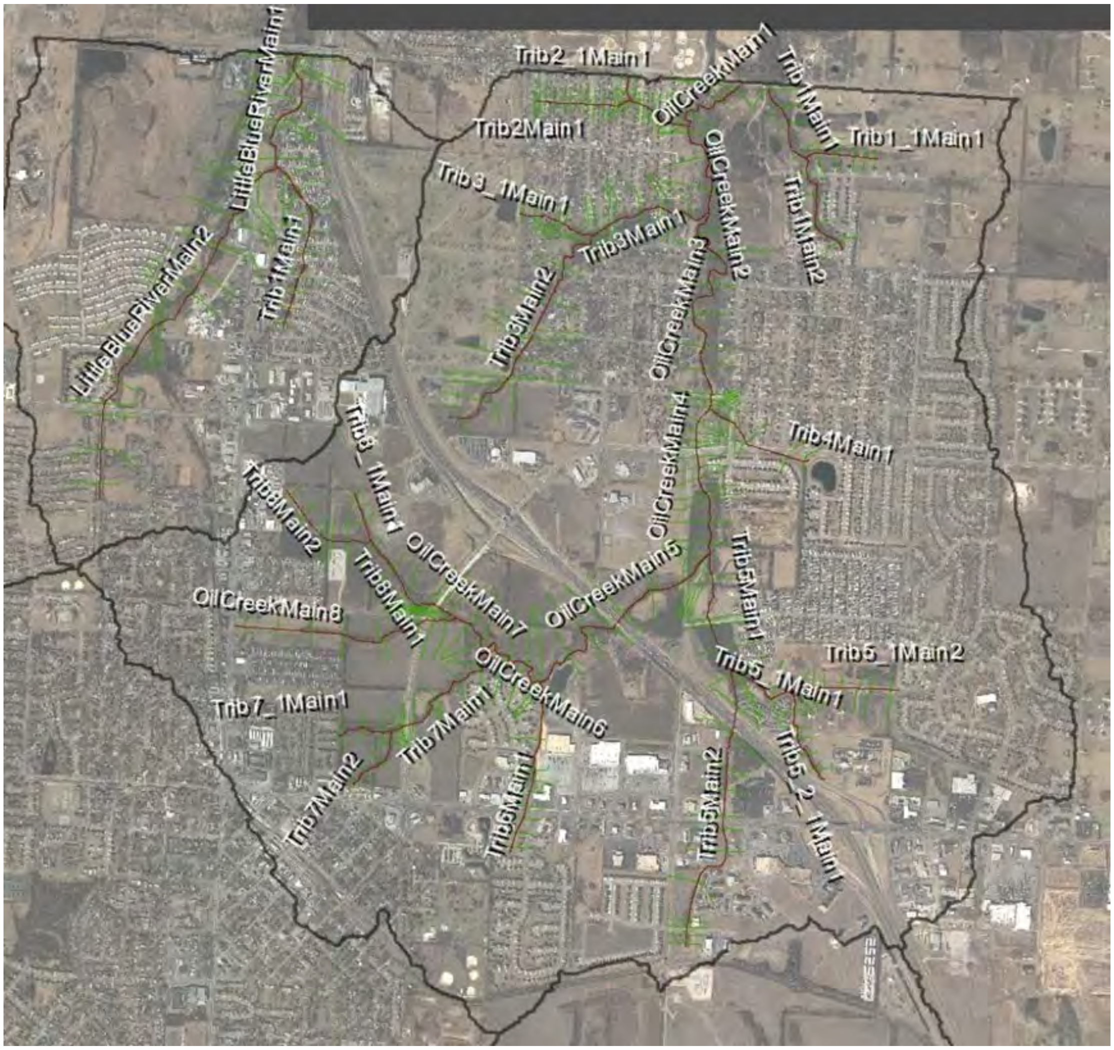


Figure C3.1 Oil Creek and Little Blue River Reaches

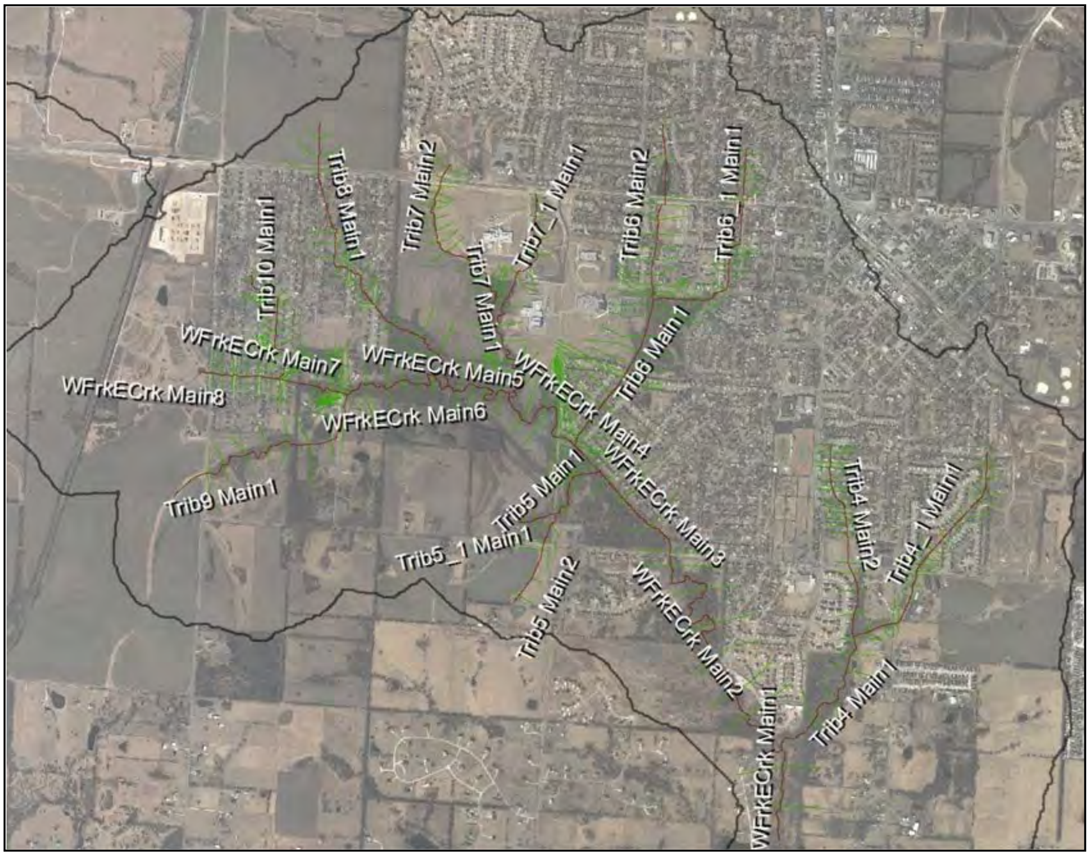


Figure C3.2 West Fork East Creek Reaches

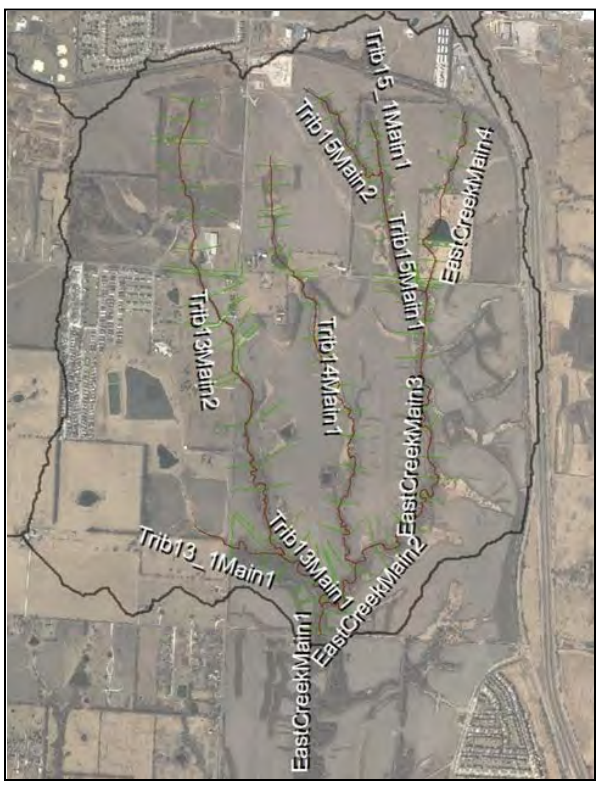
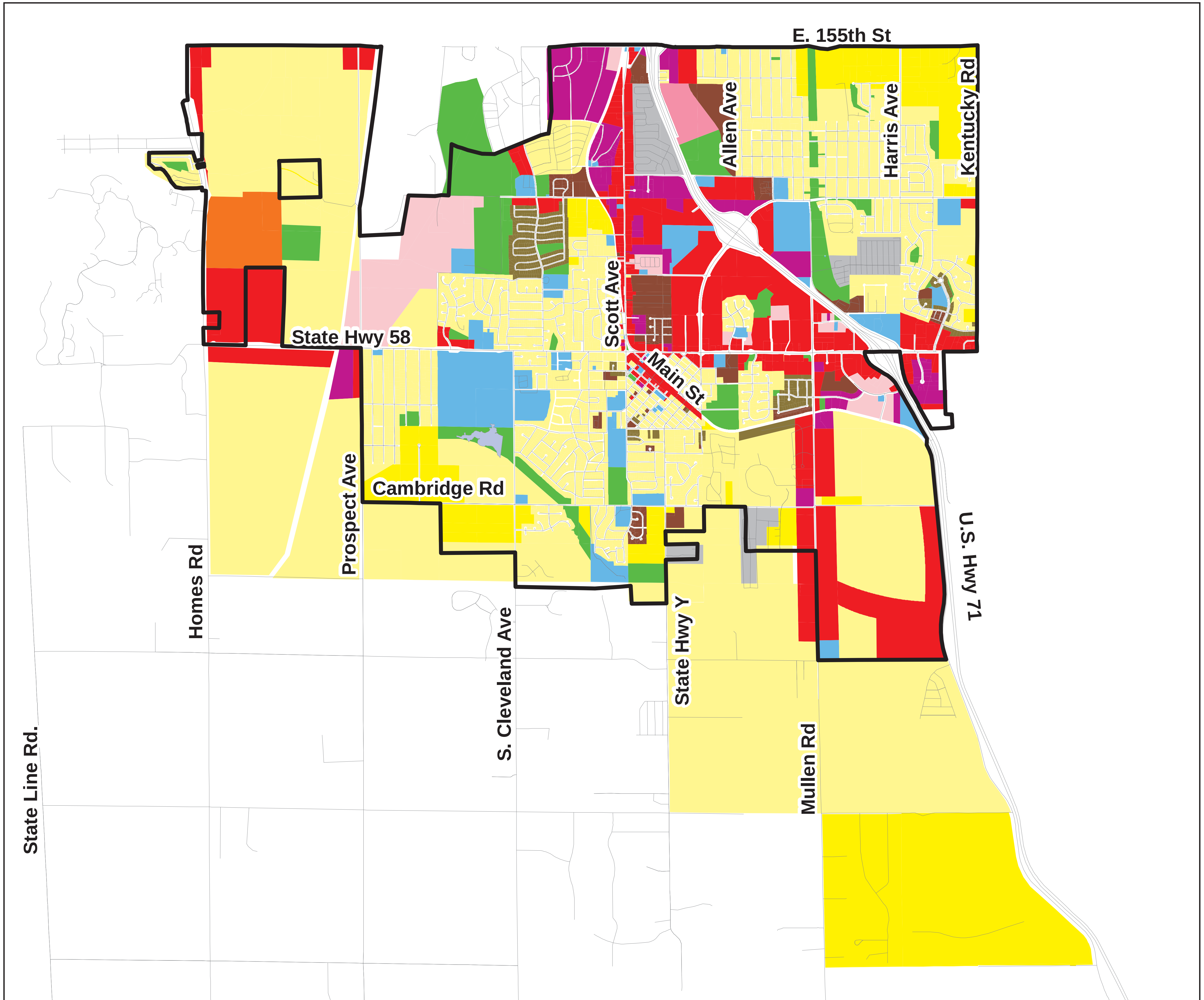


Figure C3.3 East Creek Reaches

Figure C3.4 Mill Creek Reaches

Figure C4: Future Land Use Conditions



Legend

- Roads
- Current Belton Boundary
- Cleveland Lake

Future Land Use

- Business Park, Office, Hotel
- Church, School, Institutional
- Commercial
- Hotel & Lifestyle Center
- Industrial
- Large Lot Single-Family
- Mixed Use
- Mobile Home Park
- Multiple/Tri/Quad Plex
- Parkland, Open Space, Cemetary
- Single-Family
- Two-Family
- Vacant

Miles: 0 0.5 1 2

1 inch = 3,424 feet

N

OLSSON ASSOCIATES 12/18/2012

Structure Numbering System

The bridges, culverts, and drainage structures modeled for this study were assigned river stations by HEC-GeoRAS, according to the typical conventions for that ArcView ArcGIS extension. Bridges and culverts were also labeled according to the name of the corresponding road or railroad that crosses the stream at that location. The label was added in the Note field, located within the Bridge/Culvert Data Editor of HEC-RAS. The Bridge/Culvert data editor is accessed from the Geometry Data Editor window in HEC-RAS.

Storm sewer inlets and junction boxes were numbered in the same order that they were surveyed. Storm sewers pipes and culverts are given the same name as the upstream structure they are connected to. XPSWMM requires all structures to have different names, so all conduits were given the suffix ".1". For example, the downstream conduit for Storm Inlet 4162 is given the name 4162.1. If an overflow swale or an additional downstream pipe were to be modeled, it would be given the name 4162.2.

Cross-section Numbering System

The cross sections modeled for this study were assigned river stations by HEC-GeoRAS, according to the typical conventions for that ArcView ArcGIS extension. Locations of the cross-sections used in the watershed model, together with the river stations, and computed 100-year flood elevations, are shown in the detailed flood inundation maps included in Appendix F.

C-3.2 Rainfall-Runoff Modeling

The SCS Curve Number method requires the development of detailed hydrologic parameters for each sub-area of a watershed in order to accurately model runoff. The hydraulic parameters were determined for each sub-area using the ArcView ArcGIS program in conjunction with the 2-foot contour interval topographic mapping and GIS database information provided for the City of Belton. The resulting data files were then exported to the HEC-HMS computer model.

<u>Delineation Sub-Watershed and Area</u>

The watershed sub-areas were delineated using the digital base maps and the Corps of Engineers HEC-GeoHMS extension of the ArcView ArcGIS computer program. Runoff node locations were defined at or near bridges and culverts, tributaries to the major stream channels, and at intermediate points in the model, as deemed necessary to accurately model the stream flows in the watershed. The physical properties of each sub-area, including area, length, elevations of the highest and lowest points, and the length and slope of longest flow path, were determined electronically from the digital base mapping.

<u>Land Use</u>

Land use is one of the most important factors controlling the amount of runoff from a watershed. Storm water runoff volume and peak discharge are directly related to the land use within each sub-watershed. The SCS Curve Number, is largely determined by land use, and increases in direct proportion to the percentage of impervious area in the watershed. Impervious areas prevent rainwater from infiltrating into the soil and therefore increase runoff volume. Existing land use in all of the watersheds is mixed with predominately medium density residential and commercial development. Existing land uses in the watershed were determined from digital land use files. Future land use assumptions were provided by the City's Planning and Zoning Department. Table C2 summarizes the land use categories used to model the City of Belton along with the average percent impervious values used for each land use category. These values generally follow the criteria set forth in the APWA standards.

Table C2
Land Use Percent Impervious

Land Use	Average Percent Impervious
Business Park Office, Hotel	85
Church, School, Institutional	38
Commercial	85
Hotel & Lifestyle Center	72
Industrial	72
Large Lot Single Family Residential	12
Mixed Use	45
Mobile Home Park	65
Multi Plex	65
Parkland, Open Space, Cemetary	0
Single Family Residential	38
Two Family Residential	65
Vacant	22

Figure C-4 shows the future land use mapping data used to model the City of Belton watersheds under ultimate developed conditions.

SCS Curve Number

The area-weighted curve number for each watershed was determined by overlaying the soil type and land use maps using the ArcView ArcGIS program to produce a composite curve number map. The composite curve number map was then overlaid on the watershed delineation map and the surface area was calculated for each curve number within a sub-area. The average sub-area curve number was then calculated by dividing the sum of the products of the curve numbers times their surface areas, by the total acreage of the sub-area.

Time of Concentration

The flow path was delineated and divided into three sections representing sheet flow, shallow concentrated flow, and channel flow. The length and elevation difference between the upper and lower ends of each flow path segment were determined from the digital base mapping. Using the length and slope along with information on cover type and typical cross section geometry, travel times were calculated for each segment. All three segments of the flow path were added together to get the total travel time for each sub-watershed. The travel time was multiplied by a factor of 0.6 to convert to lag time which is used in HEC-HMS calculations. Lag time is defined as the time difference between maximum precipitation during a storm and maximum runoff at the sub-watershed's outlet. Ultimate condition travel times were estimated by using the same watershed parameter, but changing to surface type to reflect reduced travel times due to impervious surfaces.

Infiltration

The soil infiltration parameters required for the SCS Curve Number method are the soil curve number and an initial abstraction value. The default value of 20 percent of the potential maximum retention after runoff begins, or 0.2*S, was used for the initial abstraction, for all sub-watersheds.

Rainfall-Design Storms

In accordance with the APWA 5600 Manual, the SCS Type-II, 24-hour storm distribution was used for the design storm. The Type II distribution assumes that approximately two-thirds of the total rainfall occurs during the six hour period between the ninth and fifteenth hour of the storm, and that over 40% of the total rainfall occurs during the peak 60 minutes of the storm. The total rainfall amounts for the 50%, 20%, 10%, 2%, 1%, and 0.2% probability design storms used for the Belton watershed study are shown in Table C3.

Table C3
Design Storm Rainfall Amounts

Return Frequency	24-Hour Rainfall (in.)
2 Year (50%)	3.5
5 Year (20%)	4.1
10 Year (10%)	5.4
50 Year (2%)	6.8
100 Year (1%)	7.6
500 Year (0.2%)	9.0

Calibration of Peak Runoff Values

Since there is no USGS gage available for comparison, the peak rates of runoff for the sub-areas were determined by the SCS Curve Number method, in accordance the procedures described in APWA 5600. Table C4 shows the parameters used to calculate the peak runoff in each sub-area and the resulting corresponding existing conditions and future conditions 100-year peak discharge expressed in cfs and 100-year average discharge expressed in cfs/acre.

Table C4 – Peak Runoff Rate Data, 100-year return frequency

Sub - Basin #	Area (ac)	Area (sq mi)	Sheet Flow Leng. (ft)	Sheet Slope (ft/ft)	SCF Length (ft)	SCF Slope (ft/ft)	Channel Length (ft)	Channel Slope (ft/ft)	Exist CN	Fut. CN	Lag time (hrs)	Ult Lag Time (min)	Peak Q100 (cfs)	Avg Q100 (cfs/ac)	Ult. Peak Q100 (cfs)	Ult Avg Q100 (cfs/ac)
6	17.0	0.026	300.0	0.007	1772.5	0.040	58.3	-0.129	90	90	16.46	7.89	99.2	5.85	137	8.08
7	104.6	0.164	300.0	0.015	2711.1	0.028	2031.5	0.021	65	79	20.58	13.09	311.6	2.98	585.5	5.59
8	44.7	0.070	300.0	0.007	1322.7	0.044	1273.4	0.005	90	90	17.99	9.74	250.3	5.60	337.3	7.54
9	80.2	0.125	160.0	0.013	3560.7	0.022	782.2	0.038	76	89	20.38	13.82	324.5	4.05	510	6.36
10	20.4	0.032	300.0	0.120	580.3	0.077	1303.3	0.000	74	74	19.04	5.10	82.6	4.05	141.7	6.94
13	68.2	0.107	300.0	0.017	2680.5	0.033	656.2	0.021	83	83	17.25	10.16	353.6	5.19	461.2	6.76
15	75.9	0.119	100.0	0.087	2884.2	0.024	1038.9	0.037	63	76	14.29	10.80	264.2	3.48	437.1	5.76
16	40.8	0.064	300.0	0.040	839.1	0.038	1603.0	0.006	79	81	12.37	8.16	234.9	5.75	288.7	7.07
19	227.2	0.355	20.0	0.019	4025.9	0.024	1885.6	0.008	80	81	19.16	17.78	1042.4	4.59	1112.3	4.90
20	80.4	0.126	300.0	0.013	2010.6	0.048	1194.3	0.007	68	80	16.69	9.83	300.1	3.73	522.1	6.49
21	96.9	0.151	50.0	0.040	1503.8	0.040	2901.9	0.012	90	90	11.23	10.27	687.6	7.10	713.9	7.37
22	138.1	0.216	300.0	0.007	2252.7	0.028	2453.0	0.015	90	90	22.69	13.56	670.3	4.85	900.6	6.52
23	180.7	0.282	275.0	0.007	2642.5	0.020	2508.4	0.021	69	80	18.11	15.70	658.2	3.64	931.4	5.15
24	32.6	0.051	50.0	0.055	1070.0	0.057	1736.7	0.011	85	85	8.82	6.35	239.2	7.34	263.5	8.09
25	81.4	0.127	300.0	0.013	2350.8	0.027	833.8	0.019	75	86	26.18	10.40	273	3.35	567.7	6.97
26	192.8	0.301	100.0	0.007	3106.9	0.016	2931.3	0.016	84	86	21.87	18.71	876.2	4.55	996	5.17
29	195.8	0.306	100.0	0.017	2297.7	0.032	3011.5	0.004	84	84	23.22	18.01	857.2	4.38	1003.4	5.12
30	330.9	0.517	300.0	0.013	2334.8	0.020	6558.3	0.018	73	84	29.57	21.76	972.5	2.94	1509.5	4.56
31	140.7	0.220	150.0	0.013	2654.1	0.020	1759.5	0.019	85	85	21.25	13.24	683.7	4.86	893.6	6.35
32	87.9	0.137	150.0	0.013	2632.7	0.016	1115.6	0.029	86	86	15.27	12.67	509	5.79	560.5	6.37
34	47.3	0.074	300.0	0.017	2240.9	0.045	196.7	0.000	67	79	14.51	7.97	185.6	3.93	324.4	6.86
35	65.5	0.102	300.0	0.010	2903.4	0.039	310.9	0.014	65	79	27.63	10.09	151.3	2.31	410.3	6.26
39	88.4	0.138	100.0	0.020	2428.0	0.025	1267.3	0.014	83	83	17.67	10.77	450	5.09	580	6.56
40	92.7	0.145	190.0	0.021	3317.7	0.018	1481.4	0.022	87	88	18.98	15.78	482.9	5.21	544.6	5.88
42	70.2	0.110	300.0	0.020	2344.1	0.028	796.0	0.003	85	86	18.40	11.77	361.8	5.15	465.4	6.63
43	188.0	0.294	300.0	0.010	2111.1	0.024	3801.2	0.014	85	85	24.66	16.53	804.9	4.28	1029.8	5.48
44	145.5	0.227	100.0	0.012	1913.9	0.031	3485.9	0.005	81	90	17.77	17.77	711.5	4.89	817.3	5.62
45	75.5	0.118	300.0	0.027	982.3	0.036	1992.4	0.011	87	87	19.74	8.51	383.7	5.08	575.5	7.62
46	126.6	0.198	300.0	0.013	2562.4	0.015	1562.1	0.013	86	91	17.94	15.31	671.8	5.31	782.9	6.18
47	291.5	0.456	300.0	0.012	2076.2	0.019	6026.8	0.020	71	84	27.49	19.56	855.4	2.93	1422.9	4.88
48	241.4	0.377	300.0	0.010	2102.9	0.027	5635.8	0.016	71	88	26.85	18.85	718.5	2.98	1278.3	5.29
51	193.4	0.302	300.0	0.007	2123.7	0.014	4668.0	0.012	84	89	42.39	21.66	557.6	2.88	952.9	4.93
54	273.9	0.428	300.0	0.023	747.0	0.030	2262.0	0.009	65	78	20.87	9.17	1344.7	4.91	1398.5	5.11
55	51.7	0.081	100.0	0.030	947.0	0.030	2262.0	0.009	84	88	13.62	8.75	277.4	5.36	380.3	7.35
57	204.8	0.320	300.0	0.027	1997.1	0.016	2554.0	0.012	90	92	27.13	14.56	883.7	4.31	1313.9	6.41
61	170.6	0.267	300.0	0.007	2140.6	0.017	3413.0	0.018	86	86	23.72	16.66	737.3	4.32	916.4	5.37
63	95.1	0.149	30.0	0.040	2597.0	0.016	1118.4	0.015	85	85	16.33	12.31	525.3	5.52	609.2	6.41
67	86.1	0.135	30.0	0.022	3054.7	0.016	911.8	0.016	89	89	18.80	13.88	464.5	5.39	549.6	6.38
68	176.4	0.276	50.0	0.023	2451.9	0.015	5200.5	0.011	87	88	22.22	22.22	834	4.73	845.9	4.79
69	196.0	0.306	100.0	0.020	2818.6	0.019	3509.6	0.013	85	85	19.99	17.98	866.6	4.42	1104.8	5.64
70	129.4	0.202	50.0	0.020	3509.6	0.019	604.0	0.013	82	90	19.49	12.24	528.8	4.09	722.3	5.58
70	61.9	0.097	50.0	0.014	3018.8	0.016	187.2	0.019	85	90	18.62	12.35	528.8	8.54	722.3	11.67
71	112.0	0.175	20.0	0.009	2805.3	0.014	1081.5	0.010	87	89	14.46	14.46	679.6	6.07	697.7	6.23
72	133.9	0.209	220.0	0.009	2258.6	0.021	2236.9	0.018	86	86	18.57	13.32	661.6	4.94	809.2	6.05
73	116.7	0.182	250.0	0.008	3354.2	0.023	1660.4	0.016	86	86	21.84	16.15	530.2	4.54	635	5.44
74	78.6	0.123	220.0	0.036	2682.4	0.019	1303.9	0.018	88	88	15.87	13.22	433.9	5.52	478	6.08
75	85.6	0.134	300.0	0.047	2158.8	0.032	1825.2	0.012	87	87	10.94	7.27	568.8	6.65	668.2	7.81
76	128.1	0.200	300.0	0.007	2305.6	0.024	3321.7	0.014	85	85	23.30	16.25	539.3	4.21	706.8	5.52
79	243.7	0.381	300.0	0.010	2017.0	0.012	3658.4	0.013	82	82	26.98	19.95	959.9	3.94	1278.3	5.25
80	90.9	0.142	300.0	0.027	1635.0	0.027	1102.8	0.005	80	80	18.52	12.37	552.3	6.08	729.4	8.03

Sub-Basin #	Area (ac)	Area (sq mi)	Sheet Flow Leng. (ft)	Sheet Slope (ft/ft)	SCF Length (ft)	SCF Slope (ft/ft)	Channel Length (ft)	Channel Slope (ft/ft)	Exist CN	Fut. CN	Lag time (hrs)	Ult Lag Time (min)	Peak Q100 (cfs)	Avg Q100 (cfs/ac)	Ult. Peak Q100 (cfs)	Ult Avg Q100 (cfs/ac)
83	214.5	0.335	100.0	0.001	2489.3	0.027	4556.5	0.011	87	87	20.61	19.96	1011.9	4.72	1032.5	4.81
84	269.6	0.421	300.0	0.020	2541.8	0.021	3297.2	0.012	79	79	24.71	18.77	443.2	1.64	563	2.09
85	63.1	0.099	300.0	0.027	2365.7	0.022	966.6	0.005	82	82	18.87	13.47	293.6	4.65	381.2	6.04
86	148.5	0.232	100.0	0.011	1875.0	0.021	3297.0	0.012	77	86	17.75	11.11	582.9	3.93	751.4	5.06
88	104.7	0.164	300.0	0.017	2416.4	0.035	1530.5	0.014	78	78	17.98	12.09	561.3	5.36	336.8	3.22
89	28.0	0.044	100.0	0.010	1741.5	0.035	1741.0	0.014	76	87	12.71	6.60	136.2	4.86	165.7	5.92
90	53.2	0.083	100.0	0.010	1741.5	0.035	520.0	0.014	74	75	12.88	6.91	258.2	4.85	185.7	3.49
92	90.3	0.141	170.0	0.024	900.0	0.025	3443.6	0.019	86	86	11.83	11.51	548.9	6.08	611.9	6.77
94	64.6	0.101	300.0	0.012	2446.6	0.025	241.9	0.017	74	83	18.03	10.08	269.7	4.18	436.7	6.76
95	105.2	0.164	250.0	0.064	665.0	0.029	3889.5	0.003	84	84	13.76	12.87	592.4	5.63	674.9	6.42
96	176.6	0.276	100.0	0.020	2584.3	0.039	4062.2	0.002	78	78	32.15	28.47	587.1	3.32	708.5	4.01
97	126.0	0.197	300.0	0.017	2497.6	0.020	2170.7	0.017	76	84	56.30	54.01	250	1.98	304.6	2.42
100	154.9	0.242	300.0	0.013	3073.3	0.020	2202.5	0.013	78	86	25.87	17.38	562	3.63	835.8	5.39
101	227.7	0.356	300.0	0.015	2176.6	0.035	5649.2	0.007	77	89	30.55	23.64	721.1	3.17	1062.8	4.67
102	160.8	0.251	300.0	0.020	3451.9	0.022	5135.8	0.012	74	86	31.70	23.90	461.2	2.87	712.7	4.43
103	94.6	0.148	300.0	0.017	2122.4	0.020	1231.6	0.018	82	88	18.33	11.24	463.6	4.90	657.8	6.95
104	257.1	0.402	230.0	0.009	2536.7	0.026	3808.0	0.015	83	83	24.49	17.88	1049.3	4.08	1324.1	5.15
106	56.4	0.088	220.0	0.011	1352.6	0.033	2119.1	0.009	79	79	16.31	10.89	278.8	4.94	349.3	6.19
107	116.5	0.182	300.0	0.017	2514.3	0.023	2166.7	0.022	83	86	28.32	13.42	438.9	3.77	724	6.21
109	323.9	0.506	280.0	0.018	2538.2	0.025	6800.9	0.010	78	78	32.55	27.22	935.4	2.89	1253.5	3.87
110	208.3	0.326	300.0	0.017	2473.1	0.028	4226.6	0.014	79	79	24.84	19.18	761	3.65	1029.3	4.94
114	167.1	0.261	50.0	0.020	1876.4	0.034	5317.1	0.011	78	90	19.59	17.13	726.1	4.35	959.9	5.74
116	94.7	0.148	300.0	0.027	2374.7	0.031	1227.2	0.013	76	84	23.01	10.70	355.2	3.75	633.6	6.69
118	60.7	0.095	300.0	0.020	1119.5	0.031	1750.0	0.016	74	74	13.06	3.46	318.2	5.24	540.2	8.90
119	88.6	0.138	260.0	0.023	710.0	0.028	2985.9	0.001	79	79	12.65	10.07	470.2	5.31	616.1	6.95
120	29.5	0.046	220.0	0.023	698.9	0.071	1041.5	0.004	76	76	10.30	6.71	160.8	5.45	224	7.59
121	31.5	0.049	270.0	0.026	924.3	0.038	1238.3	0.013	78	93	10.83	6.22	187.5	5.94	279.1	8.85
123	31.0	0.048	300.0	0.053	385.6	0.072	1336.1	0.007	76	85	8.97	5.52	190	6.13	256.1	8.27
125	22.5	0.035	300.0	0.013	1936.6	0.032	147.4	0.048	78	90	14.55	7.48	115.8	5.14	184.3	8.18

Channel Routing

The travel time and storage attenuation associated with the flow of the runoff through the various open channels and structures of the watershed were modeled using the Muskingum-Cunge routing method of the HEC-HMS computer program. The data required for channel routing includes the length and average slope of each channel reach, an eight point typical cross-section for the channel and overbank area, and the Manning's roughness coefficients for the channel and overbank areas. Typical channel cross-sections were approximated from the topographic mapping for each reach. The channels were assigned Manning's n-values between 0.035 and 0.045 and the overbank sections were assigned Manning's n-values ranging between 0.070 and 0.12 depending on the type of cover present in the overbank area. The Muskingum-Cunge routing method is also applicable to closed conduits. Concrete culverts and pipes were assigned Manning's n-values of .013, and corrugated steel pipes were assigned Manning's n-values of 0.024.

Reservoir Routing

Existing lakes and ponds and detention basins were modeled using the Modified Puls Storage-Routing method of the HEC-HMS computer program. The data required for reservoir routing includes the initial water level and elevation-storage-discharge tables for the site. Project solutions that include a proposed detention pond draining to an enclosed storm sewer system were modeled in XP-SWMM which analyzes detention areas by solving the St Venant dynamic flow equations. Ponds and detention basins with a storage volume less than approximately one-inch of runoff over the total watershed area were generally not modeled since the detention storage was not considered enough to make a significant difference in the peak discharges from the watershed.

C-3.3 Water Surface Modeling

The Corps of Engineers HEC-RAS computer program was used to develop water surface profiles and flood elevations for the natural channels and drainage structures of the Burlington Creek watershed. Water surface profiles were calculated for the peak runoff from the 10, 50, 100, and 500 year storms determined using the HEC-HMS model. Existing drainage structures were modeled using field survey data obtained as part of the watershed study. Natural channels were modeled using cross-sections developed from the 2-foot contour mapping using HEC-GeoRas in conjunction with the ArcView GIS computer program.

Natural Channels

Two hundred and thirty two cross-sections were used to model the approximately 16,750 ft long main channel of West Fork East Creek as well as its tributaries. One hundred and ninety six cross-sections were used to model the approximately 17,800 ft long main channel of West Fork East Creek as well as its tributaries. Ninety-one cross-sections were used to model the approximately 11,000ft long main channel of East Creek as well as its tributaries that fall within the corporate limits. Thirty-five cross-sections were used to model the approximately 5,600 ft long main channel of Little Blue Creek as well as its tributaries. Thirty-eight cross-sections were used to model the tributary streams to Mill Creek that fall within Belton city limits. The cross-section coordinates, channel and over bank stations and reach lengths, and Manning's n-values for each channel segment were entered directly into the HEC-RAS model using data files generated by HEC-GeoRAS. Other data required by HEC-RAS to define the properties of the channel segments, such as ineffective and blocked flow areas, and cross-sections at structures were entered manually.

Drainage Structures: Data for bridges, culverts, and storm drainage structures were entered using the field survey data obtained as part of the watershed study. The input data included the structure identification and type, structure dimensions, upstream and downstream invert elevations, Manning's n-values, entrance and exit losses, ineffective and blocked flow areas. The HEC-RAS program computes head water elevations for inlet or outlet control and automatically uses the correct method as conditions warrant. All culverts were modeled assuming that overtopping of the roadway embankment could occur.

Detention Basins and Lakes: Flood flows through lakes and detention basins were modeled by inserting a rating curve, developed from HEC-HMS, into the HEC-RAS model.

Hydraulic losses and roughness factors used in the modeling follow current adopted APWA Section 5600 standard values and critiera.

Model Validation

In order to evaluate the reasonableness of the peak flow data calculated by the HEC-HMS models, the peak flow rates were compared with peak flows from the 2006 FEMA Flood Insurance Study for Cass County. Table C5 shows a comparison of the peak flows from the FEMA FIS with the existing and future conditions peak flows from the HEC-HMS model. The calculated flowrate for Oil Creek and West Fork East Creek were, as expected, significantly higher than the FEMA flowrate. This can be attributed to the large amount of development that has occurred in Belton in the time since the time the hydrology was developed for the FEMA model. The existing condition 100 year flow for East Creek is 25% lower than the FEMA value. However, the ultimate condition 100 year peak flow is within 3% of the FEMA value. Therefore, it appears that the FEMA model represents a developed condition in the East Creek watershed.

Table C5
Comparison of Existing and Future Peak Flows with FEMA Flows

Location	Source	10 Year	50 Year	100 Year	500 Year
Oil Creek FEMA Section A	FEMA	2730	4200	4970	6700
	Olsson Existing Condition	5879	7818	9012	11124
	Olsson Ultimate Condition	5911	7958	9145	11266
East Creek FEMA Section AJ	FEMA	380	740	935	1445
	Olsson Existing Condition	422	599	702	885
	Olsson Ultimate Condition	626	839	960	1172
West Fork East Creek FEMA Section N	FEMA	2850	4800	5700	8000
	Olsson Existing Condition	4338	6110	7105	8852
	Olsson Ultimate Condition	4942	6828	7880	9743

C-4 Geomorphology Assessment

C-4.1 Geomorphic Overview and Information

The study area of this geomorphic assessment includes all major streams in the City of Belton. The majority of the streams were evaluated by current and historical aerial photographic interpretation. Based on the aerial review, a few of the reaches appeared to be threating critical public infrastructure or residential dwellings and a more detailed visual assessment was performed in the field. While a large emphasis was placed on locating troublesome reaches in urban areas that may eventually place infrastructure at risk, the assessment also documents the current condition of rural streams that remain relatively non-impacted by urbanization. This analysis will point out the geomorphic processes that are occurring as a result of urbanization and discuss the necessary actions that will be required to maintain stable channel reaches and protect existing and future infrastructure from damage.

The geomorphic relationships in the stream are based on a dynamic equilibrium that exists in stable natural channels. This equilibrium is governed by the relative ratios of run-off rate, slope, sediment supply, and sediment size. When one of the parameters is modified, streams will adjust to re-establish the equilibrium. This adjustment can be both horizontal meander changes and vertical profile changes. The following Images 1 and 2 depict the geometric variables of streams and the stream process. Sediment generation caused by meandering and downcutting is of special significance in reaches upstream of the proposed Cleveland Lake and Markey Lake projects. Limiting sediment generation in these areas is key to maintaining good water quality and storage capacity in these reservoirs.

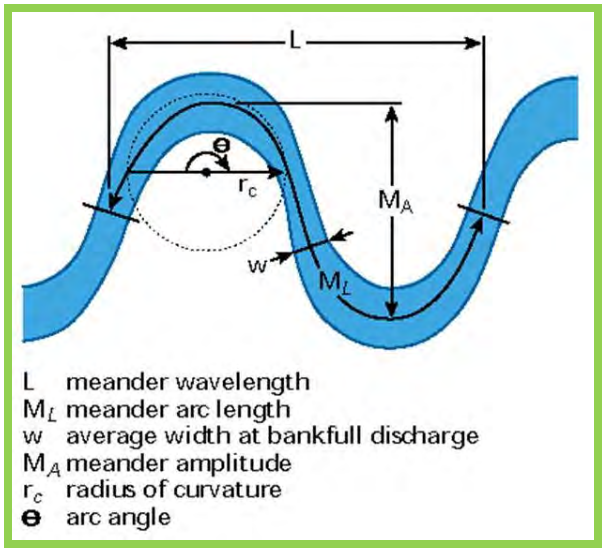


Image 1: Stream Meander Geometry

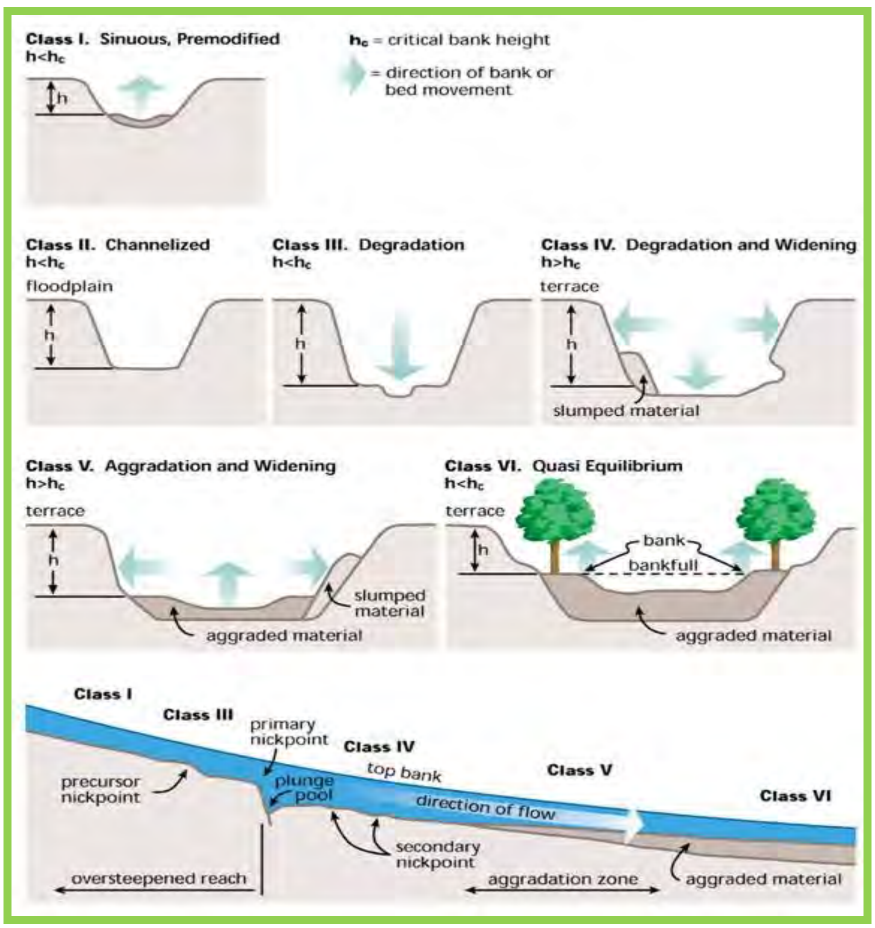


Image 2: Channel Evolution Model

The bankfull area is defined as the area that contains the channel-forming dominant discharge. This area represents the breakpoint between the processes of channel formation and floodplain formation. The bankfull height can be measured in the field using indicators, such as the first flat depositional surface or changes in vegetation. "Total Channel" elevation is the highest elevation the channel can flood before the water rises and spreads out across the valley floor. This stage represents the first indication of an "out of channel" flood and reflects the maximum width possible of channelized flow in the channel. The total channel is often referred to as the "meander belt" where lower active floodplain surfaces formed by meandering are inset between higher banks, the top of which is the total channel stage. These two areas make up a "two stage channel", which consists of a low flow channel and a valley section. The low flow channel conveys the bankfull discharge and larger flows widen out onto the valley floor.

The geomorphic assessment included an interpretation of aerial photography as well as site visits to determine the geomorphic processes that are present in each reach. The interpretation of aerial photography was performed by tracing stream thalweg visible in aerial photographs from 1950, 1970, 1991, and 2006. Review of 56 years of historical photo documentation provides guidance on how the land uses and associated channel conditions have changed over time. Aerial documentation also provides interpretive elements such as relative intensity and duration of channel forming forces. Stream tracing shape files for each of the 5 years are available for the entire city within the GIS database. Site visits were also performed to document the current conditions of streams, to determine the presence of bedrock and other factors that may limit the impacts of erosion, and to locate infrastructure that may be subject to damage by additional changes in stream geometry. The following section summarizes the geomorphic conditions of the main streams in Belton. Specific reaches that create a threat to infrastructure or demonstrate significant instability have been included in section B-2 along with recommendations for improvements to provide stabilization.

WEST FORK EAST CREEK

Common to many urban channels, West Fork East Creek has visible areas of instability that could threaten public infrastructure. Erosion of the stream banks creates water quality issues for the proposed Cleveland Lake as it liberates phosphorus-laden sediment from the banks of the channel. Shale and Limestone bedrock is common throughout the region and helps to limit the downward and outward movement of the channel. However the effects of urbanization are visible in stream sections with soft, erodible banks. Urbanization causes increased flowrates which force the stream out of its natural equilibrium state. The stream will try to adjust to the change and return to equilibrium by eroding downward and outward and generating more sediment. The main reach of West Fork East Creek has tall, unstable banks and large amounts of wood debris due to erosion of the stream banks. Trees 3 to 5 feet in diameter lay across the stream as evidence of changes in the geomorphic conditions. Tributary streams lack buffer vegetation to help stabilize banks from flows cascading over them. The analysis of aerial photography revealed areas where the stream has been straightened during development but is now making an effort to return to its previous sinuous state. The reach between Cambridge Road and Cleveland Avenue was straightened by development between 1950 and 1970 and now is the source of many resident erosional complaints. Downstream of the Cambridge Road culvert significant changes can be seen from aerial photography and the site visit revealed tall, soft, and unstable banks. It is important to establish a buffer to prevent future development from encroaching on the stream in this area. Stream meander belt width was analyzed to determine a suitable buffer requirement for the city. Further discussion is presented at the end of this section. Locations where action is recommended have been included in Section B-2 as part of the Recommended Action Plan.

OIL CREEK

Similar to West Fork East Creek, Oil Creek is a large drainage basin that drains many developed areas in Belton and, consequently, outward movement of stream banks can threaten infrastructure. The main corridor of Oil Creek runs north through a wooded corridor that bisects the eastern half of Belton. The representative channel section has tall, steep dirt banks with roots exposed and many times trees fallen over the channel. Large amounts of wood debris are present and urban forestry may be desired to remove log jams that have occurred and to create a more aesthetically pleasing stream. Ultimately, the wooded corridor provides the necessary room for the stream to move and adjust itself to equilibrium without becoming a threat to buildings or roads. Tributary streams also show the impact of development in bank erosion but the presence of intermittent, shallow bedrock creates a series of pools and prevents significant downcutting. Risk to infrastructure along this stream corridor is low to due to adequate buffer space.

LITTLE BLUE CREEK

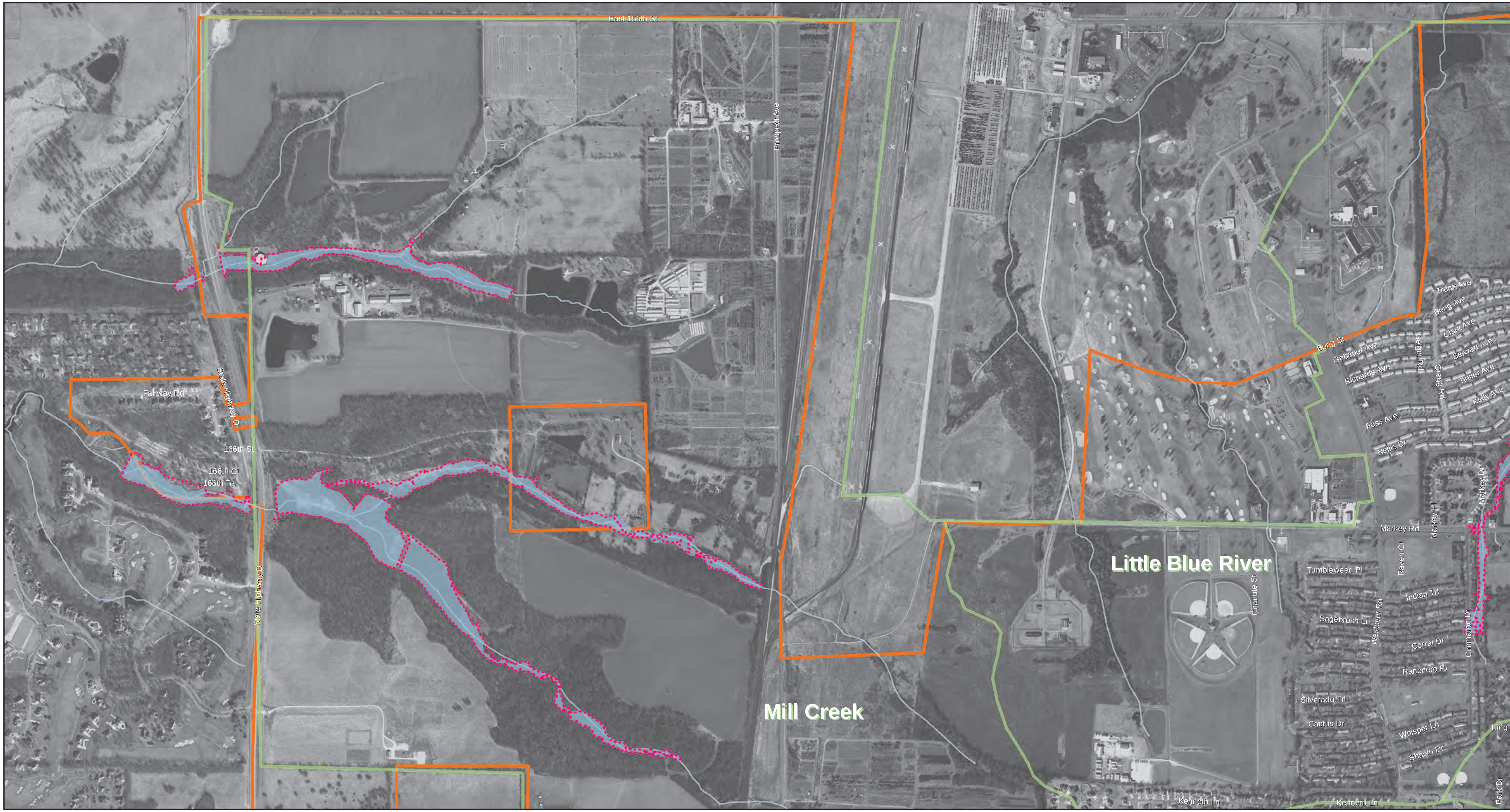
The Little Blue River drainage area is small compared to West Fork East Creek and Oil Creek but it is similarly developed. The Little Blue River has banks that are fairly flat and in many cases armored with rock or rubble. Roots are exposed on some bends as evidence that there is some movement, but there is little wood debris and, in general, no infrastructure at risk. The trailer park located on North Scott Avenue may be moderately at risk as there is little room between buildings and the top of bank. One bank has failed in this area and there is significant erosion and exposed coaxial cable on the bank upstream of the culvert in this trailer park.

MILL CREEK

The Mill Creek tributaries located in the northwest section of Belton serve as drainage for mostly undeveloped forest and farm land. The bottom of the channel is naturally lined with rock and in good condition. Some meander migration is visible near the water plant but the representative section of the stream is very healthy with flat banks. This stream currently provides no concerns but should be monitored if the watershed develops.

D-1. Ultimate Development Condition Floodplains

The planning floodplains developed for analysis of existing flooding problems were developed using existing developed conditions in the City of Belton. As a planning aid to evaluate possible floodplain expansion due to future development, future ultimate planned conditions in the watersheds were evaluated for peak runoff rate increases and incorporated into the master plan floodplain model. The future land uses were based on the data and methods described in Part C-3.2. Panel maps illustrating the potential floodplain impacts due to full watershed development per the City's comprehensive plan are provided in Figures D1 through D5.



Legend

- Streams
- Watershed Boundary
- Ultimate Conditions 100-yr Floodplain
- Existing Conditions 100-yr Floodplain
- City Limits

Figure D1:
Ultimate Development Floodplain

0 500 1,000 2,000 Feet

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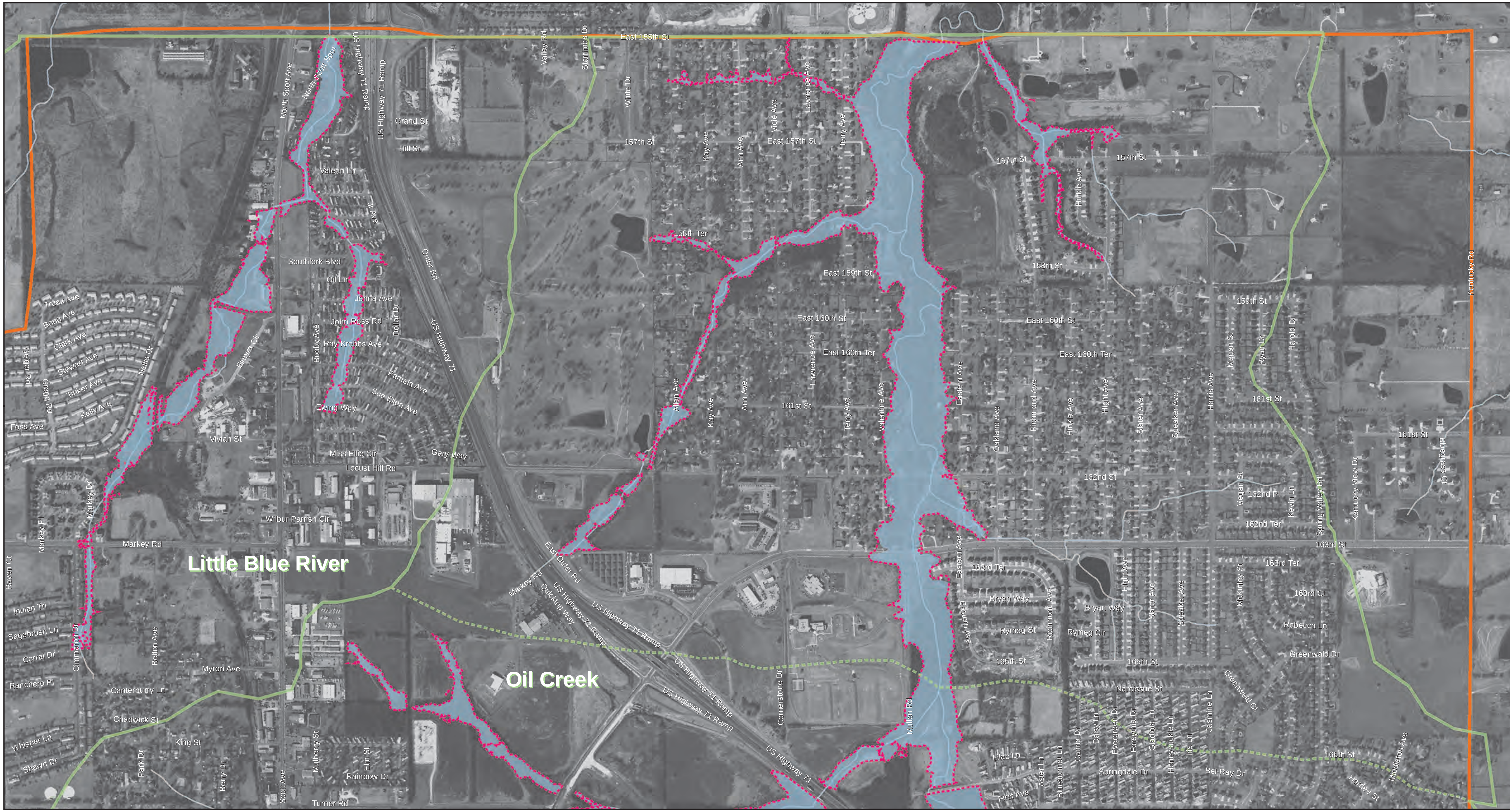
10/09/2012



Legend

- Streams
- Watershed Boundary
- Ultimate Conditions 100-yr Floodplain
- Existing Conditions 100-yr Floodplain
- City Limits

Figure D2:
Ultimate Development Floodplain

0 500 1,000 2,000 Feet

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Legend

- Streams
- Watershed Boundary
- Ultimate Conditions 100-yr Floodplain
- Existing Conditions 100-yr Floodplain
- City Limits

Figure D3:
Ultimate Development Floodplain

0 500 1,000 2,000 Feet

N

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Figure D4:
Ultimate Development Floodplain

Legend

- Streams
- Watershed Boundary
- Ultimate Conditions 100-yr Floodplain
- Existing Conditions 100-yr Floodplain
- City Limits

0 500 1,000 2,000 Feet

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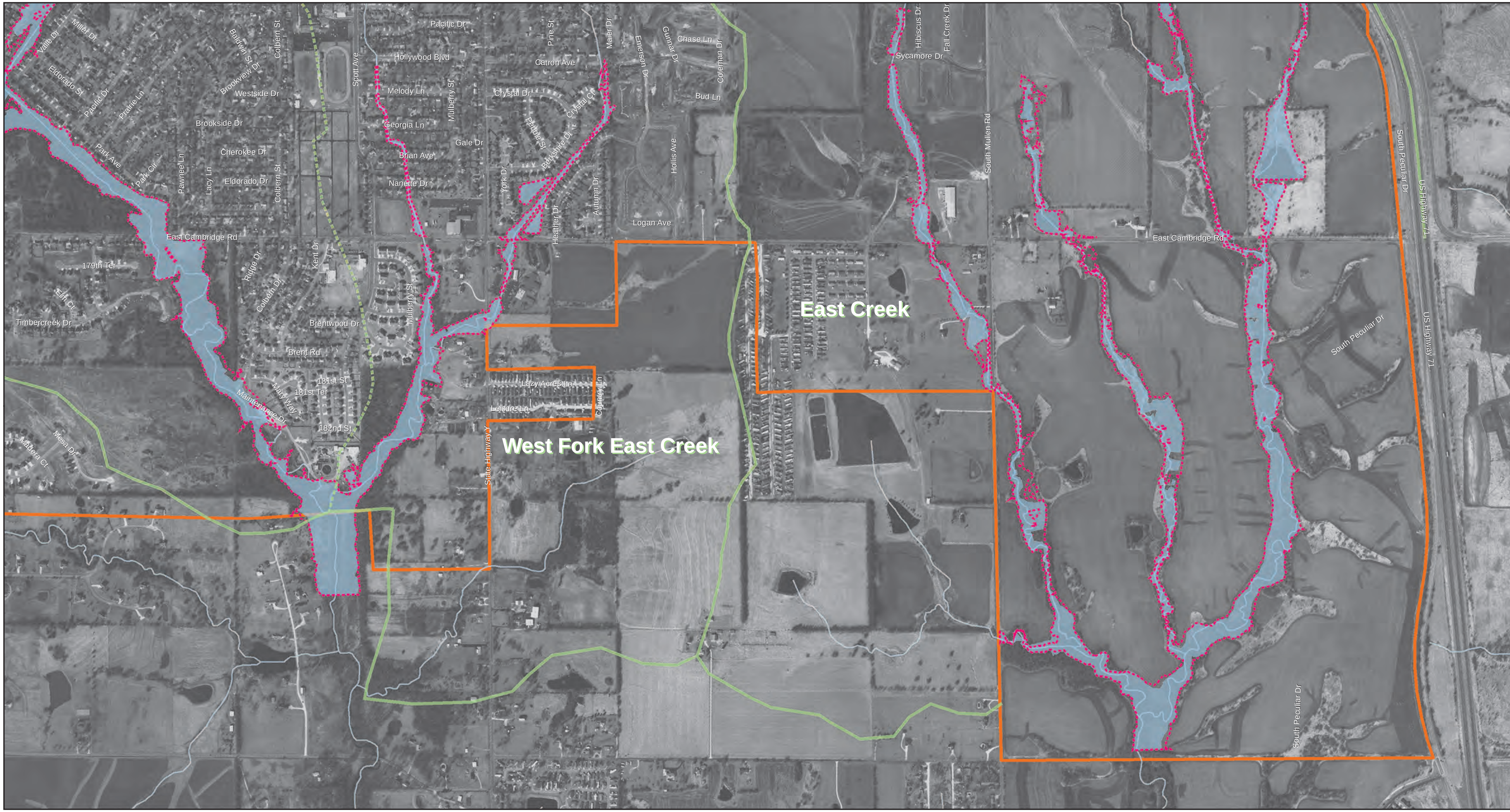
OLSSON ASSOCIATES

10/09/2012



Legend

- Streams
- Watershed Boundary
- Ultimate Conditions 100-yr Floodplain
- Existing Conditions 100-yr Floodplain
- City Limits

Figure D5:
Ultimate Development Floodplain

0 500 1,000 2,000 Feet

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D-2. Off-line Floodplain Detention Case Study

Offline detention is a detention facility that is located outside of the natural watercourse or storm sewer system. When a certain flow rate is reached the water will be diverted away from the watercourse and begin filling the offline detention storage. This type of detention focuses on reducing peak flows from storm event with return periods greater than 10 years. Low flows are allowed to bypass the detention facility and only high flows which are usually associated with flooding problems are diverted into detention. Since the storage is separate from the conveyance system, water may be stored as long necessary and then released when sufficient conveyance becomes available in the downstream system. Storage areas for offline detention may potentially be used for parks, sports fields, or other recreational purposes as they will only flood during extreme rainfall events.

Offline storage was evaluated in Oil Creek and in West Fork East Creek for possible storage locations and for overall effectiveness. The two offline storage locations that were evaluated in detail for the case study were:

- **Hargis Lake Tributary of West Fork East Creek** – Between Mill Road and W Sunrise Drive.
- **Oil Creek** – Just South of 163rd street and East of Mullen Road

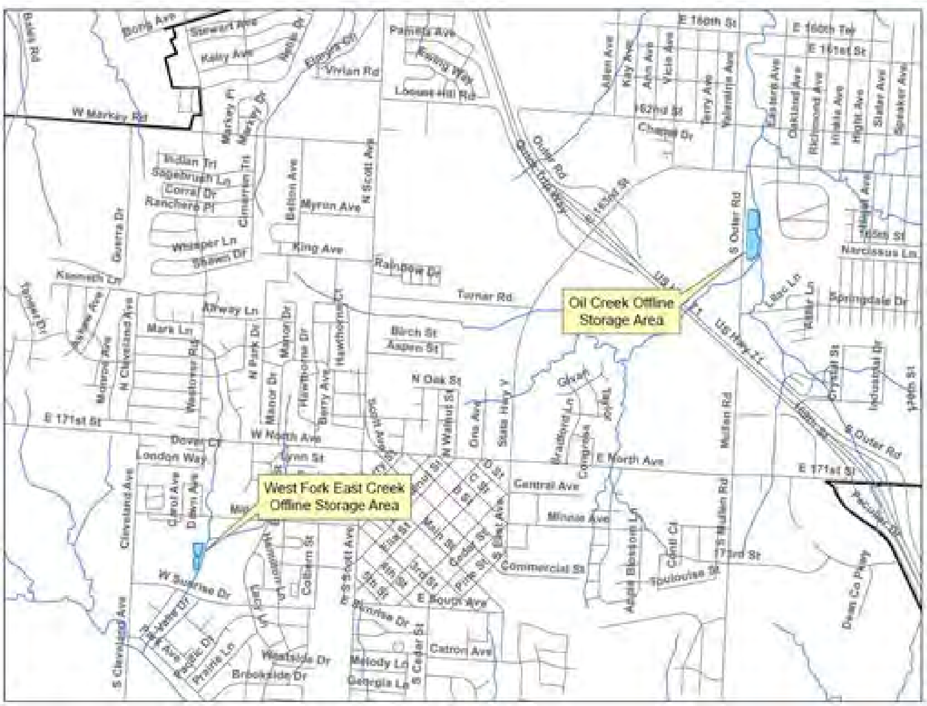


Figure D1: Offline Storage Areas Evaluated

<u>Storage Areas</u>

The conceptual offline storage area on Oil Creek would consist of 2 large storage basins that are hydraulically connected to provide maximum flood storage. The steep overbank slopes make it impractical to provide sufficient storage with one reservoir. By having multiple reservoirs that stair step down, storage can be maximized while keeping embankment heights minimal. The lower basin has a surface area of 1.5 acres and a storage volume of 4.8 acre-feet at a water surface elevation of 1012 ft. The upper basin has a surface area of 2.0 acres and a storage volume of 9.7 acre-feet at a water surface elevation of 1014 ft. The two storage areas are connected by a 24” diameter corrugated metal pipe as well as the cascading overflow spillway that is roughly 150 feet long. A 15” diameter corrugated metal pipe allows the lower basin to drain back into the channel.

The conceptual offline storage area for West Fork East Creek would also consist of 2 large hydraulically connected storage areas. The lower reservoir has a surface area of 0.52 acres and the upper reservoir has a reservoir of 1.0 acres. The lower storage area has a volume of 1.6 acre-feet at water surface elevation 1016.5, and the upper storage area has a volume of 3.46 acre-feet at water surface elevation 1018.5 ft. The two storage areas are connected by a 15” diameter corrugated metal pipe as well as the cascading overflow spillway that is roughly 100 feet long. A 15” diameter corrugated metal pipe allows the lower basin to drain back into the channel.

An unsteady flow HEC-RAS model was used to route the flood hydrograph through the channel and storage area and simulate the filling and draining of the storage area.

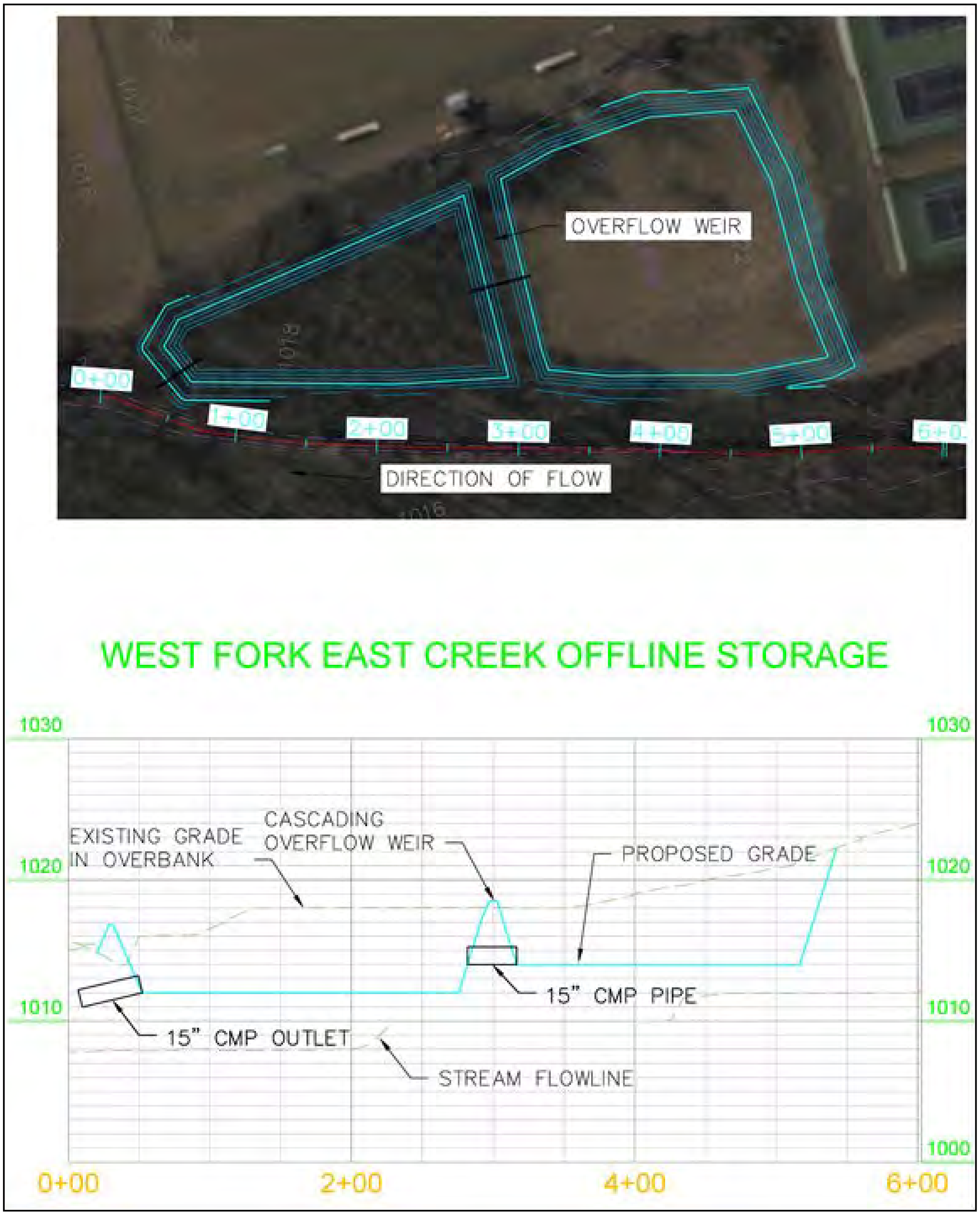


Figure D2: West Fork East Creek Offline Storage Plan and Profile

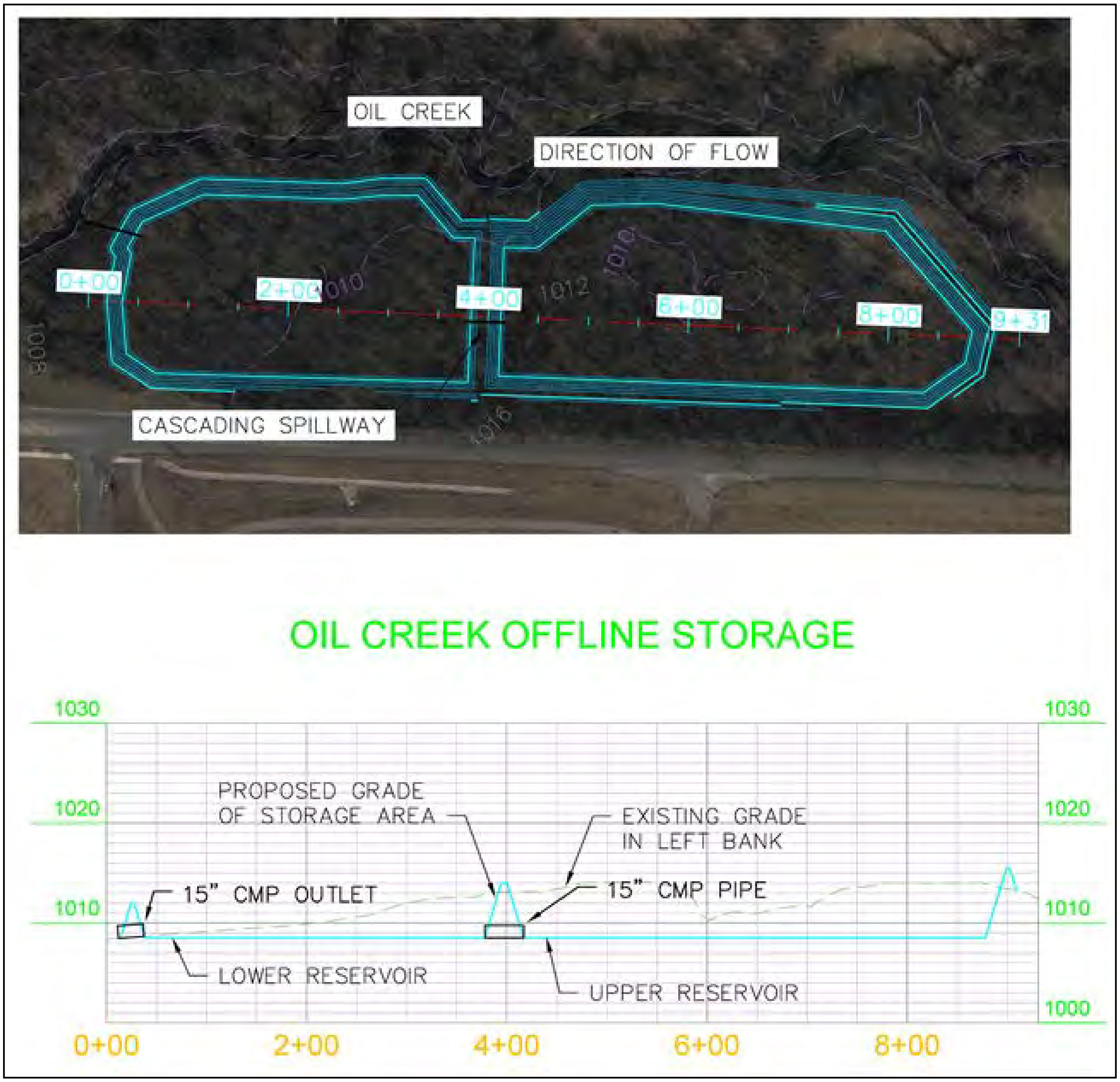


Figure D3: Oil Creek Offline Storage Plan and Profile

Modeling Results

According to the unsteady HEC-RAS model, the offline storage reservoirs in West Fork East Creek would reduce the peak flow rate roughly 15%, from 1420 cfs to 1200 cfs, which would lower the 100 year water surface 0.12 ft on average in this tributary stream to West Fork East Creek. This reduced flow rate would alleviate flooding problems caused by undersized culverts downstream of West Fork East Creek Project Area #2.

The unsteady flow analysis of the Oil Creek offline storage revealed that flow rates downstream of the storage area near 162nd Street will be reduced by 6.5%, from 7600cfs to 6900cfs, and water surface elevation will be lowered by 0.15 feet. The overall effectiveness of detention in this area may be limited by the steep slopes in the overbanks.

Conclusion

Offline detention appears to be a reasonable option for peak flow reduction in West Fork East Creek. In this area flood reduction is needed to help commonly flooded areas downstream and modeling results show that this can be an effective solution to reduce peak flows by as much as 15% during the 100 year event. One disadvantage to offline detention in this area may be the dense tree cover. Removal of trees will add to the expense of the project. This project would require roughly 11600 CY of excavation and a total project cost of $470,000.

While flow reductions were only 6.5% in Oil Creek, offline detention may still be desired to reduce flooding and provide multi-purpose recreational areas. The storage areas that were selected are also heavily wooded and removal of trees would be required. This project would require 14620 CY of excavation and a total project cost of $535,000.

West Fork East Creek Offline Detention					
Item No.	***Item Description***	***Quantity***	***Qty. Units***	***Unit Cost***	***Total Cost***
1	Mobilization	1	LS	$50,000	$50,000
2	Erosion Control	1	LS	$5,000	$5,000
3	Storm Sewer (15" RCP)	100	LF	$70	$7,000
4	Seeding	1.5	AC	$1,500	$2,250
5	Earthwork	12000	CY	$10	$120,000
				Construction Sub-Total	$184,250
				Construction Contingency	$18,425
				Engineering	$250,000
				Land Rights and Administration (10%)	$18,425
				Probable Construction Cost	$471,100

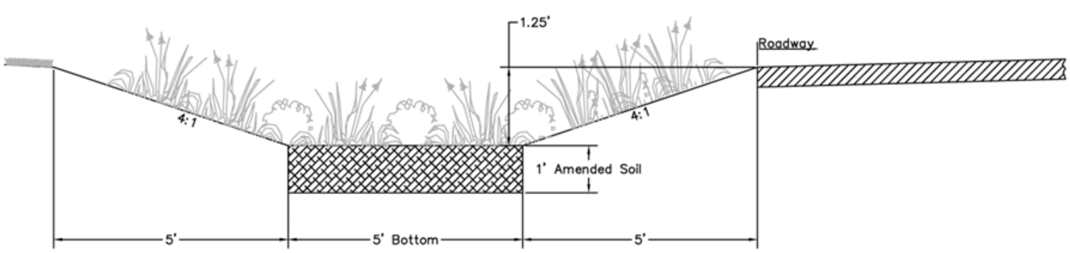
Oil Creek Offline Detention					
Item No.	***Item Description***	***Quantity***	***Qty. Units***	***Unit Cost***	***Total Cost***
1	Mobilization	1	LS	$65,000	$65,000
2	Erosion Control	1	LS	$5,000	$5,000
3	Storm Sewer (15" RCP)	55	LF	$70	$3,850
4	Storm Sewer (24" RCP)	65	LF	$80	$5,200
5	Seeding	3.5	AC	$1,500	$5,250
6	Earthwork	15000	CY	$10	$150,000
				Construction Sub-Total	$234,300
				Construction Contingency	$23,430
				Engineering	$250,000
				Land Rights and Administration (10%)	$23,430
				Probable Construction Cost	$531,160

D-3. Green Neighborhood Improvement Case Study

A case study was completed for a residential neighborhood in Belton. This neighborhood has a typical ditch and driveway culvert stormwater system. The case study was completed to determine the impact on stormwater runoff reduction with roadside vegetated swales and amended soils. The case study also looked at pollutant reduction capabilities of vegetated swales in previous roadside ditches. In addition to providing flow and pollutant reduction the conversion of the existing ditches would also serve to provide increased conveyance capacity and amenities to beautify the neighborhoods. The rendering below shows a comparison of a typical roadside ditch converted to a vegetated swale. The area that was used for the case study was located in the Oil Creek watershed on Hight Street south of 161st Street. The site can be seen in the following Figure.

Figure D4: Green Neighborhood Case Study Site

The site is typical for the area and consists of approximately 1/3 acre residential lots. Roadside ditches and driveway culverts are used to convey stormwater. It appears that the majority of the ditches in this area have not been modified since initial construction. The existing right-of-way on Hight Street is approximately 50 feet wide. For the case study it was assumed a 1.25 foot deep trapezoidal swale with a 5 foot flat bottom and 4:1 side slopes will be constructed and vegetated. A cross section illustration can be seen in the following figure.



It was also assumed that small 6 inch check dams would be installed in the channel to provide detention and encourage infiltration. For the case study it was also assumed that 1 foot of modified soil would be placed below the bottom of the channel to provide greater infiltration and vegetation establishment. The pavement edges could be treated with a ribbon curb to prevent asphalt edge failure due to runoff and to provide aesthetic appeal. An example of what such a roadway section could look like is provided at right.

The proposed channel was input into the HEC-HMS computer program and computed with various storms to determine the effect the modified ditch would have on flooding. The table below shows the volume reduction in various storms.

Table D1
Peak Flow Summary with Green Improvements

Storm	Direct Runoff	Swale Outlet	Percent Reduction
1-yr	2.98	2.90	3%
2-yr	3.84	3.84	0%
5-yr	5.41	5.45	0%
10-yr	6.41	6.42	0%
50-yr	8.4	8.41	0%
100-yr	9.53	9.53	0%

As can be seen in the table the greatest percentage reduction occurs in the 1-yr storm and smaller event. In the larger storms the swale still provides pollutant reduction but the flow reduction is limited. The greatest pollutant reduction will also occur in the smaller storms as well. The pollutants that are carried in the stormwater are usually carried in the, first flush, or initial runoff of stormwater. This first flush will be captured and infiltrated by the modified swale. The pollutants are filtered through the engineered soil media or taken up by the plants in the swale. If this strategy was implemented on a watershed basis it would provide water quality and quantity benefits. Another major benefit to the residents and the City would be the improvement in the conveyance capacity of the stormwater system. Many of the existing roadside ditches have silted in or have been altered so that conveyance is reduced. The vegetated swales would provide neighborhood beautification as well as increasing conveyance which would reduce nuisance complaints.

Initial City maintenance of the vegetated swales would be required until the vegetation has been established. Homeowner education would also be required to inform the homeowners of the function and maintenance required of the vegetated swales.

Cost estimates for the vegetated swales can be seen below. It was assumed that plant plugs would be placed at 1 per two square foot of swale area. It was assumed that the entire swale would be seeded with a native seed mix. The cost estimate accounts for 400 feet of vegetated swale. The construction costs equate to approximately $80 per foot of swale.

Vegetated Swale					
Item No.	***Item Description***	***Quantity***	***Qty. Units***	***Unit Cost***	***Total Cost***
1	Erosion Control	1	LS	$1,000	$1,000
2	Traffic Control	1	LS	$1,000	$1,000
3	Check Dams	32	EA	$180	$5,760
4	Amended Soil	74	CY	$8	$592
5	Biological Plantings	3061	EA	$5	$15,305
6	Native Seeding	0	AC	$5,000	$700
7	Ribbon Curb	400	LF	$20	$8,000
8	Earthwork	100	CY	$18	$1,800
				Construction Sub-Total	$34,157
				Construction Contingency	$8,539
				Survey, Design, and Permitting (20%)	$6,831
				Land Rights and Administration (10%)	$3,416
				Probable Construction Cost	**$52,943**

D-4 Floodplain Fill Impacts Evaluation

The potential impacts of floodplain fill were evaluated using the routing reaches developed for the HEC-HMS hydrologic model of Oil Creek. Within the Oil Creek HMS model, simulations were performed for ultimate development conditions. The first simulation included ultimate development conditions runoff hydrographs but no changes to the cross sections used to perform Muskingum-Cunge 8 Point routing through each routing reach. In the second simulation, the routing reaches for the portion of the watershed above Highway 71 were adjusted to reflect future development conditions within the upper watershed. The cross sections for these reaches were adjusted to reflect fill in the overbanks. Fill was extended to the channel banks to reflect complete fill of the floodplain outside the channel banks.

Results of the two simulations were identical, indicating flows in the routing reaches are not influenced by flood storage. These results are reinforced by the results of the steady-state HEC-RAS models, which indicate flood flows are predominantly within the channels and floodplain extents and flood storage are minimal. Encroachment, or fill in the floodplain, will affect flood flow velocities and depths but loss of flood storage will not cause an increase in peak flow rates. Thus, the "floodplain creep" issue that often occurs due to development in the floodplain does not appear to be an issue in the Oil Creek watershed. This appears to be due to the relatively narrow and steep nature of the floodplain valleys in the Oil Creek watershed and throughout Belton, which is typical of a community centered on a regional ridge where the streams run away from the center of town and the streams in Belton are primarily the headwaters of each stream system. In order to prevent excessive velocities and erosive conditions, preservation of a flood flow corridor along the stream channels is still recommended.

Conclusions:

1. Routing in stream reaches is dependent of conveyance capacity of stream.
2. Flow is mixed with both subcritical and critical flow occurring within the stream reaches, depending on location.
3. Except at road crossings routing is at normal depth.
4. Floodplain storage volume is minimal and peak flow attenuation is negligible in most cases.
5. Floodplain fill will have little to no effect on peak flow attenuation.
6. Encroachment will impact velocities and depths of flow but there will be no "floodplain creep" effect.