CITY OF
PADUCAH

COMPREHENSIVE STORMWATER MASTER PLAN

Executive Summary
DRAFT

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EXECUTIVE SUMMARY

The Executive Summary for the Comprehensive Stormwater Master Plan (CSMP) provides a brief synopsis of the overall report that documents this planning initiative, summarizing the findings of the major focus areas undertaken in completing this community-defining study. For supporting data and more detailed commentary on the findings and conclusions presented herein, the reader should refer to the separately prepared consolidated CSMP report.

1.0 INTRODUCTION

The City of Paducah (City) has a lengthy history of flooding given its location along the banks of the Ohio River just downstream of its confluence with the Tennessee River. With over 204,000 square miles of upstream drainage area to this location in the Ohio River basin as seen in Figure ES-1, known flooding issues date back literally decades to the record 1937 flood that set in motion an effort to protect the City with a floodwall and levee system. Recurring floods have continued to plague the City by other means due to frequent rainfall-induced exceedance of natural and manmade drainage conveyance systems capacity. This has resulted in extensive property damage and losses to its citizenry and the business community at large on a recurring basis. This phenomenon was most recently pronounced on July 7, 2015, when a heavy localized rainfall event befell the City, causing widespread flooding and property damage (see Figure ES-2).

Because of this increasingly recurring community problem, in August 2016, the City Commission authorized completion of a flooding-related study, framed as the City of Paducah's Comprehensive Stormwater Master Plan (CSMP). This study was commissioned to investigate documented flooding issues throughout the City and to determine the causes and limitations with existing infrastructure that may be contributing to these problems. After the broad identification of major flooding areas around the City, the study approach was structured to conduct more detailed investigations of select priority areas for more focused evaluation and identification of solutions to mitigate flooding problems. The resulting outcome of this effort is a proposed capital improvements plan with outlined strategies developed using facilitated stakeholder participation and public involvement, to help affirm critical decision-making for program implementation.

Figure ES-1 Ohio River Basin

Figure ES-2 Oakcrest Drive, July 7, 2015

2.0 COMMUNITY BACKGROUND

In conducting the underlying investigations for a community-wide stormwater master plan, it is vitally important to develop an understanding of the local context of the City and its surrounding areas. There are many facets to a community that can directly affect planning and decision-making as it relates to approaches for stormwater management and flood mitigation. As an example, long range planning and growth strategies can have a direct impact on stormwater as it relates to increased runoff volumes and corresponding changes in the floodplain. Similarly, prior studies and reports documenting these kinds of issues can also shed light on contributing factors that have influenced past decisions with infrastructure and the corresponding objectives that were intended as an outcome. In formulating this understanding, the CSMP Planning Team reviewed and studied a variety of planning considerations including the following:

- Jurisdictional Authority between City and County
- City and County Comprehensive Plan and Zoning Ordinance
- City and County Subdivision Regulations and Floodplain Ordinance
- Park and Recreation Master Plan
- Renaissance Area Master Plan
- Paducah McCracken Joint Sewer Agency Long-Term Control Plan (LTCP)
- Previous Stormwater Master Plans and Reports
- Historic Flood Records
- Local Flood Protection Project Implementation Plan

The planning area encompassing this study brings with it many unique attributes that go beyond the basic infrastructure realm that is more closely associated as the source of flooding issues within the City. While the CSMP focuses on flooding-related problems inside the City limits, the watershed basins feeding many of the drainage courses under review extend out into the county where growth and development is also permitted to similarly occur. Figure ES-3 highlights the McCracken County (County) boundary and the five major drainage basins or subwatersheds included in this study, along with an overlay of City's Corporate Limits. To illustrate the importance of this point, the study area within the City limits totals nearly 17 square miles, while the actual contributing drainage area to conveyance systems that address stormwater inside the City limits totals over 47 square miles.

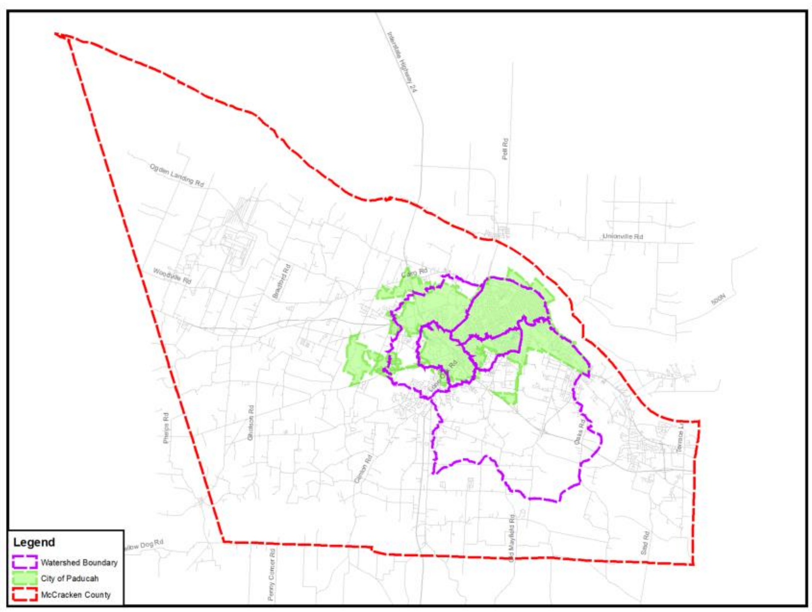


Figure ES-3 Major Drainage Basin Overview

The significance of stormwater runoff from areas within the City and County is not only defined by the watershed areas that contribute runoff to the drainage conveyance systems, but also to future development and redevelopment and the regulations that govern stormwater management controls. While both the City and County's regulations for development and redevelopment require some form of stormwater management controls, their requirements differ and are generally inadequate based on today's standards. Increased runoff volumes and peak flow rates for varying storm events can each lead to aggravation of existing flooding conditions as well as new flooding problems due to inadequate downstream conveyance system capacity.

Tables ES-1 to ES-2 provide a comparison of the various stormwater-related policies and regulations that are currently in place with the City and the County.

City of Paducah	McCracken County
1. All land-disturbing activities and all development or redevelopment activities that disturb an area greater than or equal to one acre. 2. Sites that are smaller than one acre may also be covered by these regulations if they are a part of a larger common plan of development or sale. 3. Any nonresidential development for which the area paved and under roof is equal to or greater than 10,000 square feet. 4. Contain on-site, or provide off-site, stormwater management facilities capable of controlling increased runoff equal to but not greater than its predeveloped condition.	1. Any proposed subdivision that would contain new streets and more than lots. 2. Residential subdivisions or residential planned unit developments, where minimum lot size is less than two acres. 3. Any nonresidential development for which the area paved and under roof is greater than 10,000 square feet, and a concentrated flow is created that may impact an adjacent property. 4. Contain on-site, or provide off-site, stormwater management facilities capable of controlling increased runoff relative to its predeveloped condition.

Table ES-1 Stormwater Management Requirements for Development

City of Paducah	McCracken County
10-Year/24-Hour 5.14* (4.77-5.51)*	25-Year/24-Hour 6.03* (5.58-6.47)*

*Design Storm Rates based on NOAA Atlas 14, Volume 2, Version 3

Table ES-2 Stormwater Detention Design Storms

Another equally important consideration for the CSMP is the limitation imposed by the City's combined sewer system (CSS), which defines much of the urban area context where most of the existing flooding problems have persisted for years. In general, CSSs have typically evolved over many years and not only convey sanitary sewage waste but also stormwater where connections to catch basins and other stormwater drainage components have been allowed. These systems are typically not sized to accommodate the more significant rainfall depths that are often associated with flooding occurrences. As a result, these systems are typically prone to overflows and bypasses to natural water bodies that has been under more recent scrutiny by the United States Environmental Protection Agency (USEPA) through their progressive enforcement of the Clean Water Act.

Under the authority of the Paducah McCracken Joint Sewer Agency (JSA) beginning in 1999, the City's CSS continues to evolve, following the adopted LTCP, by virtue of a Consent Judgement and Administrative Order with USEPA. As a capacity constrained system, JSA's LTCP was developed to mitigate the frequency of discharge from the CSS by implementing various improvement strategies including storm sewer separation, storage, capacity enhancement, screening, and high rate treatment systems among others. However, a primary caveat to this program is the relatively small rain event required to meet compliance expectations as compared to the larger rain events that typically result in widespread community flooding.

JSA's design basis for its LTCP uses a representative rainfall period of 5 years focusing on design storms ranging from 1-year to 5-year events with a target of eliminating or treating 85 percent of the combined sewagecollected on a system-wide annual average basis. While considered a significant requirement for implementation of system-wide CSS controls, this design basis suggests the need for careful planning and partnering in finding sustainable solutions that respect JSA CSS capacity concerns while supporting the City's flood mitigation efforts. This issue can be seen firsthand in the complexity of the CSS by the numerous interbasin regulators that redirect flow from one area to another based on rainfall induced surcharge depths within the system. To illustrate the magnitude of the JSA CSS, the system extents are graphically depicted in Figure ES-4.

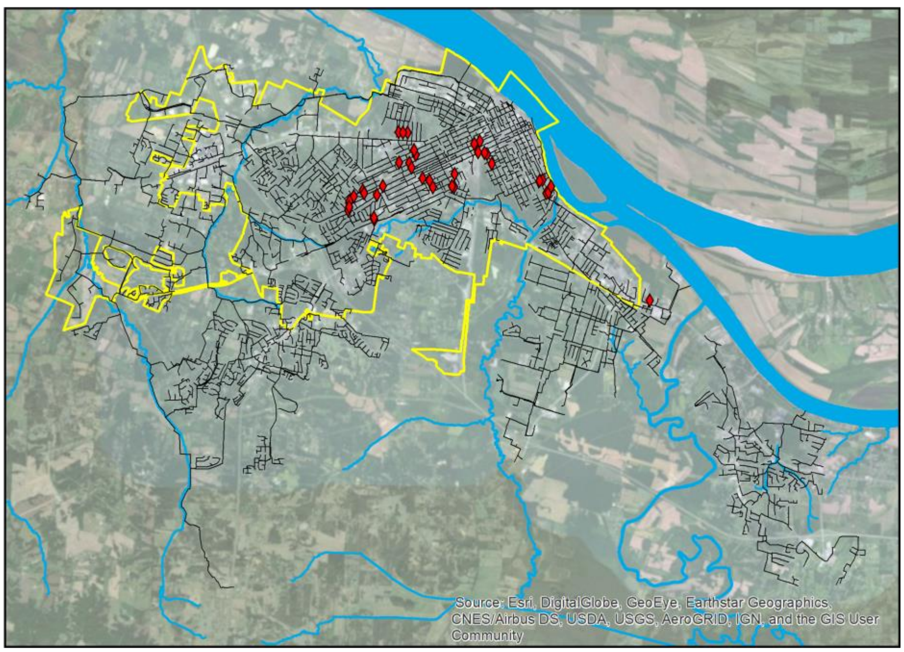


Figure ES-4 JSA CSS Service Area Extents Overview

The result of the community background review suggests a number of important action steps going forward as the City seeks to address existing flooding problems and better manage the impacts of future planning and growth decisions. Recommended action steps include the following:

1. Work with County to modernize regulations for stormwater management that are consistently applied between both jurisdictions.
2. Develop land use policies through the Comprehensive Plan that compliment future efforts to mitigate community flooding problems.
3. Consider needs for additional peak flow reductions for new and redevelopment projects located within areas of the CSS.
4. Review and update floodplain ordinance and associated policies to reduce the adverse effects of allowable filling in the floodplain and loss of riparian habitat.
5. Partner with JSA to review and consider win-win opportunities for implementation of CSMP and LTCP improvements programs.

3.0 EXISTING DRAINAGE FACILITIES AND INFRASTRUCTURE

The CSMP Study area is defined by the five major drainage basins or subwatersheds that contribute stormwater runoff to the natural and manmade conveyance systems that serve these areas. The conveyances for these drainage basins include major streams such as Crooked Creek, Cross Creek, Island Creek, and Perkins Creek as well as the various closed pipe and culverted systems that serve the more densely developed urban area of the City Massac Creek includes a small area of the City's corporate limits, but was excluded from the study scope for purposes of detailed problem area evaluations. Figure ES-5 illustrates the location of these drainage basins in relation to the Corporate Limits of the City.

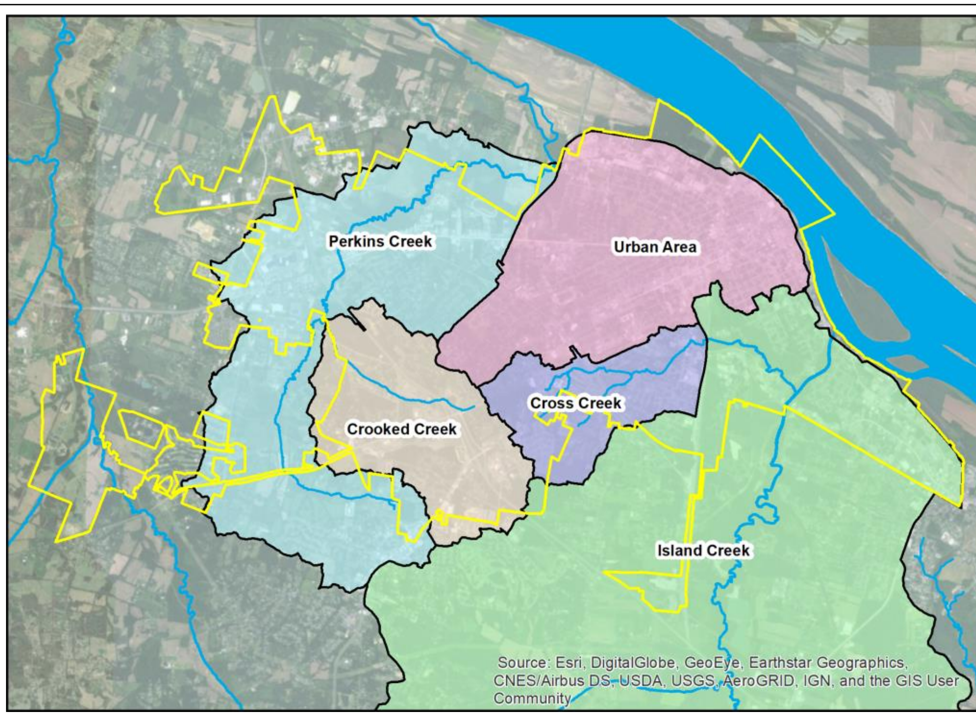


Figure ES-5 Study Area Watershed Limits

In addition to overall size, each drainage basin includes certain unique characteristics that define the local runoff patterns and contribute to flow received by its respective drainage conveyances. These factors range from the steepness of topography and type of ground cover to soil types and the density of urban development that is currently in place. Remaining undeveloped land is also an important consideration with stormwater master planning since nearly all new development that occurs will result in increased runoff volume to the downstream receiving systems. Similarly, redevelopment activity can add further to this phenomenon, since these kinds of projects can also result in increased densities and impervious area. Table ES-3 on the following page highlights the major characteristics that define each drainage basin included in this study.

Watershed Name	Area (acres)	Approximate Impervious Area (%)	Portion of Watershed in City Limits (%)	Primary Conveyance Method
Island Creek	17,988	9	12	Natural Stream
Cross Creek	1,309	31	80	Natural Stream
Crooked Creek	2,102	25	86	Natural Stream
Perkins Creek	5,101	18	51	Natural Stream
Urban Area	3,509	49	100	Pipe/Culvert

Table ES-3 Study Area Subwatershed Statistics

As illustrated in Table ES-3, four of the five drainage basins are primarily served by natural stream conveyance systems with the lone exception being the Urban Area subwatershed. The urban area includes both separate and combined sewers that are formed by an extensive network of inlets and piping that capture and convey stormwater flow to major outfalls near the Ohio River. JSA owns and maintains the major components of the piping network in the combined sewer area, which is designed to direct wastewater and any base flow in this system to the existing wastewater treatment plant. The City owns and maintains the separate storm sewer system including the storm sewer catch basins and piping that connect to the CSS. During heavy rainfall events, the CSS can become surcharged with stormwater, which sometimes results in overflow releases into the natural receiving system at controlled locations. Table ES-4 includes a summary of the major components that comprise the existing closed pipe network.

Component	Quantity
Pipe	170 Miles
0” to 15”	73 Miles
15” to 24:	56 Miles
24” to 48”	29 Miles
48” and Larger	12 Miles
Manholes	1651
Regulator Manholes	47
Inlets	6,399
Outfalls	842

Table ES-4 Major Conveyance System Components

In undertaking this study, existing flooding-related complaints were also reviewed and compiled to correlate the nature of the stated problem and its location with respect to each major drainage basin. Between 2007 and 2016, the City documented over 440 complaints on its Drainage Complaint Log for various issues associated with drainage and stormwater. Through a detailed screening process, many of these complaints were found not applicable to the CSMP, since they related to private property matters or other unrelated issues. the remaining complaints applicable to the CSMP initiative were grouped and categorized by watershed as detailed in Table ES-5. These complaints are also georeferenced according to each subwatershed drainage basin in Figure ES-6, to illustrate their concentration for the study.

Drainage Basin	Structural	Sinkhole	System Maintenance	Yard Flooding	Total
Crooked Creek	4	2	3	2	11
Cross Creek	1	-	14	3	18
Island Creek	1	1	1	1	4
Perkins Creek	-	4	4	5	13
Urban Area	7	4	53	15	79
Total	**13**	**11**	**75**	**26**	**125**

Table ES-5 Drainage Complaints Per Study Basin 2007-2016

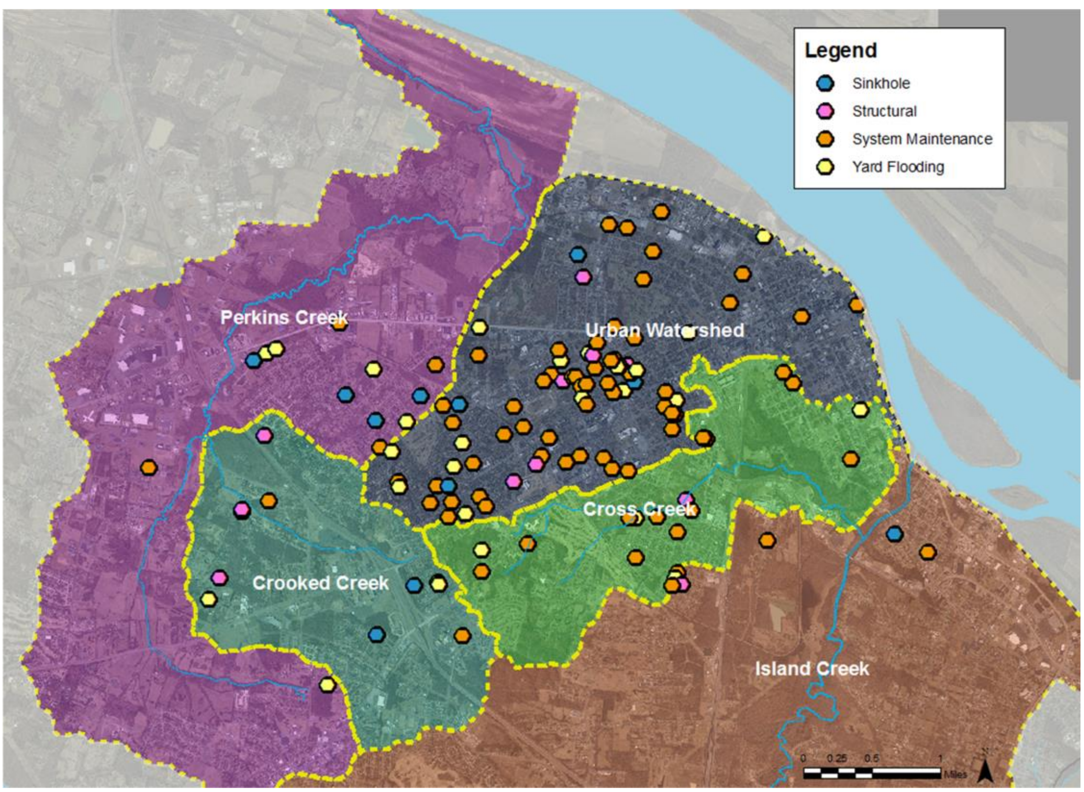


Figure ES-6 Mapped Drainage Complaints 2007 to 2016

Based on the 10-year complaint history provided by the City, the overwhelming majority were situated in urban area locations and determined to be more maintenance related in scope. From this data, it was concluded that additional public outreach was needed to correlate past flooding history with documented property owner flooding accounts.

4.0 LOCAL FLOOD PROTECTION SYSTEM

Following the historic flood of 1937, the Federal Government authorized implementation of the Paducah Local Flood Protection Project in response to the catastrophic flood damage experienced from the Ohio River. This system continues to exist and operate today as a vitally important part of this City's overall strategy for flood protection. Comprised of over 12 miles of earthen levee and concrete floodwalls with 12 pump plants, this system is designed to protect 17.3 square miles of combined City and County area containing over $1.2 billion dollars in community assets, against flooding from the Ohio River. The City's budget includes an allocation of over $600,000 annually to support the various operational needs for this system. Figure ES-7 highlights the extents of the floodwall and flood protected areas as well as the pump plants that service upstream area drainage needs.

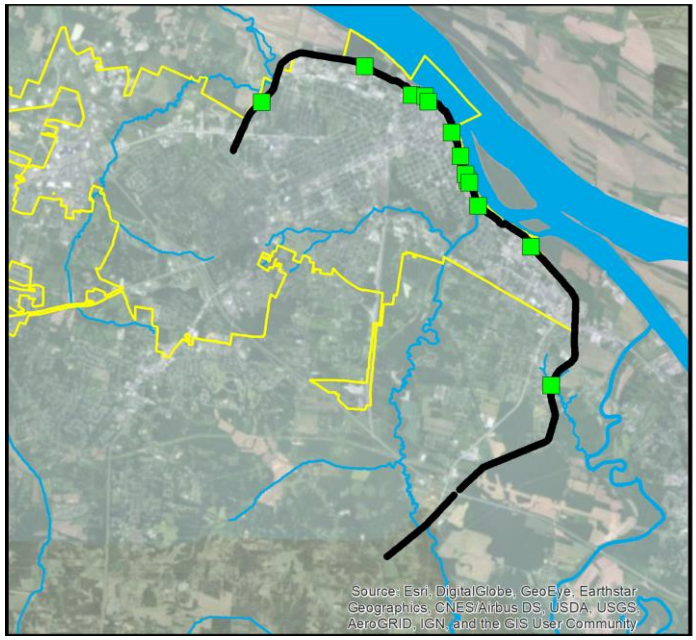


Figure ES-7 Local Flood Protection System

Under normal river stages below flood level, this system operates in an open condition allowing flow from pipes and streams on the landward side of the levee and floodwall to flow through directly to the river by natural conveyance or piped flow. When the river stage is high, and the flood protection system is activated, pump plants are needed to convey accumulated stormwater from the landward side of the levee and floodwall to the river. In certain locations such as Noble Park, the operations of this system must be carefully considered in context with the performance of the upstream area storm drainage conveyance system. For high intensity localized rain events that occur when the flood gates are closed, this system can surcharge and contribute to upstream area flooding. Given this condition, the study approach included a review of pump plant operations and capacities, and their corresponding upstream drainage system networks for consideration in the modeling phase and evaluation of alternatives.

5.0 STORMWATER MODELING TOOLS

The five subwatershed drainage basins comprising the CSMP study area include two distinctly differing conveyance systems for purposes of stormwater drainage. In the Cross Creek, Crooked Creek, Perkins Creek, and Island Creek subwatersheds, natural streams and open channel segments are the primary means for stormwater conveyance. In contrast, the Urban Area subwatershed relies on a highly connected closed pipe network that serves as the principal means of stormwater conveyance. For each of these areas, existing modeling tools were reviewed for their adequacy in supporting the analysis required for the CSMP. In open channel areas, hydraulic and hydrologic models were obtained from FEMA as approved from their most recent map update in 2009. Similarly, JSA provided the EPA SWMM model prepared for the analysis and development of the LTCP for the Urban Area CSS.

The existing model datasets provided by FEMA included portions of Cross, Crooked, and Perkins Creeks. No existing model products were available for the Island Creek subwatershed, however this basin essentially operates as a reservoir at stages affecting the City when the flood gates are closed and modeling of this basin was not required for the CSMP. In evaluating the existing model datasets for Cross, Crooked, and Perkins Creeks, updates were required to conform with the project study limits. In addition, field visits were conducted at bridge and culvert structure crossings and along the stream channel systems to verify and obtain additional data for model updates and refinements. In order to maintain consistency between the existing floodplain mapping of record, and the proposed alternatives for flood mitigation, the latest versions of HEC-HMS and HEC-RAS were used for subsequent modeling efforts with the updated datasets. Figure ES-8 provides an illustrative perspective of the model geometry and floodplain associated with Crooked Creek.

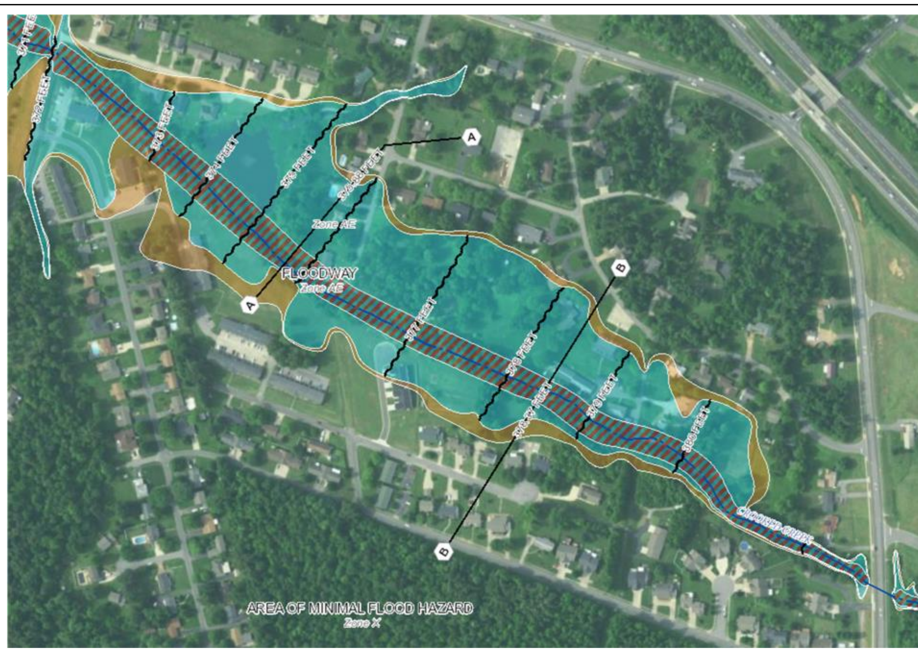


Figure ES-8 Crooked Creek FEMA Flood Mapping

For the City's urbanized area, JSA's skeletonized wet weather EPA SWMM model was used as the base model platform. This model consisted of over 35 miles of the CSS pipe network that was carefully reviewed in establishing the framework for its use as a stormwater modeling tool. The JSA model dataset required a number of refinements and upgrades in several respects, to allow for its use in evaluating large storm events that exceed the normal precipitation standard applied for wastewater conveyance-related applications. Existing data in the model was reviewed in detail with JSA staff to confirm the consistency of existing model data with stormwater data utilized from the City's GIS system for the CSMP. Flood pump plant data was also inserted in the model for select locations to accurately reflect system performance for the storm events considered in the CSMP. Figure ES-9, represents the extent of the JSA EPA SWMM skeletonized model.

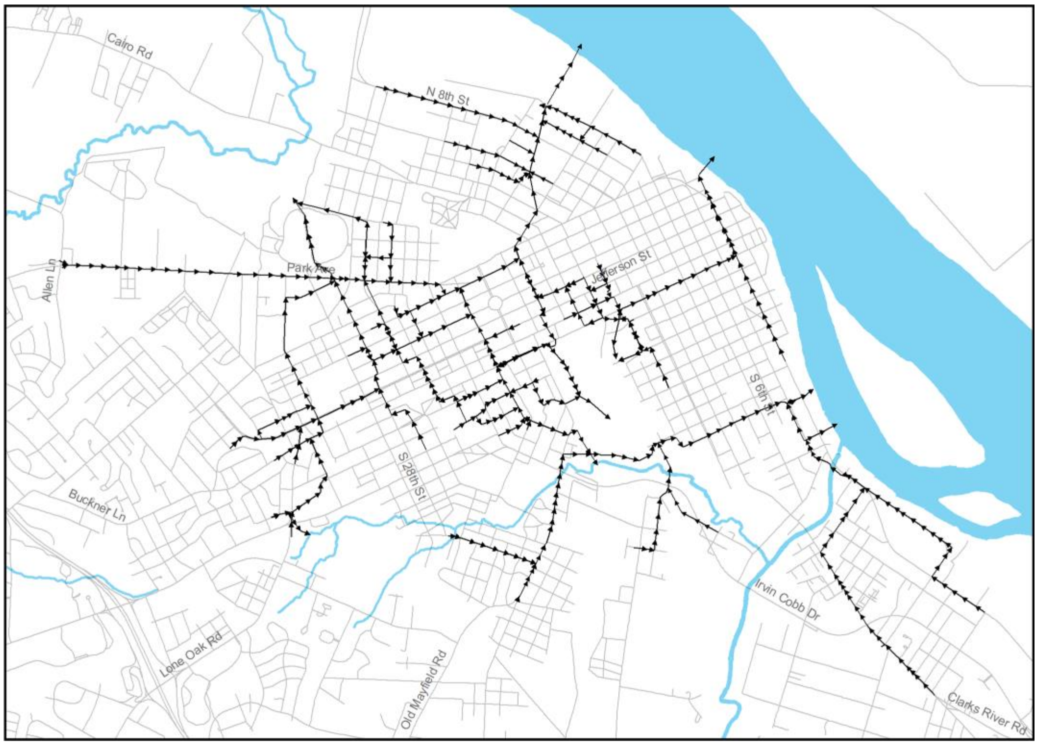


Figure ES-9 JSA Skeletonized EPA SWMM Model Extents

To better suit subsequent alternatives analyses, the XPSWMM 2D modeling platform was selected for the urban area evaluation to allow for more comprehensive analyses of the system. Because of the flat topography in the urban area, the number of regulator structures, the variations in system operation because of floodwall closures, and the widespread nature of the flooding issues, it was deemed imperative that model functionality for overland flow and interbasin transfers be considered. By attaching a digital terrain model to the hydraulic system, excess runoff and surcharges out of the piped system can be stored on the surface in low areas or continue along an overland flow path until it finds a location within the system having capacity. Where the CSS model typically evaluates smaller events, disregarding surface storage and overland flow, the 2D model platform allows the excess flow to be accounted for and graphically represented to visually understand impacts that might occur on other parts of the system. A sample of the XP SWMM 2D model output is illustrated in Figure ES-10, graphically depicting surcharge conditions and accommodating continuity of flow for the associated storm event being modeled.

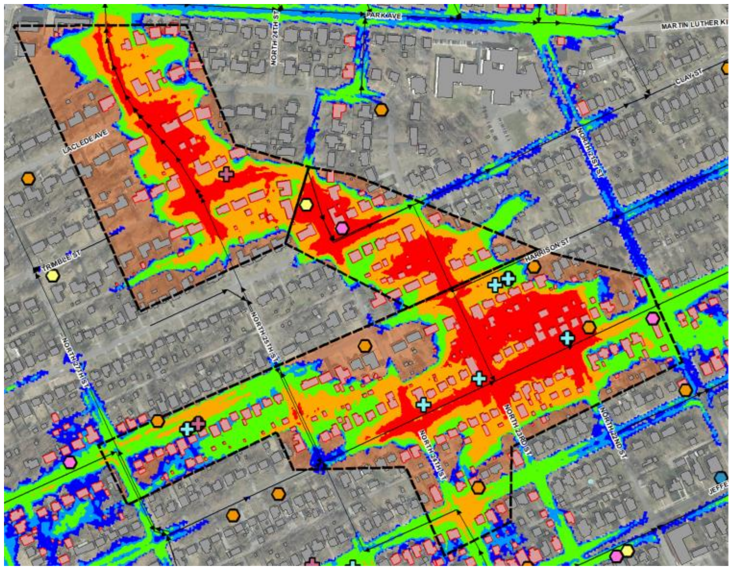


Figure ES-10 XP SWMM 2D Graphic Output (Madison Street Area)

Details of other adjustments to these models can be found in the consolidated CSMP report.

6.0 STORMWATER ASSET MANAGEMENT SYSTEM

The City's existing geographic information system (GIS) served as an important resource for various aspects of the CSMP study process. Principal among these were GIS coverages for the separate storm sewer and combined sanitary sewer systems that extend throughout the urban areas of the City's infrastructure realm. Additional related GIS coverages were also provided to aid in translating the hydrologic network and understanding important characteristics for system background review and model development. Access to this information also provided a unique opportunity to evaluate the extent of the City's existing infrastructure, and the completeness of available information included from archived drawings and records of major system components considered for the CSMP hydraulic model.

Storm Sewer		Length (Feet)	Percentage
24-Inches and >	With invert information:	105,859	34%
	Without invert information:	208,013	66%
27-Inches and >	With invert information:	66,431	31%
	Without invert information:	14,160	69%

Table ES-6 Storm Sewer Infrastructure 24-Inches and Greater

In addition to the City's GIS datasets for the separate and combined sewers, JSA also maintains a separate GIS System for the CSS that they operate and maintain. JSA has a significant portion of the urban area combined sewer network, where numerous connections to the separate storm sewer system also exist. On review of JSA's system information, various data gaps and discrepancies were discovered in comparison with the City's GIS datasets that were reconciled for the CSMP study. This was accomplished by augmenting JSA's skeletonized CSS model with additional pipe data for infrastructure 24 inches in diameter and larger from the City's GIS datasets. The remaining data gaps were then reconciled with as-built and sewer plat drawings provided by the City and supplemental field surveys conducted to confirm pipe connectivity and obtain manhole- and pipe-related data for the hydraulic model.

As the City continues to advance efforts to proactively improve its existing separate storm sewer system, synchronization of these two asset management databases should be considered. This will improve understanding of system connectivity and aid in coordinating subsequent efforts between each jurisdiction with maintenance activities and responses to customer service requests for maintenance and other related areas of concern.

7.0 EXISTING CONDITIONS MODELING

The development and refinement of the baseline existing conditions model provides the underlying foundation for the CSMP. This important step in the study process relies on carefully developed modeling tools that establish baseline conditions for a record storm event to be used for evaluation of flood mitigation alternatives. The approach applied for this purpose includes reliance on available data to help approximate a major record flood event having a known rainfall distribution and corresponding documentation for high water levels at locations in the study area. By correlating this approach with feedback from the community at large, the confidence level for the scope and scale of improvements required to mitigate flooding is increased.

Through use of JSA's existing wet weather SWMM model, major considerations for the urban area included redelineation of sewershed drainage areas to more appropriately correlate surface water runoff to existing inlet structures. The initial redelineation of the skeletonized model was based on a target watershed size of 15 acres, however subsequent analyses required that smaller delineations be applied to better simulate watershed runoff response for the stormwater model. Runoff curve numbers were assigned using a GIS overlay of the developed impervious surface area combined with data from the NRCS Soil Survey for McCracken County. Values for times of concentration (TC) were calculated using the NRCS TR-55 method with a maximum sheet flow length of 100 feet, with a minimum TC of 10 minutes for purposes of this study.

For open channel areas an extensive review of input parameters was conducted for both the FEMA HEC-HMS and HEC-RAS models to affirm channel flow rates at key locations along stream corridors and at major bridge and culvert crossings where storage and peak flow attenuation would likely occur. This effort included additional field surveys to verify structure data and obtain supplemental cross sections to improve simulation of structure crossings and open channel conveyances. Based on field observations, a variety of changes were made to the existing HEC-RAS models to more accurately reflect current existing conditions. In addition, the existing HEC-HMS models were originally developed using the Muskingum-Cunge routing method to calculate hydrologic transport. However, to more accurately reflect peak flow attenuation, the Modified Puls method was applied to calculate lag and incorporate channel flow-storage affects.

Following initial model development and completion of trial runs for both the urban and open channel areas, efforts shifted to model calibration. Through feedback with City staff and documented media accounts of associated flooding, the July 7, 2015 storm event was selected to correlate model predicted flows with this recently documented historical rainfall-runoff flood event. This 5.9-inch rain event resulted in widespread flooding throughout the community and was well chronicled by the media and citizen accounts of flooding and flood damage losses. A variety of photographic documentation, as shown below in Figures ES-11 and ES-12, was provided throughout the CSMP study area from impacted residents and property owners with reported accounts of high water marks, some which were clearly visible in the images that were provided.

Figure ES-11 Madison Street July 7, 2015

Figure ES-12 Buckner Lake Circle July 7, 2015

For the urban area, Next Generation Weather Radar (NEXRAD) data was obtained from NOAA's National Centers for Environmental Information (NCEI). The actual rainfall distribution for the July 7 event was then replicated according to the varying intensities experienced across the watershed and then inserted in the urban area XPSWMM 2D runoff model to simulate flood conditions (see Figure ES-13). This model was also associated with the City's LIDAR mapping, allowing the 2D model to graphically depict model predicted flood depths in areas of identified concern. Coupled with field surveys to confirm approximate high-water marks, this evaluation technique informed needs for subsequent extensions and refinements to the model structure to more closely replicate the actual flooding conditions for the July 7, 2015 storm event. An example of modeled flooding output from the model and the associated

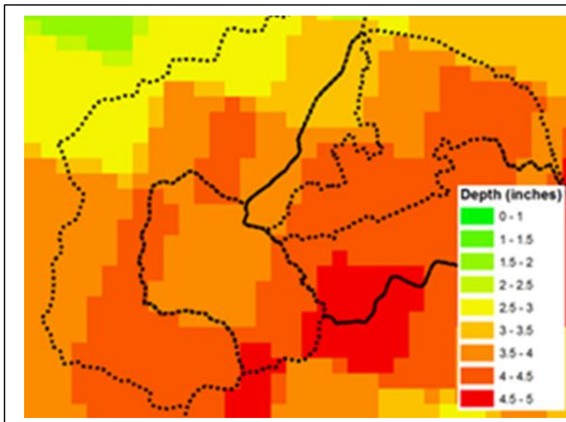


Figure ES-13 NEXRAD Rainfall Imagery July 7, 2015

photographic evidence can be seen in Figures ES-14 and ES-15.

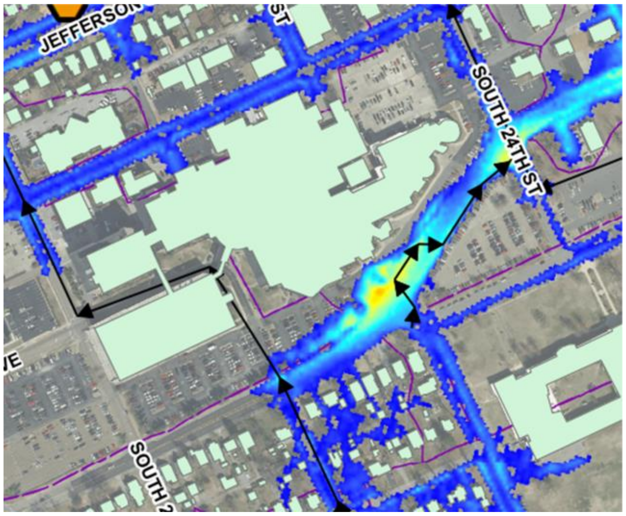


Figure ES-14 Modeled Flooding at Hospital July 7, 2015

Figure ES-15 Hospital Entrance at Kentucky Avenue July 7, 2015

In the open channel areas of Crooked, Cross, and Perkins Creeks, observed high water elevations for the July 7, 2015 storm event were estimated for comparison with model predicted peak flood stages at those same locations. Runoff curve numbers were then incrementally reduced to correlate the revised model runs with the estimated flood elevations that were identified. The runoff curve numbers were reduced by approximately 5 percent to more closely simulate the outcome of the July 7 calibration flood event. Additional efforts were also applied in conducting critical duration analyses for each subwatershed area to determine the appropriate basis for selected design storms to be used in the subsequent evaluation of alternatives. The critical duration analyses concluded that a 3-hour storm duration should be applied for the Crooked-Perkins Creek watersheds while a 12-hour storm duration was most appropriate for Cross Creek. Calculated flows for each subwatershed were also correlated with the 2009 FEMA-developed flow rates at record locations throughout each stream reach.

8.0 FLOOD PROBLEM AREA IDENTIFICATION

The CSMP study scope required identification of problem areas and a subsequent screening effort to shortlist priority areas for more detailed evaluations and development of flood mitigation strategies. In addressing this requirement, identification and assessment of flood-related problem areas was centered on two parallel fronts in determining these major areas of concern. Initially, this involved analysis of existing conditions model runs for the July 7, 2015 storm event and the corresponding delineation of model predicted flood depths and structures inundated or affected by flooding. In the urban area this involved utilization of the graphic output from the XPSWMM 2D model for this purpose, while in the open channel areas of Crooked, Cross, and Perkins Creeks, flooding limits for each stream was extracted from model output to provide similar mapping for evaluation. This information was then correlated with the City's drainage complaint log and feedback from engineering staff on past flooding and known historically floodprone areas.

Following this approach, 23 floodprone areas were initially delineated throughout the City and documented by the number of flood-impacted structures, and in some cases critical thoroughfares. The assessment included assignment of additional qualitative criteria for likely solutions such as project complexity, order of magnitude cost, and project interdependency, as detailed in the example analysis for Kentucky Avenue in Figure ES-16. These areas were then further vetted by evaluating a range of lesser design storms (10- and 25-year) to gage the frequency of recurring flooding for these same areas for events having smaller rainfall depths. This subsequent step yielded certain areas where flooding occurred on as frequently as a 2-year to 5-year interval, while others experienced little or no flooding. After presentation and discussion of these findings with the City Commission, and Stormwater Advisory Committee, this body of information and feedback was further reviewed and discussed with several members of the Technical Advisory Group, who by general consensus, selected the 10 priority areas for more detailed evaluation of alternatives.

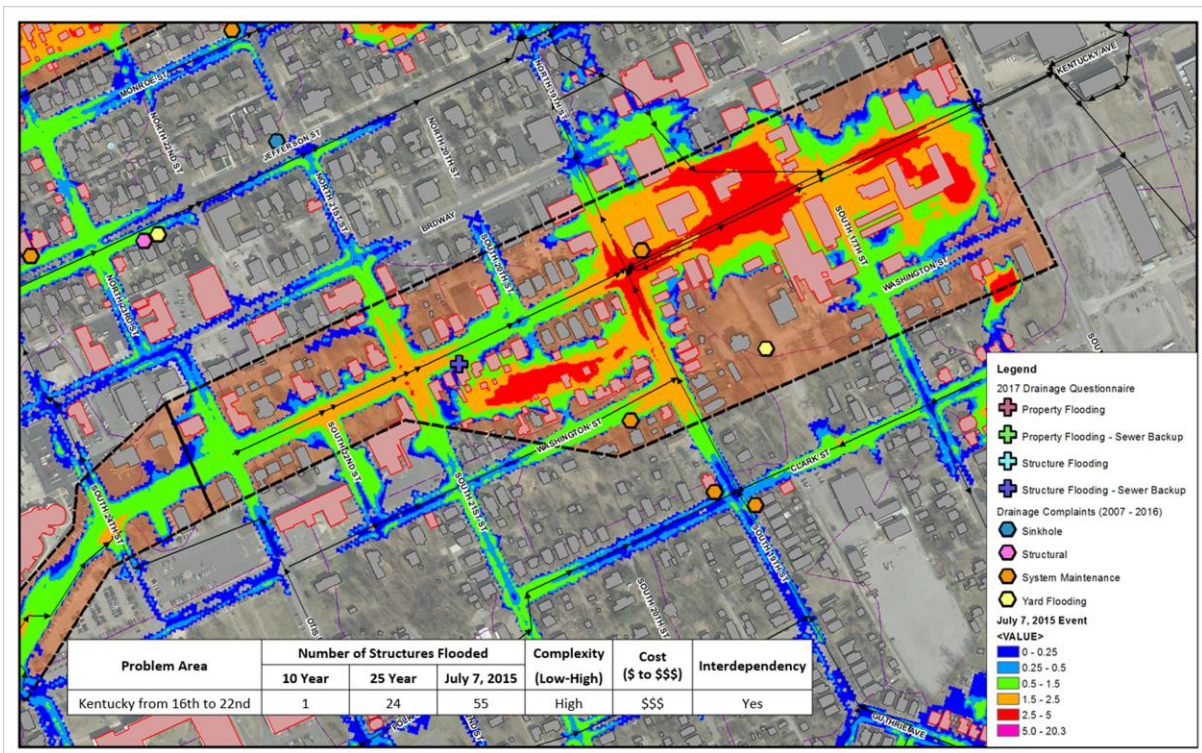


Figure ES-16 Kentucky Avenue Initial Problem Area Assessment

The 23 identified flood problem areas with the ten highlighted priority areas are detailed in Figure ES-17 on the following page with corresponding flood-related statistics in Figure ES-18.

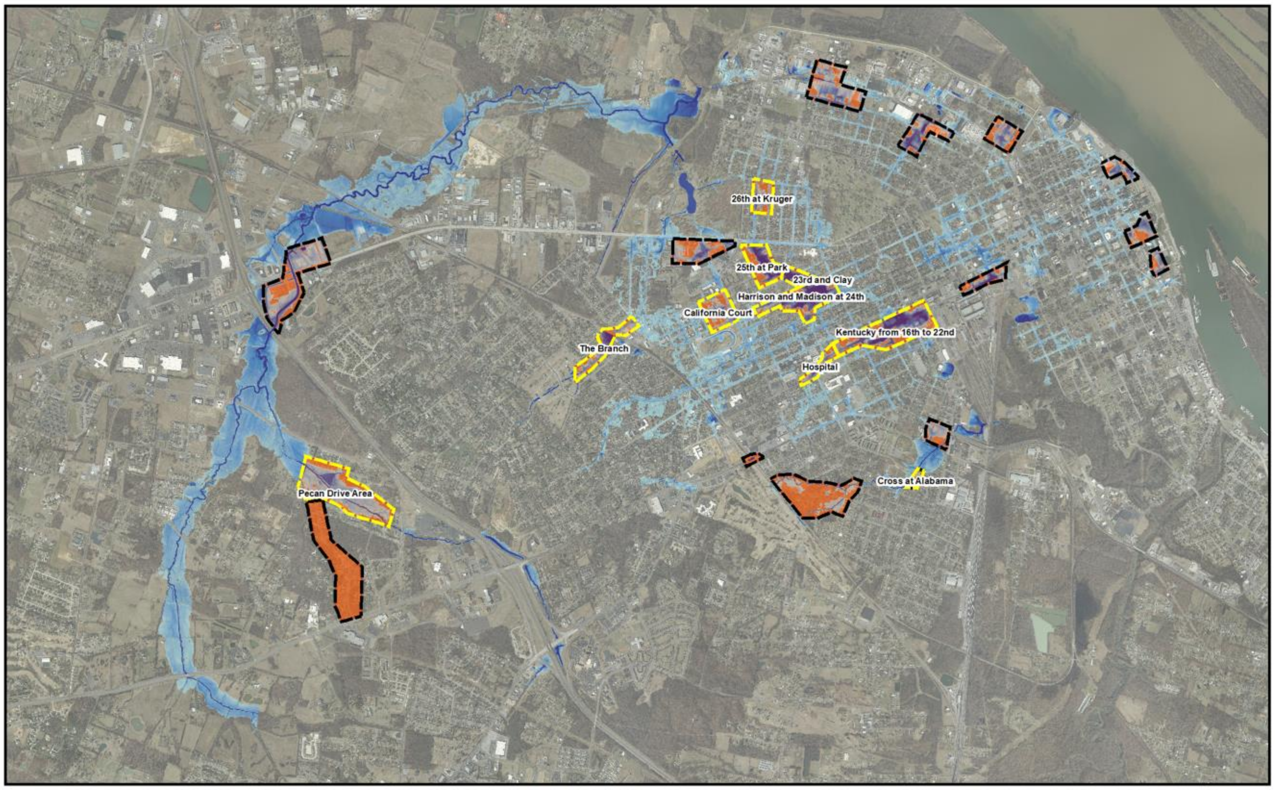


Figure ES-17 Identified Floodprone Locations and Selected Priority Problem Areas

Problem Area	Number of Structures Flooded			Complexity	Cost	Interdependency
	10 Year	25 Year	July 7, 2015	(Low-High)	($ to $$$)	
The Branch	0	11	19	Med	$$	No
Ross Avenue	0	4	9	Med	$$	Possible
California Court	10	19	27	Med	$$$	Possible
26th and Kruger	5	12	24	Med	$$	Yes
25th at Park	12	17	26	High	$$$	Yes
23rd at Clay	6	13	21	High	$$$	Yes
Harrison and Madison at 24th	23	60	82	High	$$$	Yes
Hospital	0	0	1	Med	$$$	Yes
Kentucky from 16th to 22nd	1	24	55	High	$$$	Yes
Kentucky 12th to 13th	0	4	9	Med	$$	No
Marine Way from Adams to Oscar Cross	0	0	3	Low	$	No
Marine Way from Washington to Clark	1	3	7	Med	$$	No
2nd and Monroe	2	2	4	Low	$	No
8th at Anderson Court	1	6	19	Low	$	No
10th and Flournoy	0	1	10	Low	$$	No
10th and Oak at Olive	10	11	31	Low	$	No
Jackson Street Underpass	0	0	0	Low	$	No
Cross 24th to Railroad	0	1	15	Low	$	No
Cross at 25th	0	0	5	Low	$$	Yes
Cross at 21st	0	0	10	Med	$$	Yes
Pecan Drive	6	11	32	Med	$$	Possible
Oakcrest and Springwell	0	0	0	Low	$	Possible
Coleman Road	2	7	10	Med	$$$	Possible

Figure ES-18 Preliminary Problem Area Evaluation

9.0 FLOOD MITIGATION ALTERNATIVES DEVELOPMENT

Development of a preliminary alternatives solutions matrix provided the basis for discussion of the initial evaluation of alternatives. The purpose of the matrix was to identify a wide range of flood mitigation strategies for determination of the appropriate solutions to be permitted for each priority problem area. The major categories for the solutions considered in the matrix were grouped as follows: Conveyance, Storage, Runoff Reduction, and Regulatory. This matrix was reviewed and discussed with the Technical Advisory Group for each of the priority areas as shown in Table ES-7.

Problem Area	Control Type																					
	Underground Storage	Surface Storage	Above Ground Storage Tanks	Basin Retrofits	Pond Conversion	Improved Conduit Conveyance	Sewer Separation	New Open Channel Conveyance	Overland Flow Path (Greenway)	Floodplain Modification	Road Culvert Replacement	Bridge Upsizing	Increased Flood PS Capacity	Stormwater Pump Station/ Forcemain	Basin Transfers	Property Buyouts	Infill/ Redevelop	Zoning Amendment	Street Curb Bump Outs	Rain Barrels	Pervious Driveways	Rain Gardens
The Branch	✗	✓	N/A	✓	✗	✓	✓ - 3	✓	✓	✗	✗	✗	✗	✓ - 3	✓ - 3	✓	✓ - 1	✓ - 1	✓ - 2	✓ - 2	✓ - 2	✓ - 2
California Court	✓	✓	N/A	✗	✗	✓	✓	✗	✗	✗	✗	✗	✓	✓	✓	✓						
26th and Kruger	✓	✓	N/A	✗	✗	✓	✓	✗	✓	✗	✗	✗	✓	✓	✓	✓						
25th at Park	✓	✓	N/A	✗	✗	✓	✓	✗	✓	✗	✗	✗	✓	✓	✓	✓						
23rd at Clay	✓	✓	N/A	✗	✗	✓	✓	✗	✓	✗	✗	✗	✓	✓	✓	✓						
Harrison and Madison at 24th	✓	✓	N/A	✗	✗	✓	✓	✗	✓	✗	✗	✗	✓	✓	✓	✓						
Hospital	✓	✓	N/A	✗	✗	✓	✓	✗	✗	✗	✗	✗	✓	✓	✓	✓						
Kentucky from 16th to 22nd	✓	✓	N/A	✗	✗	✓	✓	✗	✗	✗	✗	✗	✓	✓	✓	✓						
Cross at 25th	✗	✓	N/A	✓	✓	✗	✗	✓	✗	✓	✓	✓	✗	✗	✗	✓						
Pecan Drive	✗	✓	N/A	✓	✓	✓	✗	✗	✗	✓	✓	✓	✗	✗	✗	✓						

Notes:
1. Flood Reduction will be slow but provide long term impacts and prevent erosion of benefits realized through other control types.
2. Options will provide benefits in smaller storm events but can be incorporated in to most control types.
3. Only applies to Friedman Lane Interconnection option.
4. Separation may be required based on the control type selected. Stormwater may re-enter the CSS or CSO pipes following control.

✓ = Yes, ✗ = No

Table ES-7 Flood Mitigation Alternatives Solutions Matrix

The initial target design storm selected by the City for flood mitigation was the 100-year event. Through the initial analysis the peak flows and runoff volumes generated by this design storm required alternatives that focused on conveyance instead of detention or runoff reduction because of the limited available space for storage. These initial alternatives became the basis for a trial benefit cost analysis to gauge feasibility of the evaluated solutions. The XPSWMM 2D modeling platform allowed generation of surface flood extents and depths to be evaluated against building footprints. Using GIS, depth of flooding was assigned to individual structures and a depth-damage curve was applied to develop a base damage cost and subsequent flood mitigation benefit to evaluate the performance of each alternative.

Rough order-of-magnitude cost estimates were then developed for these alternatives to generate an expected benefit and cost for flood mitigation targeting the 100-year event in the 10 priority areas. A single project was selected and further refined to target 25-year and 10-year events as a case study to develop expected reductions in benefits and cost by reducing the effective level of performance. These reduction factors were then applied to the balance of the urban area projects to develop overall projections for cost, benefit, and impacted structures. These factors were not applied to the open channel alternatives as reducing the performance of the proposed projects to target events less than the 100-year storm would be atypical. A summary of the findings is included in Tables ES-8 and ES-9.

Magnitude of Design	(1) Lifetime Benefit Range	(2) Alternative Cost Range	(1) ÷ (2) BCR Range	Primary Structures Removed from Flooding	Primary Structures with Reduced Flooding Risk
100-Year BCR (1% Chance)	$37.6 to $46.2	$43.1 to $47.6	0.79 to 1.07	270 to 300	240 to 265
25-Year BCR (4% Chance)	$36.8 to $45.3	$32.8 to $36.2	1.02 to 1.38	160 to 180	275 to 310
10-Year BCR (10% Chance)	$32.7 to $40.2	$25.9 to $28.6	1.14 to 1.55	105 to 120	300 to 330

Table ES-8 Urban Area Priority Problem Area Case Study Results

Magnitude of Design	(1) Lifetime Benefit Range	(2) Alternative Cost Range	(1) ÷ (2) BCR Range	Primary Structures Removed from Flooding	Primary Structures with Reduced Flooding Risk
100-Year BCR (1% Chance)	$16.6 to $22.4	$1.0 to $7.7	17.47 to 2.91	29 to 57	19 to 45

Table ES-9 Open Channel Area Preliminary Alternatives Analysis

The case study findings were presented to the Stormwater Advisory Committee, to provide a perspective on cost versus expected performance for the various design storms under consideration. While the decision was not unanimous, a majority of committee members selected the 25-year event as the appropriate target design storm for development of flood mitigation alternatives.

Following this selection, the preliminary flood mitigation alternatives were refined using the 25-year storm event. This design storm reduced the peak flow rates and corresponding runoff volumes to be mitigated allowing utilization of additional solutions, mainly a storage component, to be considered. This in turn led to a reduction in the size and cost of the required conveyance infrastructure without significantly compromising the overall benefits and performance of each project alternative. Additionally, overland flood relief paths were considered as an option in lieu of underground conveyance. However, in the urban areas, available land to develop regional storage is nearly impossible to find without acquiring properties. The options for storage and overland flow path relief were shared both with the Commission and the public. In both instances, though the costs were significantly lower, the necessity for property acquisition was not fully embraced by those voicing opinions. As such, the capital improvement plan as presented, includes flood mitigation strategies that generally avoid acquisition of properties by the City for storage as an alternative to larger-sized conveyance facilities.

10.0 PUBLIC INVOLVEMENT PROCESS

Public involvement for the CSMP necessitated a carefully planned stakeholder engagement strategy supported by citizen feedback and City Commission focused input at critical stages of the study process. This multilevel outreach approach allowed the study team to more thoroughly vet and affirm important planning and decision-making criteria. The stakeholder forums included a Technical Advisory Group comprised of internal representatives of the City, County and JSA and a Stormwater Advisory Committee composed of 13 members who represented neighborhoods, business interests, and allied community agencies. The effect of stakeholder participation was to insure a broad base of input from a variety of community interests including representation from some individuals who have been directly affected by flooding.

Figure ES-19 Public Meeting No. 1

Figure ES-20 City Commission Meeting No. 2

The outreach approach included three public meetings sequenced at key junctures throughout the study process to engage with interested citizens on their personal experiences with flooding. These meetings included presentations to help inform and educate attendees on facets of the study and to solicit firsthand accounts of flooding experiences through discussion and completion of stormwater flood questionnaires. Their input also aided in various steps in the evaluation of existing conditions and affirming model accuracy for purposes of alternatives development.

The public meetings also included opportunities for individual property owner discussions where the CSMP study team shared model results of flooding at specific residence or business locations to affirm their past flooding experiences. These meetings also provided opportunities for citizens to complete a Stormwater Flood Questionnaire to document their personal flooding accounts. The following listing chronicles the various stakeholder and public meetings that were conducted throughout the study process. Additional meetings with various City departments and staff and other allied community agencies also provided other important input and feedback in shaping the approach for the CSMP.

Meeting Name	Date
City Commission Meeting No. 1	9/16/2016
TAG No. 1	2/28/2017
SWAC No. 1	5/11/2017
Public Meeting No. 1	6/19/2017
TAG No. 2	7/18/2017
SWAC No. 2	10/26/2017
TAG No. 3	10/26/2017
Public Meeting No. 2	11/13/2017
TAG No. 4	11/29/2017
City Commission Meeting No. 2	12/12/2017
TAG No. 5	12/13/2017
TAG No. 6	1/11/2018
Modeling Update Meeting	2/21/2018
SWAC No. 3	3/22/2018
Alternative Update Meeting	5/3/2018
SWAC No. 4	5/23/2018
TAG No. 7	6/11/2018
City Commission Meeting No. 3	7/10/2018
Public Meeting No. 3	7/30/2018
City Commission Meeting No. 4	10/23/2018

Table ES-10 CSMP Meeting Schedule

11.0 CAPITAL IMPROVEMENT PLAN

The initial project outlay for the CSMP stormwater Capital Improvement Plan (CIP) is represented by flood mitigation strategies for each of the ten (10) selected priority problem areas. As indicated earlier the base solution for each area is generally focused on a conveyance strategy to achieve the flood mitigation benefit. Other options are also available including storage and overland flow path relief, however these generally require property acquisition as a foundation for their implementation. The alternatives presented are based on the 25-year or 4 percent chance design storm. Table ES-11 provides an overall project summary categorized by area (Open Channel or Urban), with relevant data on structure flooding, lifetime benefit, cost and benefit cost ratio (BCR). The data in the table is intended to illustrate the overall scale and benefit of the CIP as a whole for the investment required. The calculated benefit cost ratio is greater than 1.0 for each project as well as the combined sum total of all projects. This ratio does not reflect other monetary and non-monetary benefits that would also like accrue to the City’s benefit through implementation of this capital program.

Area	25-Year Design (4% Chance)				
	Flooding Eliminated	Flooding Reduced	Lifetime Benefit	Project Cost (Millions)	Structure Only BCR
Open Channel Areas	57	19	22.4	7.7	2.91
Urban Areas	188	270	61.8	35.6	1.73
Totals	245	289	84.2	43.3	1.94

Table ES-11 Capital Improvement Plan Summary

Table ES-12 further delineates the proposed capital projects for each priority problem area with similarly reflected performance criteria and cost information. It is important to note, that the Cross Creek Priority Area includes two distinctly separate problem areas that are grouped together. Likewise, the Noble Park Phases 1, 2 and 3 projects in the Madison Street area, represent three separate priority areas having a common solution with phased implementation. Individual project profiles were also developed for each priority problem area and are included on the following pages. These one-page documents provide more detailed descriptions and additional supporting data for each project to help inform future implementation considerations.

With the future advancement of the CIP, consideration should also be given to prioritization and ranking of individual projects to help inform decision making for the order of implementation. This is not to say that a ranking methodology should be the only approach to implementation, since other community-based considerations and/or priorities may suggest a different strategy. There are any number of factors that can be considered and weighted in developing a formal ranking methodology. These could include criteria such as cost, benefit, ease of implementation, property acquisition and environmental concerns, among a host of other parameters. However, until a funding stream and corresponding implementation horizon is known, such an exercise could be ill conceived and is premature at this time.

Priority Problem Area	Project Description	25-Year Design (4% Chance)				
		Flooding Eliminated	Flooding Reduced	Lifetime Benefit	Project Cost (Millions)	Structure Only BCR
Cross Creek	Golf Course Restrictors and Downstream Culvert Upsizing	40	4	19.4	7.1	2.73
Pecan Drive	Bridge Replacement and Existing Basin Retrofits	17	15	3.0	0.6	5.00
Hospital and Kentucky Avenue	Washington Street Relief Sewer	58	140	20.0	11.4	1.75
26th at Kruger	14th Street Relief Sewer	12	6	2.9	1.3	2.23
The Branch	Parallel Pipe Conveyance with Additional Storage	24	6	3.5	2.8	1.25
26th and Park 25rd and Clay Madison at 24th	Noble Park Relief Sewer (Phases 1, 2, and 3)	60	93	23.8	17.7	1.29
California Court Harrison at 27th	Trimble and Harrison Relief Sewer (Requires Noble Park Relief Sewer Phase 1)	34	25	11.6	2.4	4.83

Table ES-12 Project Summary Table

CITY OF PADUCAH, KENTUCKY
COMPREHENSIVE STORMWATER
MASTER PLAN

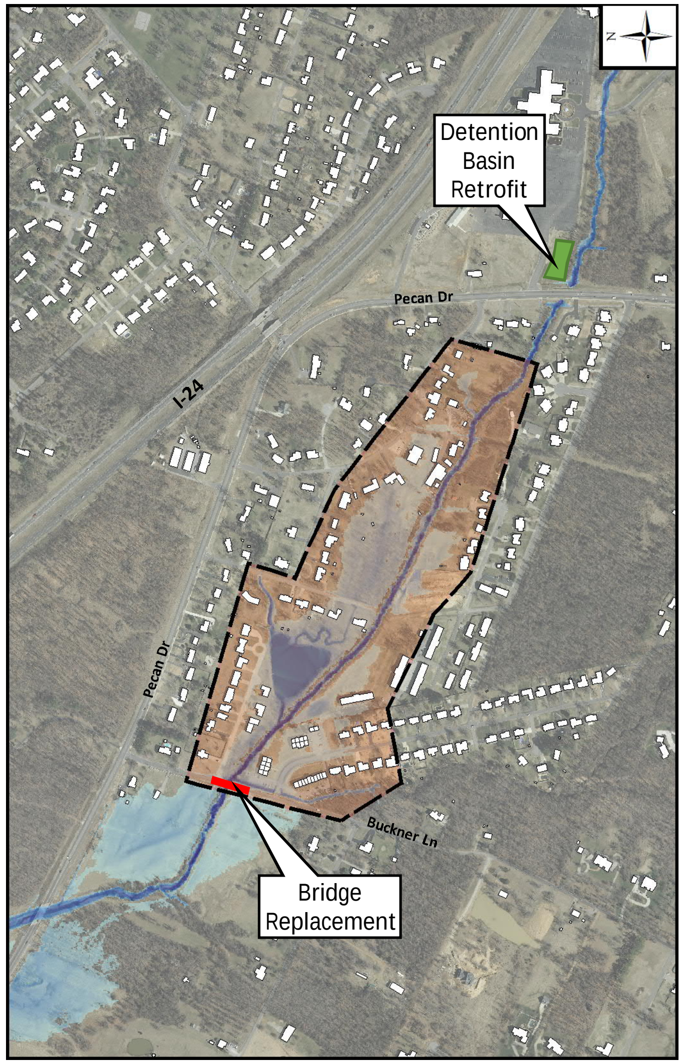
BUCKNER LANE BRIDGE REPLACEMENT

Project Area: Crooked Creek/Pecan Drive

Description:

The existing Buckner Lane bridge crossing over Crooked Creek is a heavily used access route that serves as an important link to neighborhood areas between US 62 and Pecan Drive. The existing bridge is severely undersized, prone to frequent flood-related overtopping, and has been identified as structurally deficient and in urgent need of replacement. Additionally, upstream detention basins within the watershed are sized to control larger but infrequent storm events.

The proposed project will replace the existing bridge with a longer span to promote improved channel conveyance without overtopping the roadway. Several upstream detention basins are targeted for retrofit improvements to provide peak flow control in smaller more frequent storm events.



Project Benefits:

- Basin retrofits can be completed separately allowing project phasing.
- Flood reduction on heavily used roadway.
- Stormwater flow reduction in conveyance system downstream from basin retrofits.

Additional Considerations:

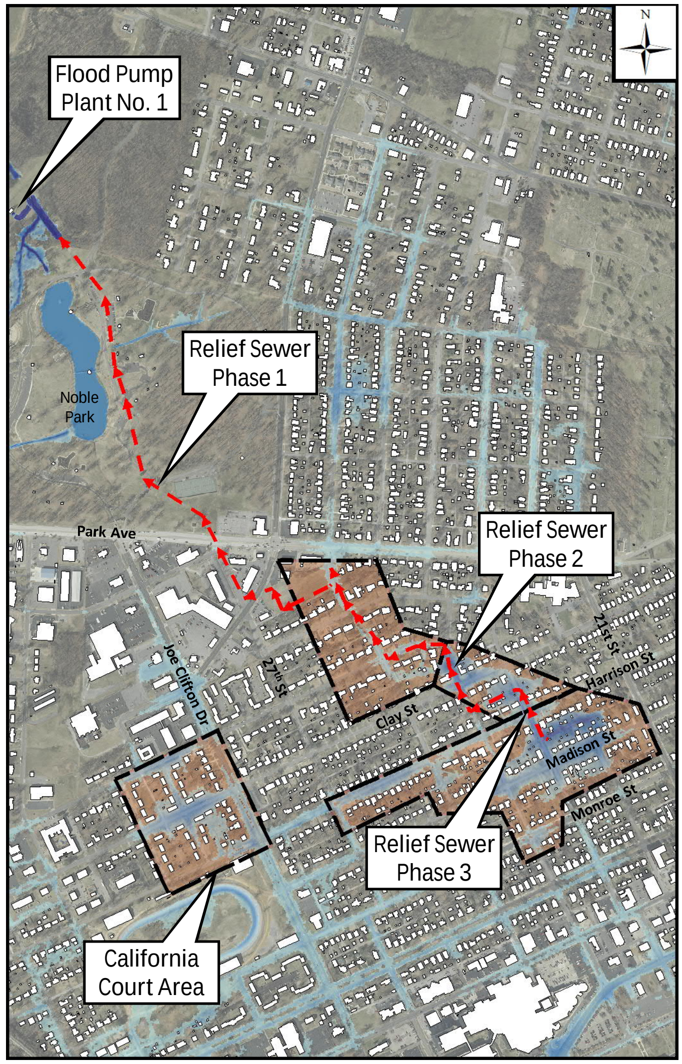
- System maintenance is needed to reduce nuisance flooding within the tributary areas.
- No significant reduction in the FEMA-mapped floodplain. Some homes that were built in the floodplain will remain in the floodplain though flood frequency may be reduced.
- Buyouts may be considered to mitigate flooding in remaining flood-prone structures.
- Additional peak flow controls through improved stormwater management regulations can help mitigate future flooding issues.

Key Statistics:

Structure Flooding Eliminated	17
Structure Flooding Reduced	15
Straight Line Benefit	$3,000,000
Project Cost	$600,000
Benefit-Cost Ratio	5.0

NOBLE PARK RELIEF SEWER PHASES 1, 2, AND 3

Project Areas: 26th and Park (Phase 1)
25th and Clay (Phase 2)
Madison and 24th (Phase 3)



Description:

The area bounded generally by Park Avenue, Monroe Avenue, 21st Street, and 27th Street defines a low inland area with no overland flood path. This sag area is served by a combined sewer and multiple relief sewers, however it is still prone to frequent flooding.

The proposed project provides additional flood conveyance capacity to augment the existing conveyance system. This box culvert relief sewer begins at the existing outfall near Flood Pump Plant No. 1, follows the existing relief sewer through Noble Park, and crosses Park Avenue into the first of the three consecutive priority areas. This first phase provides conveyance for two additional phases in these project areas along with the conveyance required to support mitigation efforts in the California Court area.

Project Benefits:

- Routing through Noble Park minimizes cost and impact during construction.
- Benefits not only priority areas but also adjacent areas.
- Provides infrastructure to support future California Court flood mitigation efforts.
- Stormwater is routed away from Flood Pump Plant No. 2 that is frequently engaged and toward Flood Pump Plant No. 1, which is less frequently used.

Additional Considerations:

- High likelihood of significant utility impacts.
- Inclusion of storage within priority areas can reduce infrastructure size and project cost.
- Storage only and overland flow path options are available in these areas however significant land acquisitions would be required.

Key Statistics:

Structure Flooding Eliminated	60
Structure Flooding Reduced	93
Straight Line Benefit	$23,800,000
Project Cost	$17,700,000
Benefit-Cost Ratio	1.29

CALIFORNIA COURT AND HARRISON STREET RELIEF

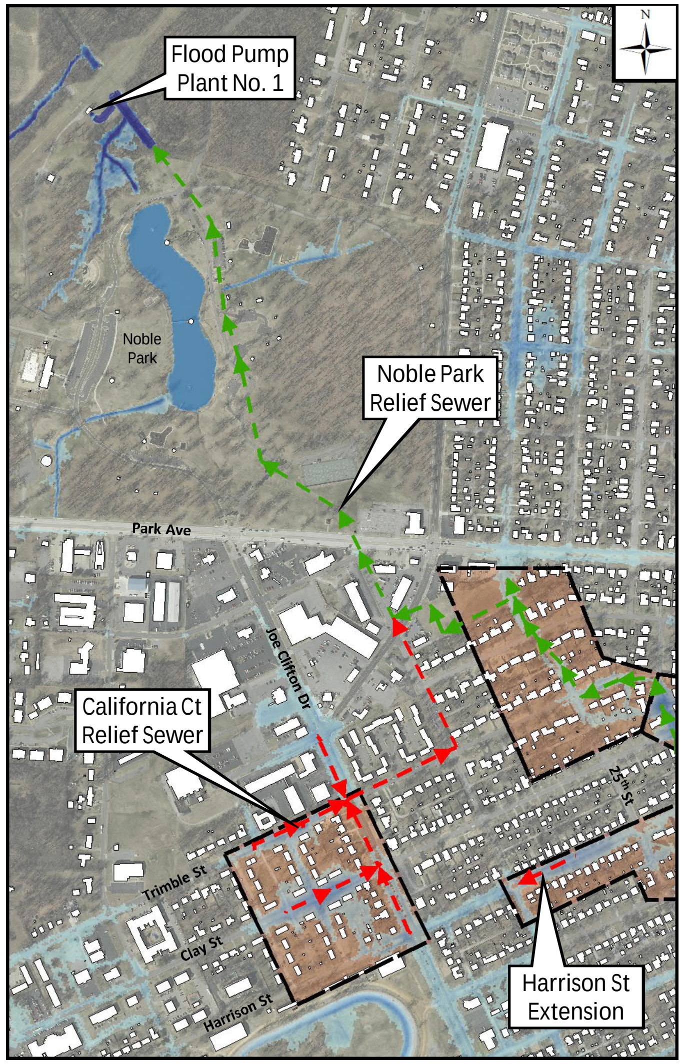
Project Areas: California Court
Harrison at 27th

Description:

The California Court area is a low laying area served by a small diameter combined sewer. When the downstream conveyance system is full, the roads and yards within this area act as storage until capacity is available.

This project provides separate storm sewers and high capacity inlets along Trimble Street, Clay Street, and Joe Clifton Drive. These storm sewers are connected to the existing relief sewer and Noble Park Relief Sewer Phase 1.

Additionally, the upsized conveyance allows inlets to be connected at the H C Mathis Drive intersection and Harrison Street sag to capitalize on flood mitigation opportunities.



Project Benefits:

- Provides separation of the stormwater runoff from the combined sewer system.
- Project can be phased following installation of Noble Park Relief Sewer Phase 1.
- Additional benefits realized though further extension of storm sewer to adjacent areas.

Additional Considerations:

- The cost of this project does not include any portion of the downstream conveyance provided by the Noble Park Relief Sewer.
- Alternatives in this area include buyouts and the removal of structures to create storage and downsize the conveyance.

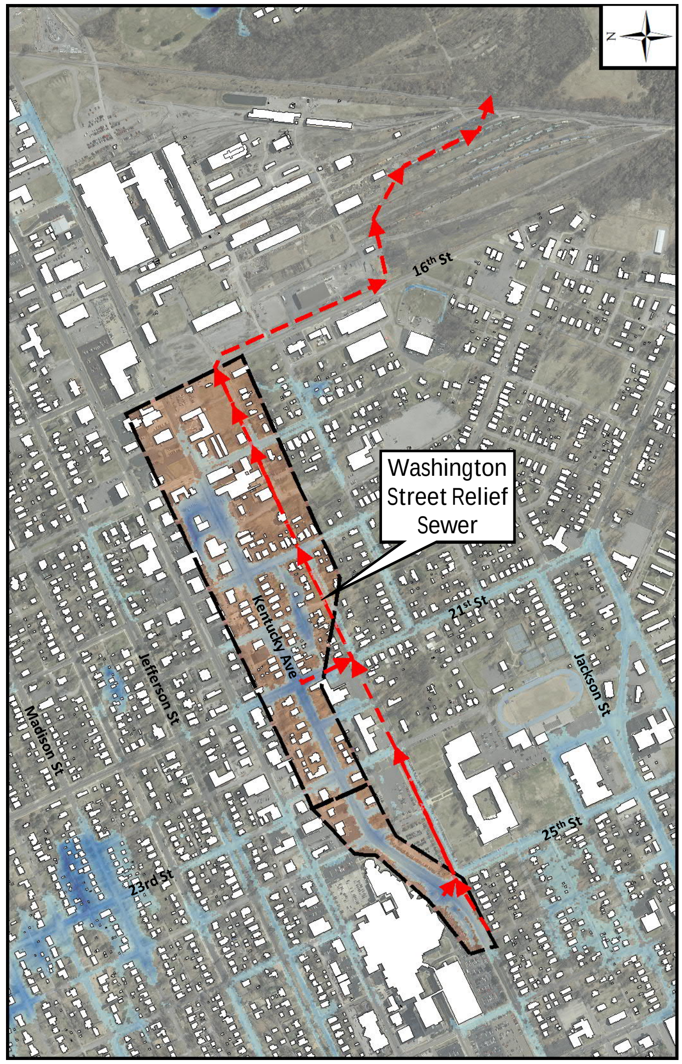
Key Statistics:

Structure Flooding Eliminated	34
Structure Flooding Reduced	25
Straight Line Benefit	$11,600,000
Project Cost	$2,400,000
Benefit-Cost Ratio	4.83

CITY OF PADUCAH, KENTUCKY
COMPREHENSIVE STORMWATER
MASTER PLAN

WASHINGTON STREET RELIEF SEWER

Project Area: Kentucky from 16th to 22nd
Hospital Entrance at 25th



Description:

Kentucky Avenue from 16th Street to 22nd Street has been the location of several previous flood mitigation efforts. Multiple relief sewers flow both north and west in an attempt to convey stormwater away from this area.

The front entrance to the hospital at the intersection of Kentucky Avenue and 25th Street is a localized sag that collects bypass water from small upstream inlets along the adjacent streets and backflow from the 26th Street relief sewer. Small diameter pipes connected to an undersized relief sewer cause frequent ponding in this area. This ponded water overflows the intersection at 24th Street further aggravating the flooding along Kentucky Avenue .

This project provides a box culvert relief sewer along Washington Street for the backflow from the 26th Street Relief Sewer as well as the relief sewers along 23rd Street and 19th Street. Additional high-capacity inlets are provided at the hospital entrance and 21st Street along Kentucky Avenue. The relief sewer turns south along 16th Street before paralleling an existing relief sewer through the railyard.

Project Benefits:

- Significant flood mitigation along a highly traveled commercial corridor.
- Benefits extend outside project areas.

Additional Considerations:

- Little benefit is realized from phasing as the major flood mitigation comes from the relief at 26th Street.
- Culvert under railyard may require annual license agreement.
- Additional evaluation of outfall at Island Creek will be required.

Key Statistics:

Structure Flooding Eliminated	58
Structure Flooding Reduced	140
Straight Line Benefit	$20,000,000
Project Cost	$11,400,000
Benefit-Cost Ratio	1.75

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CITY OF PADUCAH, KENTUCKY
COMPREHENSIVE STORMWATER
MASTER PLAN

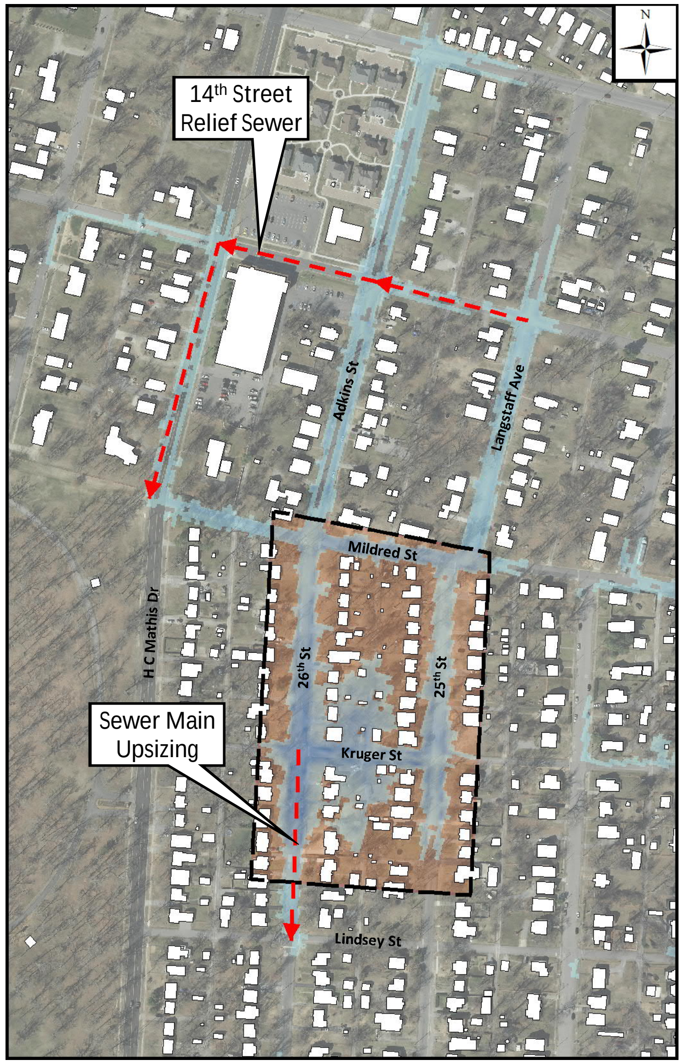
14TH STREET RELIEF SEWER

Project Area: 26th at Kruger

Description:

The area around the intersection of 26th Street and Kruger Street sag area is without an overland flow path and is prone to flooding. Locally, the flooding is caused by undersized storm sewer mains. Additionally, areas to the north between 13th Street and Mildred Street are served by undersized combined sewers. When the system surcharges, overland flow follows Adkins Street and Langstaff Avenue ending at the sag at the intersection of 26th Street and Kruger Street.

This project provides a large diameter relief sewer along 14th street and H C Mathis Drive to offload the combined sewers along Adkins Street and Langstaff Avenue mitigating the overland flow condition. This is coupled with local area separation and upsizing of the storm sewer main for the existing storm sewer inlets.



Project Benefits:

- This project leverages existing infrastructure with underutilized conveyance capacity.
- Local area storm separation along 26th Street is possible through parallel construction of an upsized main.

Additional Considerations:

- Additional work in the project area could provide the means for area-wide combined sewer separation in addition to flood mitigation.

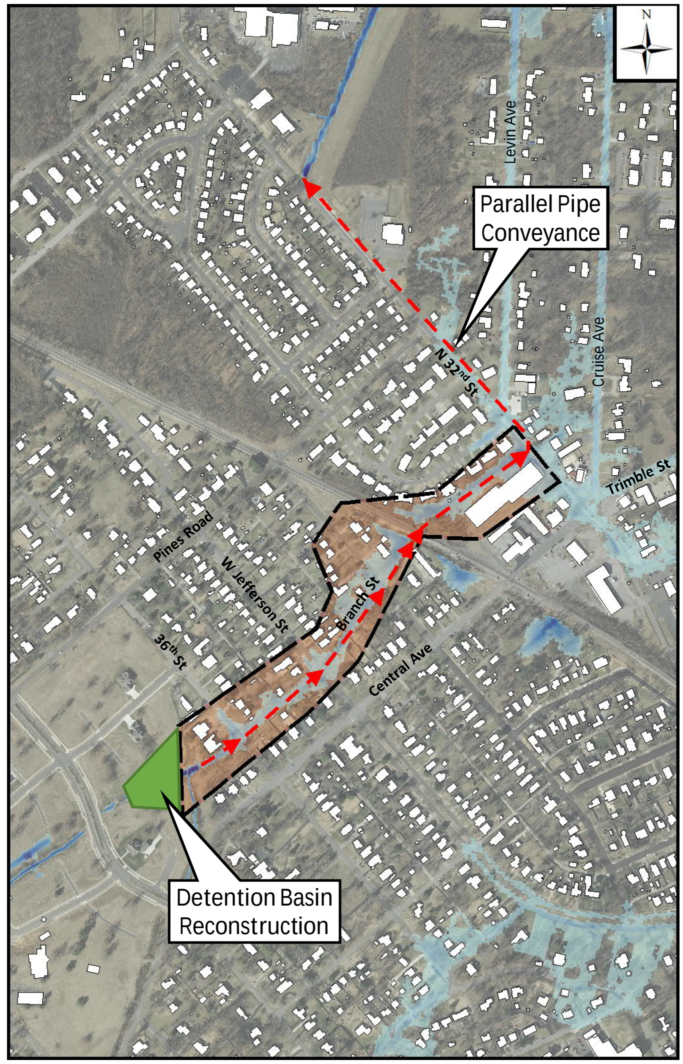
Key Statistics:

Structure Flooding Eliminated	12
Structure Flooding Reduced	6
Straight Line Benefit	$2,900,000
Project Cost	$1,300,000
Benefit-Cost Ratio	2.23

CITY OF PADUCAH, KENTUCKY
COMPREHENSIVE STORMWATER
MASTER PLAN

PARALLEL PIPE CONVEYANCE WITH ADDITIONAL STORAGE

Project Area: The Branch



Description:

Under heavy rain events, the existing underground pipe conveyance surcharges and overland flow follows Branch Street to the railroad where it collects in a low area until it can reenter the pipe conveyance or flows through an old railroad culvert. The overland flow continues on to 32nd Street where it splits and follows Levin Avenue and Cruise Avenue into the combined sewer system collection area.

This project will provide additional conveyance in the form of a new large-diameter pipe parallel to the existing storm sewer. The inlet structure at the southern end of the Branch Street will be reconstructed to promote both improved inlet capacity and safety. The existing side-saddle detention basins upstream will be reconstructed to provide staged peak flow control for multiple storm events.

Project Benefits:

- Removes overland flow from entering the combined sewer system.
- Eliminates flooding along Branch Street.
- Offloads flow going to Pump Plant 1.

Additional Considerations:

- An optional greenway serving as an overland flow path could be considered to reduce project cost and promote green infrastructure practices.
- Installation of pipe underneath railroad will be costly and may require an annual license agreement.

Key Statistics:

Structure Flooding Eliminated	25
Structure Flooding Reduced	7
Straight Line Benefit	$3,700,000
Project Cost	$1,500,000
Benefit-Cost Ratio	2.46

CITY OF PADUCAH, KENTUCKY
COMPREHENSIVE STORMWATER
MASTER PLAN

GOLF COURSE RESTRICTORS AND DOWNSTREAM CULVERT UPSIZING

Project Areas: Upstream Cross Creek
Downstream Cross Creek

Description:

There are two distinct types of flooding associated with the Cross Creek area. One is flooding along the channels in the upper reaches where the creek exceeds its banks and flows in the flood fringe area. The conveyance channel is narrow, there are several culverts along the upper channels for road crossings, and some homes are located within the flood fringe area.

The second type of flooding is the result of undersized downstream culverts underneath the railroad, Old Mayfield Road, and Irvin Cobb Drive which impacts upstream areas.

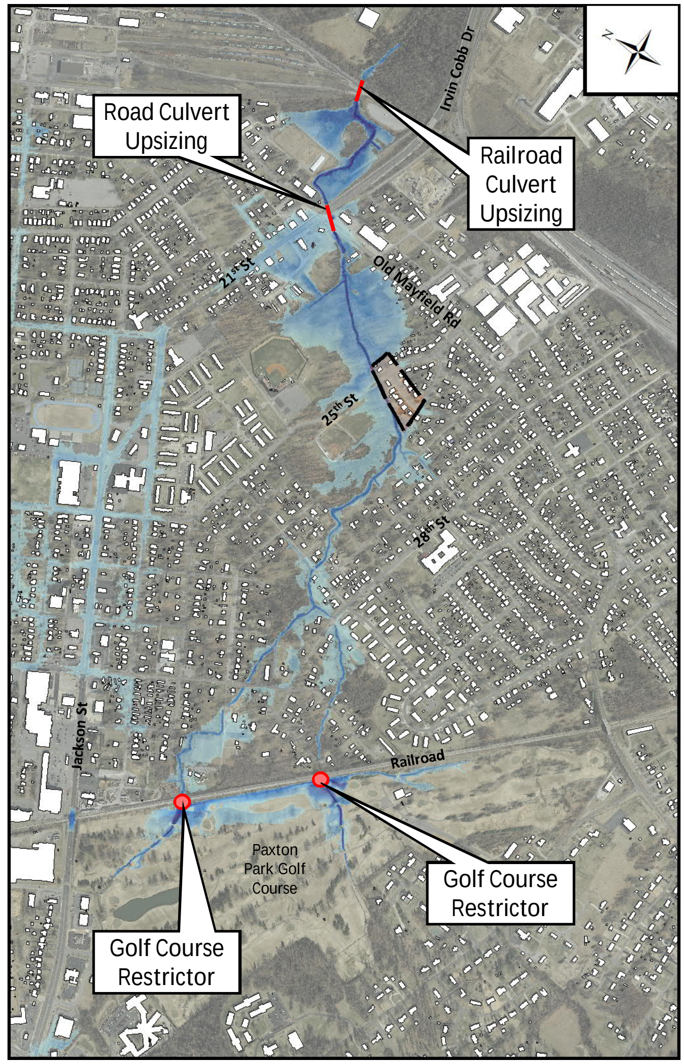
Two independent projects were developed to address these concerns. The first project will install structures to restrict flow underneath the railroad and use the existing flood storage area within the golf course. The second will add culverts underneath Old Mayfield Road, Irvin Cobb Drive, and the Railroad to increase downstream conveyance capacity.

Project Benefits:

- Projects can be phased to realize early benefits. Golf course restrictors are low cost with high impact.
- Flood reduction on major roadway.

Additional Considerations:

- Irvin Cobb is a state owned roadway and will require coordination with the transportation cabinet.
- Culvert under railroad may require annual license agreement.
- Increased storage depth against railroad berm will need to be coordinated with the railroad authority.
- Roadway inlet and conveyance improvements should be considered to help mitigate intersection flooding at Old Mayfield Road.



Key Statistics:

Structure Flooding Eliminated	40
Structure Flooding Reduced	4
Straight Line Benefit	$19,400,000
Project Cost	$7,100,000
Benefit-Cost Ratio	2.73

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