August 2012

Stormwater Master Plan 2012

CITY OF ST. PETERS, MISSOURI

BLACK AND VEATCH
PATTI BANKS ASSOCIATES

August 2012

Stormwater Master Plan 2012

CITY OF ST. PETERS, MISSOURI

BLACK AND VEATCH
PATTI BANKS ASSOCIATES

Report Summary

This Stormwater Master Plan will be used for planning of future capital improvements, improving water quality, and continuing compliance with Missouri Department of Natural Resources Municipal Separate Storm Sewer Systems (MDNR MS4) regulations. Preliminary investigations have evaluated the existing conditions of the City's open-channel stormwater infrastructure based on hydrologic and hydraulic modeling, field reconnaissance, water quality modeling, and review of relevant policies at the City, State, and Federal levels.

The City of St. Peters has a population of approximately 57,000 and encompasses about 22 square miles. The City owns, operates and maintains over 165 miles of storm sewer pipe and associated structures, as well as 3 pump stations. The City contains more than 47 miles of waterway, 55 stream/roadway crossings, 43 wet retention basins and 207 dry detention basins. The majority of the City is situated in the Dardenne Creek Watershed, a 29 mile long basin that covers approximately the middle third of St. Charles County and drains to the Mississippi River. The primary subwatershed in St. Peters is Spencer Creek. Other subwatersheds identified by the US Army Corps of Engineers (USACE) include East Dardenne, Sandfort Creek, and un-named Tributaries No. 1 and No. 2. A small portion in the southeast of St. Peters drains to the Missouri River.

Hydrologic and Hydraulic Modeling

The City's current stormwater master plan, completed in 2002, included computer models developed at a level of detail suitable for master planning. The 2002 study identified flooding and erosion problems within the City's watersheds, and provided conceptual improvements to alleviate the defined problems. In 2007, the USACE St. Louis District completed a study of the entire Dardenne Creek watershed. Both the 2002 and 2007 studies were referenced during the analysis of existing conditions.

The HEC-HMS model developed by the USACE St. Louis District was used as the basis for hydrologic modeling of the watersheds within and around St. Peters. The detention basins selected through a screening process were incorporated into the USACE hydrology model to allow the opportunity to gage effectiveness, model detention basin improvements, and evaluate downstream erosion effects. The methodology developed by the USACE St. Louis District was maintained for the hydrologic analysis of this watershed study and modifications to the model were limited to the addition of detention basins.

To evaluate open channel hydraulics, the HEC-RAS model developed by the USACE St. Louis District in 2007 was refined to represent the most current topographic information within the City limits. The USACE 2007 was based on a 3D terrain model created with digital orthophotos. The 2007 study model was based on additional data including limited bridge and culvert drawings, previous hydraulic models, rainfall and streamflow data, land use and soil maps, and other GIS data. Black & Veatch evaluated the existing model to establish continuity of peak flows, determine extents, and identify modeling constraints within the city limits. The review of the 2007 hydraulic model produced several concerns described in this report. For this study, Black & Veatch refined the 2007 HEC-RAS hydraulic model to represent the most current topographic information within the City limits, based on LiDAR data collected in 2008.

Flooding

Based on the updated hydraulic modeling, the area of inundation was established for the revised existing conditions model during the 100-year event. The results of the 2007 USACE hydraulic model were compared to the results of the updated model. On average, there was less than one foot of change in 100-year water surface elevation between the revised existing conditions model and the original 2007 USACE model. Typically, the water surface elevation decreased. There were, however, significant differences between the areas of inundation and the updated FEMA floodplain maps.

Stream Stability and Habitat

In April and May of 2011, Black & Veatch and PBA staff joined the City to evaluate stream stability and habitat within the City limits. As a team, Black & Veatch and PBA conducted a geomorphology and stream health field survey of the 47 miles of streams in the City of St. Peters. The team applied standards developed by the Kansas City Metropolitan Chapter of American Public Works Association and the United States Department of Agriculture to evaluate stream stability throughout the City.

A majority of the stream network in St. Peters was documented to be incised, as described in the 2002 watershed study. Channel incision is a response to changes in the hydrology of the contributing drainage area as well as to changes in channel bed materials and downstream conditions. The stream network within the City limits has varying levels of stability and incision. The downstream ends of the main tributaries to Spencer Creek, West Spencer and East Spencer, have already experienced changes in structure and are now very incised. In these streams, further incision is likely to occur due to a small low flow channel cutting into the hard clay bed that was documented in the field. Reaches higher up in the watershed have very steep profiles and debris jams of roots or other material were often found to provide temporary vertical grade control.

Water Quality

The P8 model was used to predict pollutant removal efficiencies for each of the selected stormwater detention basins. The model simulated the generation and transport of stormwater runoff pollutants in the watersheds contributing to the detention basins. The simulations were driven by continuous hourly rainfall based on ten years of data recorded at the Lambert International Airport provided by the National Climatic Data Center.

Policies

This study provides a summary existing policies, ordinances, and design criteria. It also identifies regulations and other factors that may influence future policies and identifies preliminary recommendations for updating and adopting polices to meet regulations and achieve the goals for storm water management in St. Peters. The recommendations to the City’s stormwater policies are suggested in the following areas: 1) Best Management Practices, 2) Low Impact Development, 3) Stream Setbacks, 4) FEMA Community Rating System, 5) Street Sweeping, 6) Sediment and Erosion Control, 7) Homeowner Drainage Issues, and 8) Education and Awareness.

CIP

This study resulted in the development of over 100 projects with a total cost of $125,000,000. These projects are located throughout the City and are classified as flooding, stream stability, detention, or preservation projects. Some projects are multi-functional and are associated with two or more of these categories. A comprehensive approach to solving stormwater-related concerns will include projects that are rated with a high priority score, projects that have a low cost benefit ratio and projects that preserve the City's existing resources. An ESRI geodatabase accompanies this report and provides a tool for the City to use in managing CIP projects.

Nine Critical Element Plan

The Nine Critical Element plan is provided in Appendix A.

Table of Contents

Appendices

Tables

Figures

1. Introduction

This master plan will be used for planning of future stormwater capital improvements, improving water quality, and continuing compliance with Missouri Department of Natural Resources Municipal Separate Storm Sewer Systems (MDNR MS4) regulations. The Nine Critical Element Plan, presented in Appendix A, may be used to help secure funding for water quality related improvements.

The City of St. Peters, Missouri has a population of approximately 57,000 and encompasses approximately 22 square miles. The City owns, operates and maintains over 166 miles of storm sewer pipe and associated structures, as well as three pump stations. The City contains more than 47 miles of waterway, 55 stream/roadway crossings, 43 wet retention basins and 207 dry detention basins. The majority of the City is situated in the Dardenne Creek Watershed, a 29 mile long basin that covers approximately the middle third of St. Charles County and drains to the Mississippi River. The primary subwatershed in St. Peters is Spencer Creek. Other subwatersheds identified by the Corps of Engineers include East Dardenne, Sandfort Creek, and un-named Tributaries No. 1 and No. 2. A small portion in the southeast of St. Peters drains to the Missouri River.

2.0 Review of Existing Data and Conditions

2.1 Existing Data

At the beginning of the study, the City provided a copy of the existing stormwater master plan, completed in 2002. This master plan included computer models developed at a level of detail suitable for master planning, identified flooding and erosion problems within the City's watersheds, and provided conceptual improvements to alleviate the defined problems.

The City also provided hydrologic and hydraulic models developed by the USACE St. Louis District for a 2007 study of the Dardenne Creek Watershed. GIS data was provided by the City and USACE. After Black & Veatch conducted a detention basin screening analysis, described later in the report, the City compiled available documentation for each detention basin of interest. Additional information provided by the City through the study included CAD drawings of the Highway 94 improvements and pipe information related to the drainage east of Old Town.

2.1.1 Hydrologic Model

The hydrologic model was provided to Black & Veatch by the USACE St. Louis District. This model, developed by the USACE St. Louis District in 2006 - 2007, encompasses nearly the entire City limits and was calibrated to a series of rainfall events using two gauges along Dardenne Creek. Existing condition and future condition peak flows were developed for use in the hydraulic modeling.

2.1.2 Hydraulic Model

The steady state HEC-RAS model, developed by the USACE in 2007, uses the output flows from the HEC-HMS model and routes these flows through a stream network that includes approximately 20 miles of stream within the City limits.

2.1.3 GIS Data

Data received from the City and the Corps of Engineers (District) is presented in Table 1.

TABLE 1. GIS DATA AND SOURCES

GIS Data Received	Source
Aerials	*City of St. Peters*
2-foot contours	*City of St. Peters*
Geodatabase Layers	*City of St. Peters*
City Boundary	
Floodplain and Floodway	
Building Footprints	
Parcels and Easements	
Streams and Water Bodies	
Watersheds	
Land Use and Zoning Areas	
Transportation Corridors	
Stormwater Infrastructure	
Sewer Infrastructure	
Water Infrastructure	
GeoHMS Data	*USACE*
Gages	
Survey Points	
Subwatersheds	
GeoRAS Data	*USACE*
Cross sections	
Flowpaths	
Stream Centerline	

2.1.4 Detention Basin Documentation

The City compiled available documentation for each detention basin of interest. The level of detail in each document was variable and Black & Veatch was able to confirm existing conditions as documented on most detention basins. For each detention basin, Black & Veatch conducted a more thorough field survey to document existing conditions and to better determine outfall and storage characteristics. A standard documentation form, provided in Appendix B, was completed for each detention basin, and multiple pictures were taken for the modeling and development of conceptual recommendations.

Detention Basin Screening Process

Black & Veatch developed a screening process with the City to prioritize existing detention facilities for inclusion in the hydrologic model. A total of 248 detention basins were included on the geodatabase provided by the City of St. Peters. The scope of the project included modeling of up to 75 detention basins. The screening process outlined below resulted in the selection of the most significant detention in the City.

Of the 248 detention basins, 82 had a surface area greater than ½ acre. The 166 detention basins with a smaller surface area were considered to have a less significant impact on the hydrology and were excluded. There were 29 basins with a surface area greater than 1 acre and these facilities were automatically included. The 53 basins that were between ½ acre and 1 acre in surface area were further analyzed to determine their significance. An additional four selection criteria were developed to screen the remaining basins. Basins that are located on public or vacant land are more easily retrofitted or altered because of ownership issues. Detention facilities that are properly sized for the associated contributing drainage area have increased functionality for affecting peak flows. Contributing drainage areas were established automatically using the ESRI ArcHydro tools. Similarly, detention basins in the floodplain are adjacent to streams and typically show improved function. Of the 53 intermediate sized basins, 5 basins were located on public land, 7 basins were situated on vacant land, 15 basins had a surface area that was greater than 5% of the contributing drainage area, 4 basins were located within a new subdivision, and 3 basins were located within a floodplain. One of the basins located within a floodplain, DB-7270-05 in Carrington Estates, was selected by the screening process and then excluded due to lack of available data. An additional 12 basins were selected by the City to be evaluated, bringing the total to 74 basins. The detention basins included in the study are presented in Figure 1. Each of these basins was visited in the field. A list of selected basins is presented in Table 2.

TABLE 2. SELECTED DETENTION BASINS

Detention ID	Location	CDA (acres)	% Impervious
DB-6869-02	FAWN LAKE	31	26%
DB-6870-15	CHURCH	5	34%
DB-6870-16	MANLIN HOMES AT BELLEAU CREEK	17	9%
DB-6871-01	I-70 TRADE CENTER	28	65%
DB-6871-03	INDUSTRIAL PARK WEST	27	66%
DB-6965-01	MONTECITO	7	13%
DB-6968-02	COUNTRY CROSSING MANOR	33	21%
DB-6969-02	WOODLANDS SPORK PARK	10	5%
DB-6969-03	LAKES OF DEVONDALE	41	10%
DB-6969-04	WOODLANDS SPORT PARK	35	1%
DB-6969-06	OHMES FARM	1	21%
DB-6969-07	OHMES FARM	10	5%
DB-6969-08	OHMES FARM	33	13%
DB-6969-09	OHMES FARM	5	8%
DB-6969-10	OHMES FARM	22	13%
DB-6970-03	LAKES OF DEVONDALE	15	17%
DB-6971-08	RICHMOND	24	35%
DB-7065-01	HIGHLAND ESTATES	1	22%
DB-7065-02	THE HIGHLANDS	2	17%
DB-7065-03	THE HIGHLANDS	5	20%
DB-7065-04	THE HIGHLANDS	197	11%

Detention ID	Location	CDA (acres)	% Impervious
DB-7065-05	MONTECITO	19	15%
DB-7067-01	MID RIVERS TOWN CENTER	44	54%
DB-7067-02	MID RIVERS PLACE	56	0%
DB-7069-06	CRYSTAL LAKE ESTATES	116	7%
DB-7069-07	CRYSTAL LAKE ESTATES	15	24%
DB-7069-08	LAKES OF DEVONDALE	11	24%
DB-7069-10	SAVANNAH	43	17%
DB-7069-12	BELLEMEADE	2	5%
DB-7069-13	OHMES FARM	16	13%
DB-7070-03	ST. PETERS VILLAS	38	52%
DB-7070-10	BELLEMEADE	10	1%
DB-7071-04	MID RIVERS MALL	32	78%
DB-7169-01	CARRINGTON PLACE	3	22%
DB-7169-02	DUBRAY MIDDLE SCHOOL	49	37%
DB-7169-04	PEGASUS FARMS	58	30%
DB-7169-08	BELLEMEADE	5	7%
DB-7169-09	BELLEMEADE	5	21%
DB-7169-10	BELLEMEADE	10	3%
DB-7169-11	BELLEMEADE	6	7%
DB-7267-04	PARK RIDGE ESTATES	32	29%
DB-7267-14	WALMART FIRST ADDITION	68	36%
DB-7268-04	COUNTRY CREEK	13	24%
DB-7268-06	ENWOOD	16	29%
DB-7268-07	HIDDEN LAKE ESTATES	21	12%
DB-7269-01	PENNY LANE	65	27%
DB-7270-01	ST. PETERS EXECUTIVE CENTRE	12	35%
DB-7270-09	I-70 EXECUTIVE CENTRE	37	26%
DB-7270-10	EXECUTIVE CENTRE PARKWAY	12	52%
DB-7270-15	CITY OF ST PETERS	27	43%
DB-7366-01	CANYON CREEK	72	37%
DB-7367-04	MC CLAY JUNGERMANN COMMERCIAL	6	41%
DB-7367-07	ASHLEIGH COMMERCIAL	7	42%
DB-7367-10	ASHLEIGH ESTATES	13	26%
DB-7367-19	QUEENSBROOKE VILLAGE	18	22%
DB-7367-20	BELLA VISTA	60	13%
DB-7368-08	COUNTRY LAKE ESTATES	13	25%
DB-7368-09	LAUREL PARK	7	10%
DB-7369-04	APPLEWOOD SUBDIVISION	13	18%
DB-7369-06	HI-POINT ACRES	93	16%
DB-7369-07	ST. PETERS CONDOS	29	28%

Detention ID	Location	CDA (acres)	% Impervious
DB-7369-11	OAK TREE VILLAGE RETIREMENT	40	37%
DB-7370-14	ST. PETERS CENTRE	51	24%
DB-7370-16	FORT ZUMWALT EAST	29	62%
DB-7467-04	SUN RIVER VILLAGE	46	35%
DB-7467-06	HERITAGE MANOR	21	28%
DB-7467-07	REGENCY ESTATES	19	50%
DB-7467-12	VILLAGES OF WINDWOOD	27	35%
DB-7467-13	FIRST CHRISTIAN CHURCH OF HARV	7	51%
DB-7467-14	BELLA VISTA	6	4%
DB-7467-15	BELLA VISTA	15	4%
DB-7467-16	BELLA VISTA	23	26%
DB-7468-01	HUNTLEIGH ESTATES	4	15%
DB-7468-06	LAUREL VILLAGE	161	21%

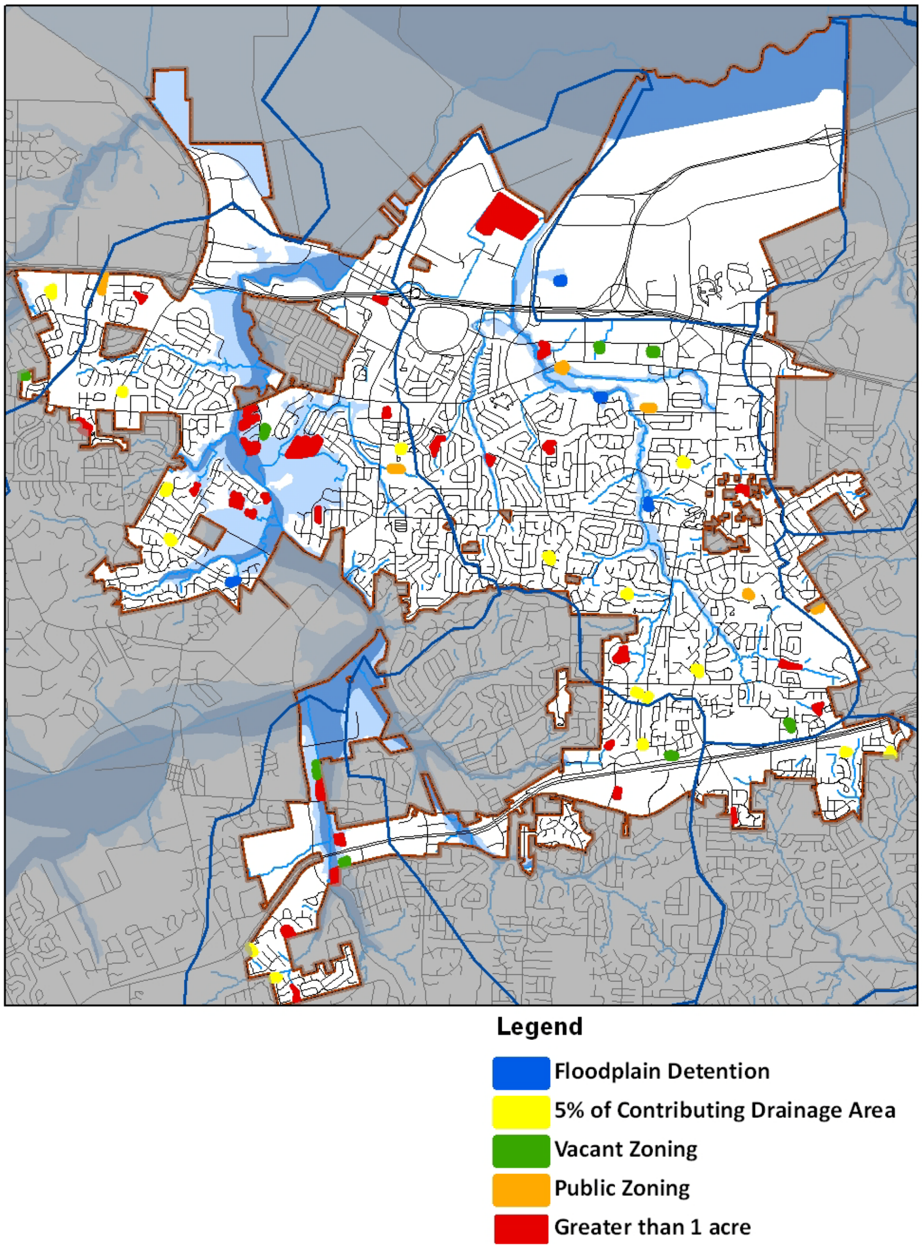


FIGURE 1. DETENTION BASINS INCLUDED IN STUDY

A larger version of Figure 1 is provided in Appendix J.

2.2 Hydrologic Model of Existing Conditions

The HEC-HMS model developed by the USACE St. Louis District was used as the basis for hydrologic modeling of the watersheds within and around St. Peters. The detention basins selected through the detention basin screening process were input into the USACE hydrology model to allow the opportunity to gage their effectiveness, model detention basin improvements, and evaluate downstream erosion effects.

2.2.1 HEC HMS Methodology

The methodology developed by the USACE St. Louis District was used for the hydrologic analysis of this watershed study. Modifications to the model were limited to the addition of detention basins, as described in detail in the following section. For a more complete description of the USACE's hydrologic methods, see the document, "Dardenne Creek Watershed Study," prepared by the USACE St. Louis District in 2007.

In order to input the selected detention basins, it was necessary to delineate sub-watersheds contributing drainage to these detention basins. It was also necessary to gather information regarding the storage and outfall characteristics of each detention basin. Storage and outflow characteristics were input as provided by the City. In some instances however, the information available from the City was not sufficient to approximate the hydrologic performance of the detention basin. In these cases, detention basin characteristics were gathered from the topography and field investigations in order to provide a more complete model. This secondary information is not optimal, and for this reason it is suggested that field topography and structure survey be gathered before design decisions are made using the model information.

Loss Method

The SCS Curve Number method was used to calculate losses, in conjunction with a percent imperviousness. That is to say that the curve numbers used were not composite curve numbers, but rather the raw curve numbers representing soil types. When drainage areas were spit in order to include a detention basin, the curve number for the larger basin was used for both basins.

Transform Method

The Clark Transform Method was used to create a unit hydrograph based on characteristics of the sub-watershed. This method uses two inputs: time of concentration and a storage coefficient. The time of concentration is calculated as the travel time for a drop of rain along the longest flowpath within the sub-watershed. The storage coefficient used by the USACE was calculated as 2/3 of the time of concentration. For detention basins, the TR-55 method was used to calculate new times of concentration. A minimum of 0.25 hours was used for model stability.

Baseflow Method

The USACE model used the Recession Baseflow method to calculate baseflow from each sub-watershed. The calibrated value of baseflow was based upon the size of the sub-watershed, and was found to be 0.6 cfs/square mile.

Modified Puls Routing Method

Routing in reaches was achieved using the Modified Puls Routing method, which requires a storage-discharge relationship for each reach. This method lags and attenuates the hydrographs produced by the sub-watersheds as flow travels down reaches.

METEOROLOGICAL DATA

This study used the hypothetical storms developed by the USACE to produce streamflows. These flows were calibrated as described in the USACE report.

2.2.2 Detention Basin Entry Methodology

Black & Veatch refined the USACE HMS model by adding detention basins selected in the screening process (Section 2.1.4). To incorporate the selected detention basins, it was necessary to break the USACE sub-watersheds into at least two portions. One portion is the part of the sub-watershed that does not drain to one of the selected detention basins. The other portion(s) drain to a detention basin, then out of the sub-basin. It should be noted that in many instances, several detention basins are located within a single USACE sub-watershed, requiring that the sub-basin be split into several different portions. An example is shown in Figures 2 and 3. Figure 2 shows the sub-watershed as depicted in the GIS and HMS model before being split. Figure 3 shows the same sub-watershed with an additional sub-area draining to a detention basin.

FIGURE 2. WATERSHED IN ORIGINAL USACE MODEL

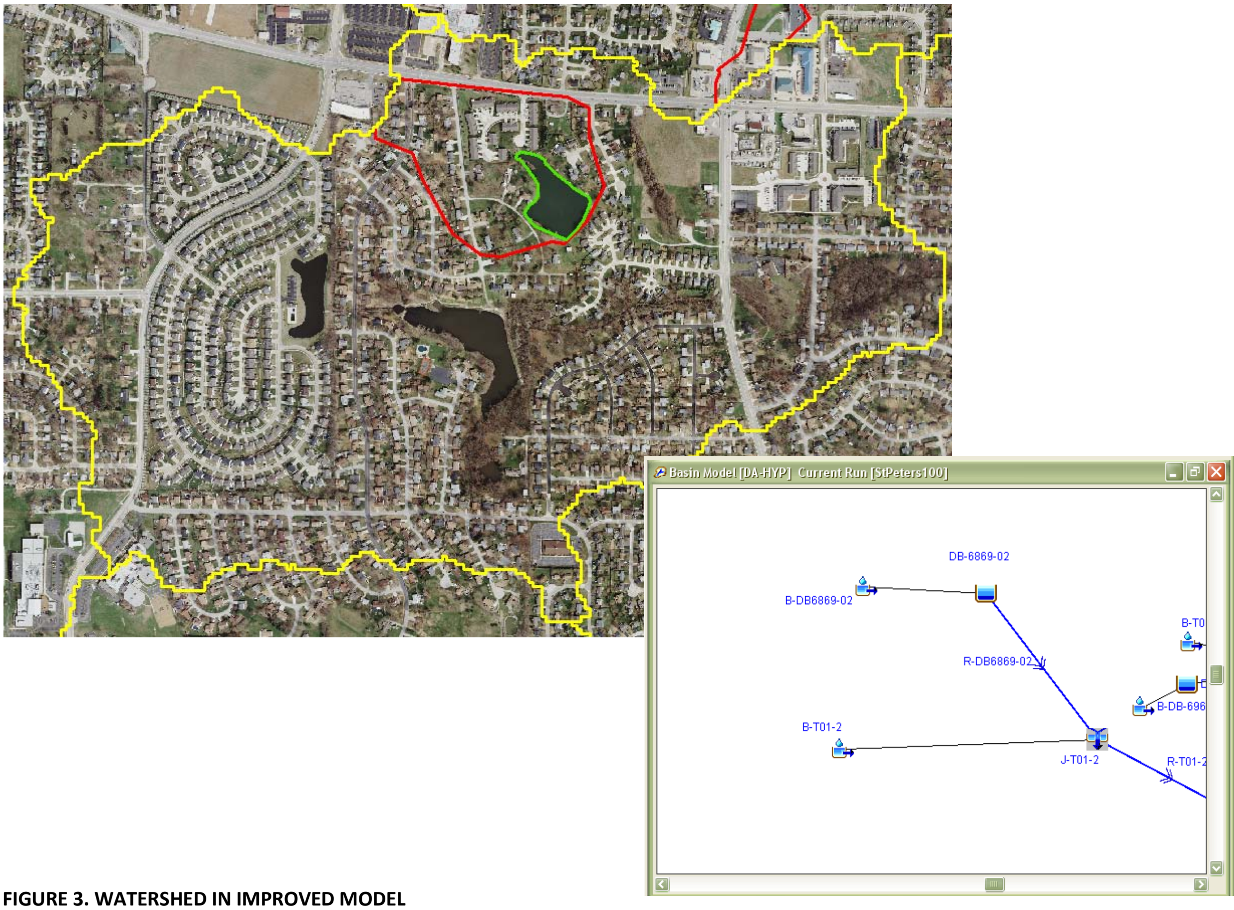


FIGURE 3. WATERSHED IN IMPROVED MODEL

As the detention basins and their contributing drainage areas are entered into the model, it was necessary to make the following changes:

Drainage Area Corrections

The drainage areas for the respective portions were updated to accurately reflect the size of the portion draining to the detention basin and the corresponding decrease in area of the un-detained portion.

Loss Characteristics

The loss characteristics (Initial Abstraction, Curve Number, and Percent Imperviousness) of the detained portion were assumed to be the same as the un-detained portion.

Clark Transform Parameters

The parameters associated with the Clark Transform (Time of Concentration and Storage Coefficient) were determined for each portion on a case-by-case basis. In general, the un-detained portion kept the same parameters, unless the longest flowpath within the sub-watershed was interrupted by the newly input detention basin. In these cases, a new time of concentration was determined.

For the detained portion(s), new times of concentration were determined using the TR-55 methodology. Storage coefficients for the detained portions were assumed to be 0.5, the smallest value that would allow the model to run. This prevents the model from over-estimating detention in the detained portion.

Baseflow Characteristics

No baseflow was assumed for the detained portion. Baseflow information was left unchanged for the un-detained portion.

The detention basins were input using stage/storage and storage/outflow tables. When information was available, these tables were developed using detention reports supplied by the City. When detention reports were not available, best efforts were made to develop these tables using available GIS information and field reports.

2.2.3 HEC-HMS Calibration Notes

The model supplied by the USACE was calibrated using two USGS gages along Dardenne Creek. The addition of detention basins into the USACE model resulted in a general reduction in flow across the sub-watersheds. To address this reduction in flow, the storage coefficients of the un-detained portions were reduced to match the 100-year (1% exceedence probability) hypothetical event.

By reducing the storage coefficients, the model has been transformed from using implied detention to explicit detention. In other words, instead of providing the sub-watershed with a large storage coefficient to imply detention within the sub-watershed, the improved model explicitly models the storage effects by including a detention basin.

This calibration effort produces peak flows that are generally within +/- 1% of the USACE HEC-HMS model for the 100-year event.

2.2.4 Suggestions for Improvement of the HEC-HMS Model

There are several opportunities for improvement of the HEC-HMS model for future preliminary engineering work. This model was initially developed by the USACE for the purpose of a generalized flood study of the Dardenne Creek watershed. This original purpose does not make the model an optimal one for preliminary engineering study. Some opportunities for improvement include:

- Re-delineation of sub-watersheds. The sub-watersheds were originally delineated using the USACE DEM and automated GeoHMS software. This produces coarsely-defined sub-watersheds that only roughly follow the contours developed through the more recent LiDAR mapping.
- Additionally, some of the sub-watersheds are delineated to points that are not optimal within the watershed.
- Topographic survey of detention basins and outfall structures. Many of the detention basins are input into the model using GIS-level contour information and field notes regarding the outlet structure. In some cases, these two information sources offer conflicting information about the detention basin characteristics.

- Times of Concentration. In general, times of concentration for the detained portions were developed primarily using overland flow. Local, in-depth analyses of times of concentration may be appropriate.
- Time step. The HMS model time step was set by the USACE as 15 minutes. This means that flows are only calculated at 15 minute intervals. In order to match peaks, this convention was retained. However, smaller time steps may provide more accurate flow estimates. Additionally, the smallest time of concentration allowed by the model is equal to a time step. This means that if a time of concentration for a small detained portion is below 15 minutes, the model automatically increases the time of concentration to 15 minutes.

2.3 Hydraulic Modeling of Existing Conditions

2.3.1 Existing Conditions Model

For this study, the Dardenne Creek hydraulic model developed by the USACE St. Louis District in 2007 was refined to represent the most current topographic information within the City limits. The extents of the hydraulic model are presented in Figure 4. A larger version of Figure 4 is presented in Appendix J. The USACE 2007 model was based on a 3D terrain model created with digital orthophotos. The 2007 study model also utilized additional data including bridge and culvert drawings, previous hydraulic models, rainfall and streamflow data, land use and soil maps, and other GIS data. The 2007 HEC-RAS model was developed using a GeoRAS extension of Arcview GIS and previous hydraulic models were used to describe the channel sections for streams that were not surveyed completely. Some of the cross sections in the 2007 HEC-RAS models were developed from field surveys conducted as part of the study. The cross sections that are based on survey information are noted within the model.

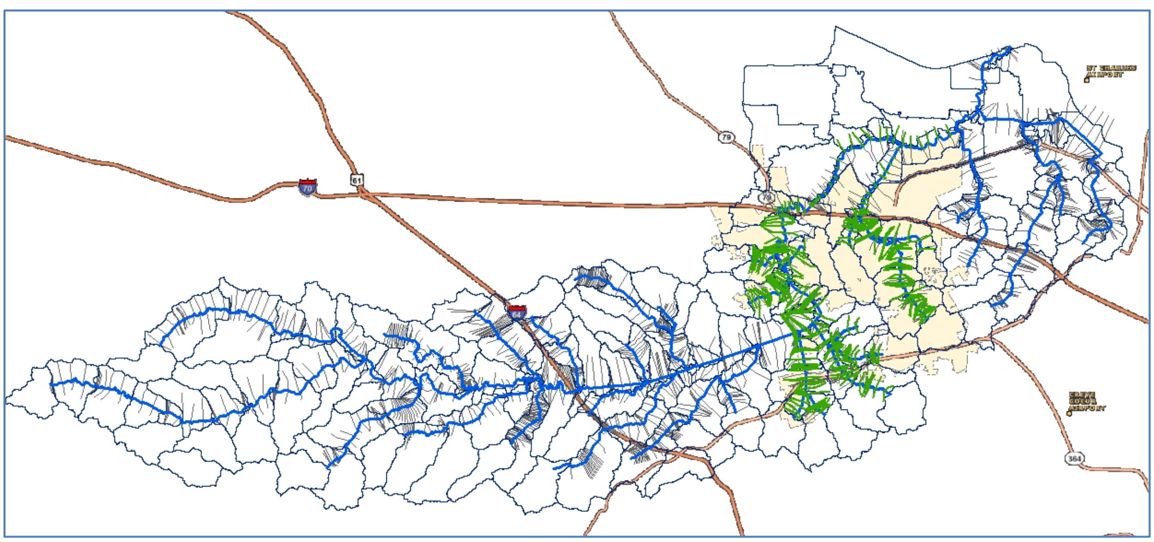


FIGURE 4. DARDENNE CREEK WATERSHED, HEC-RAS MODEL EXTENTS

The base condition modeling effort of the 2007 USACE hydraulic model analyzed eight different storm frequencies over the entire Dardenne Creek basin. The USACE model did not include a floodway calculation. The forecasted condition modeling used the same flood frequencies with a forecasted condition that included changes to the hydrology based on anticipated developments in the watershed.

2.3.2 Evaluation of Existing Conditions Model

The existing model was evaluated to establish continuity of peak flows, determine extents, and identify modeling constraints within the city limits. The use of following model components was evaluated: bounded cross sections, ineffective flow areas, blocked obstructions, Manning's n values, lateral and storage structures, and bridge and culvert routines.

The review of the 2007 hydraulic model produced several concerns. First, the GIS data provided by the USACE was incomplete because USACE cross sections did not correspond to the 2007 USACE HEC-RAS model and were spaced infrequently, as shown in Figure 5. To develop the refined model, Black & Veatch used the 2007 HEC-RAS model to develop a GIS database that included the correct cross sections and stream centerlines. GeoRAS was utilized to export the complete set of cross sections and stream networks.

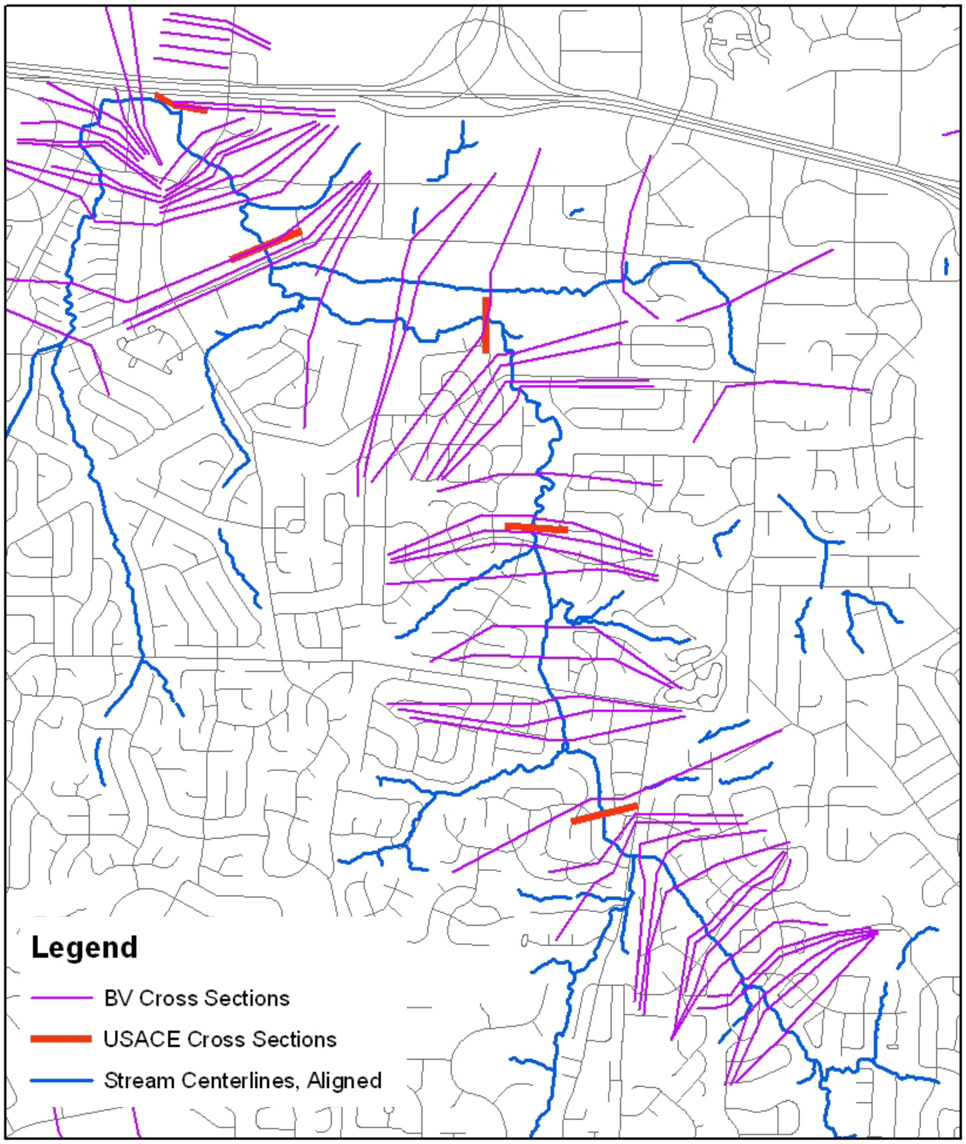


FIGURE 5. HEC-RAS CROSS SECTIONS, BV AND USACE MODELS

Additionally, the 2007 HEC-RAS model provided by the COE was read only and incomplete. Data missing from this model included the following: upstream boundary conditions for the flow file, storage area elevations, and ineffective flow area designation on several cross sections. The 2007 HEC-RAS model presented a steady state model that included storage areas and lateral structures. Storage areas and lateral structures are typically used in unsteady models to determine how much flow moves across a weir over a duration of time*.* As noted in the 2007 report, there is a limitation in the ability of HEC-RAS to perform an iterative optimization calculation for several levees at the same time in a steady flow analysis. Therefore, the 2007 study accounted for the flow leaving the channel by way of the levees with another method applied within the hydrologic analysis: the Modified Puls method of routing. The lateral structures and storage areas were left in the 2007 HEC-RAS models to be used in later modeling efforts when the steady flow calculations in the RAS program are improved.

The Manning's n values used in the model are presented in Table 3. Manning's n values depend on several factors including surface roughness, channel alignment, scour and deposition of materials, obstructions, and seasonal changes. For the 2007 USACE study, the Manning's n value was used to calibrate the model and therefore was not modified in the revised hydraulic model.

TABLE 3. HEC-RAS MANNING'S N VALUES

Creek	Manning's n value		Typical Overbank Land Cover
	Channel	Overbanks	
Dardenne	0.04-0.055	0.06-0.07	Agricultural and Levee, Forested, Golf Course, Residential Development
Spencer	0.045-0.05	0.05-0.065	Parkland, Wooded Areas, Residential Development, Commercial Development

Finally, the downstream boundary condition for the USACE hydraulic model is based on backwater conditions of the Mississippi River for each hypothetical storm event. In a steady flow hydraulic analysis, the downstream boundary condition must be defined and the standard step backwater calculations begin at this most downstream point of the model. In the 2007 HEC-RAS model, the mouth of Dardenne Creek at the Mississippi River is the most downstream point and the elevation of the Mississippi River therefore provides the starting point. The 2007 USACE study applied a conservative estimate for this starting water surface elevation. For each hypothetical event in the study, the corresponding flood elevation of the same frequency on the Mississippi River was used. These were based on Mississippi River Flood Frequency profiles from the USACE Water Control Office. The downstream boundary conditions of the existing conditions model are presented in Table 4.

TABLE 4. 2007 HEC-RAS MODEL DOWNSTREAM BOUNDARY CONDITIONS

Recurrence Interval	**Discharge** *(cfs)*	**Water Surface Elevation** *(ft)*
2-year	5,558	429
5-year	8,635	433.2
10-year	10,304	434.6
15-year	10,926	435.7
25-year	12,044	437.4
50-year	14,222	439.5
100-year	17,423	441.4
200-year	25,943	444.3

2.3.4 Revisions to Existing Model

For this study, the 2007 HEC-RAS hydraulic model was refined to represent the most current topographic information within the City limits, based on LiDAR data collected in 2009. The extents of the hydraulic model within the City limits are presented in Figure 6. The dark green lines represent cross sections that were updated based on current topography. The dark blue line represents the stream centerline for the model.

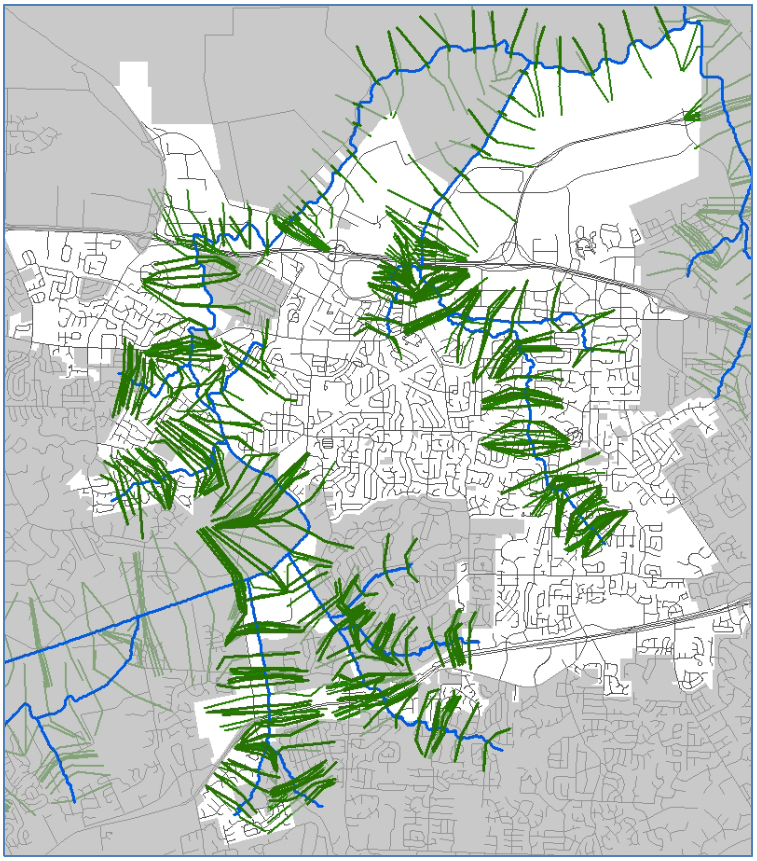


FIGURE 6. HEC-RAS MODEL EXTENTS, CITY OF ST. PETERS

The GeoRAS extension to ArcView GIS was utilized to update cross section geometry. A digital elevation model with 1 meter resolution, provided by the City, was used to define the new terrain. Cross sections and stream centerlines developed in the 2007 hydraulic model were overlaid on this new terrain. Several stream centerlines and the majority of the cross sections were updated to correctly represent the new terrain. Each cross section that was revised to correctly represent the new terrain is compared with the closest original cross section but the majority of revised cross sections do not overlap original sections at the exact location.

In most instances, surveyed cross sections from the 2007 study were evaluated but not included in the revised area of interest. These cross sections defined the topography in the channel however they were not consistently higher or lower than the GIS terrain. The average difference in elevation was 0.2 feet with a standard deviation of 2.5 feet. In most cases, using only the LiDAR digital elevation model to define the new terrain provided a more conservative approach because any conveyance area under the water surface elevation is not included in the hydraulic model. The downstream reaches of Dardenne Creek (between Mexico Road and the confluence), however, were represented with 2007 information because the LIDAR information did not accurately represent the channel conveyance.

The revised cross sections and stream centerline were imported into a revised HEC-RAS model watershed using the GeoRAS program. The cross sections highlighted in dark green in Figure 6 were replaced in the existing conditions hydraulic model. As part of the model revision, ineffective flow area and levee designations were added at appropriate locations within the City limits. Assumptions developed in the 2007 HEC-RAS model related to Manning's n values, contraction and expansion losses were retained. The revised model of existing conditions also retained the same hypothetical storm events provided in the 2007 HEC-RAS model.

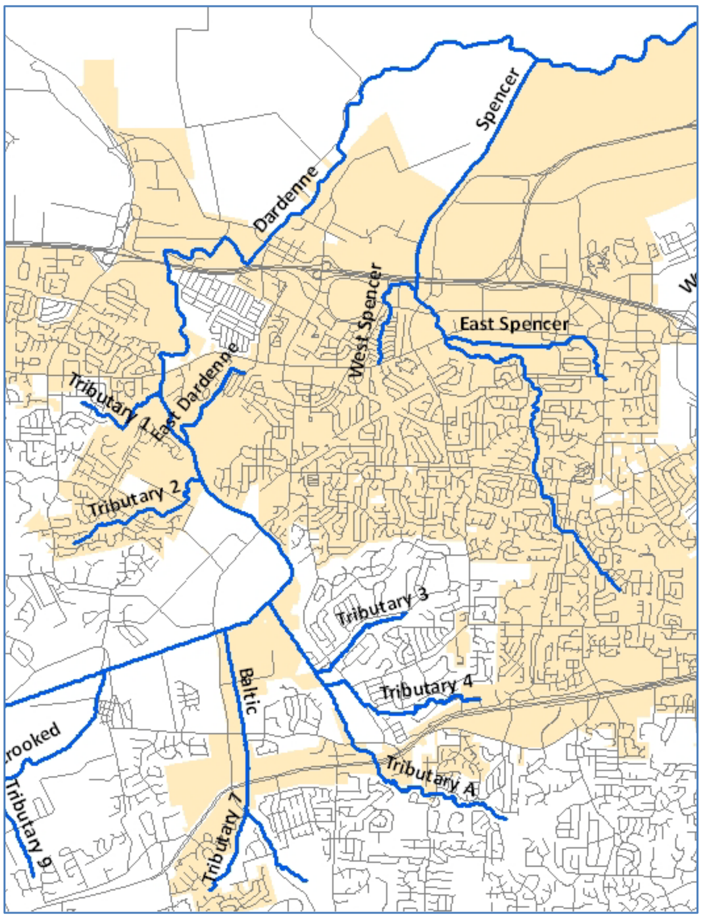


FIGURE 7. HEC-RAS MODEL STREAM CENTERLINES

Downstream boundary conditions were updated in the refined model of existing conditions. In order to represent more realistic boundary conditions with each hypothetical storm event, the 2-year water surface elevation was assumed for the Mississippi River.

The following table presents changes in water surface elevations at main points throughout the City as a result of these revisions to the HEC-RAS model. Figure 7 shows the names of the reaches referenced in Table 5. It is important to note that the revised cross sections are not at the exact location of the original cross section and therefore the comparison of water surface elevation is not exact. The inundation maps present the most accurate comparison of any changes in water surface elevation.

TABLE 5. WATER SURFACE ELEVATION COMPARISON, HEC-RAS EXISTING CONDITIONS MODELS

Stream	Reach	Comment	USACE Model		Refined Model		Difference
			River Station	*W.S. Elev (ft)*	*River Station*	*W.S. Elev (ft)*	*(ft)*
Baltic	2	Just downstream of Robertridge Court and Pittman Hill Road	10909	486.71	10939.1	483.34	-3.37
Baltic	1	Just upstream of Highway 94	7350	481.17	7589.226	475.32	-5.85
Baltic	1	Upstream of Dye Club Drive	2511	473.33	2747.017	473.38	0.05
Dardenne	9	Downstream of Mid Rivers Mall Drive	76865	473.25	76914.59	472.94	-0.31
Dardenne	7	Upstream of Mid Rivers Mall Drive	70035	469.85	70036.03	467.65	-2.2
Dardenne	4	Downstream of Confluence with Tributary 1	61578	463.48	61578	463.47	-0.01
Dardenne	4	Upstream of Mexico Road	60613	462.54	60613	462.52	-0.02
Dardenne	4	Adjacent to Dardenne Drive and Maple Street	54412	460.95	54412	460.93	-0.02
Dardenne	4	Adjacent to bend in Brown Road	49463	455.37	49463	455.35	-0.02
Dardenne	4	Upstream of Main Street	46762	454.9	46762	454.89	-0.01
Dardenne	3	Downstream of Confluence with Spencer Creek	27167	442.56	27167	439.82	-2.74
East Dardenne	1	Adjacent to Settlers Circle	383	465.09	3113.922	464.69	-0.4
East Spencer	1	Upstream of First Executive Drive	5447	468.61	5472.929	469.96	1.35
Spencer	3	Adjacent to Waterbury Court	29026	500.94	28950.23	498.99	-1.95
Spencer	3	Upstream of Willott Road	26168	488.46	26304.94	488.05	-0.41
Spencer	3	Upstream of Sutters Mill Road	23927	482.72	23873.98	479.74	-2.98
Spencer	3	Adjacent to Lantana Lane West	22447	475.73	22479.98	474.11	-1.62
Spencer	3	Adjacent to White Falls Court	20095	469.71	20040.57	467.7	-2.01
Spencer	2	Upstream of I-70	12737	451.98	12844.4	451.59	-0.39
Spencer	1	Adjacent to Spencer Road	8271	442.79	8277.905	440.8	-1.99

Stream	Reach	Comment	USACE Model		Refined Model		Difference
			River Station	*W.S. Elev (ft)*	*River Station*	*W.S. Elev (ft)*	*(ft)*
Spencer	1	Upstream of confluence with Dardenne Creek	672	442.57	630.0797	439.9	-2.67
Tributary 1	1	Adjacent to Carpenter Court cul-de-sac	4077	464.61	4047.269	464.62	0.01
Tributary 1	1	Upstream of confluence with Dardenne Creek	511	464.3	613.7575	464.5	0.2
Tributary 2	1	Adjacent to Country Squire Circle	5512.5	467.34	5528.229	468.33	0.99
Tributary 2	1	Upstream of confluence with Dardenne Creek	685	465.8	665.5778	465.24	-0.56
Tributary 3	1	Upstream end of Tributary 3	5066	504.05	4851.662	503.83	-0.22
Tributary 3	1	Downstream of St. Peters Howell Road	695	472.4	747.4638	470.75	-1.65
Tributary 4	1	Upstream of Woodstream Drive	7370	509.69	7383.865	509.8	0.11
Tributary 4	1	Adjacent to St. Peters Howell Road	1689.5	476.18	1885.409	476.53	0.35
Tributary A	3	Upstream of Dingledine Road	13469	495.17	13528.44	494.05	-1.12
Tributary A	3	Adjacent to Pine Bluff Drive Cul-de-sac	12090	487.71	12127.7	486.21	-1.5
Tributary A	3	Upstream of Central School Road	7864	475.21	7852.112	472.98	-2.23
Tributary A	2	Upstream of Fox Pointe Circle	4561	472.42	4449.625	471.28	-1.14
West Spencer	1	Adjacent to Madrid Court cul-de-sac	4536	456.94	4542.916	457.13	0.19
West Spencer	1	Upstream of Executive Centre Pkwy	2770	456.08	2788.375	456.02	-0.06
West Spencer	1	Upstream of Costco Way	1150	452.14	1020.302	451.96	-0.18
Tributary 7	1	Adjacent to San Marco Way	1404	483.25	1540.299	483.55	0.3

On average, there is less than one foot of change in 100-year water surface elevation between the revised existing conditions model and the 2007 USACE model. Typically, the water surface elevation decreased. There was a maximum increase within the City limits of 1.35 feet associated with the 100-year water surface elevation, located at Station 5447 on East Spencer Creek, upstream of First Executive Drive. There was a maximum decrease of 5.85 feet associated with the 100-year water surface, located at Station7350 on Baltic Creek, just upstream of the Highway 94 crossing. This is due to a culvert project that was installed in 2010-2011.

2.3.5 Calibration Assessment

The calibration of the 2007 HEC-RAS model compared the computed flood elevations to observed data along Dardenne Creek. There are two recording stream gauges along Dardenne Creek; these gauges are located at O'Fallon and St. Peters and provide data from late 1999 to the present. The 2007 study used the observed high water marks from the storm of January 2005 and the hydrograph from the November 2003 storm event. The 2007 study modified Manning's n values and some bridge and culvert data to calibrate the model to the observed high water marks. The 2007 study acknowledged that the limited number of rainfall gauges and various antecedent moisture conditions could not accurately portray complex storm patterns for the HEC-HMS analysis.

For this study, the same flows were used for each hypothetical storm event because the revised HMS model was calibrated to the USACE HMS model. These flows produced water surface elevations that were within 1 foot of those in the 2007 hydraulic model, on average. Calibrating the revised model to match the water surface elevations with the new topography would require changing the Manning's n values beyond the reasonable range.

Rain events in April and June (2011) produced localized flooding and additional high water marks that were recorded by the City. The anecdotal records from this event were used to evaluate specific areas of the existing conditions model. Two particular locations were highlighted by the City: flooding at Jungermann Road and Rachel's Trail. The flooding recorded at Jungermann Road is not accurately represented in the existing model because the hydrologic drainage basin in this area overlaps the roadway and the storm event discharge is associated with a flow change location downstream of the bridge, rather than at a point upstream. Figure 8 presents the HEC-HMS subarea B-SP7 that overlaps Jungermann Road. The upstream basin produces a flow of 2279 cfs during the 100-year event and B-SP7 produces a flow of 4378 cfs during the same event. The higher flow is applied to a cross section downstream of Jungermann Road in the HEC-RAS model and therefore the evaluation of Jungermann Road in the existing conditions model was not based on an appropriate break point.

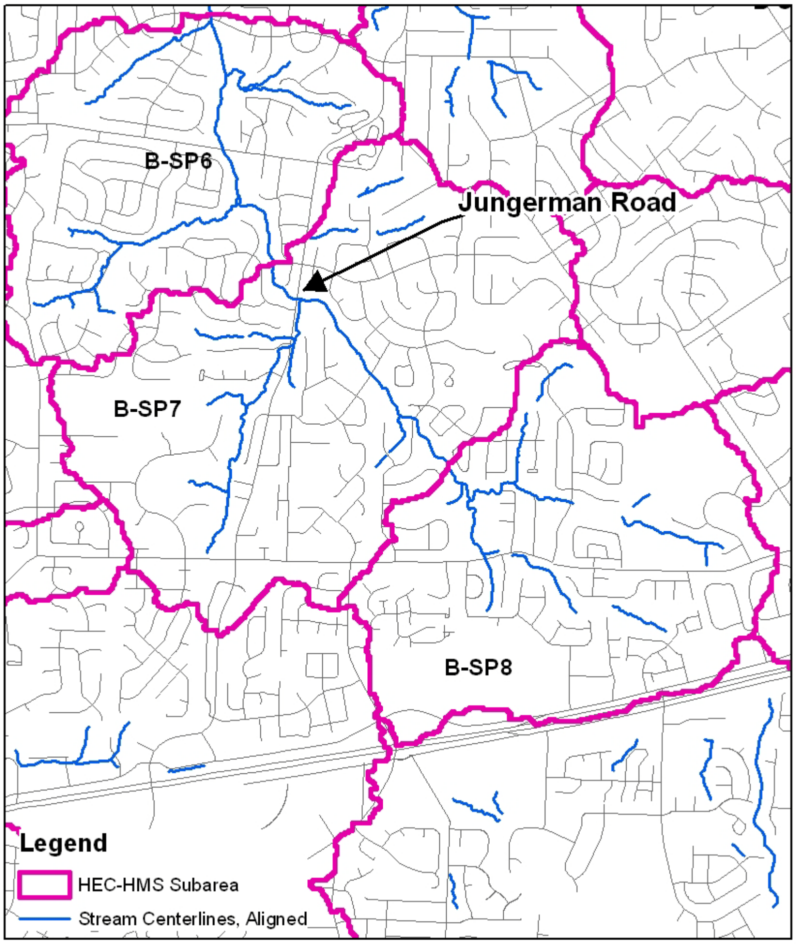


FIGURE 8. HEC HMS SUBAREAS, JUNGERMANN ROAD VICINITY

The second location that the City highlighted was at Rachel's Trail Drive. This area is influenced by the capacity of the stormwater pipe conveyance system and is not within the scope of this master plan.

2.3.6 Flooding Identified in Existing HEC-RAS Model

The area of inundation was established for the revised existing conditions model during the 100-year event. The 2007 USACE hydraulic model area of inundation was also developed for the purposes of comparison. The revised existing conditions hydraulic model results in a water surface elevation that will be used for comparison to conceptual recommendations. This inundation map is presented in Figure 9.

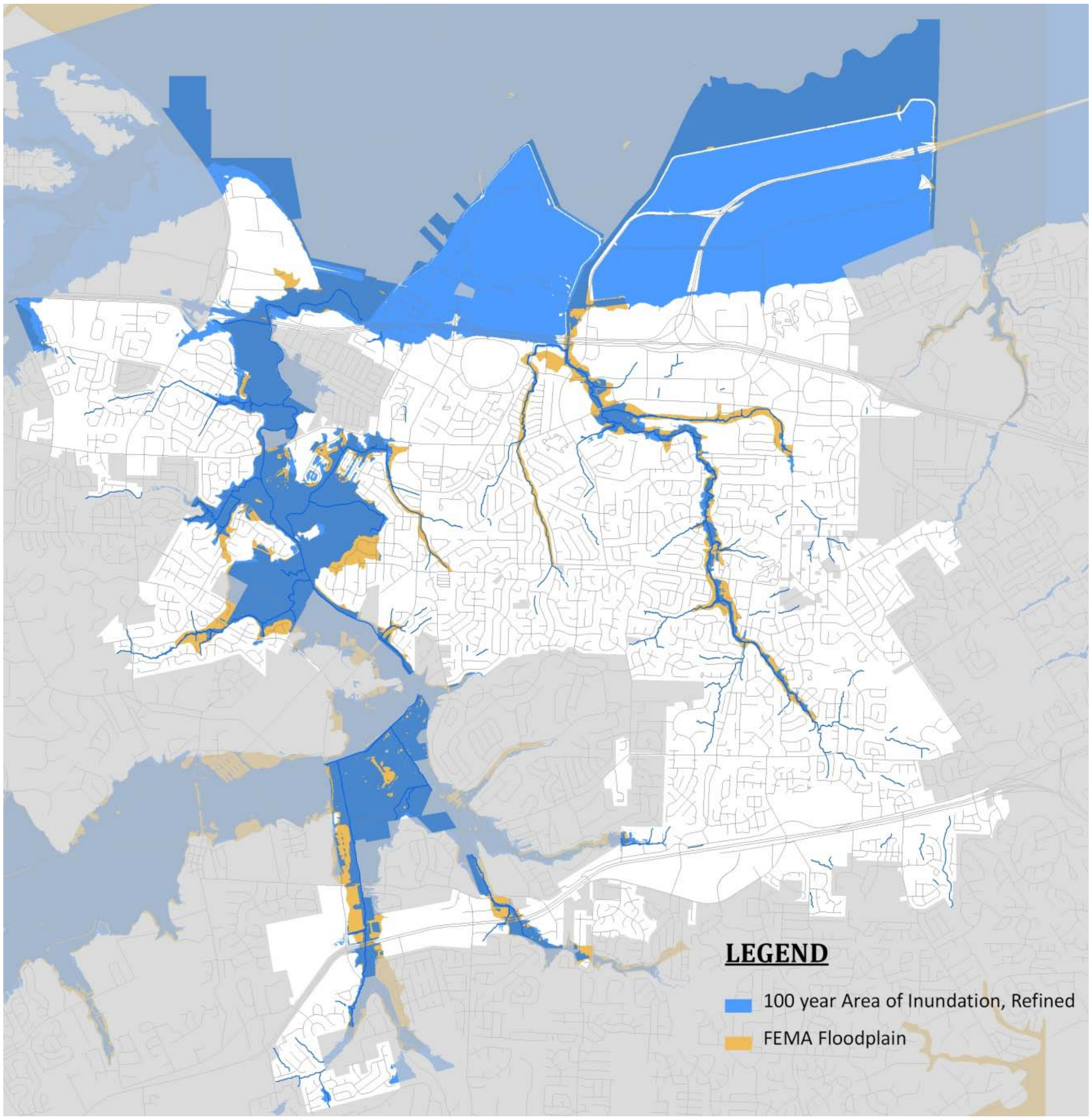


FIGURE 9. COMPARISON OF HEC-RAS INUNDATION AREAS (EFFECTIVE FEMA FLOODPLAIN, 1996)

Along Spencer Creek, the revised area of inundation lies mostly within the FEMA floodplain and is significantly narrower in many reaches. Several residential structures are within this floodplain and area of inundation. Low spots were documented along Jungermann Road and Boone Hills Drive, presented in Figures 10 through 14.

FIGURE 10. JUNGERMANN ROAD OVERTOPPING ALONG SPENCER CREEK

FIGURE 11. BOONE HILLS DRIVE OVERTOPPING ALONG SPENCER CREEK

FIGURE 12. JUNGERMAN ROAD OVERTOPPING ALONG EAST SPENCER CREEK

The area of inundation along Dardenne Creek is significantly wider. Within the City limits, development within this floodplain is mostly recreational. The revised model of existing conditions shows overtopping of Mexico Road and the residential area south of Mexico Road is within the area of inundation.

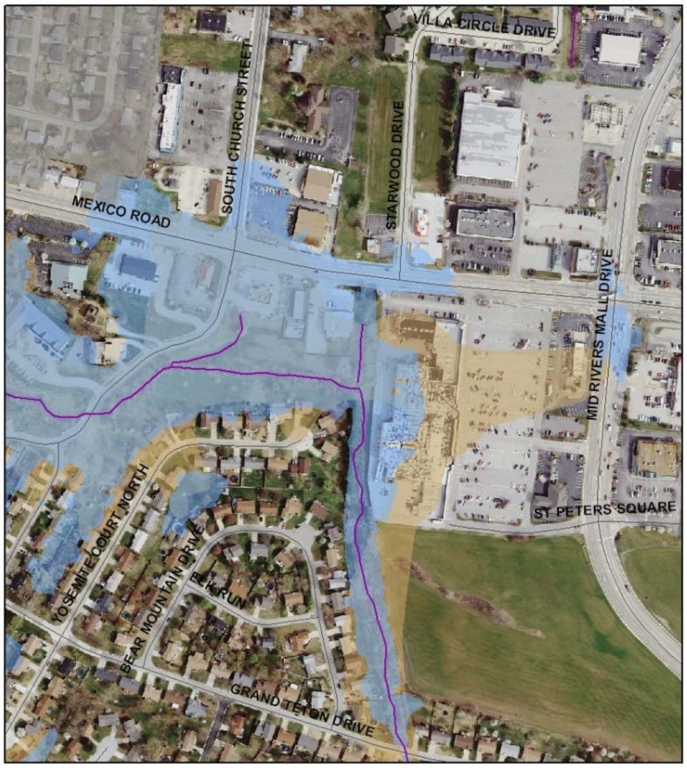


FIGURE 13. MEXICO ROAD OVERTOPPING NEAR MID RIVERS MALL DRIVE, TRIBUTARY TO DARDENNE

The 2007 hydraulic model and the revised existing condition model produce inundation areas that are different from the FEMA flood insurance study maps. As the 2007 USACE study highlighted, FEMA's St. Charles County Flood Insurance Study is still the official document for determining the floodplain and floodway areas. The revised model of existing conditions does not estimate the floodway width or define encroachments on the floodplain. This FEMA flood insurance study is the official document for decisions related to floodplain development.

2.3.7 Bridge and Culvert Crossings

Bridge and culvert crossings within the City limits were evaluated within the revised hydraulic model. Bridge design guidance is provided in Section 4.040 of the St. Louis MSD 'Rules, Regulations, and Design Requirements'. This document states that the "lowest point of bridge superstructure shall have 2-ft of freeboard from the 15-yr water surface elevation and 1-ft freeboard from the 100-yr water surface elevation." Table 6 presents the freeboard at each bridge and culvert crossing within the City limits, as calculated in the hydraulic model. Thirteen crossings were considered for project locations because of overtopping or insufficient freeboard during the 15- or 100-yr event. For individual reasons (i.e. the bridge crossing is located at a private property), eight of these crossings were not included as projects in the CIP. A summary of the data for each crossing is provided in the table below.

TABLE 6. BRIDGE AND CULVERT CROSSINGS

Reach	Project ID	Crossing	Low Chord or Low Point on Deck	Refined Existing Conditions Model Water Surface Elevation		Freeboard (ft)		PROJECT
				15 year	*100 year*	*15 year*	*100 year*	
Baltic		Dye Club Road Bridge	463.5	470.35	473.38	-6.85	-9.88	Considered but excluded because private ownership
Baltic		Central School Road	477.5	471	471	6.5	6.5	NO
Baltic		Hwy 94						NO
Baltic		Private Road Bridge	489	484.92	485.6	4.08	3.4	NO
Dardenne		N&W RR Bridge	450	449.61	450	0.39	0	Considered but excluded because private ownership
Dardenne	IP-7071-4-2	Hwy C Bridge	454.07	450.23	453.73	3.84	0.34	YES
Dardenne	IP-6970-4-3	I-70	456.9	454.77	460.34	2.13	-3.44	YES
Dardenne	IP-6970-4-3	Mexico	460.5	459.06	462.22	1.44	-1.72	YES
Dardenne - 7		Mid Rivers Mall	473.5	464.43	467.34	9.07	6.16	NO
Dardenne - 9		Mid Rivers Mall	474	470.14	473.5	3.86	0.5	Considered but excluded because of relatively new construction
East Spencer		St. Peters Walkway Bridge	457.5	456.49	458.76	1.01	-1.26	Considered but excluded because of pedestrian usage
East Spencer		St. Peters Rec Plex	464.61	457.77	459.56	6.84	5.05	NO
Spencer		N&W RR Bridge	442	442.89	444.04	-0.89	-2.04	Considered but excluded because private ownership

Spencer		I-70	449.22	444.77	447.25	4.45	1.97	NO
Spencer		Spencer Road Bridge	461.95	450.72	452.67	11.23	9.28	NO
Spencer		Executive Center	459.5	452.17	454.4	7.33	5.1	NO
Spencer		Mexico	457.45	454.11	457.46	3.34	-0.01	Considered
Spencer		Boone Hills	469.94	466.17	467.31	3.77	2.63	NO
Spencer		Sutters Mill Road	480	474.5	476.51	5.5	3.49	NO
Spencer		Willott	489	484.14	485.9	4.86	3.1	NO
Spencer	IP-7368-1-3	Jungermann	500.12	498.24	502.35	1.88	-2.23	YES
Spencer		Burning Leaf	514.93	509.69	511.69	5.24	3.24	NO
Spencer		Millwood Drive	526.6	517.4	517.4	9.2	9.2	NO
Tributary 2		Woodlands Parkway	454	462.18	465.26	-8.18	-11.26	Considered but excluded because of park location
Tributary 2		Ohmes Road Culvert	471.63	462.85	465.31	8.78	6.32	NO
Tributary 7	IP-7066-4-1	Pittman Hill Road	480.4	480.81	482.01	-0.41	-1.61	YES
Tributary A		Central School Road	480.5	470.58	472.68	9.92	7.82	NO
Tributary A		Private Road Culvert	478.51	478.51	478.51	0	0	Considered but excluded because private ownership
Tributary A		Hwy 94						NO
Tributary A		Dingledine Road Culvert	500.15	489.92	491.23	10.23	8.92	NO
West Spencer		Costco Culvert	454.7	449.48	451.61	5.22	3.09	NO
West Spencer		Suemandy Culvert	454	450	450	4	4	NO
West Spencer		Suemandy Culvert	458.21	451	451	7.21	7.21	NO

2.3.8 Closed System Hydraulics

The closed system hydraulic analysis was performed with the stormwater analysis software, XP-SWMM 2011. The model was developed initially using the MIKE SWMM files provided by the city of St. Peters, but much of the pipe system shown in the model has been updated and no subcatchment delineations were provided with it making it impossible to delineate new catchments for the new system. Therefore, a new version of the Old Town stormwater system was developed, which utilized infiltration parameters from the MIKE SWMM model and the same general stormwater system configuration with updates to the pipe system and the pump station. The pipe system updates were taken from the Old Town St. Peters Storm Sewer Improvements Plan drawings and the pump station information was provided by the City. These drawings represent improvements constructed in 2000. When new data was required to complete the model, the GIS datasets (specifically, the 2-ft contours, the impervious area, and the storm sewer coverages) were utilized, and if further information was needed, reasonable assumptions made for the model.

Stormwater Conveyance

The Old Town stormwater drainage basin is a relatively flat basin that is bordered on the west by the Dardenne Creek levee, and road and highway embankments in the other directions; however there is a significant amount of drainage area to the south of I-70 that is conveyed underneath the highway and makes its way into the Old Town drainage system. The stormwater is conveyed in a pipe system to the Old Town Pump Station and discharges to Dardenne Creek. When the water surface elevation in Dardenne Creek is higher, flow is then pumped into Dardenne Creek. In a system such as this, not only do the pipes and storm water inlets need to have adequate capacity for the level of service design event, but so does the pump station. It should be noted that the modeling performed in this basin only evaluated the pipe system shown and did not evaluate stormwater inlets. If stormwater inlets are inadequate, then localized flooding issues can occur; however, their impact is generally limited as excess flows will usually flow down roads to other entry locations into the stormwater system. If the pipe system or pump station capacity is inadequate, more severe flooding can occur. The following Figures 14 and 15 show an overview of the Old Town basin and a schematic of the stormwater system analyzed.

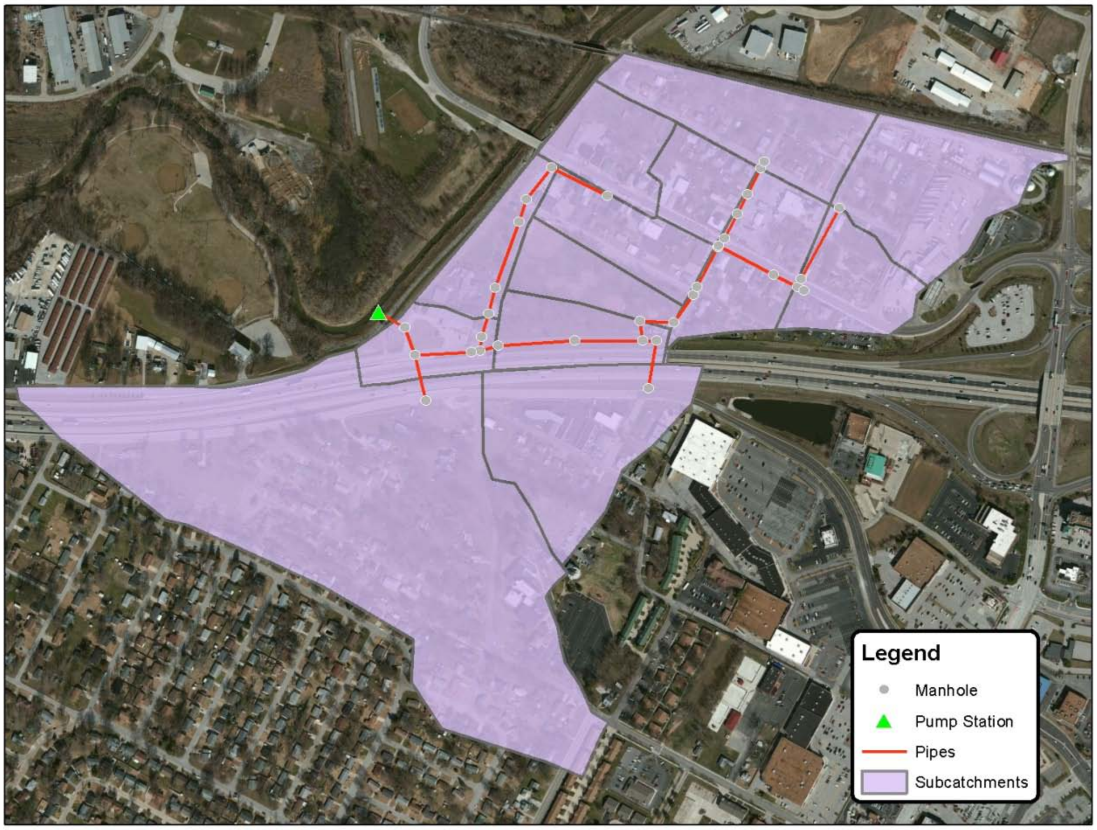


FIGURE 14. OLD TOWN DRAINAGE SYSTEM AND SUBAREAS

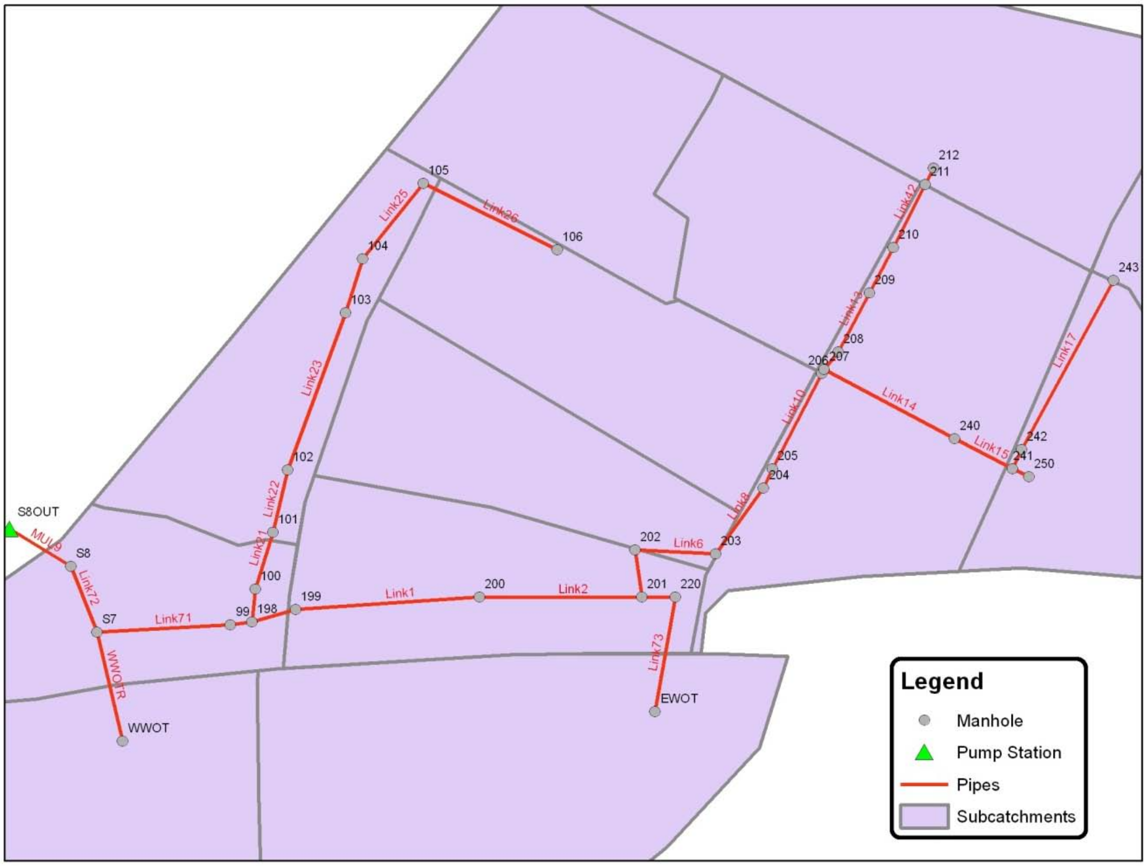


FIGURE 15. OLD TOWN PIPE SYSTEM, XP-SWMM MODEL

Pipe System Capacity Analysis

Within the XP-SWMM model, the pipes are represented by links and the manholes are represented by nodes. The pipe system should be able to convey the design storm without flooding the manholes. To analyze just the pipe system conveyance performance, the pump station was excluded. This prevents the pump station from creating a backwater condition that controls the stormwater conveyance system, which does not allow for the individual pipe capacities to be evaluated. The pump station was evaluated separately. Using this model, the 2-yr, 24-hr and 15-yr, 24-hr SCS Type II storms were simulated in the model. The 15-yr, 20 minute design storm is contained within the 15-yr, 24-hr storm and provides the same peak flow although the 24-hr storm analysis provides conservative volume results. The model indicated that the system experiences minor surcharging (i.e., when the water surface elevation exceeds the top of the pipe crown) and flooding (i.e., when water would flow out of the tops of manholes). For the pipe system analysis, the cause of surcharging and flooding is inadequate pipe capacity. Table 7 summarizes the flows and pipe capacities for the Old Town system (pipes highlighted in grey surcharged or contributed to flooding during the 15-yr, 24-hr storm):

TABLE 7. EXISTING OLD TOWN PIPE SYSTEM CAPACITY ANALYSIS

Pipe	2-yr flow (cfs)	15-yr flow (cfs)	Full Pipe Capacity (cfs)	Current Pipe Size (ft)*	15-year Flow to Full Pipe Capacity Ratio
Link43	7	22	19.6	3	113%
Link42	7	22	31.2	3.5	70%
Link41	7	21	32.24	3.5	67%
Link13	11	31	44.1	4	71%
Link12	11	31	44.5	4	70%
Link17	18	34	13	2.5	260%
Link16	18	34	32.29	3.5	106%
Link20	9	21	12.7	2.5	163%
Link15	26	53	42.6		124%
Link14	26	52	49		106%
Link11**	47	102	N/A	4.5	
Link10	47	102	60.44	4.5	169%
Link9	56	119	68	4.5	175%
Link8	56	119	64	4.5	187%
Link6	57	121	82	5	147%
Link5	57	125	88	5	141%
Link73	22	49	67	3	73%
Link3	22	49	157	3	31%
Link2	77	167	135	6	123%
Link1	77	167	135	6	123%
Link44	81	176	171.5	6.5	103%
Link26	7	15	22	2.5	69%
Link25	7	15	22	2.5	68%
Link24	7	15	22	2.5	68%
Link23	7	15	36	3	41%
Link22	7	15	36	3	43%
Link21	11	25	33	3	76%
Link46	11	25	38	3	66%
Link45	92	201	158.5	6.5	127%
Link71	93	204	268	Twin 6-ft RCPs	76%
WWOTR	60	133	382	6x3 RCB	35%
Link72	149	325	268	Twin 6-ft RCPs	121%
* - All dimensions are pipe diameters except where indicated					
** - This is a short segment of flat pipe, which therefore does not have a calculated full flow by Manning's equation					

Based on Table 7, it can be seen that there are a number of pipe segments that have more flow than their full pipe capacity can convey by gravity; however, exceeding the pipe capacity by a limited amount does not necessarily cause flooding.

Pump Station Conveyance Analysis

In a basin such as Old Town, the most severe flooding can occur if the pump station cannot convey the stormwater produced by the design storm. The information provided by the City indicates that the current pump station can convey approximately 44 cfs (20,000 gpm), which corresponds with two pumps that can convey 22 cfs at the Old Town Pump Station. From the Old Town stormwater model, approximately 160 cfs is conveyed to the pump station during the 2-yr, 24-hr storm and approximately 340 cfs during the 15-yr, 24-hr storm. It should be noted that for the analysis, it was assumed that the water surface within Dardenne Creek corresponded with the same return interval as the design storm. For the 2-yr storm, this does not impact the pump station as the pump station discharges at a greater elevation; however for the 15-yr storm, there is some submergence of the pump discharge, which reduces the capacity of the pumps (however, this is submergence is offset by lower lift requirements on the suction side of the pump during the peak flow of the design storm).

When the pump station is introduced into the model, it acts as a bottleneck in the system for both the 2-yr and 15-yr storms effectively causing most of the low lying areas in Old Town to flood. From a modeling standpoint, it is difficult to determine the exact extent and depth of the surface flooding within a relatively flat basin such as Old Town. Essentially, as the flow escapes from the tops of the low lying manholes, it spills onto the surface and begins to spread out, forming a pool of inundation at the surface. In a one dimensional (1D) model such as SWMM, the challenge is to determine the surface storage volume where excess flow temporarily pools until the pump station can drain the system.

XP-SWMM 2011 has an optional two dimensional (2D) model that can be coupled with the one dimensional model to address this situation. For reference, the one dimensional model used by XP-SWMM is based on the EPA SWMM's model while the two dimensional model is called TUFLOW. For the 2D model, a surface model created from terrain data, such as contour or point data, is added to the top of the one dimensional model manholes. As the water surface elevation increases, eventually the water will spill out the tops of the manholes onto the surface, and the model determines the inundation extents on the surface.

Using the coupled 1D-2D XP-SWMM model, the extents of the flooding were determined for Old Town. Figure 16 shows the extent of the flooding within Old Town:

FIGURE 16. OLD TOWN AREA OF INUNDATION, 15-YR, 24-HR EXISTING CONDITIONS

In the existing conditions, approximately 29 acres of Old Town is inundated to a water surface elevation of 440.3 ft (as the water surface elevation is a two dimensional surface, there is variation across the surface, but for this analysis the concern is the elevation near the lower elevations of the basin). Most of the basin located within the 29 acre inundation area has a surface elevation of approximately 440, which means that much of the area would experience relatively shallow inundation (0.3 ft) and much of the deeper inundation would be in localized low areas.

East Old Town Conveyance System

The City noted that the existing swale draining east Old Town to the regional detention basin along Iffrig Road may be causing additional flooding of the Old Town area. This conveyance system was analyzed in a new XP SWMM model and it was determined that the swale and pipe capacity was undersized.

2.4 Assessment of Water Quality, Existing Conditions

Water quality in the City is influenced by several factors including the rate of development, consistent application of wet and dry detention basins, and stream stability.

There are 248 stormwater detention ponds within the City limits. Using the screening process described in Section 2.1.4, the most significant 74 detention ponds were selected. Each basin's potential to remove total suspended solids (TSS) was evaluated. The resulting data was evaluated in the context of each of the eight regional drainage areas in the City. Four of the drainage areas are in the Spencer Creek watershed and four are in the Dardenne Creek watershed.

Stream stability strongly influences water quality as well. There are 47 miles of stream corridor within the City limits. Stream bank and bed degradation was observed during field reconnaissance in April and May 2011. Nearly 12 miles of stream were documented as experiencing systemic instability, represented by mass wasting of banks, streambed degradation, or lack of riparian corridor.

2.4.1 Stormwater Runoff Model

The P8 urban stormwater runoff model was used to predict pollutant removal efficiencies for each of the 74 existing stormwater detention basins. The model simulated the generation and transport of stormwater runoff pollutants in the watersheds contributing to the detention basins. The simulations were driven by continuous hourly rainfall based on ten years of data recorded at the Lambert International Airport provided by the National Climatic Data Center. During the period of 2001 to 2009, the annual precipitation averaged 40.6 inches and ranged from a minimum of 29.8 inches in 2006 to a maximum of 58.0 inches in 2008.

The P8 model was pre-calibrated by its developer using the Nationwide Urban Runoff Program (NURP) database. Since data characterizing the quantity and quality of stormwater entering the basins were not available, a site-specific calibration of the P8 model was not possible. Although P8 is capable of simulating total suspended solids (TSS), total phosphorus, total Kjeldahl nitrogen, copper, lead, zinc, and total hydrocarbons, TSS was assumed to be a surrogate pollutant because in stormwater runoff the other pollutants are almost all associated with the suspended solids.

P8 input parameters for each detention basin included the area and impervious fraction of the detention basin's contributing drainage area, the detention basin area and volume, and whether the basin was normally dry (extended detention) or contained a permanent pool (wet detention). The watershed areas and imperviousness were based on GIS data provided by the City and the HEC-HMS hydrology model. Detention basin volumes were determined by one of two methods. The method used depended upon the information that was available from the City. If a complete hydrologic design report was available from the city for a given basin, the stage/storage/outflow information from the hydrologic report was incorporated into the model. If a hydrologic design report was not available from the City, the stage/storage curve was developed using the LiDAR contours. In this case, outflow information was developed based on field observations of the outlet works of the basin.

2.4.2 Removal Efficiencies of the Existing Stormwater Detention Basins

Of the 74 stormwater detention basins evaluated, 19 were located in the Spencer Creek watershed, upstream of Interstate-70. This watershed is named "Spencer (US)" and is shown in Figure 17.

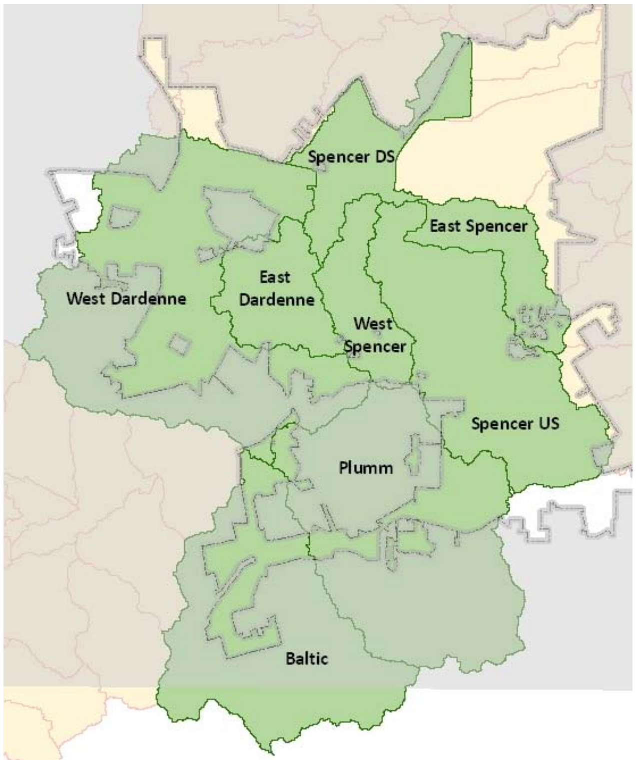


FIGURE 17. REGIONAL DRAINAGE AREAS IN ST. PETERS

The P8 model predicted that the wet basin removal efficiencies are significantly higher than the dry detention, averaging over 90 percent; the average removal of the dry detention is approximately 25 percent. Wet detention basins were more efficient in TSS removal because a full pond provides a longer hydraulic retention time, allowing more time for the TSS to settle out of the water column.

The average TSS removal of all the detention basins in the upstream Spencer drainage area was 65 percent. Approximately 87,000 lbs of TSS is removed by the 19 detention basins each year, under existing conditions. The P8 model predicted that approximately 689,000 lbs per year of TSS would be contained in stormwater runoff from the entire drainage area (Spencer US); therefore, the overall TSS removal in the 19 detention basins, with respect to the loading from the entire regional drainage area, is 12.6 percent. The total TSS loading for eight regional drainage areas is approximately 3.5 million lb/yr, including 1.1 million lb/yr contributed by the four Dardenne Creek drainage areas, Baltic, Plumm, West Dardenne, and East Dardenne.

Of the 74 basins evaluated, 67 are located in regional drainage areas. The following table summarizes the removal overall efficiencies for the 67 detention basins in the eight regional drainage areas.

TABLE 8. REMOVAL EFFICIENCIES FOR EXISTING STORMWATER DETENTION BASINS

Regional Drainage Area	Number of Detention Basins	Total Regional Drainage Area	Detention Basin In	Detention Basin Out	Detention Basin Removed	Detention Basin Removed	Overall Removal
		TSS-lb/yr	*TSS-lb/yr*	*TSS-lb/yr*	*TSS-lb/yr*	*%*	*%*
Baltic	8	298,595	44,878	14,184	30,694	68	10.3
West Dardenne	17	915,435	86,769	26,087	60,682	70	6.6
East Dardenne	9	252,434	73,836	41,436	32,400	44	12.8
East Spencer	5	271,909	61,911	21,479	40,432	65	14.9
Plumm	4	590,753	39,304	30,969	8,335	21	1.4
Spencer Downstream	0	226,128	0	0	0	0	0.0
West Spencer	5	232,583	7,215	1,868	5,347	74	2.3
Spencer Upstream	19	688,865	134,126	47,549	86,577	65	12.6
Totals	67	3,476,702	448,039	183,572	264,467	59	7.6

**Only 67 of the 74 detention basins evaluated in this study are within the regional drainage areas.*

Tables of removal efficiencies and other characteristics for each of the existing basins are included in Appendix C.

2.5 Geomorphic Assessment of Existing Conditions

In April and May 2011, Black & Veatch and PBA staff joined the City to evaluate stream stability and habitat within the City limits. As a team, Black & Veatch and PBA conducted a geomorphology and stream health field survey of the 47 miles of streams in the City of St. Peters. The team applied standards developed by the Kansas City Metropolitan Chapter of American Public Works Association and various state and federal natural resource agencies. The field assessment data was used to characterize each reach of the stream network with a rating that reflects the level of stability. Field data was collected in a Trimble unit that allowed for each data point to be georeferenced. Photographs were linked to these data points as well. The resulting GIS data, with scores and photographs along each reach, is provided in the geodatabase deliverable.

2.5.1 Channel Condition Scoring Matrix

Black & Veatch applied a scoring matrix based on the APWA 5600 Channel Condition Scoring Matrix (CCSM) to determine the stability of stream reaches throughout the City. The CCSM indices used include the channel geometry, bank slope stability, streambed and bank material composition, and erosion issues. Existing channel bed and bank geometry was established using the LiDAR data. Stream bank and bed material were evaluated based on soil texture, sediment composition, consolidation, armoring materials, and vegetative protection. Bank cutting, mass wasting, and excessive sediment deposition in localized areas were recorded. At select locations, existing riparian vegetation was documented. For each channel reach, the score of the indicator and the weighted rating for the stream were compiled in a GIS database.

The matrix provides a comparative score of reaches throughout the City and was used to identify areas of significant instability and to prioritize projects. The resulting score was divided into three groups that range between 10 and 25. A rating of 13 or less indicates a stream of moderate stability and may require only standard levels of protection during construction. A rating between 13 and 19 indicates limited instability and special measures may be needed to address specific issues that were rated poorly (i.e. debris jam). A rating that is greater than 19 indicates that the stream may be experiencing significant system-wide instability.

2.5.2 Stream Asset Inventory

The Stream Asset Inventory (SAI) methodology provided rapid and scientifically defensible indicators of water quality, stream stability, and habitat conditions at a given location that is selected to be representative of a larger stream reach. Assessment criteria of the SAI include erosion indicators; bed and bank composition; aquatic habitat features; tree canopy and understory coverage and composition; and indirect water quality indicators (visible or detectable degradation and presence/absence of aquatic life). The assessment criteria are assigned individual weighted scores to create a composite score of stream quality at each sampled location and a relative ranking of stream quality throughout the entire watershed.

Sample locations were selected in the field based on preliminary map assessments, the assessor's professional judgment, as well as accessibility and ability to observe as many assessment criteria as practical. Data was collected at least 100 feet from major human-made influences if possible (such as roads, bridges and culverts), as past experience indicates that these localized features negatively bias the assessment results. Some stream reaches smaller than 4th order streams were not sampled due to insufficient reach length necessary for sampling. Finally, the SAI procedure is not intended for ephemeral streams or man-made channels. In other locations not all components were observable but data were collected if the locations otherwise met assessment criteria. PBA staff completed a survey checklist at 120 locations, or approximately every 3/8th stream mile, which exceeded the recommended data density of at least one survey point every stream mile.

The SAI procedure has four major categories with each category composed of five scoring components. Each component has a maximum potential score of 10 which creates a possible total SAI score of 200. By dividing the total SAI score by 20 (or by the number of measured components), the assessment provides a qualitative numerical score ranging from 0.0 to 10.0. A score of 10.0 would be considered optimal stream conditions while a score of 0.0 would indicate poor stream conditions. Some components were not applicable or observable in certain situations, and if so, the evaluation team did not assess that component. The final sampling point Total Score was calculated by dividing the sum of all four SAI categories by the number of components observed at that sampling location. For example, where bed composition could not be observed due to high flows or turbid conditions, no points are assigned for the bed composition component and the total site score was divided by 19 rather than 20.

As explained in the methodology description, stream reaches were assigned a composite score from 10.0 to 0.0 and were classified Type 1 (highest quality - 10.0) through Type 5 (lowest quality - 0.0) based on the statistical distribution of all study data. For example, a Type 3 stream score falls one standard deviation above or below the mean score, a Type 2 stream scores more than one standard deviation above the mean, etc. Stream segments were classified into five types:

> Type 1 - Highest Quality: Generally described as the highest quality naturally occurring stream with little negative impact. Erosion and sedimentation is low, water quality indicators are positive and the surrounding riparian zone is healthy, mature woodland or other high-quality environment. Approximately 1% of evaluated streams were placed in this category.
>
> Type 2 - High Quality: This type of stream may have some down or side-cutting; however, bank and bed composition (bedrock) assist in keeping the impact low. Water quality is generally good and the riparian zone is largely intact, although vegetation may be negatively altered from that of a typical native plant association. Approximately 12% of evaluated streams were placed in this category.
>
> Type 3 – Restorable: Deterioration of the channel and riparian corridor are more noticeable. While some remnant plant associations may be present, overall vegetative canopy cover is comprised of immature tree species. Water quality may be fair to marginal. The potential for restoration exists although erosion and sedimentation can be greater than desirable. Approximately 63% of evaluated streams were placed in this category.
>
> Type 4 - Low Quality: Impacts are greater on this stream type with significant indicators of bank erosion and channel instability. The adjoining riparian corridor may be intact but vegetation is not representative of a native plant association. Water quality is typically poor. Approximately 23% of evaluated streams were placed in this category.
>
> Type 5 - Lowest Quality: The channel in this type is the most changed. The riparian corridor is impaired to the point of providing little protection or benefit, and erosion and sedimentation indicators are significantly high. Water quality is poor with degradation and absence of macro-invertebrates, fish, mollusks, and amphibians. Approximately 1% of evaluated streams were placed in this category.

The surveyed stream segments were classified relative to the sample population of surveyed streams, rather than applying an absolute score. The relative ranking is used for several reasons: (1) Scoring streams on an absolute scale may imply that the break points between classes are based on some quantitative linkage between the score and stream function, which is not the case; (2) Streams should be classified in comparison to general, regional conditions so that streams are assigned scores reasonable for their physiographic and development settings; and (3) Relative distribution allows the assessor to identify the truly high-quality and low-quality streams within the study area.

2.5.3 Geomorphic Stream Survey - Impairment of Streams

A majority of the stream network is incised, as documented in the 2002 watershed study and as shown in Figure 18. Channel incision is a response to changes in the hydrology of the contributing drainage area as well as channel bed materials and downstream conditions. The stream network within the City limits has varying levels of stability and incision. The downstream ends of the main tributaries to Spencer Creek have already experienced changes in structure and are now very incised. In these streams, further incision is likely to occur as a small low flow channel cutting into the hard clay bed was documented in the field. Reaches higher up in the watershed have very steep profiles and debris jams of roots or other material were often found to provide temporary vertical grade control.

FIGURE 18. INCISED REACH, EAST SPENCER TRIBUTARY NEAR CONFLUENCE WITH SPENCER CREEK

The field assessment highlighted soils in the lower part of both watersheds as a predominant concern. These soils significantly contribute to the sediment load in Spencer and Dardenne Creeks. The sandy clay soil composition found in several of these reaches has little resistance to shear stresses of flow. This type of soil is stable at a very mild slope and therefore will continue to degrade more rapidly in these areas. Many of the channels are incised and the banks with sandy or loamy clay material that will continue to degrade at a more rapid pace than hard clay or rocky banks. Rock check structures are highlighted in Section 3 as a recommendation for many of these incising streams in order to control the rate of degradation and soil loss.

PBA analyzed the SAI data to identify obvious trends. The quality riparian vegetation and water quality indicators appear to have the greatest correlation with overall stream quality (R= 0.60). When PBA narrowed the analysis to sample locations where all 20 components were scored (i.e. where all of the conditions were present and could be observed), the terrestrial habitat and water quality components correlated more strongly with the overall stream condition (R = 0.67). The presence or absence of quality riparian vegetation appears to have the greatest influence on overall stream quality, and water quality appears to be better in streams that are in better overall condition. Field observations and SAI scores support the theory that urbanization and degradation or loss of stream buffers negatively impact the overall stability and quality of streams throughout St. Peters. This is consistent with regional and national research indicating that an intact riparian buffer can reduce the impacts of impervious cover and intense runoff conditions in urban watersheds (Center for Watershed Protection 2003; PBA 2005a and 2005b; PBA 2007; Schulte, Scott A., Patricia A. Elbert Noll and Jeffrey Henson, 2008). These findings further support the importance of riparian buffers for protecting stream quality.

A stream classification summary is provided in Appendix D.

Immediate Concerns

Several localized issues were identified during the field assessment as immediate need or concern areas. These locations are typically pipe crossings or outfalls that are immediately threatening existing infrastructure. A database of immediate concern locations was presented to the City.

3.0 Management Measures

The existing conditions of stormwater management in the City demonstrated concerns related to flooding, stormwater detention, stream stability, water quality, and existing policies. This section introduces management measures that were considered to address these stormwater concerns. The following chapter describes how these measures were evaluated. Typical renderings of management recommendations are provided in Appendix E.

Three sections of management measures were considered: stream management, stormwater best management practices throughout the watershed, and policy and ordinance updates. Each of these measures will play a part in achieving load reductions.

3.1 Stream Management Measures

Hydraulic modeling and field reconnaissance documented a variety of flooding and stability conditions, as presented in Section 2.

3.1.1 Flooding Management Measures

Flooding locations were identified during the assessment of existing conditions with the use of hydraulic models and the geodatabase of anecdotal concerns provided by the City. Most flooding locations were addressed with a conceptual recommendation as part of the CIP. Some bridge crossings with flooding or insufficient freeboard were excluded, such as crossings on private roads.

3.1.2 Stream Stability Measures

The stream network in St. Peters includes approximately 12 miles of stream that are highly degraded and unstable, rated with a CCSM score of 19 or more. System stability is based not only on the stability of the banks, but also the vertical stability of the channel bed.

Bank Stability

The areas of mass wasting, bank slumping, and bank scour are representative of the channel's response to the rapid development that occurred over the last 30 years in the City. To prevent further migration of the bank in critical areas, several stability measures were considered.

Over the past decade, the City has applied a variety of bioengineered techniques incorporating synthetic and vegetative materials – with varying levels of success. Based on field observation, one of the most critical elements of successful stabilization projects is to ensure that sufficient flow and sediment conveyance are provided.

FIGURE 19. TRM SYNTHETIC STABILIZATION METHOD FAILURE

Three levels of bank stabilization were evaluated with consideration to materials that have demonstrated successful application in past City projects. The basic level includes riprap toe protection and establishment of vegetation to protect banks. The second level builds upon the basic cross section to include the integration of a floodbench so that higher flows can spread out over a wider conveyance area. The final level applies to reaches where there is not sufficient area to establish a stable bank slope or flood bench and a wall structure is integrated into the stream bank. This last case only applies to a few locations throughout the City.

Vertical Stability of the Channel Bed

The recommended management measure for vertical grade control is the establishment of rock check dams using riprap. A durable riprap should be used; in the field, evidence of riprap deterioration was prevalent. Grade control structures are installed perpendicular to flow. They are designed with respect to the channel bed and bedload materials and their height and spacing depends upon achieving an equilibrium slope, preventing channel incision from migrating upstream. The riprap size is designed to resist velocities and shear stresses during a typical design event (i.e. 100-yr). Scour analyses is also necessary to understand localized channel hydraulics and critical shear stress values. The depth of excavation and placement of riprap below the channel bed is dependent on these calculations of scour. Hydraulic analysis is also used to evaluate the location of shear stress on the banks. To establish vegetation, riprap voids may be filled with a granular soil mixture, sometimes using on-site excavated materials. Root cuttings such as willows have shown successful establishment in restoration projects in the City as well, as shown in Figure 20. Table 9 provides a summary of project locations where rock check stabilization is recommended. The geodatabase provides more detailed information at each of these project sites.

TABLE 9. CIP PROJECTS WITH ROCK CHECKS

Project_ID	Location Description	Estimated Rock Check width	Channel Bed Improvement (No. of Rock Checks)
IP-6965-2-1	Wolfrum Way	Category 2: Rock Check (10-15 feet across)	3
IP-6965-2-2	Deer Meadow Ct.	Category 2: Rock Check (10-15 feet across)	7
IP-6968-1-1	NW Ohmes Farm	Category 2: Rock Check (10-15 feet across)	6
IP-6969-2-2	Hope Drive	Category 2: Rock Check (10-15 feet across)	2
IP-6970-1-1	Calwood	Category 2: Rock Check (10-15 feet across)	5
IP-6970-4-2	Dardenne Creek between Mexico Road and I-70	Category 4: Rock Check (>20 feet across)	4
IP-7065-1-3	Highlands	Category 2: Rock Check (10-15 feet across)	4

Project_ID	Location Description	Estimated Rock Check width	Channel Bed Improvement (No. of Rock Checks)
IP-7067-1-1	Baltic Creek, downstream of Central School Road	Category 3: Rock Check (15-20 feet across)	4
IP-7067-2-3	Old Hickory GC	Category 3: Rock Check (15-20 feet across)	2
IP-7068-2-1	Bruns Place	Category 2: Rock Check (10-15 feet across)	7
IP-7068-4-1	Dardenne Creek at Fairfax	Category 4: Rock Check (>20 feet across)	1
IP-7069-1-1	Crystal Lake Detention	Category 2: Rock Check (10-15 feet across)	2
IP-7069-1-2	Crystal Lake	Category 1: Rock Check (5-10 feet across)	2
IP-7069-2-3	Parkdale	Category 1: Rock Check (5-10 feet across)	4
IP-7069-3-2	Woodlands GRG	Category 2: Rock Check (10-15 feet across)	4
IP-7071-3-1	Dardenne Creek, downstream of I-70	Category 4: Rock Check (>20 feet across)	10
IP-7166-1-1	Old Farmhouse Rd.	Category 2: Rock Check (10-15 feet across)	2
IP-7168-1-1	Athens Drive	Category 1: Rock Check (5-10 feet across)	3
IP-7169-1-2	Dubray Middle School	Category 1: Rock Check (5-10 feet across)	10
IP-7169-2-1	Carrington Place	Category 3: Rock Check (15-20 feet across)	22
IP-7170-2-1	Eldorado	Category 2: Rock Check (10-15 feet across)	5
IP-7267-4-3	Park Ridge Estates	Category 2: Rock Check (10-15 feet across)	1

Project_ID	Location Description	Estimated Rock Check width	Channel Bed Improvement (No. of Rock Checks)
IP-7268-2-2	Wood Path	Category 2: Rock Check (10-15 feet across)	8
IP-7269-1-1	Colby Drive	Category 1: Rock Check (5-10 feet across)	21
IP-7269-4-1	Oak Creek Park	Category 2: Rock Check (10-15 feet across)	12
IP-7270-1-1	St. Peters Executive Centre	Category 2: Rock Check (10-15 feet across)	10
IP-7270-1-2	Executive Centre	Category 4: Rock Check (>20 feet across)	1
IP-7270-3-2	Carrington Estates	Category 2: Rock Check (10-15 feet across)	4
IP-7270-4-1	City Centre	Category 3: Rock Check (15-20 feet across)	4
IP-7368-1-4	Tanglewood	Category 2: Rock Check (10-15 feet across)	2
IP-7368-2-1	Burning Leaf Drive	Category 1: Rock Check (5-10 feet across)	1
IP-7368-2-3	Kelly Leaf	Category 2: Rock Check (10-15 feet across)	6
IP-7368-3-1	Jungermann Office Center	Category 2: Rock Check (10-15 feet across)	6
IP-7368-3-2	Hidden Pine Estates	Category 2: Rock Check (10-15 feet across)	8
IP-7368-4-3	Spencer Creek in Millwood Subdivision	Category 2: Rock Check (10-15 feet across)	7
IP-7369-1-1	Spencer Creek between Sutters Mill Road and Boone Hills Drive	Category 2: Rock Check (10-15 feet across)	4

Project_ID	Location Description	Estimated Rock Check width	Channel Bed Improvement (No. of Rock Checks)
IP-7369-2-1	Boone Hills Drive and Jungermann Road	Category 2: Rock Check (10-15 feet across)	3
IP-7369-3-2	Spencer Trail	Category 4: Rock Check (>20 feet across)	2
IP-7369-4-1	West Drive	Category 2: Rock Check (10-15 feet across)	6
IP-7370-4-1	East Spencer Creek downstream of Jungermann Road	Category 1: Rock Check (5-10 feet across)	5
IP-7467-4-1	Magnolia Manor	Category 2: Rock Check (10-15 feet across)	5
IP-7467-4-3	Pointe of Heritage	Category 3: Rock Check (15-20 feet across)	6

FIGURE 20. STABLE STREAM EXAMPLE WITH WILLOW CUTTING ESTABLISHMENT

3.1.3 Riparian Renovation

The primary goal of riparian preservation is to protect the function and aesthetics of streams through proper management of the riparian corridor vegetation. Preservation begins with floodplain management or stream setback policies (or both) that help limit encroachment of structures in the riparian corridor, and regulations and education to discourage inappropriate uses and activities that degrade natural function. However, preservation does not end there; there are three key components to consider with riparian preservation: management, vegetation type, and corridor width.

First, preservation does not mean taking a hands-off approach. Vegetative management must occur if the riparian corridor is to function properly. Second, management practices generally focus on reducing or eliminating non-native vegetation in an effort to support the growth of more desirable native varieties. Even some aggressive native plant species like bittersweet and trumpet vine can be undesirable within a riparian corridor. This may include replanting native species where non-native or aggressive vegetation is removed to prevent it from re-establishing, and planting natives where existing vegetation is thin (particularly along streambanks where the vegetation helps prevent erosion). Third, the width of the riparian zone is equally important in preserving function. A narrow riparian corridor is far less effective in buffering streams from adjoining land uses than a wider corridor. Buffer widths vary with stream type (ephemeral, intermittent, or perennial) but, the general rule of thumb is to place wider buffers on smaller headwater streams that are often most neglected and impacted, and where benefits are often the greatest due to the preponderance of smaller streams in a watershed. Wider buffers are also desirable where high-quality riparian corridors exist to protect the integrity of these resources; and where stream restoration is a high priority.

A list of tree and shrub species, provided in Appendix F, includes varieties that are present in healthy, regional stream corridors. These species should be used for preservation and restoration efforts.

"Reference sites" are healthy stream corridors that provide helpful guides for riparian preservation and restoration. There are a few sites in the Spencer Creek and Dardenne Creek watersheds that would be considered reference sites for proper vegetation and buffer width. Most of these reference sites are located within parkland already owned and managed by the City. These sites include:

- Spencer Creek from Jungermann Road to Millwood Drive.
- Spencer Creek upstream of extended wet detention facility east of McClay Valley Boulevard.
- Tributary to Dardenne Creek in the southern portion of Old Hickory Golf Course located within the wooded area surrounding the golf course maintenance facility (western tributary)

Figures 21 and 22 illustrate a healthy riparian corridor, and a stream corridor with undesirable vegetation for comparison.

Desirable riparian corridor: this photo is of an area east of Jungermann Road and illustrates a good mix of canopy and understory species with very little undesirables; trees are a mix of ages, and the canopy is open enough to allow for good understory vegetation.

FIGURE 21. DESIRABLE RIPARIAN CORRIDOR CONDITIONS

Undesirable riparian corridor: this photo shows undesirable vegetation (honeysuckle) dominating one side of corridor; and a thin, almost non-existent corridor on the other side.

FIGURE 22. UNDESIRABLE RIPARIAN CORRIDOR CONDITIONS

3.2 Watershed Improvements

The management of stormwater as it flows across the landscape is the second critical section of management measures. This section presents the approach to developing detention basin retrofit options and general stormwater best management practices. Regional detention opportunities evaluated in this study are presented in Section 4.

3.2.1 Detention Basins

The detention basin improvements considered for this study considered the hydrologic as well as water quality needs of the watershed. The hydrologic needs were addressed largely by recommending improvements to the dam structure or outlet works, or by recommending increased storage behind the structure. Water quality improvements were addressed by recommending an alternative storage regime (dry detention to wet detention), improved plantings, or by the construction of a sediment forebay.

Three retrofit options were evaluated in this study. These options were based the most current best management practices for improving stormwater runoff quality.

Dry Detention Retrofit

A dry detention retrofit established a temporary pool that is sized to detain the water quality volume. Typically, this retrofit includes the establishment of native vegetation and amendment to the soil in the bottom of the basin to enhance infiltration.

Dry to Wet Detention Retrofit

Upon retrofit of a dry detention to a wet pond, a permanent pool that is equal to the volume of the water quality volume was established for each basin. Typically, a wetland bench of planting is recommended around the basin perimeter.

Wet Detention Retrofit

A wet basin retrofit includes establishment of a wetland buffer planting around the perimeter of the basin.

Additionally, sediment forebays were suggested for some detention basins based upon watershed characteristics or anecdotal information that sediment is an issue for that basin. In general, it is suggested that the City reference the Mid-America Regional Council (MARC) guidance on the construction and features of a sediment forebay. Key features of a sediment forebay include:

- Maintenance Schedule: Sediment forebays must be maintained on a frequent basis. Sediment must be removed periodically and hauled off-site. If a forebay is not periodically maintained, it will become choked with sediment, cease to function, and actually become a detriment to downstream facilities.
- Proper sizing: according to the maintenance schedule determined for the forebay, the facility must be properly sized to accept sediment between maintenance events.
- Access: Proper access must be afforded to maintenance crews to allow for upkeep of the facility. Typically, a backhoe can be expected to handle the excavation of accumulated sediment.
- Plantings: Plantings within the sediment forebay are welcomed. During maintenance events, the plantings can simply be scraped off the top of the sediment, placed to the side, and then replaced in the sediment forebay after excavation is completed.

3.2.2 Stormwater Best Management Practices

A water quality best management practices (BMP) locator assessment was used to identify optimal locations for BMPs within the City. The objective was to assess and classify the relative value of land for capturing, storing, and infiltrating stormwater runoff; and to identify vacant land that could be used to construct new water quality BMPs if desired to meet the City's stormwater management objectives.

3.3 Ordinance and Policy Improvements

This section briefly summarizes existing policies, ordinances, and design criteria and identifies regulations and other factors that may influence future policies. Following the review of the existing situation recommendations for updating and adopting polices to meet regulations and achieve the goals for storm water management in St. Peters are presented.

3.3.1 Existing Ordinances and Regulations

The City's current existing ordinances and regulations provide for management of storm water. State and federal regulations also impact storm water management.

Current City Storm water Management Regulations

Existing ordinances and standards that address storm water and flood risk management in the City are briefly summarized below.

- Chapter 410 – Floodplain Management. Criteria in this section are consistent with FEMA requirements and limit development in the 100-year floodplain.
- Chapter 530 – Grading Regulations. These regulations require a permit when development will grade more than 300 cubic yards, or 20,000 square feet and are in general consistent with MDNR requirements.
- Chapter 550 – Storm Sewer and Drainage Facility Guidelines. A storm water management plan is required for every development under these guidelines sized for the 15-year, 20 minute design storm. These guidelines also require detention if runoff is increased by 15 % or more as a result of development. A 25 foot setback from streams is also required.
- Standards for Erosion and Sediment Management Practices, January 2001. This document provides design criteria for many erosion and sediment control best management practices. Many additional effective best management practices have been developed since 1991.

- Chapter 550 references "Standard Construction Specifications for Sewers and Drainage Facilities of the Metropolitan St. Louis Sewer District," 1992 and Chapter 4 "The Metropolitan St. Louis Sewer District – Rules and Regulations and Engineering Design Requirements for Sanitary Sewage and Storm Water Drainage Facilities", February 1997. Both of these documents have been updated.

State Stormwater Management Regulations

Construction Site Runoff Controls

The MDNR storm water regulations for Construction or Land Disturbance Activity MO-R101000 and MO-R100000 for existing sites and M0-R10A000 for new sites address construction site runoff controls. These permits are valid through February 7, 2012. The City's existing ordinance and design standards appear to address these requirements. However, newer design criteria are available that expand the number of BMPs that can be used to limit sediment from being discharged. These new design criteria are available in the following document: Protecting Water Quality: A field guide to erosion, sediment and storm water best management practices for development sites in Missouri and Kansas, January 2011.

Stormwater Discharge Permit

The MDNR storm water regulations for discharge from the Municipal Separate Storm Sewer System MO-R040044 (MS4 Permit) require that the storm water management program address the six minimum control measures. This permit is in effect until June 12, 2013.

Control measure 5 requires implementation of post construction storm water management in new development and redevelopment. From the permit, "prevent or minimize water quality impacts by reasonably mimicking pre-construction runoff conditions on all affected new development projects and by effectively utilizing water quality strategies and technologies on all affected redevelopment projects to the maximum extent practicable". The City's existing design criteria require predevelopment peak flows to be managed for 2-year and 25-year design storms. The largest impact on water quality resulting from runoff is from more frequent events.

Federal Stormwater Management Regulations

EPA expects to publish new storm water regulations by the end of 2012 as result of the Natural Resources Commission study and report on the effectiveness of the current storm water regulations. Key findings and recommendations from that report are listed below.

Key findings of NRC report

- Current approach is unlikely to produce an accurate picture of the problem and unlikely to adequately control storm water's contribution to water body impairment
- Current requirements leave a great deal of discretion to dischargers to set their own standards and ensure compliance, which results in inconsistency across the nation
- Poor accountability and uncertain effectiveness in current approach to stormwater management

Key Recommendations

- A straightforward way to regulate storm water contributions to water body impairment would be to use flow or a surrogate like impervious cover as a measure of storm water loading
- Efforts to reduce storm water flow will automatically achieve reductions in pollutant loading. Moreover, flow is itself responsible for additional erosion and sedimentation that adversely impacts surface water quality
- Stormwater control measures that harvest, infiltrate and evapo-transpire storm water are critical to reducing the volume and pollutant loading of small storms

3.3.2 Recommended Best Management Practices

The current MS4 NPDES permit will expire in June 2013. Compliance with minimum control 5 – post construction runoff controls is the biggest issue. The City's current storm water regulations partially address this by requiring post construction runoff rates to match predevelopment runoff rates for the 2-year and 25-year design storms. While this minimizes changes in peak flows, it does not specifically address minimizing impacts to water quality. Therefore, it is recommended that the City adopt criteria to capture and treat runoff from common rainfall events to ensure compliance with the permit.

Communities in Missouri, including Kansas City and St. Louis MSD, have adopted criteria that capture and treat runoff from the Water Quality storm. The Water Quality storm is a storm in which the rainfall depth is equal to or less than the rainfall depth from 90 to 95% of the storms in a given year. St. Louis has adopted criteria that use the 90% value or 1.14 inches of rainfall and it is recommended that St. Peters adopt these criteria as well. Similar to the existing criteria, it is recommended that this apply when the volume of runoff from a site will increase by 15 percent or more as a result of a 2-year 24 hour storm event.

The volume that is captured and treated is defined as the Water Quality Volume, WQ_v, where:

$$WQ_v = [(P)(R_v)(A)]/12$$

Where:

WQ_v = Water Quality Volume (acre-feet)

P = Rainfall depth in inches equal to the 90% runoff event (inches)

R_v = Volumetric runoff coefficient (dimensionless)

A = Area (acres)

$R_v = 0.05 + 0.009(I)$, I is the percent (whole number) impervious cover

Best management practices (BMP) are then designed to capture and treat this volume of runoff. BMP manuals tailored to a specific community and developed from scratch are typically expensive to develop. Much reference material has been developed within Missouri, the Midwest and across the country, so it is not recommended that the City develop its own BMP manual. Rather, it is recommended that appropriate sections of existing manuals and reference materials be adopted.

Existing BMP references used in Missouri include:

- Manual of Best Management Practices for Stormwater Quality, Mid America Regional Council, March 2008, used in the Kansas City area (MARC manual).
- Erosion Prevention and Sediment Control Guidelines, City of Springfield Department of Public Works Storm Water Services Division, October 2008.
- Joplin, Missouri Stormwater Management Criteria, Allgeier, Martin and Associates, Inc., April 2009.
- Maryland Stormwater Design Manual, Volumes I & II, Center for Watershed Protection and the State of Maryland Department of the Environment, October 2000 effective date July 1, 2001, used by St. Louis MSD (Maryland manual).

It is recommended that the focus be placed on using extended dry or wet detention to capture and treat the water quality volume storm. This will minimize impacts to the local development community because detention is already required by existing criteria. The basins should be configured to provide 40 hours of detention for the water quality volume storm. Extended dry detention typically provides 60 to 80 percent removal of sediments while extended wet detention typically removes 90 percent of the sediments. Both the MARC and Maryland manuals provide criteria for design of extended detention basins.

In addition to upgraded detention, the City should require hydrodynamic separators, filtration practices or proprietary BMP devices for "hot spots". Hot spots are land uses that contribute higher concentrations of metals, hydrocarbons and other pollutants and include the following (from the MARC manual):

- Fuel dispensing facilities
- Aboveground storage of liquid materials
- Exterior storage of bulk materials
- Material transfer areas and loading docks
- Equipment and vehicle washing facilities
- Covered vehicle parking areas
- High-use vehicle and equipment traffic areas, parking and vehicle storage
- Dog kennels, doggie day care, and veterinary clinics

Both the MARC and Maryland manuals provide design guidance BMPs for these areas. In addition, St. Louis MSD has developed specific information on hydrodynamic separators and proprietary devices for hot spots that can be found at the following websites:

- http://www.stlmsd.com/engineering/planreview/PlanReviewInformation/ProprietaryBMPs
- http://www.stlmsd.com/portal/page/portal/engineering/planreview/PlanReviewInformation/ProprietaryBMPs/MSDProprietaryBMPProgramGuidance-080213rev090105.pdf

3.3.3 Low Impact Development Recommendations

Creating an ordinance or other regulatory mechanism to require low impact development is not recommended because little developable property is left. Therefore, it is recommended that low impact development (LID) be encouraged but not required in new development or redevelopment projects. The purpose of encouraging LID is to minimize the runoff that occurs from development which reduces the detention and capture and treatment requirements discussed above. Principles of low impact development include the following:

- Plan first
- Prevent, then mitigate
- Minimize the disturbance
- Manage stormwater as a resource – not a waste
- Mimic the natural water cycle
- Disconnect, decentralize, distribute
- Integrate natural systems
- Maximize multiple benefits
- Make maintenance a priority

Planning for stormwater management from the earliest stages of the development process helps to ensure that natural resources are protected and the impacts of the site are minimized. Minimizing the amount of runoff generated from the site is the most effective way to manage stormwater. This is accomplished by **minimizing the disturbance** of existing vegetation and soils as well as minimizing the impervious area of the site. BMPs should be designed to capture and treat the runoff that does occur.

Designing sites to take advantage of stormwater runoff instead of getting rid of it can create community amenities, reduce irrigation needs and costs through rainwater harvesting for building and site uses, and protect natural resources. Designing ways to capture and store runoff supports all of these benefits. Planning a development around streams, ponds, wetlands, and rain gardens often attracts residents and adds value to lots near them.

Mimic the natural water cycle. Designing the site to control peak flows as well the volume of runoff and infiltration of precipitation minimizes the impacts on water quality and stream health. This results in management of the full range of precipitation from frequent rainfalls to the infrequent flood events.

Disconnect, decentralize, distribute. Capturing rainfall where it falls is a very effective stormwater management technique. This is accomplished by disconnecting impervious areas from the drainage system, installing BMPs at individual lots and neighborhoods, and spreading them throughout the development.

Integrate natural systems. Protecting and taking advantage of native soils, vegetation, and natural resources minimizes the impacts of a development and can increase its value. Natural resources are effective stormwater management systems that provide water quality benefits and reduce flood peaks.

Maximize multiple benefits. Designing the site to preserve natural resources and incorporate BMPs using native vegetation can add to the social and economic value of a development and community as well as provide water quality benefits including:

- creating open space for recreation and amenity value,
- increasing property values, and
- decreasing construction and maintenance costs.

Make maintenance a priority. BMPs often require different types of maintenance than typical crews are used to performing. Designing BMPs with maintenance requirements in mind reduces their impacts. They may often require more frequent maintenance than inlet and pipe systems. Placing priority on training crews to properly care for BMPs and planning for and committing to scheduled maintenance programs is important for their long-term function.

It is suggested that implementation of LID can be encouraged through reductions in any fees collected for storm water management in the future.

3.3.4 Policy Recommendations Impact on Development Code

Section 405 of the City's Code of Ordinances is known as the "The City of St. Peters, Missouri, Zoning and Subdivision Codes" (Section 405). Section 405 has been reviewed to identify potential conflicts between these policy recommendations and the existing code.

Low Impact Development

Many of the concepts promoted in LID involve minimizing impervious areas. Areas of conflict identified in Section 405 include the following:

- Minimum residential lot size of 10,000 square feet
- Overall density of a development should be 12,000 square feet per lot
- Impervious area can not cover more than 50% of the area of a lot
- Minimum home size of 1800 square feet for a one story house

Communities have adopted or allowed reduced requirements for these criteria in concepts such as cluster development where homes and businesses are concentrated in a portion of the overall development. The overall imperviousness of the development can be maintained or reduced and open space or natural resource areas increased.

PHOTO: CLUSTER DEVELOPMENT, METROPOLITAN DESIGN CENTER

A Planned Unit Development (PUD) can be developed to allow these concepts under Section 405. The PUD allows an increase in density of development of up to 30%. Also, PUD's commonly also allow other criteria to be modified as part of the agreement between the developer and the City. This existing mechanism can be promoted to encourage developers to employ LID principles.

Longer-term, adoption of Conservation Development code language is recommended. This code would specify the terms and conditions of the use of LID and reduce costs and staff-time in reviews compared to achieving LID through the PUD. The city of Kansas City, Missouri recently adopted conservation development and the code language can be accessed at the following website.

http://library.municode.com/index.aspx?clientID=10156&stateID=25&statename=Missouri

Once at this website, the Conservation Development code is Section 80-209 within Chapter 80.

Reduced Parking Space Requirements

Many communities have considered reducing parking space requirements to minimize impervious areas and impacts to stormwater runoff. Another method for reducing these impacts is to promote use of permeable pavement in low volume traffic areas. This is especially viable in large mall areas where the majority of the parking is used seasonally.

Reduced Pavement Widths

Communities have also used narrower pavement widths in the proper setting such as residential streets. Emergency vehicle access needs must be considered. If the City considers this as a means to reduce runoff, the emergency response groups should be involved in the development of the criteria.

3.3.5 Stream Setback Recommendations

The City's current stream setback requirement provides basic separation of development from the streams. Much of the City is already developed therefore; an extensive stream setback ordinance is not recommended. However, several enhancements are recommended to reduce the potential for new development in flood-prone areas, development of areas susceptible to erosion along the streams, and to preserve and restore the natural setting of the City's streams.

1. Prevent construction of habitable buildings resulting from new development or redevelopment in the 100-year floodplain. Updated mapping has been developed that shows the limits of the 100-year floodplain. For stream reaches that do not have a defined floodplain, require that the floodplain be delineated as part of the development or redevelopment plan. Keep the 25 foot setback preventing all development from occurring in the 25 foot setback zone, and allow storage sheds and other small structures in the area outside of the 25 foot setback.
2. Prevent new development or redevelopment adjacent to areas of significant stream instability until the stream segment is stabilized.
3. Develop an education program for neighborhoods that provides information on stream stability and how the residents' actions impact the streams. An example brochure is provided in Appendix I. Meetings with neighborhoods should be scheduled to provide an overview of the City's stream protection/enhancement program and identify ways they can help protect/enhance the streams.
4. A figure presenting stream segments identified for protection and target recommendations for no new development is presented in Appendix J. This should be included in the City's Comprehensive Plan to bolster their legitimacy and effectiveness.
5. Encourage use of native and riparian species in the 25 foot setback zone and discourage turf grasses and mowing.
6. Establish setbacks as wide as practicable when completing improvement projects or easements along the streams. The goal of this program will be to achieve the performance as outlined in item 1, but will need to be determined on a project-by-project basis.

3.3.6 FEMA Community Rating System Recommendations

The Community Rating System (CRS) is a program within the National Flood Insurance Program (NFIP). The stated objective of the CRS is to "reward communities that are doing more than meeting the minimum NFIP requirements to help their citizens prevent or reduce flood losses".

The CRS offers discounts of up to 45-percent on flood insurance premiums for property owners in participating communities. Other benefits to citizens and the City of performing CRS creditable activities include:

- Enhanced public safety
- Reduction in damage to property and public infrastructure
- Avoidance of economic disruption and losses
- Reduction of human suffering
- Protection of the environment

- The ability to evaluate the effectiveness of its flood program against a nationally recognized benchmark
- Technical assistance in designing and implementing some activities is available at no charge
- Implementing some CRS activities, such as floodplain management planning, can help a community qualify for certain federal assistance programs

It is recommended that the City contact the local FEMA office to discuss participation in this program. FEMA staff can assist with an evaluation of on-going activities to determine if reduced insurance premiums are likely and will identify the types of information required by FEMA for participation.

3.3.7 Street Sweeping Recommendations

Recent research has shown that street sweeping is most effective when it occurs every two weeks. While that may not be practical for St. Peters, targeting the roadways that are nearest the streams and detention basins is recommended. This should be completed monthly.

Research has also shown that street sweeping following thawing of significant snow events can be effective at removing the sand and salt and other debris buildup from these events. If budgets allow, this practice is recommended and at a minimum the streets should be cleaned early in the Spring.

3.3.8 Sediment and Erosion Control Recommendations

The silt load in the City's streams has been identified as an on-going problem. One of the identified sources of the silt load is silt-laden runoff from construction sites. The existing ordinance provides the regulatory mechanism to address this issue for larger sites. Enforcement and education are recommended to minimize the impacts of construction. Enforcement requires adequate staff resources to inspect each site frequently enough to identify issues and require remedies before multiple storm events occur. Two existing staff are dedicated to conducting Inspecting erosion and sediment control facilities weekly and after rain events. In addition, four engineers can fill in if needed. Another concern is the amount of sediment eroded from individual building lots. The current regulations exempt most residential home construction. Many examples exist where the exemption limits are much lower than St. Peters. One good example is in St. Louis County where the limits for exemption are a volume of 30 cubic yards or surface area of 2000 square feet. Lowering your limits to these values would significantly increase the number of home construction sites that are required to include sediment and erosion control. Building permits range from 30 to 100 annually. The City of Lincoln, Nebraska has recently implemented a program that addresses this issue. It can be found at the following website:

http://www.lincoln.ne.gov/city/pworks/watrshed/require/erosion/ilnoi.htm

It requires an individual lot notice of intent to comply with the City's requirements as well as a storm water pollution prevention plan to be submitted with the building permit.

The design standards used in St. Peters were adopted in the early 2000's. A new design guideline has been published by MDNR titled: **Protecting Water Quality: A field guide to erosion, sediment and storm water best management practices for development sites in Missouri and Kansas, January 2011.** It provides design standards for many newer BMPs for sediment and erosion control as well as updates to many included in the existing design standards which incorporate lessons learned over the last decade. It is recommended that this document be adopted as a supplement to the existing design standard. MDNR completed a series of training sessions on this document. The City should send selected staff if additional training is scheduled. Further, developers and homeowners operating in St. Peters should be encouraged to attend.

The existing City code prohibits dumping of lawn waste into stream corridors in section 215.010.J.5. Dumping of other types of refuse is prohibited by 215.010.F. Abatement measures are also addressed in section 215.030. Therefore, additional ordinance language or policies are not required. However, current staff resources are not adequate to identify the sources of illegal dumping and enforce the existing ordinances. A public education program to inform residents of the existing rules, impacts of illegal dumping, and reporting mechanisms is recommended to reduce the amount and frequency of illegal dumping.

3.3.9 Homeowner Drainage Issues Recommendations

During field investigations, it was noted that downspouts and pool drainage pipes extended beyond the stream banks. These cause erosion and are vulnerable to being swept away during large runoff events. Development of a program to educate homeowners of alternatives to this is recommended. Alternatives for downspouts include discharge to a rain garden, swale with bed protection as needed, or burying the discharge pipe in the bank of the stream and directing its discharge to a pool or riffle in the stream. The MARC Manual includes rain garden design guidelines and many other on-line resources are available.

For pool drainage, use of temporary pipes to direct the flow into a pool riffle area of the stream is recommended.

Education and Awareness

A comprehensive education and awareness program is recommended to involve the community in the new approaches to storm water management. This should include not only the residents as noted above, but also developers, builders, and the designers that work in the City.

Homeowner Training

- Use of the City's compost program for grass clippings
- Importance of maintaining a buffer in your backyard
- Connection of downspouts to rain gardens or proper locations in the streams
- Native plant identification

Developer Training

- Participation program to inform them of the new policies and incorporate appropriate modifications
- Education on new extended detention basin and "hot spot" BMP design guidelines
- Education on erosion and sediment controls

Staff Training including other Departments that help manage Storm Water

- Checklist and training on proper installation and maintenance of erosion and sediment controls
- Vegetation identification for honeysuckle management
- BMP maintenance
- New policies

Water Quality Related Programming

- Clean Stream Teams to remove litter from streams
- Adopt-a-Wetland Teams

3.3.10 Summary of Recommendations

BMPs

- Require capture and treatment of the Water Quality Volume storm for new development and redevelopment when the volume of runoff from a site will increase by 15 percent or more.
- Focus on capturing and treating the runoff through extended dry or extended wet detention.

LID

- Require BMPs such as hydrodynamic separators or filters to treat runoff from "hot spots".
- Encourage LID and provide incentives for using LID in new development and redevelopment.

Stream Setbacks

- Prevent construction of habitable buildings in the 100-year floodplain.
- Keep the 25-foot setback preventing any development in this zone.
- Allow non-habitable structures outside of the 25 foot setback zone.

FEMA

- Investigate participation in the Community Rating System through the National Flood Insurance Program to reduce insurance rates for residents and businesses.

Street Sweeping

- Sweep streets near streams monthly beginning in early Spring.

Sediment and Erosion Control

- Reduce the threshold for requiring sediment and erosion control to movement of 30 cubic yards of material or disturbing 2000 square feet.
- Adopt the new guideline published by MDNR: Protecting Water Quality: A field guide to erosion, sediment, and storm water best management practices for development sites in Missouri and Kansas, January 2011.

Homeowner Drainage Issues

- Develop a program to educate homeowners about alternative downspout and pool discharge practices.

EDUCATION AND AWARENESS

- Develop a comprehensive education program that targets homeowners, developers, staff and water quality related programming.

4.0 Modeling of Recommendations

This section provides a summary of the modeling completed to apply the management measures discussed in Section 3 to solve the City's stormwater concerns.

4.1 Hydrology Model

4.1.1 Detention Basin Analysis

The HEC-HMS model received from the USACE was previously updated to include the screened detention basins. This updated HEC-HMS model was used to evaluate potential detention improvements throughout the watershed.

The need for hydrologic improvements to a detention basin was generally indicated by either downstream flooding or by overtopping of the dam structure. Hydrologic improvements to the detention basins were modeled and determined using HEC-HMS. This process involved determining the available potential on-site for increasing the flood pool of the facility. If additional area was not available for increased storage, the field observation materials were reviewed to determine the feasibility of improvements to the outlet works or embankment of the facility. Once a plan was developed for the detention basin, the stage-storage and storage-outflow tables within HEC-HMS were modified to reflect the proposed improvements.

Detention improvements were modeled by altering the basin's stage-storage and storage-discharge tables. These tables were also used to evaluate the extent of overtopping by expanding the table to capture the overtopping flow.

4.1.2 Regional Detention Analysis

Regional detention modeling was also performed to evaluate the potential of this watershed improvement measure. Regional detention opportunities to prevent large-scale flooding were evaluated, in contrast to the design of most detention basins in the City which address local peak flow management. Regional flooding was observed in several locations around the City. The regional detention locations considered were largely located in the Spencer Creek watershed. Figure 23 presents all regional detention locations considered in the City. Table 10 presents the list of locations that were investigated in HEC-HMS:

TABLE 10. REGIONAL DETENTION ANALYSIS

Location	Project Identifier	100-year Flow Goal	Reduction in 100-year Flow
Structure Flooding along Main Spencer Creek	IP-7368-4-3	1200 cfs	1073 cfs
Burning Leaf Drive	IP-7368-2-1	850 cfs	1423 cfs
Structure Flooding along Main Spencer Creek	IP 7369-3-1	3500 cfs	895 cfs

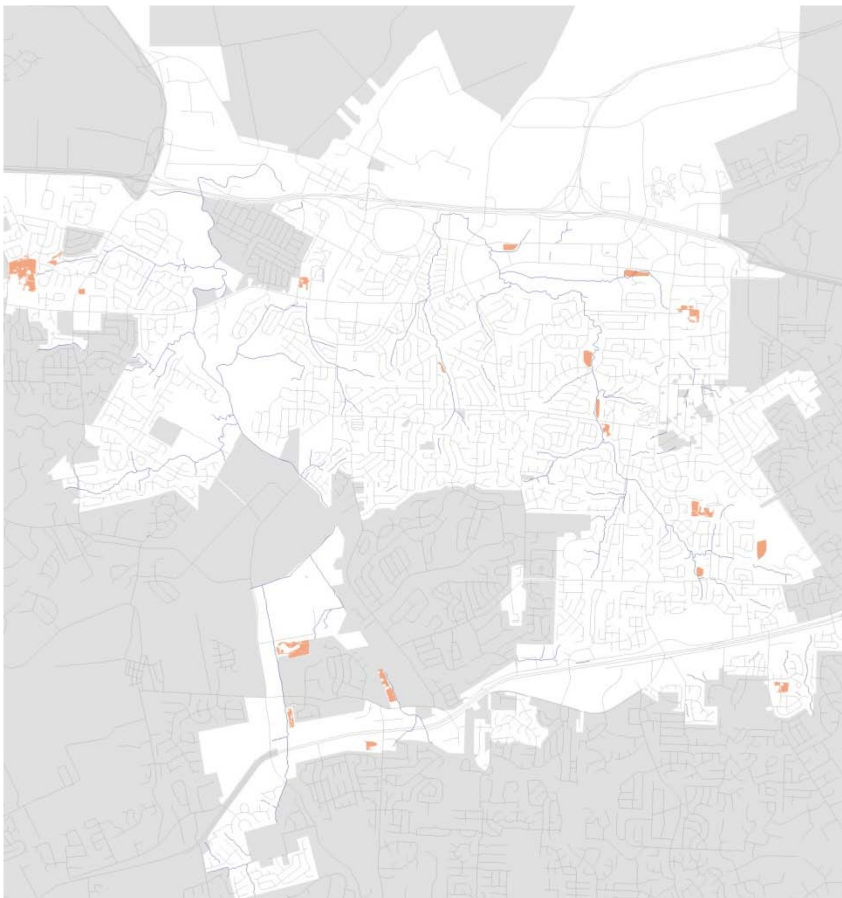


FIGURE 23. REGIONAL DETENTION OPPORTUNITIES

The first avenue when considering regional detention was to increase the detention provided by existing facilities. The first and best opportunity to impact the flows along Spencer Creek at an existing facility is the McClay Valley detention basin (DB-7468-06). However, even if the McClay Valley facility detained all flow draining to it during the 100-year event, only 593 cfs would be removed from Spencer Creek. This flow reduction does not come close to solving the regional flooding downstream. Even removing all flow exiting each of the existing detention basins contributing to Spencer Creek would not alleviate the regional flooding.

Regional flooding was observed within the Dardenne Creek watershed. Sufficient area within the City was not available to provide regional detention that would address this flooding. In order to detain flows along Dardenne Creek within the City limits, a large facility would be required. This is mainly due to the location of the City in the watershed; the City is located at the downstream end of a large drainage area. Additionally, regional detention along Dardenne tributaries was not deemed feasible for two reasons. Again, sufficient vacant area was not available within the Dardenne tributary watershed in the City's limits. In addition, even if sufficient space were available to detain the flows produced by Dardenne tributaries within the City, the reduction in flow provided by these facilities would not be sufficient to alleviate regional flooding in Dardenne Creek. Municipalities within the Dardenne Creek watershed can improve the flooding conditions by preventing fill and development in the floodplain. In the Crystal Lake subdivision, many structures are flood prone because they were built within the 100-year area of inundation.

4.2 Hydraulic Model

4.2.1 HEC-RAS Modeling

The analysis of existing conditions documented several flooding locations in neighborhood locations and at stream crossings. These locations are summarized in Section 2.3.

Level of Service

Each conceptual solution was designed to achieve a specific level of service. For overbank flooding, the objective was to remove as many buildings as possible from the 100-year floodplain. For bridge and culver crossings, conceptual crossings were input to the model to achieve sufficient freeboard. Bridge design guidance is provided in Section 4.040 of the St. Louis MSD 'Rules, Regulations, and Design Requirements'. This states that the "lowest point of bridge superstructure shall have 2-ft of freeboard from the 15-yr water surface elevation and 1-ft freeboard from the 100-yr water surface elevation."

Modeling the Concepts

The hydraulic model was used to develop conceptual recommendations at each of these locations. Additionally, opportunities for regional detention were explored based on a proposed peak 100-year flow. Table 11 summarizes the hydraulic modeling updates developed to address flooding at each project location.

TABLE 11. HEC-RAS MODELING OF PROJECTS TO ADDRESS FLOODING

Project ID	Location Description	Stream Improvement
IP-6970-1-2	Richmond	Enlarged XS 53654, lowered inverts on either side of Mexico, raised low steel on Mexico, widened downstream of Mexico
IP-6970-4-2	Dardenne Creek between Mexico Road and I-70	
IP-7069-1-2	Crystal Lake	
IP-6970-4-1	Calwood	
IP-7069-1-1	Crystal Lake Detention	
IP-7368-2-1	Burning Leaf Drive	Install 3 10x10 culverts with wingwalls, each is 32' long
IP-7369-1-1	Spencer Creek between Sutters Mill Road and Boone Hills Drive	Fill in sump area along Boone Hills Road, Replace culvert array with 4 - 12x15 (W*H), and fill in flloodplain areas just north of Showboat Circle on both sides of channel to raise floodplain grade by 2 feet, slope back to channel.
IP-7369-3-1	Mill Race Ct.	Lower channel invert and develop more consistent slope for approximately 1800 linear feet of stream between Stations 26969.20 and 25137.03.
IP-7066-4-1	Pittman Hill Road	Replace culvert with bridge crossing.
IP-7368-4-3	Spencer Creek in Millwood Subdivision	Fill in floodplain along the reach 50 feet downstream of Millwood Drive, channel improvements to reduce invert elevation, AND complete project IP-7368-2-1 (Install 3 10x10 culverts with wingwalls, each is 32' long)
IP-7368-1-3	Jungermann Road at Spencer Creek	Need to add a berm on the downstream side along 160 linear feet or buyout 1 Waterbury Court property. Culvert improvements would include: Replace existing culvert with raised bridge crossing and fill sump area. Replace stormwater infrastructure. Overall impacts to 600 LF of roadway.

The hydraulic model developed for this study was not sufficient to analyze stream reach design velocities; however, the velocities produced in the model were used as reference during concept development.

4.2.2 XP-SWMM Model Development

PUMP STATION ANALYSIS

To eliminate the flooding completely within Old Town during the 15-yr, 24-hr storm, a model was constructed using the Old Town improved condition model (model with pipe improvements shown in Table 2) and the pump station capacity was increased until all flooding was eliminated during the 15-yr, 24-hr storm. This analysis showed that it would take a pump station that could convey approximately 275 cfs (~123,000 gpm) to completely eliminate flooding within Old Town for the 15-yr event. As this is a significant increase in pump station capacity, two additional scenarios were evaluated with pump station capacities between the existing capacity and the capacity required to eliminate flooding. Table 12 summarizes those results:

TABLE 122. PUMP STATION CAPACITY ANALYSIS

Pump Station Capacity (cfs)*	Approximate Inundation Water Surface Elevation (ft)	Maximum Inundation Area (ac)
54	440.3	28.8
110	440.2	28.3
220	440.1	26.4
275	N/A	0

* - Although the Old Town Pump Station nominal capacity is listed as 44 cfs, during a flood event the static lift of the pump is reduced due to the high water surface elevation in the wet well. The flows listed in the table are based on the maximum flow produced by the model for the pumps.

The existing pump station is undersized and additional capacity is needed. The table above shows that significant improvements are necessary however there was not sufficient detail at this study level to determine the exact recommendation for the pump station upgrade.

East Old Town Conveyance System

This system should be studied in more detail to verify elevations of swale. From the information provided and a rough model of the drainage system, the following recommendations have been developed: 1) reduce the amount of vegetation in the swale to reduce roughness (ongoing maintenance not included in capital cost), and 2) replace pipes with 48" RCP, set at slightly lower elevations.

4.3 Water Quality Model

P8 input parameters for each retrofit detention basin included the area and impervious fraction of the detention basin's contributing drainage area, the detention basin adjusted area and volume, and whether the detention basin was normally dry (extended detention) or contained a permanent pool (wet detention). For each retrofit, the area was defined within ArcView, using LIDAR contours and assuming a 4 ft deep average pool depth to determine the average pool area. The watershed areas and imperviousness were based on GIS data provided by the City and the HEC-HMS hydrology model. A summary of the design standards applied to detention retrofits is provided in Section 3.

4.3.1 Dry Detention Retrofit Modeling

To simulate a dry detention retrofit, only a flood pool volume was used. A permanent pool does not exist in a dry detention basin. The flood pool volume was established using a stage storage curve (if available) or estimated with LIDAR contours. The existing depth was established by taking the flood pool volume and dividing by the revised area. The flood pool volume was assumed to be the storage up to the spillway elevation. For a dry to wet basin retrofit, the flood pool volume does not change.

The flood pool volume was updated to include the water quality volume and any additional storage capacity included in the recommendation. A revised flood pool area was calculated using the new flood pool volume and the existing depth.

4.3.2 Dry to Wet Detention Retrofit Modeling

To simulate the retrofit of a dry detention basin to a wet detention basin, a permanent pool that is equal to the volume of the water quality volume was established for each basin. The area of this pool was assumed to remain constant to existing conditions. The existing flood pool volume was established using stage storage curve (if available) or LIDAR contours. The existing depth was established by taking the flood pool volume and dividing by the revised area. The flood pool volume was assumed to be the storage up to the spillway elevation. For a dry to wet basin retrofit, the flood pool volume and area does not change.

4.3.3 Wet Detention Retrofit Modeling

For a wet basin retrofit, the permanent pool was not changed. There was no modeled benefit for wet detention retrofits.

4.3.4 Removal Efficiencies of Retrofitted Detention Basins

As discussed in Section 2.4.2, the removal efficiencies of 74 existing stormwater detention basins were evaluated using the P8 model. Fifty-eight of these basins were recommended for retrofitting to improve their TSS removal efficiencies. For the West Dardenne regional drainage area, 11 of the 17 existing detention basins were recommended for retrofits. Of those, 7 were dry to wet retrofits and 4 were wet basin retrofits. The P8 model predicted the most improvement in the dry to wet retrofits because of the increase in the hydraulic retention times. Detention basins that were previously less than 30 percent efficient would be over 90 percent efficient with the retrofits.

The P8 model predicted that the average TSS removal of all the ponds in the West Dardenne regional drainage area, including the 11 retrofits, was 74 percent compared to 70 percent for the sub-basin without retrofits, as shown in Table 13. The P8 model predicted that approximately 69,000 lb/yr removal by these 17 detention basins. Approximately 915,000 lbs per year (lb/yr) of TSS would be contained in stormwater runoff from the entire drainage area; therefore, the overall TSS removal of the 17 detention basins with respect to the loading from the entire regional drainage area was 7.5 percent compared to 6.6 percent removal of the detention basins without the retrofits, as shown in Table 13. Table 13 summarizes the removal overall efficiencies for the retrofitted stormwater detention basins in the eight regional drainage area. Tables of removal efficiencies and other characteristics for each of the retrofitted basin are included in Appendix C.

TABLE 133. REMOVAL EFFICIENCIES FOR RETROFITTED STORMWATER DETENTION BASINS

		Total Regional Drainage Areas	Detention Basins			
			In	Out	Removed	Removed
Regional Drainage Areas	Number of Retro/Total Basins	TSS-lb/yr	TSS-lb/yr	TSS-lb/yr	TSS-lb/yr	%
Baltic	8/8	298,595	44,878	11,739	33,139	74
West Dardenne	11/17	915,435	86,769	18,077	68,692	79
East Dardenne	9/9	252,434	73,836	26,479	47,357	64
East Spencer	3/5	271,909	61,911	21,479	40,432	65
Plumm	4/4	590,753	39,304	30,298	9,006	23
Spencer Downstream	0	226,128	0	0	0	0
West Spencer	5/5	232,583	7,215	819	6,396	89
Spencer Upstream	18/19	688,865	134,126	31,725	102,401	76
Totals	58/67	3,476,702	448,039	140,617	307,423	69

4.4 GIS Modeling

The application of geo-spatial databases is an efficient approach to asset management. The ESRI ArcView GIS was integrally related to the progress of this study and the development of the products. This section describes the GIS deliverables that result from this study and a GIS process used to determine optimal locations for stormwater BMPs.

4.4.1 Environmental Sensitivity Index

A water quality best management practices (BMP) locator assessment was completed for the watersheds located within the City. The objective was to assess and classify the relative value of land for capturing, storing, and infiltrating stormwater runoff; and to identify vacant land that could be used to construct new water quality BMPs if desired to meet the City's stormwater management objectives. The following sections document the BMP locator process and summarize the inventory results.

The basic principal for the environmental sensitivity index (ESI) comes from the weighted factor overlay technique by Ian McHarg (1992). In GIS, the weighted overlay is done with numeric combinations of factor values that produce results which are good for spatial and statistical analysis, and map visualization. In the St Peters ESI model, 14 factors were combined into five categories for analysis: soils, hydrology, surface cover, topography, and social value.

After completing this initial analysis, the following additional analyses were completed to identify locations that are actually feasible for consideration as future BMP locations.

1. Surface flow patterns were analyzed using the DEM, and screened out parcels that are not on significant flow lines.

2. The analysis isolated parcels that are either public, semi-public, or institutionally owned, and privately owned vacant parcels that could potentially be acquired for BMP creation (either for this project, or future projects). This subset of parcels was then sorted by size to help categorize each opportunity’s relative potential benefit into tiers. The tiers were: less than 2 acres; 2 to 10 acres; 10 to 40 acres; and greater than 40 acres.

In St. Peters, Missouri, high stormwater BMP suitability exists where soil, hydrologic, and vegetative systems overlay in a distinctive dissected, dendritic landscape matrix pattern with upland connections through suburban open space, roadways, and linear easements.

4.4.2 GIS Deliverables

Table 14 summarizes the deliverables within the database.

TABLE 144. GIS DATABASE DELIVERABLES

Layers Identifying WQ Challenges	
Water Quality Concern Points	This layer identifies locations where a water quality concern was noted during field reconnaissance.
Water Quality Concern Reaches	This layer identifies locations where a water quality concern was noted during field reconnaissance.
Existing Stream Geomorphology Layers	
CCSM Reaches	This layer includes information gathered in the field and the CCSM score for each reach in the City.
CCSM Points	This layer includes information gathered in the field at the point it was taken.
Comments	This layer provides comments from the field at the point taken.
SAI Stream Type	This layer provides the SAI stream type and associated data gathered in the field.
Flood Prone Areas Layer	
Refined 100-year	This layer provides the refined 100-year area of inundation generated as a part of this study.
Detention Basin Utilization Layers	
Selected Detention Basins	This layer presents the 75 detention basins that were selected for the 2011 study. It includes DB-7270-05, a basin that was not analyzed due to lack of available data.
Detention Basins CDA	This layer provides approximated contributing drainage area information, generated using ArcHydro tools
Selected Detention Basins CDA	This layer provides approximated contributing drainage area information generated using ArcHydro tools
Layer of existing Stormwater BMPS and Proposed BMPS	
ESI Results	This layer presents the results of the environmental sensitivity index, identifying future BMP locations.
Stormwater Improvements CIP Layer	
CIP Projects	This layer includes all 2011 CIP projects.
Other	
Impervious Cover	This layer is an aggregate of the impervious cover layers provided by the City.
P8 Watersheds	This layer includes P8 regional drainage areas referenced in the report.
XP SWMM Subcatchments	This layer includes subcatchments used in the XP SWMM modeling.
Spencer Watershed	This layer is a polygon of the Spencer Creek watershed.
CCSM Reaches in Projects	This layer includes aggregated CCSM reaches within CIP project polygons.

5.0 Stormwater CIP

5.1 Project Locations and Conceptual Improvements

Field data and GIS analysis of existing conditions was used to establish project locations. The majority of flooding locations were selected as project locations. Stream reaches with scores greater than 13 were selected for stability improvements and then reaches were grouped with consideration to constructability. Special consideration was given to documentation of stream stability relative to infrastructure or buildings. Stream reaches with SAI scores of 1 and 2 were identified as preservation project areas. Detention basins that showed evidence of flooding or water quality issues such as excessive erosion or algae were selected as project locations. Project polygons were developed to encase project areas. The following outlines the project selection process.

1. Known Flooding Locations
    a. HEC-RAS Model
    b. Anecdotal
2. Detention Basins
    a. Undersized (Model)
    b. Anecdotal Issues or Problem Spots
    c. Opportunity to place or retrofit to In-Line Structure
    d. Downstream Concerns (Field Notes)
    e. Opportunities (Field Notes)
3. Stream Stability
    a. CCSM Score (>18)
    b. SAI Score (3-5)
    c. Field Notes, Anecdotal Selections
4. Water Quality Concern Locations
    a. Noted in Field
    b. Nutrients
    c. Sediment Contributions
5. Restoration Opportunities
    a. Select SAI Score (1-2)
    b. Select CCSM Score (>13)
6. Preservation Opportunities
    a. Select SAI Score (1)
    b. Select CCSM Score (<13)

The selected conceptual improvements are described in Section 3.0. Additional information related to plant palettes and plant species to be controlled is provided in Appendices F and G.

5.2 Opinion of Probable Costs

Black & Veatch compiled an opinion of probable cost for each project based on unit cost data that reflects recent project experience in the region. A general contingency of 25% was added to each cost.

Mobilization and erosion control is estimated at 15% and engineering at 15% of the subtotal cost. A 10% contingency is added for potential utility conflicts. The following table presents the unit cost of each project component.

TABLE 15. UNIT COSTS

General	Unit Cost	Unit
Category 1: Asphalt, 30-ft wide	$150	LF
Category 2: Asphalt, 50-ft wide	$250	LF
Category 3: Asphalt, 75-ft wide	$375	LF
General Concrete (CY)	$1,000	CY
General Site Grading	$2	SY
Category 1: Pipe removal cost (24-36 inch)	$90	LF
Category 2: Pipe removal cost (>36-inch)	$150	LF
Category 1: 4x4 Culvert Box	$210	LF
Category 2: 10x10 Culvert Box (Burning Leaf Drive)	$520	LF
Category 3: 12x15 Culvert Box (Boone Hills Drive)	$800	LF
Detention		
Structure Excavation	$20	CY
Category 1: Replacement Structure	$5,000	EA
Category 2:Replacement Structure	$10,000	EA
Category 1: Modification Structure	$3,000	EA
General	**Unit Cost**	**Unit**
Category 2: Modification Structure	$5,000	EA
Remove concrete swale	$10	LF
CUT	$15	CY
FILL	$25	CY
Reinforced Concrete (Slab on Grade)	$550	CY
Category 1: Small Forebay	$10,000	EA
Category 2: Large Forebay	$15,000	EA
Wetland Plantings (area, sf)	$3	SF
Vegetation Buffer area, (sf)	$0.16	SF
Establish native seeding in basin, include amendment of soils* update cost	$3	SF
Grading and Vegetation Establishment on Slopes for Erosion Stabilization	$0.16	SF
Riprap (D50 18-inch through 36-inch)	$65	CY
Detention - Community Asset Cost		LS
Stream Stability		
Category 1: Rock Check (5-10 feet across)	$3,000	EA
Category 2: Rock Check (10-15 feet across)	$4,000	EA
Category 3: Rock Check (15-20 feet across)	$7,500	EA

Category 4: Rock Check (>20 feet across)	$10,000	EA
Category 1: Left Bank, Slope and Vegetate (Bank Height: 5 ft)	$195	LF
Category 2: Left Bank, Slope and Vegetate (Bank Height: 10 ft)	$286	LF
Category 3: Left Bank, Slope and Vegetate (Bank Height: 15 ft)	$430	LF
Category 4: Left Bank, Slope and Vegetate (Bank Height: 20 ft)	$879	LF
Category 5: Left Bank, Low Flow Bench, Slope and Vegetate (Bank Height: 10 ft)	$247	LF
Category 6: Left Bank, Low Flow Bench, Slope and Vegetate (Bank Height: 15 ft)	$346	LF
Category 7: Left Bank, Low Flow Bench, Slope and Vegetate (Bank Height: 20 ft)	$645	LF
Category 8: Left Bank, 5-ft Wall, Slope and Vegetate (Bank Height: 5 ft)	$565	LF
Category 9: Left Bank, 5-ft Wall, Slope and Vegetate (Bank Height: 10 ft)	$656	LF
Category 10: Left Bank, 10-ft Wall, Slope and Vegetate (Bank Height: 10 ft)	$1,050	LF
Category 11: Left Bank, 15-ft Wall, Slope and Vegetate (Bank Height: 10 ft)	$1,507	LF
Category 1:Right Bank, Slope and Vegetate (Bank Height: 5 ft)	$195	LF
Category 2:Right Bank, Slope and Vegetate (Bank Height: 10 ft)	$286	LF
Category 3:Right Bank, Slope and Vegetate (Bank Height: 15 ft)	$430	LF
Category 4:Right Bank, Slope and Vegetate (Bank Height: 20 ft)	$879	LF
Category 5:Right Bank, Low Flow Bench, Slope and Vegetate (Bank Height: 10 ft)	$247	LF
Category 6:Right Bank, Low Flow Bench, Slope and Vegetate (Bank Height: 15 ft)	$346	LF
Category 7:Right Bank, Bench, Slope and Vegetate (Bank Height: 20 ft)	$645	LF
Category 8:Right Bank, 5-ft Wall, Slope and Vegetate (Bank Height: 5 ft)	$565	LF
Category 9:Right Bank, 5-ft Wall, Slope and Vegetate (Bank Height: 10 ft)	$656	LF
Category 10:Right Bank, 10-ft Wall, Slope and Vegetate (Bank Height: 10 ft)	$1,050	LF
General	**Unit Cost**	**Unit**
Category 11:Right Bank, 15-ft Wall, Slope and Vegetate (Bank Height: 10 ft)	$1,507	LF
Filter strips	$4	LF
Riparian Buffer (RPM Trees, Native Seeding)	$0.25	SF
Riparian Renovation (Management and Replanting)	$4,300	AC
Tree/Shrub Landscape (area,sf)	$17	SF
Signage (EA)	$5,000	EA
New Trail (LF)	$40	LF
Category 1: 15-inch RCP	$75	LF
Category 2: 24-inch RCP	$120	LF
Category 3: 30-inch RCP	$180	LF
Category 4: 36-inch RCP	$216	LF
Category 5: 48-inch RCP	$288	LF
Category 6: 60-inch RCP	$300	LF
New Inlets or Junctions	$5,000	EA
Pipe Crossing Protection	$5,000	EA
Drainage Outfalls to Channel	$3,000	EA

5.3 Prioritization of Improvements

The integration of stormwater best management practices with management of the City's natural waterways may substantially benefit flooding, water quality, habitat, and provide opportunities for public education regarding water resource issues. A prioritization scheme was developed based on the conditions established during this study. To evaluate the priority of each CIP project, the following categories were evaluated: flooding, stream stability, and ecology. These categories were weighted and summed to develop a subtotal value.

TABLE 156. WEIGHTED CATEGORIES FOR PRIORITIZATION

Flooding	Stream Stability	Ecology
40%	35%	25%

5.3.1 Flooding

Flooding locations were identified using hydrologic and hydraulic modeling results and anecdotal reports documented by the City and provided in a GIS database. The hydrologic model was used to determine when detention basin overtopping occurred during the 25-year event. The refined hydraulic model of the City waterways was used to generate a mapped area of inundation. This layer was evaluated to determine flooding locations. At each flooded location, the number of impacted structures or the impacted roadway was documented. Each bridge crossing was also evaluated within the hydraulic model to determine overtopping of bridge or culvert crossings. Project areas identified in this study, particularly regional flooding areas, should be further evaluated to characterize the extent of flooding in more detail.

5.3.2 Stream Stability

Stream stability was prioritized using the Channel Condition Scoring Matrix (CCSM) and the assessment of a stream reach's impact on infrastructure or property. During the field evaluation, each stream reach was evaluated using the CCSM. A resulting score was documented for each reach. Project areas often overlapped multiple stream reach and therefore, a weighted CCSM score was developed for each project reach. Each project was evaluated to determine if structures or property was negatively impacted by stream stability.

5.3.3 Ecology

The final category of prioritization relates to the ecology of the system. A water quality benefit was established for each detention basin retrofit. The categories were developed based on the potential increased removal of total suspended solid (TSS) provided by a retrofit option. This accounts for the contributing watershed characteristics and is influenced by the basin retrofit type. During the field evaluation, each stream reach was evaluated using the Stream Asset Inventory, as presented in Section 2.4.2. The resulting SAI score was used to establish a priority for restoring or protecting the stream reach within each project.

5.3.4 Other

Additional multipliers were used to influence the ultimate score, including frequency, visibility, and education.

TABLE 167. PRIORITIZATION SCHEME

Flooding Multipliers	
Regional Flooding	10
6 - 15 Homes &/or Businesses	2
1-5 Homes &/or Businesses	1
Major Street	2.5
Other Street	1
Dam Overtopping	2
Stream Stability Multipliers	
CCSM Score > 19	2
CCSM Score 13 - 19	1
Threatens Private Structure	1.5
Threatens Public Utility or Infrastructure	1.5
Threatens Public or Private Property	1
Ecology Multipliers	
Detention Basin WQ Benefit (Significant)	3
Detention Basin WQ Benefit (Good)	2
Detention Basin WQ Benefit (Average)	1
Detention Basin WQ Benefit (None)	0
SAI Category 5	2
SAI Category 3 & 4	1
Project Multipliers	
Frequency	
Common	2
Annual	1.5
Infrequent	1

5.3.5 Final Prioritization

Once the scores for the flooding, stream stability, and ecology were tallied and multiplied as described in the form and paragraphs above, the result is a final prioritization score. This can be considered a measure of the project’s benefit to the City stormwater system. This score is one important measure to be considered as the City allots capital funds to stormwater improvements over the coming years.

Another important measure to be considered is the cost benefit ratio that can be calculated for each project. This ratio is simply calculated by dividing the cost by the benefit score. For this study, the cost benefit scores were uniformly multiplied by 100 to avoid cumbersome decimal displays. Those projects with the smallest cost benefit ratios will provide the City with the most efficient use of improvement funds.

5.4 Schedule

The schedule for improvements will be based upon the prioritization scheme presented in Section 5.3 and the capital allotted to improvements in a given year. Some consideration of the prioritization scheme's inherent bias must occur when discussing the schedule of improvements.

For instance, if the City were to use the cost benefit ratio as the sole means to select projects, only a series of small projects would be completed. This is due to the fact that many of the projects with low cost benefit ratios are small projects that, while providing benefit to the watershed, have lower costs.

Alternatively, if the City were to use the benefit scores as the sole means to select projects, the City would likely only complete a very few, perhaps only a single, project(s) each year. This is due to the fact that many of the projects that provide a large benefit to the City's stormwater system are also large and expensive.

To avoid these scenarios, it is suggested that the City develop a hybrid selection and scheduling process. By this method, the City will develop a balanced schedule that will address multiple projects across the watersheds, but will also address important (high benefit) projects in as timely a manner as funding will permit.

5.5 GIS Databases

Several GIS database were developed during this study to manage data collected in the field and data created during analysis. These geodatabases will be a valuable tool to manage assets during implementation of the stormwater CIP. The geodatabase organization is provided in Appendix I and the database is stored on the CD attached with this report.

6.0 Recommendations

This study resulted in the development of over 100 projects with a total cost of $125,000,000. These projects are located throughout the City and are classified as flooding, stream stability, detention, or preservation projects. Some projects are multi-functional and are associated with two or more of these categories. A comprehensive approach to solving stormwater-related concerns will include projects that are rated with a high priority score, projects that have a low cost benefit ratio and projects that preserve the City's existing resources. Sections 6.1, 6.2, and 6.3 include the top 10 projects in each of the following categories: high priority, low cost benefit and preservation value. One project is represented as both a high priority and a low cost benefit project. The total estimated cost for these 29 projects is approximately $17,500,000.

Summaries for each project developed for the CIP are provided in Appendix H.

6.1 Top 10 Priority Projects

The following locations received the highest priority rating. These projects are not the most cost effective but represent significant stormwater concerns in the City.

1. Dardenne Creek at Mexico Road and I-70 (IP-6970-4-3)

This flooding project received a priority score of 1061 points and an estimated project cost of $4,915,000.

Existing Description

The project location is located at the Mexico Road and I-70 crossings of Dardenne Creek. The bridge information provided in the HEC-RAS model showed that these bridges cause constrictions during high flow events in Dardenne Creek, resulting in flooding upstream.

Improvement Description

Address flooding by replacing the bridge at Mexico Road and raising the low steel. Channel widening is recommended along 2,000 linear feet, extending through the I-70 bridge crossing. This solution lowers the water surface elevation and removes some houses from the 100-year floodplain.

2. Burning Leaf Drive (IP-7368-2-1)

This flooding project received a priority score of 795 points and an estimated project cost of $258,000.

Existing Description

The crossing of Burning Leaf Drive in the Tanglewood subdivision is currently overtopping in the hydraulic model. Six structures are impacted by the 100-year inundation area.

Improvement Description

The low area at Burning Leaf Drive should be raised along approximately 300 linear feet and a new triple array of 10x10 culverts should replace the existing bridge crossing. Additionally, 150 linear feet of channel improvements will be necessary as part of the culvert installation. One other option evaluated was new regional detention upstream; however, there was not sufficient land available to add the capacity needed to reduce peak 100-year discharge.

3. Jungermann Road at Spencer Creek (IP-7368-1-3)

This flooding project received a priority score of 730 points and an estimated project cost of $2,347,000.

Existing Description

The Jungermann Road Bridge project is located along the main channel of Spencer Creek. This has been an area of concern during each of the significant 2011 storm events. The existing hydraulic model did not accurately reflect flooding at this location because the USACE hydrologic analysis for the area was not representative of contributing drainage area. Flooding is the result of insufficient conveyance area and downstream conditions. The hydrology of this area should be studied further.

Improvement Description

To address overtopping that resulted from the conservative modeling approach, the existing culvert at Jungermann should be replaced with a bridge. The sump area along Jungermann should be filled - impacting approximately 800 linear feet of this road. Additionally, a berm should be constructed on the north side of the channel, downstream of Jungermann Road.

4. Pittman Hill Road (IP-7066-4-1)

This flooding project received a priority score of 607 points and an estimated project cost of $1,453,000.

Existing Description

Pittman Hill Road is overtopping in the hydraulic model. Two structures are shown within the FEMA floodplain and this study's refined area of inundation during the 100-year event. There was one tall shear bank noted on the downstream side of Pittman Hill Road. Owners on the adjacent property said that this bank was eroding quickly. Upstream of Pittman Hill Road, the riparian corridor is in fair condition but very narrow on the west side. The main channel banks show evidence of continuous scouring. Debris jams were noted in the field study.

Improvement Description

The concept includes replacement of the Pittman Hill Road culverts with a bridge to address overtopping. Additionally, bank stabilization of the 24-ft tall shear bank downstream of Pittman Hill Road is recommended. This bank is upstream of the area that was protected as part of the Hwy 94 construction project (2010-2011). This project also includes vegetative and riprap toe protection of the reach upstream of the culvert crossing where shorter banks show evidence of continuous scouring. The corridor upstream of Pittman Hill Road should be renovated. The corridor downstream of Pittman Hill Road will require the establishment of a new riparian corridor and limited stream widening.

5. Old Town I-70 Service Road North (IP-7171-2-1)

This flooding project received a priority score of 540 points and an estimated project cost of $765,000.

Existing Description

Swale draining east Old Town toward regional detention basin along Iffrig Road is flooding Old Town.

Improvement Description

This system should be studied in more detail to verify elevations of the swale. From the information provided and a rough model of the drainage system, recommendations include: reducing the amount of vegetation in the swale to reduce roughness (ongoing maintenance not included in capital cost) nad replacing pipes with 48" RCP, at a lower elevation.

6. McClay Valley Detention (IP-7468-3-3)

This detention and stream stability project received a priority score of 525 points and an estimated project cost of $1,650,000.

Existing Description

The McClay Valley Detention Basin (DB-7468-1) receives a significant amount of debris and flow from upstream sources and presents a unique demonstration opportunity as a larger detention basin in the watershed. Additionally, the City noted that the contributing storm sewer infrastructure is not designed to adequately drain the surrounding area to the basin. Hydrologic modeling showed overtopping of the downstream road during the 15-yr event.

Improvement Description

The conceptual solution is focused on addressing the issues at the McClay Valley detention basin and developing a second detention upstream of the large basin. A berm embankment and outlet works would be constructed for the upstream detention basin. At the main basin, a forebay would be developed with wetland plantings and the outlet structure may be modified. Local drainage to the main detention basin would be replaced to allow functional drainage. Edge treatment may include a vegetative buffer, wetland bench, or combination established on the perimeter of the main basin.

7. West Drive (IP-7369-4-1)

This detention and stream stability project received a priority score of 428 points and an estimated project cost of $990,000.

Existing Description

This project area includes the West Drive wet detention and stream reaches in the contributing drainage area, which extends over City and county property. The West Drive detention basin is currently used for recreation (i.e. fishing) and is owned by the City. There are three contributing tributaries that drain into the basin: Elm Tree Tributary is at the far west, Hi Pointe Tributary is the center tributary, and Peach Street Tributary is at the far east of the project area. The upstream two thirds of Elm Tree Tributary were characterized as a fairly incised channel with unconsolidated leaf litter debris and loose sediment bed material. Between pools in this reach, there were nick points (dropping as much as 2 feet). The Hi Pointe Tributary was characterized as an incised channel with debris dumping in the downstream half. In the upstream half it is a meandering intermittent channel with poor understory vegetation. The Peach Street Tributary flows through backyards and has been associated with flooding problems at Peach Street. The City has made some improvements to remedy flooding problems, however, neighbors complain of bank erosion encroaching on backyards. The reach upstream of Peach Street is a low flow channel through a backyard that functions as a detention basin. The reach downstream of Peach Street lacks a buffer and dumping is prevalent.

Improvement Description

This concept includes improvements to the West Drive detention basin and each of the contributing tributaries. At the detention basin, the capacity should be increased by raising the profile of West Drive and replacing the basin outlet structure. The West Drive detention basin should be further studied to refine the proposed solution. Wetland benching and a buffer should be established on the southwest and a vegetated buffer should be installed around the entire perimeter. Stabilization of the Elm Tree tributary should include vertical grade control to prevent further degradation, establishment of a riparian buffer when it is not present, renovation of the existing corridor and bench slopes on the incised channel (upstream two thirds of the tributary). The Hi Pointe Tributary should be routed to drain into the south end of the detention basin and the existing tributary should be cleared and graded to be included as part of the detention basin (reducing the stream length by 529 linear feet). Riparian renovation is recommended throughout the remaining reach. Stabilization of the Peach Street Tributary includes two strategies, 1) the reach between Peach Street and the wet detention basin should be stabilized and revegetated, 2) the reach upstream of Peach Street should have a narrow riparian corridor re-established.

8. Spencer Creek between Sutters Mill Road and Boone Hills Drive (IP-7369-1-1)

This stream stability and flooding project received a priority score of 402 points and an estimated project cost of $3,186,000.

Existing Description

This project reach is along the main channel of Spencer Creek between Sutters Mill Road and Boone Hills Drive. There is a section in the middle of the reach, close to Showboat Circle cul-de-sac, where concrete chunks have been used as toe protection and the banks have successfully vegetated (although vegetation was not diverse). The reach upstream of this stabilized area showed evidence of significant bank erosion and debris jams which should be addressed to reduce sediment loading into the channel

Improvement Description

The proposed solution addresses flooding by replacing the existing culvert array at Boone Hills Drive with 4 12x15 boxes and filling floodpain areas just north of Showboat Circle Drive on both sides of channel to raise floodplain grade by 2 feet. This project also includes imited stream stabilization approaches are included along the upstream 2414 linear feet of this project reach. Four rock checks are included to stabilize the bed profile of the channel. Riparian renovation is included in the entire project area (3597 linear feet).

9. Spencer Creek in Millwood Subdivision (IP-7368-4-3)

This stream stability and flooding project received a priority score of 380 points and an estimated project cost of $ 520,000.

Existing Description

This project reach is along both the main channel of Spencer Creek and the Millwood tributary in the Millwood subdivision. Minor flooding, stream stability, debris jams, and backyard erosion were documented in the study. A significant amount of riprap is already present in the main channel of Spencer Creek, however in localized areas bank protection is needed (such as the high bank threatening the existing trail along Spencer Creek).

Improvement Description

The proposed solution addresses flooding of 2 residences by adding fill in the floodplain downstream of Millwood Drive and completing channel improvements along Spencer Creek. Additionally, IP-7368-2-1, a project that includes improvements to Burning Leaf Drive, must be completed to address flooding. Limited stream stabilization approaches are included along 25% of the Spencer Creek main channel (the most upstream reach within project boundary) and riparian renovation is included in the entire project area. Seven rock checks are included to stabilize the bed profile. Upstream regional detention was evaluated as an alternative, however, it was determined that insufficient area was available to add a level of detention that would significantly reduce the 100-year water surface elevation.

10. Boone Hills Drive and Jungermann Road (IP-7369-2-1)

This stream stability and detention project received a priority score of 375 points and an estimated project cost of $ 492,000.

Existing Description

This project area includes a stream reach along East Spencer Branch, existing detention at DB-7369-11, and a proposed detention location. These improvements may be related to potential flooding at the intersection of Boone Hills Drive and Jungermann Road. The existing aerated wet detention basin is well landscaped and the shoreline protected with a stacked stone wall and tree buffer on the west. Very turbid water was documented during the field visit. The stream has good overall structure in the upstream section, although an excessive amount of debris associated with brush and dumping at the Tieman Property was noted. This dumping has also compromised bank stability along 400 feet of the reach. The existing corridor has a significant amount of honeysuckle brush that is preventing the growth of a diverse riparian corridor.

Improvement Description

This concept includes improvements to the existing detention basin, development of a new dry detention basin west of Jungermann, and limited channel improvements. At the existing basin, the outfall structure should be further studied with additional information about backwater influences. To operate effectively, this structure must be maintained. Debris and sediment from the upstream channel reach should be managed with a forebay structure. A vegetative buffer should be established along the street that runs adjacent to the basin along 700 linear feet. In the upstream reach, the left bank at Tieman property (approximately 400 linear feet) should be repaired with a 5-ft wall and sloped/vegetated section. Use of the wall prevents further encroachment on the property and the channel is already connected to a floodplain on the right bank. Three rock check structures are included to stabilize the bed profile of the channel. The riparian corridor should be renovated along the entire reach (950 lf). To the west of Jungermann Road behind 410 Jungermann Road, a new dry detention facility is proposed with the addition of a 70-ft long berm that raises the grade 4 feet. A new outlet structure will be replaced and tie into the existing piped system.

6.2 Top 10 Cost Benefit Projects

The following locations will provide the greatest benefit for the associated cost. Preservation projects with low cost benefit were excluded from this list. The benefit is assumed to be correlated with the priority score.

1. Spencer Rd. Storage (IP-7270-3-1)

This flooding project received a priority score of 319 points and an estimated project cost of $22,000.

Existing Description

This project includes the downstream portion of the Spencer Place Tributary, located between Spencer Road and the confluence with main Spencer Creek in the Avemco subdivision. Three storage structures are located within the area of inundation during the 100-year event in Spencer Creek.

Improvement Description

Construct a 300-foot long berm, 2-4 feet tall around the northern and eastern sides of the storage facilities, bringing the elevation up to 462-ft.

2. Magnolia Manor (IP-7467-4-1)

This stream stability project received a priority score of 245 points and an estimated project cost of $37,000.

Existing Description

This project area includes a reach directly west of Magnolia Manor Court. The field notes documented headcutting at the 90 degree bend behind the residence at 1343 Magnolia Manor Court. A twin CMP discharge in the right bank may have been abandoned. Invasive vegetation was present in this channel and preventing the establishment of a diverse corridor.

Improvement Description

This concept includes 5 vertical grade control structures and renovation of the riparian corridor. There will be significant grading and clearing to establish a stable slope and remove debris in the channel.

3. Athens Drive (IP-7168-1-1)

This stream stability project received a priority score of 320 points and an estimated project cost of $81,000.

Existing Description

This existing channel, in Pegasus Farms, is formed by a pipe outlet from Morningside Drive. This pipe discharges to a steep ravine and re-enters a piped system to Kenworth Drive. This very steep channel has an average slope of 0.054 ft/ft with bank heights up to 12 feet. Active bank erosion and dumping of lawn waste was noted in the upstream portion of this reach. The existing woodland corridor should be preserved on this upstream portion. On the downstream portion of the project reach, the corridor is lacking. Access for construction may be difficult because the channel is located in backyards and there are not street crossings in the project area.

Improvement Description

This concept utilizes a series of 13 rock checks to stabilize the invert elevation of the channel. The upstream corridor (200 feet) should be preserved and a downstream corridor, along 315 linear feet, should be enhanced. Large debris should be removed from the channel (shopping cart, old truck).

4. Koenig Orchard (IP-7370-3-1)

This stream stability project received a priority score of 170 points and an estimated project cost of $54,000.

Existing Description

The existing reach of East Spencer Creek/Koenig Tributary was characterized as having a bedrock bottom, some bank cutting, and good rock material on most banks. The channel is located in an agricultural area without buffers and significant invasive vegetation in the riparian corridor was documented during field reconnaissance.

Improvement Description

Riparian renovation is recommended for this stream corridor. Additionally, a vegetated filter strip should be added to all agricultural buffers that are adjacent to this reach. Debris on the culvert face should be removed during typical maintenance activities.

5. Burning Leaf Drive (IP-7368-2-1)

This flooding project received a priority score of 795 points and an estimated project cost of $258,000 and is also listed as a top 10 priority project.

6. Bruns Place (IP-7068-2-1)

This stream stability project received a priority score of 245 points and an estimated project cost of $89,000.

Existing Description

This stream reach extends through a neighborhood at Bruns Place Court, under Mid Rivers Mall Drive and then confluences with Dardenne Creek. The channel has a very steep profile in the reach upstream of Mid Rivers Mall Drive, dropping approximately 20 feet over a distance of 850 feet. The channel transitions to a braided channel before flowing to Dardenne Creek. A section of the channel has been piped through the backyard of the residence at 109 Bruns Place Court - the pipe entrance has become blocked and is therefore not functional.

Improvement Description

The proposed concept includes the installation of grade control structures and riparian renovation of the corridor. The piped system at 109 Bruns Place Court should have the inlet structure replaced to allow appropriate drainage of the upstream channel. No additional bank stabilization is recommended at this time. The downstream end of the tributary should be stabilized with a series of vertical grade controls as well to prevent further degradation and incision.

7. Applewood (IP-7369-1-2)

This detention project received a priority score of 209 points and an estimated project cost of $98,000.

Existing Description

This existing wet detention DB-7369-04, located in the Applewood subdivision, is south of Bartley Street. The basin does not have sufficient capacity and is overtopping Bartley Street.

Improvement Description

The concept recommendation includes replacement of the outfall structure, implementing a shoreline buffer of vegetation and riprap, and increasing capacity by excavating an additional 2 feet from the bed of the basin. The basin has borderline 25-year capacity and this additional storage will prevent street flooding.

8. Kelly Leaf (IP-7368-2-3)

This stream stability project received a priority score of 95 points and an estimated project cost of $49,000.

Existing Description

This stream reach along the Tanglewood tributary was characterized as slightly incised with sharp meanders, significant debris jams, and good cobble bars. The buffer on the left bank was documented to be in good condition.

Improvement Description

The recommendation for this project reach is to preserve the corridor through riparian renovation. Six rock checks are included for vertical grade control.

9. Calwood (IP-6970-1-1)

This stream stability project received a priority score of 137 points and an estimated project cost of $52,000.

Existing Description

The existing channel reach is a small tributary within the Dardenne Creek watershed. During the field visit, excessive debris in the channel and invasive vegetation on the banks were noted. The channel profile is too steep for the bed materials to establish equilibrium. During high events, flow in this channel may be influenced by Dardenne Creek.

Improvement Description

Riparian renovation is recommended for this stream corridor. Debris jams should be removed. Additionally, 2 rock checks should be installed to stabilize the invert elevation.

10. Bella Vista Subdivision and MC-1 Stream (IP-7367-2-1)

This detention and stream stability project received a priority score of 248 points and an estimated project cost of $156,000.

Existing Description

This project area, located south of McClay Road in the Bella Vista subdivision includes an existing wet detention basin, DB-7367-20, and a channel reach that was modified during a previous stabilization project. The channel area is impacted by the upstream detention basin and very turbid water was documented in the field.

Improvement Description

This concept includes improvements to the detention basin and riparian renovation of the stream corridor with some spot fixes for areas with erosion. Wetland plantings and a vegetated buffer should be established around the perimeter of the detention basin. A forebay structure should be added to control sediment in runoff from the contributing drainage area which is currently under development. Additional volume should be considered to prevent overtopping.

6.3 Top 10 Preservation Projects

The following locations will provide the greatest preservation benefit for the associated cost.

1. Spanish Trails (IP-6870-1-1)

This preservation project received a priority score of 95 points and an estimated project cost of $3,000.

Existing Description

The existing channel has good structure but too much shade inhibits understory growth. Riparian corridor should be restored.

Improvement Description

Riparian renovation is recommended for this stream corridor.

2. Trailside Court, Villages of Windwood (IP-7467-3-2)

This preservation project received a priority score of 95 points and an estimated project cost of $6,000.

Existing Description

This existing reach showed evidence of polluted water and is too shaded for a healthy riparian corridor.

Improvement Description

Riparian renovation is recommended for this stream corridor.

3. Laurel Park Stream, McClay Valley Boulevard (IP-7468-3-1)
This preservation project received a priority score of 95 points and an estimated project cost of $8,000.

EXISTING DESCRIPTION

The existing channel has very good structure but the presence of honeysuckle and other invasive vegetation needs to be addressed.

IMPROVEMENT DESCRIPTION

Riparian renovation is recommended for this stream corridor.

4. Crescent Hills (IP-7368-1-2)
This preservation project received a priority score of 95 points and an estimated project cost of $11,000.

EXISTING DESCRIPTION

This reach of the Crescent Hills Tributary was characterized with good structure and vegetation.

IMPROVEMENT DESCRIPTION

The recommendation in this project reach is to preserve the existing corridor through riparian renovation (1313 linear feet).

5. Ohmes Mitigation (IP-6969-1-1)
This preservation project received a priority score of 95 points and an estimated project cost of $20,000.

EXISTING DESCRIPTION

This reach of stream, located adjacent to the mitigation site for the Ohmes Farm Development, has a good riffle pool structure but significant amount of honeysuckle that should be managed.

IMPROVEMENT DESCRIPTION

Riparian renovation is recommended for this stream corridor.

6. McClay Valley /Woodstream (IP-7468-3-2)
This preservation project received a priority score of 95 points and an estimated project cost of $17,000.

EXISTING DESCRIPTION

This existing channel was identified as a potential linkage between two channels in good condition.

IMPROVEMENT DESCRIPTION

Riparian renovation is recommended for this stream corridor.

7. Harvestowne (IP-7166-2-1)
This preservation project received a priority score of 75 points and an estimated project cost of $7,000.

EXISTING DESCRIPTION

The existing channel, south of Hwy 94, has very good structure, with stable sloped banks and a diverse riparian corridor but the presence of invasive vegetation should be addressed.

Improvement Description

Riparian renovation is recommended for this stream corridor. The buffer on the east side should be enhanced.

8. Spencer Crossing (IP-7269-2-1)

This preservation project received a priority score of 75 points and an estimated project cost of $23,000.

Existing Description

This reach of the Oak Creek Park Tributary was documented as a meandering sandy, cobble bed channel with bank cutting around bends, scour under TRM, and riprap on some bank toes.

Improvement Description

Riparian renovation is recommended for this stream corridor.

9. Country Crossing (IP-6868-2-1)

This preservation project received a priority score of 75points and an estimated project cost of $26,000.

Existing Description

The existing channel has very good structure but the presence of honeysuckle and other invasive vegetation needs to be addressed.

Improvement Description

Riparian Renovation suggested for stream corridor (1602 linear feet).

10. Millwood (IP-7368-1-1)

This preservation project received a priority score of 75 points and an estimated project cost of $46,000.

Existing Description

This project includes the preservation and enhancement of a high-quality (SAI Type 1 and 2) riparian corridor on Spencer Creek between Jungermann Road and Millbrook Court/Mill Run Lane. The project intent is to maintain the corridor's existing health and function, and to demonstrate how vegetative plantings on residential properties that border riparian corridors can protect and enhance stream health.

Improvement Description

The concept is to remove invasive species such as shrub honeysuckle in up to 20 acres of riparian corridor, and to re-vegetate these areas with appropriate riparian trees, forbs and grasses. Doing so will help ensure that these invasive species don't get a foothold and degrade this otherwise high-quality stream corridor. In addition, residential properties border the riparian corridor on the northern side of the stream along a half-mile reach from Jungermann Drive to Millwood Drive; the concept would be to plant an appropriate, 25-foot vegetated buffer along most or all of this reach. The plantings would consist of native shrubs, forbs and grasses that would form an attractive, defined edge between residential lawns and the stream corridor.

6.4 General Detention Basin Recommendations

6.4.1 Detention Basin Management Program

The 248 detention basins in the City have a significant impact on stormwater management reducing peak flows and improving runoff water quality. However, many of these are not maintained properly and therefore do not reduce peak flows and improve water quality as designed and originally constructed. Therefore, the City is developing a plan to manage these basins so they function properly and provide benefits to the community. A prioritized approach has been developed for the Detention Basin Management Program.

One of the most important considerations in management of the basins is the annual costs the City will incur. General operations and maintenance (O&M) costs have been estimated from the Water Environment Research Foundation's "Performance and Whole-Life Costs of Best Management Practices (BMPs) and Sustainable Urban Drainage Systems (SUDS)" (WERF Report). The WERF Report examined BMP performance and costs primarily in the US and the UK and created a whole-life cost spreadsheet that can be used to estimate O&M costs. Many assumptions are made in the spreadsheet and the most significant is the level of maintenance provided with choices of low, medium, or high. For the purposes of this project, a medium level of maintenance was chosen. This choice then defines the frequency of the following:

- Inspection of facilities – once every three years
- vegetation management – once a year
- vector control – once every three years
- intermittent maintenance – once a year
- sediment removal – once every ten years

The Detention Basin Management Plan includes a prioritization of the basins for acquiring them and taking over responsibility for O&M. The highest priority basins are the 57 included in the Capital Improvements Program CIP. When they are upgraded as recommended in the CIP, the City will consider management of these basins. The estimated annual O&M cost for these basins is approximately $110,000. These include five basins currently owned by the City of St. Peters.

Seven basins owned by the City that are not included in the CIP are also in the group of highest priority basins. The estimated annual operations and maintenance cost for these basins is approximately $36,000.

TABLE 178. DETENTION BASINS OWNED BY THE CITY

Basin	Location	Approximate Drainage Area (*acres*)
DB-6870-04	SPANISH TRAILS	3
DB-6871-01	I-70 TRADE CENTER	33
DB-6969-02	WOODLANDS SPORK PARK	16
DB-6969-04	WOODLANDS SPORT PARK	27
DB-7169-05	COMMUNITY & ARTS CENTER	2
DB-7171-01	CITY OF ST PETERS	875
DB-7467-06	HERITAGE MANOR	13

The 68 residential basins are the next priority. The basins are prioritized in Table 18 by their type with wet basins having a higher priority than dry basins because they provide more water quality benefit. The drainage area served is also used to prioritize the basins with the larger tributary areas having a higher priority. The estimated annual cost for O&M for these basins is approximately $142,000.

TABLE 1918. RESIDENTIAL DETENTION BASINS

Basin	Location	Type	Approximate Drainage Area (*acres*)
DB-7468-06	LAUREL VILLAGE	WET	167
DB-7066-03	MEADOWRIDGE	WET	152
DB-6968-03	COUNTRY CROSSING ESTATES	WET	77
DB-6869-02	FAWN LAKE	WET	40
DB-7269-03	HICKORY RIDGE	WET	19
DB-6970-03	LAKES OF DEVONDALE	WET	17
DB-7069-08	LAKES OF DEVONDALE	WET	12
DB-7369-05	CAP-AU-GRIS	WET	7
DB-7169-03	MID RIVERS CHRISTIAN CHURCH	WET	5
DB-7268-05	COUNTRY CREEK	WET	4
DB-6870-11	RICHMOND	WET	2
DB-7269-02	HICKORY RIDGE	DRY	124
DB-6870-01	ESTATES OF CHATEAU WOODS	DRY	62
DB-7467-11	TRIANGLE APARTMENTS	DRY	59
DB-7168-03	PEGASUS FARMS	DRY	52
DB-7065-06	THE HIGHLANDS	DRY	43
DB-7270-02	VANDERBILT APARTMENTS	DRY	37
DB-6869-01	HOLLOW CREEK	DRY	29
DB-7267-02	PARK RIDGE ESTATES	DRY	27

Basin	Location	Type	Approximate Drainage Area *(acres)*
DB-7370-09	TWILL VALLEY	DRY	26
DB-7467-01	MC CLAY MEADOWS	DRY	19
DB-7467-07	REGENCY ESTATES	DRY	18
DB-7168-02	SPRING VALLEY WAY	DRY	12
DB-7367-09	SUGARWOOD	DRY	12
DB-6968-04	COUNTRY CROSSING ESTATES	DRY	12
DB-7468-03	MC CLAY VALLEY	DRY	11
DB-7268-03	HANOVER CROSSING	DRY	11
DB-6870-07	FORT ZUMWALT SOUTH	DRY	9
DB-7268-01	HANOVER CROSSING	DRY	9
DB-7468-02	FRANCIS HOWELL SCHOOL DISTRICT	DRY	8
DB-7368-03	BRIARWICK	DRY	8
DB-7066-02	WHITTINGTON PLACE	DRY	8
DB-6868-01	ASPEN RIDGE	DRY	8
DB-6870-08	CANDLEWICK ESTATES	DRY	7
DB-7069-01	BUCHHOLZ	DRY	7
DB-7270-04	SPENCER HILL	DRY	7
DB-6870-13	DEER RIDGE	DRY	6
DB-7367-05	SUGARWOOD	DRY	5
DB-7369-10	CHAPEL OF THE CROSS LUTHERAN CHURCH	DRY	5
DB-7367-02	HARVEST POINT	DRY	5
DB-7267-01	FAIRFIELD PLACE	DRY	5
DB-7468-04	MC CLAY VALLEY	DRY	5
DB-7267-12	ST JOACHIM & ANN CATH SCHOOL	DRY	4
DB-7367-13	LIENEMANN FOREST	DRY	4
DB-7268-02	HANOVER CROSSING	DRY	4
DB-7367-08	HARVEST POINT	DRY	4
DB-7468-05	FRANCIS HOWELL SCHOOL DISTRICT	DRY	3
DB-7267-15	CALVARY TEMPLE ASMBLY OF GOD	DRY	3
DB-6870-03	BELLEAU CREEK ESTATES	DRY	3
DB-7367-03	HEATHER RIDGE	DRY	3
DB-6970-01	DARDENNE LAKE ESTATES PLAT 1	DRY	3
DB-6870-02	ESTATES OF CHATEAU WOODS	DRY	3
DB-7170-01	LEWIS & CLARK ELEMENTARY SCHOOL	DRY	2
DB-7368-07	COUNTRY MANOR	DRY	2
DB-6870-05	BROOKWOOD ESTATES	DRY	2
DB-7467-02	MC CLAY MEADOWS	DRY	2
DB-7366-02	CANYON CREEK	DRY	2

Basin	Location	Type	Approximate Drainage Area *(acres)*
DB-7070-04	FORT ZUMWALT PLACE	DRY	1
DB-7070-06	FORT ZUMWALT PLACE	DRY	1
DB-7367-14	SUMMERGATE TOWNHOMES	DRY	1
DB-7366-05	PARKWAY VILLAS	DRY	1
DB-7369-09	CHAPEL OF THE CROSS LUTHERAN CHURCH	DRY	1
DB-6870-06	MID RIVERS SEVENTH DAY ADVENTIST	DRY	1
DB-6870-12	CANTERBURY PARK	DRY	1
DB-7367-06	HEATHER RIDGE	DRY	1
DB-7070-01	OLD TOWN SOUTH	DRY	1
DB-6970-02	FIRE STATION	DRY	1

The remaining 116 basins are in commercial or industrial areas. The maintenance of these should be provided by their owner. Therefore, it is recommended that the City not take over O&M of these basins and ensure their performance through inspection and enforcement of existing ordinances requiring maintenance by the owner.

The O&M costs of the 57 basins included in the CIP and the seven basins owned by the City totals approximately $146,000. The schedule for taking over ownership and O&M of the 68 residential basins will be determined by available funding and staff resources.

6.4.2 Low-flow Flume Replacement

Many detention basins in the City include concrete flumes that convey low-flows from the discharge pipes to the basin outlet. These eliminate most wet areas and erosion in the bottom of grass-lined basins; however they convey the first flush of runoff through the basin with no storage time or exposure to the vegetation. This allows what is typically the most polluted runoff to move through the basin with no treatment or attenuation. The following recommendations are made to upgrade the flumes so they provide some water quality benefit while not impacting the detention basin's peak flow control performance significantly.

Intact Flumes

Flumes that are not in need of structural repair do not need to be replaced to provide some water quality benefit. A small berm made of selected rip-rap can be placed across the flume in the vicinity of the outlet structure. The berm will cause water to pond allowing it to spread out into the vegetated area of the basin. This will slow the water down allowing sediment to settle and for some of the water to be exposed to the vegetation allowing further removal of sediments and other water quality benefits. The berm should be permeable or have a low flow outlet to allow the ponded water to drain within 40 hours. Provisions should be made to allow sediment removal and the basins should be inspected once a year to identify maintenance needs and ensure that small semi-permanent pools are not being created.

The size of the rip-rap should be determined based on anticipated velocities in the flume. Also, the need for some type of stabilization in the vegetated area should be evaluated based on anticipated velocities and visual inspection.

A pilot program should be initiated to test the performance of the berm in trapping sediment and draining within 40 hours. A few basins should be retrofitted with the berms and inspected after storm events to monitor their performance and identify adjustments needed for satisfactory performance.

Flumes Needing Repair

For flumes needing concrete repair, it is recommended that the concrete sections be removed and replaced with rip-rap. The rip-rap should extend from the area needing repair to the low flow outlet. A berm should be placed near the outlet as described above. The rip-rap should be planted with appropriate plants as listed in Appendix F. The rip-rapped section will slow the water down allowing it to pond and trap sediment. Provisions should be made to allow sediment removal and the basins should be inspected once a year to identify maintenance needs and ensure that small semi-permanent pools are not being created.

The size of the rip-rap should be determined based on anticipated velocities in the flume. Also, the need for some type of stabilization in the vegetated area should be evaluated based on anticipated velocities and visual inspection.

A pilot program should be initiated to test the performance of the rip-rapped section and berm in trapping sediment and draining within 40 hours. A few basins should be retrofitted and inspected after storm events to monitor their performance and identify adjustments needed for satisfactory performance.

Flumes Needing Replacement

The concrete should be completely removed and replaced with a rip-rap channel. If possible, the channel should be designed with meanders to further slow the water down thereby trapping more sediment. The rip-rap should be planted with appropriate plants as listed in Appendix F. Provisions should be made to allow sediment removal and the basins should be inspected once a year to identify maintenance needs and ensure that small semi-permanent pools are not being created.

The size of the rip-rap should be determined based on anticipated velocities in the flume. Also, the need for some type of stabilization in the vegetated area should be evaluated based on anticipated velocities and visual inspection.

A pilot program should be initiated to test the performance of the rip-rapped channel in trapping sediment and draining within 40 hours. A few basins should be retrofitted and inspected after storm events to monitor their performance and identify adjustments needed for satisfactory performance.

6.4.3 Forebays

New detention basins should be designed with a forebay to capture sediment and trash from all inlets to the basin. The forebay should be sized to accumulate 5-years of sediment before requiring sediment removal. A maintenance ramp and access should be provided to allow the required equipment to be used for forebay maintenance (MARC Manual). Forebays should be inspected annually to ensure they drain properly and that small pools are not being created.

6.4.4 Basin Retrofits

The 57 basins recommended for upgrades in the CIP include provisions for adding forebays. As the City considers management of additional basins as part of the Detention Basin Management Program, the basins should be evaluated for the presence of a forebay or whether one can be added over time. The rip-rap dam recommended in the Flumes discussion above creates a sediment trap and in essence creates a forebay. This is a low-cost way to provide sediment removal and water quality benefit if the addition of a dedicated forebay is not feasible.

6.4.5 Detention Basin Location

Detention basins have been shown to be effective in providing water quality benefit and to reduce peak flows in the portion of the City south of I-70. Additionally, those basins located in areas protected by levees north of I-70 are effective at providing storage areas for subsequent pumping when the Mississippi River is in flood stage. For areas north of I-70 not protected by levees, the area within the City is flood prone from Mississippi River, Dardenne Creek and Spencer Creek flooding. Therefore, these areas are not going to benefit as much from local detention and can be excluded from the detention basin requirements.

7.0 References

Center for Watershed Protection. 2003. Impacts of Impervious Cover on Aquatic Systems. March.

McHarg, Ian. 1992. Design with Nature. John Wiley & Sons, Garden City, New York.

PBA. 2007. KC One Stream Asset Inventory Technical Memorandum. Prepared for the City of Kansas City Water Services. November 19.

PBA. 2005a. Kansas City Stream Asset Inventory Phase I-II Final Report. Prepared for the Kansas City, Missouri City Planning and Development Department. September 19.

PBA. 2005b. Johnson County Stream Asset Inventory – Project Summary. Prepared for Johnson County, Kansas Stormwater Management. August 31.

Schulte, Scott A., Patricia A. Elbert Noll and Jeffrey Henson. 2008. "Riparian Buffer Benefits and Kansas City, Missouri's Stream Setback Ordinance." Paper presented at the StormCon 2008 conference, Orlando, Florida. August.

Seattle Public Utilities and Harrera Environmental Consultants, "Seattle Street Sweeping Pilot Study," April 22, 2009.

Southeast Michigan Council of Governments (SEMCOG), "Low Impact Development Manual for Michigan: A Design Guide for Implementers and Reviewers," 2008.

Tetra Tech EMI, Patti Banks Associates, Applied Ecological Services. 2004. Stream Asset Inventory Field Sampling Procedure. Prepared for Johnson County, Kansas Public Works Department. August.

Appendix A. Nine Critical Element Plan, Spencer Creek

To view the Nine Critical Element Plan for the Spencer Creek Watershed, go online to www.stpetersmo.net/storm-water-management.aspx.

Appendix B. Detention Basin Evaluation Form

ST. PETERS STORMWATER MASTER PLAN

DETENTION BASIN EVALUATION

Detention Basin ID:______________________ Evaluator:________________________

Inspection Date: __________________

Photo Numbers and Directions:

________________________________ ____________________________________

________________________________ ____________________________________

________________________________ ____________________________________

________________________________ ____________________________________

1. Detention Type: Wet Dry

2. General Condition Description: ____

____

____

3. Outfall Structure Type: ____

4. Describe Erosion Issues: ____

____

5. Describe Sedimentation Issues: ____

____

6. Describe Land Use of Immediately Contributing Drainage Area: _____________________________

6. Threat to Infrastructure?: Yes No Describe:

7. Severity Severe 1 2 3 4 5 Minor Unknown (-1)

8. Correctability Best 1 2 3 4 5 Worst Unknown (-1)

Describe Access: ____

Appendix C. Detention Basin Water Quality Summary Tables

Detention Basin Summary Tables

Table 1. Stormwater Detention Basin Removal Efficiencies

This table summarizes the results from P8 modeling of TSS for each basin, given existing conditions. The area and general category (wet or dry) of the basin is also included.

Table 2. Stormwater Detention Basin Removal Efficiencies with Retrofits

This table summarizes the results from P8 modeling of TSS for each basin, given retrofit conditions. The area, general category (wet or dry), recommended retrofit, and flow input of the basin is also included.

Table 3. Detention Basin Characteristics

This table summarizes the detention basin and contributing watershed characteristics that were used for the P8 modeling of existing conditions.

Table 4. Detention Basin Characteristics with Retrofits

This table summarizes the detention basin and contributing watershed characteristics that were used for the P8 modeling of retrofit conditions.

Table 1. Stormwater Detention Basin Removal Efficiencies

Basin ID	Area	Wet/ Dry	TSS In	TSS Out	TSS Removal	TSS In	TSS Out
	ac	W or D	lb/yr	lb/yr	%	mg/L	mg/L
DB-6869-02	3.52	W	7,787	201	97.4	107	2.8
DB-6870-15	0.34	D	1,681	1,080	35.8	108	70.0
DB-6870-16	0.22	D	1,539	1,122	27.1	105	77.3
DB-6871-01	0.38	D	17,369	12,528	27.9	108	79.7
DB-6871-03	0.27	D	17,284	12,779	26.1	108	81.0
DB-6965-01	0.44	D	871	560	35.7	106	68.6
DB-6968-02	0.76	W	6,804	628	90.8	107	9.9
DB-6969-02	1.91	W	571	6	99.0	103	1.0
DB-6969-03	4.63	W	4,183	30	99.3	105	0.8
DB-6969-04	1.22	W	589	52	91.3	91	8.0
DB-6969-06	0.34	D	238	158	33.6	107	71.0
DB-6969-07	0.86	D	789	412	47.8	105	54.9
DB-6969-08	0.47	D	4,333	3,447	20.4	106	85.2
DB-6969-09	0.60	D	436	254	41.7	105	60.8
DB-6969-10	0.39	D	2,882	2,439	15.4	106	88.5
DB-6970-03	5.83	W	2,583	10	99.6	107	0.4
DB-6971-08	1.27	W	8,257	612	92.6	108	8.0
DB-7065-01	0.42	D	314	186	40.8	107	62.3
DB-7065-02	0.39	D	267	170	36.3	107	67.6
DB-7065-03	0.53	D	927	405	56.3	107	46.7

Basin ID	Area	Wet/ Dry	TSS In	TSS Out	TSS Removal	TSS In	TSS Out
	ac	W or D	lb/yr	lb/yr	%	mg/L	mg/L
DB-7065-04	0.21	D	22,034	11,671	47.0	106	57.5
DB-7065-05	2.89	W	2,915	37	98.7	106	1.4
DB-7067-01	3.31	W	17,131	886	94.8	121	6.3
DB-7067-02	0.53	D	419	269	35.8	76	48.5
DB-7069-06	15.56	W	8,593	33	99.6	104	0.4
DB-7069-07	1.40	W	3,548	81	97.7	107	81.4
DB-7069-08	0.88	W	2,494	77	96.9	107	3.3
DB-7069-10	1.54	W	7,289	290	96.0	107	4.2
DB-7069-12	0.14	D	112	67	40.4	103	60.8
DB-7069-13	0.63	D	2,143	1,529	28.7	106	76.1
DB-7070-03	0.19	D	19,124	15,815	17.3	108	89.4
DB-7070-10	0.85	D	111	52	53.1	91	42.7
DB-7071-04	1.40	W	23,630	2,625	88.9	108	12.0
DB-7169-01	0.43	D	692	483	30.2	107	73.0
DB-7169-02	0.16	D	17,617	12,465	29.2	108	78.4
DB-7169-04	0.27	D	17,041	12,621	25.9	107	81.1
DB-7169-08	0.55	W	401	11	97.2	104	3.0
DB-7169-09	0.20	D	1,026	684	33.3	107	71.9
DB-7169-10	1.20	D	370	162	56.2	100	43.6
DB-7169-11	0.14	D	478	334	30.1	104	72.8
DB-7267-04	0.37	D	8,939	6,031	32.5	93	25.8
DB-7267-14	0.44	D	23,090	18,710	19.0	108	88.8

Basin ID	Area ac	Wet/ Dry W or D	TSS In lb/yr	TSS Out lb/yr	TSS Removal %	TSS In mg/L	TSS Out mg/L
DB-7268-04	0.84	D	2,951	1,547	47.6	107	56.8
DB-7268-06	0.90	W	4,649	205	95.6	107	4.7
DB-7268-07	4.38	W	2,556	8	99.7	106	0.3
DB-7269-01	2.13	W	17,214	1,293	92.5	107	8.1
DB-7270-01	1.04	W	4,064	110	97.3	108	2.9
DB-7270-09	0.63	D	9,460	7,001	26.0	107	80.4
DB-7270-10	1.37	W	6,111	162	97.3	108	2.9
DB-7270-15	0.92	W	11,305	1,075	90.5	108	10.3
DB-7366-01	0.35	D	25,834	22,061	14.6	108	93.5
DB-7367-04	0.23	D	2,535	2,094	17.4	108	90.2
DB-7367-07	0.27	D	2,694	1,833	32.0	108	74.2
DB-7367-10	0.24	D	3,278	2,665	18.7	107	80.1
DB-7367-19	0.25	D	3,997	3,563	10.9	107	83.0
DB-7367-20	0.93	W	7,877	1,211	84.6	106	16.3
DB-7368-08	0.86	W	3,241	125	96.1	107	4.1
DB-7368-09	0.57	W	701	10	98.6	105	1.5
DB-7369-04	0.97	W	2,273	43	98.1	107	2.0
DB-7369-06	1.79	W	14,745	765	94.8	107	5.6
DB-7369-07	0.32	D	7,934	5,476	31.0	107	73.3
DB-7369-11	0.92	W	14,424	2,391	83.4	108	18.0
DB-7370-14	0.72	D	11,977	10,247	14.4	107	91.9
DB-7370-16	0.18	D	17,531	12,464	28.9	108	77.4

Basin ID	Area ac	Wet/ Dry W or D	TSS In lb/yr	TSS Out lb/yr	TSS Removal %	TSS In mg/L	TSS Out mg/L
DB-7467-04	0.15	D	15,689	12,406	20.9	108	86.0
DB-7467-06	0.24	D	5,816	3,927	32.5	107	66.5
DB-7467-07	0.40	D	9,236	8,047	12.9	108	94.6
DB-7467-12	0.11	D	9,086	8,076	11.1	108	95.2
DB-7467-13	0.44	D	3,290	224	93.2	108	7.3
DB-7467-14	0.11	D	274	201	26.6	101	74.0
DB-7467-15	0.26	D	683	579	15.2	101	84.6
DB-7467-16	0.38	D	5,849	4,471	23.6	107	82.5
DB-7468-01	0.37	W	631	12	98.1	106	2.0
DB-7468-06	2.21	W	33,318	3,504	89.5	107	11.3

Appendix C Table 2. Stormwater Detention Basin Removal Efficiencies with Retrofits

Basin ID	Area ac	Wet/Dry W or D	Retrofit	Flow Input ac-ft	TSS In lb/yr	TSS Out lb/yr	TSS Removal %	TSS In mg/L	TSS Out mg/L
DB-6869-02	3.52	W	WBR	267	7787	201	97.4	107	2.8
DB-6870-15	0.34	D	DWR	57.5	1681	163	90.3	108	10.4
DB-6870-16	0.22	D	DDR	53.9	1539	839	45.5	105	57.2
DB-6871-01	0.38	D	None	591	17369	12528	27.9	108	79.7
DB-6871-03	0.27	D	DDR	588	17284	11982	30.7	108	42.9
DB-6965-01	0.44	D	DDR	30.2	871	516	40.8	106	62.9
DB-6968-02	0.76	W	WBR	234	6804	628	90.8	107	9.9
DB-6969-02	0.86	W	None	20.5	571	5.8	99.0	103	1
DB-6969-03	4.63	W	None	146	4183	30.1	99.3	105	0.8
DB-6969-04	1.22	W	None	23.8	589	51.5	91.3	91	8
DB-6969-06	0.34	D	DWR	8.2	238	4.4	98.2	107	2
DB-6969-07	0.86	D	DWR	27.6	789	30.4	96.1	105	4.1
DB-6969-08	0.47	D	DWR	150	4333	411	90.5	106	10.1
DB-6969-09	0.60	D	DDR	15.3	436	252	42.2	107	60.4
DB-6969-10	0.39	D	DWR	100	2882	251	91.3	106	9.2
DB-6970-03	5.83	W	None	89.1	2583	10.4	99.6	107	0.4
DB-6971-08	1.27	W	WBR	282	8257	612	92.6	108	8
DB-7065-01	0.42	D	DDR	10.8	314	180	42.7	107	60
DB-7065-02	0.39	D	DDR	9.2	267	170	36.3	107	67.7
DB-7065-03	0.53	D	DDR	31.9	927	403	56.5	107	46.4
DB-7065-04	0.21	D	DDR	767	22034	9285	57.9	106	48.2
DB-7065-05	2.89	W	WBR	100.8	2915	37.4	98.7	106	1.4
DB-7067-01	3.31	W	WBR	519	17131	886	94.8	121	6.3
DB-7067-02	0.31	D	DDR	20.4	419	262	37.5	75.6	47.4
DB-7069-06	15.56	W	WBR	304	8593	33.2	99.6	104	0.4
DB-7069-07	1.40	W	WBR	212.7	3548	81.4	97.7	107	81.4

Basin ID	Area ac	Wet/Dry W or D	Retrofit	Flow Input ac-ft	TSS In lb/yr	TSS Out lb/yr	TSS Removal %	TSS In mg/L	TSS Out mg/L
DB-7069-08	0.88	W	None	85.6	2494	76.5	96.9	107	3.3
DB-7069-10	1.54	W	WBR	251	7289	290	96.0	107	4.2
DB-7069-12	0.14	D	DWR	4	112	5.2	95.4	103	4.8
DB-7069-13	0.63	D	DWR	74.3	2143	197	90.8	106	9.8
DB-7070-03	0.19	D	DDR	651	19124	15618	18.3	108	84.5
DB-7070-10	0.85	D	DWR	4.5	111	6.9	93.8	91	5.6
DB-7071-04	1.40	W	WBR	803.2	23630	2625.1	88.9	108	12
DB-7169-01	0.43	D	DDR	23.8	692	472	31.8	107	72.1
DB-7169-02	0.16	D	DWR	602	17617	4859	67.9	108	32.2
DB-7169-04	0.27	D	DWR	583	17041	5574	70.4	107	35.1
DB-7169-08	0.55	W	WBR	14.2	401	11.4	97.2	104	3
DB-7169-09	0.20	D	DWR	35.3	1026	96.1	90.6	107	10
DB-7169-10	1.20	D	DWR	13.6	370	13.7	96.3	100	3.7
DB-7169-11	0.14	D	DWR	16.9	478	32.4	93.2	104	7.1
DB-7267-04	0.37	D	DDR	306	8939	6019	32.7	107	71.5
DB-7267-14	0.44	D	DDR	789	23090	18069	21.7	108	85.3
DB-7268-04	0.84	W	WBR	101	2951	1547	47.6	107	56.8
DB-7268-06	0.90	W	WBR	159	4649	205	95.6	107	4.7
DB-7268-07	4.38	W	WBR	88.8	2556	8.3	99.7	106	0.3
DB-7269-01	2.13	W	WBR	590	17214	1293	92.5	107	8.1
DB-7270-01	1.04	W	WBR	139	4064	110	97.3	108	2.9
DB-7270-09	0.63	D	None	324	9460	7001	26.0	107	80.4
DB-7270-10	1.37	W	WBR	208	6111	162	97.3	108	2.9
DB-7270-15	0.92	W	WBR	386	11305	1075	90.5	108	10.3
DB-7366-01	0.35	D	DDR	882	25834	21562	16.5	108	91.3
DB-7367-04	0.23	D	DWR	86.5	2535	392	84.5	108	16.7
DB-7367-07	0.27	D	DWR	91.9	2694	380	85.9	108	14.7
DB-7367-10	0.24	D	DDR	112	3278	2663	18.8	107	15.2

Basin ID	Area ac	Wet/Dry W or D	Retrofit	Flow Input ac-ft	TSS In lb/yr	TSS Out lb/yr	TSS Removal %	TSS In mg/L	TSS Out mg/L
DB-7367-19	0.25	D	DDR	137	3997	3547	11.3	107	80.2
DB-7367-20	0.93	W	WBR	272	7877	1211	84.6	106	16.3
DB-7368-08	0.86	W	WBR	111	3241	125	96.1	107	4.1
DB-7368-09	0.57	W	WBR	24.5	701	9.8	98.6	105	1.5
DB-7369-04	0.97	W	WBR	78.3	2273	42.5	98.1	107	2
DB-7369-06	1.79	W	WBR	509	14745	765	94.8	107	5.6
DB-7369-07	0.32	D	DDR	272	7934	4810	39.4	107	65.8
DB-7369-11	0.92	W	WBR	493	14424	2391	83.4	108	18
DB-7370-14	0.72	D	None	411	11977	10247	14.4	107	91.9
DB-7370-16	0.18	D	DDR	597	17531	7656	56.3	108	47.2
DB-7467-04	0.15	D	DWR	536	15689	5323	66.1	108	36.5
DB-7467-06	0.24	D	None	199	5816	3927	32.5	107	66.5
DB-7467-07	0.40	D	None	315	9236	8047	12.9	108	94.6
DB-7467-12	0.11	D	DDR	310	9086	8055	11.3	108	96.1
DB-7467-13	0.44	D	None	112	3290	224	93.2	108	7.3
DB-7467-14	0.11	D	DDR	9.9	274	194	29.2	101	72.1
DB-7467-15	0.26	D	DDR	24.5	683	575	15.8	101	84.4
DB-7467-16	0.38	D	DDR	201	5849	4370	25.3	107	80.7
DB-7468-01	0.37	W	WBR	21.8	631	12	98.1	106	2
DB-7468-06	2.21	W	None	1145	33318	3504	89.5	107	11.3

WBR - Wet Basin Retrofit - No change in basin volume

DWR - Dry to Wet Basin Retrofit - Provide permanent pool volume

DDR - Dry Basin Retrofit - Increase in flood pool volume

Appendix C Table 3. Detention Basin Characteristics

	Detention Basin Characteristics						Watershed	
	Wet/Dry	Area	Perm Pool VOLUME	Flood Pool VOLUME	Weir Length	Orifice Equivalent Diameter	Area	Impervious
Basin ID	W or D	ac	ac-ft	ac-ft	ft	ft	ac	Fraction
DB-6869-02	W	3.52	10.19	14.13	20	-	30.6	0.26
DB-6870-15	D	0.34	0	1	-	0.92	5.1	0.34
DB-6870-16	D	0.22	0	0.88	-	0.92	16.6	0.09
DB-6871-01	D	0.38	0	1.3	-	1.49	27.8	0.65
DB-6871-03	D	0.27	0	1.76	-	0.86	27.3	0.66
DB-6965-01	D	0.44	0	1.82	-	0.83	6.7	0.13
DB-6968-02	W	0.76	2.1	6.65	12	-	32.9	0.21
DB-6969-02	W	1.91	3.6	4.61	15	-	10.4	0.05
DB-6969-03	W	4.63	44	0	10	-	40.9	0.10
DB-6969-04	W	1.22	1.8	3.68	5	-	35.0	0.01
DB-6969-06	D	0.34	0	2	-	0.98	1.1	0.21
DB-6969-07	D	0.86	0	2.04	-	1.03	8.5	0.09
DB-6969-08	D	0.47	0	2.8	-	1.69	33.1	0.13
DB-6969-09	D	0.60	0	1.8	-	1.13	5.2	0.08
DB-6969-10	D	0.39	0	2.3	-	2.26	22.0	0.13
DB-6970-03	W	5.83	32.6	0	10	-	15.3	0.17
DB-6971-08	W	1.27	3	14.1	20	-	24.3	0.35
DB-7065-01	D	0.42	0	1.82	-	2.39	1.5	0.22
DB-7065-02	D	0.39	0	1.9	-	0.83	1.6	0.17
DB-7065-03	D	0.53	0	2.1	-	0.33	4.7	0.20
DB-7065-04	D	0.21	0	1.4	-	0.33	197.1	0.11
DB-7065-05	W	2.89	6	3.5	10	-	19.5	0.15
DB-7067-01	W	3.31	15.8	15.1	35	-	43.5	0.54

	Detention Basin Characteristics						Watershed	
	Wet/Dry	Area	Perm Pool VOLUME	Flood Pool VOLUME	Weir Length	Orifice Equivalent Diameter	Area	Impervious
Basin ID	W or D	ac	ac-ft	ac-ft	ft	ft	ac	Fraction
DB-7067-02	D	0.42	0	3	-	0.65	56.5	0.00
DB-7069-06	W	0.39	114	22	3	-	116.4	0.07
DB-7069-07	W	0.53	6.6	0	3	-	15.1	0.24
DB-7069-08	W	0.21	2.9	0	35	-	10.6	0.24
DB-7069-10	W	1.54	8.5	0	10	-	43.2	0.17
DB-7069-12	D	0.14	0	0.42	-	0.46	2.0	0.05
DB-7069-13	D	0.63	0	4.5	-	1.13	16.4	0.13
DB-7070-03	D	0.19	0	1.17	-	4.00	38.1	0.52
DB-7070-10	D	0.85	0	3.3	-	0.83	6.6	0.01
DB-7071-04	W	1.40	4.2	2.9	3.5	-	31.6	0.78
DB-7169-01	D	0.43	0	2.4	-	2.50	3.2	0.22
DB-7169-02	D	0.16	0	0.89	-	0.63	49.1	0.37
DB-7169-04	D	0.27	0	1.3	-	1.00	58.3	0.30
DB-7169-08	W	0.55	0.4	1.32	10	-	5.4	0.07
DB-7169-09	D	0.20	0	0.53	-	0.80	5.0	0.21
DB-7169-10	D	1.20	0	2.1	-	1.13	10.3	0.03
DB-7169-11	D	0.14	0	0.58	-	0.56	6.5	0.07
DB-7267-04	D	0.37	0	0.75	-	2.75	31.6	0.29
DB-7267-14	D	0.44	0	4.1	-	1.50	67.9	0.36
DB-7268-04	D	0.84	0	1.2	-	1.38	12.5	0.24
DB-7268-06	W	0.90	4.3	3.2	20	-	16.4	0.29
DB-7268-07	W	4.38	29.2	4.5	1	-	21.1	0.12
DB-7269-01	W	2.13	7.6	0	2	-	65.2	0.27
DB-7270-01	W	1.04	3.4	1.9	1	-	12.0	0.35
DB-7270-09	D	0.63	0	2.5	-	2.36	37.2	0.26

	Detention Basin Characteristics						**Watershed**	
	Wet/Dry	**Area**	**Perm Pool VOLUME**	**Flood Pool VOLUME**	**Weir Length**	**Orifice Equivalent Diameter**	**Area**	**Impervious**
Basin ID	**W or D**	**ac**	**ac-ft**	**ac-ft**	**ft**	**ft**	**ac**	**Fraction**
DB-7270-10	W	1.37	14.3	0	100	-	12.2	0.52
DB-7270-15	W	0.92	4.1	0	4	-	27.2	0.43
DB-7366-01	D	0.35	0	3.8	-	2.00	72.0	0.37
DB-7367-04	D	0.23	0	1.94	-	1.00	6.4	0.41
DB-7367-07	D	0.27	0	1.07	-	0.84	6.6	0.42
DB-7367-10	D	0.24	0	1.08	-	2.76	12.9	0.26
DB-7367-19	D	0.25	0	2.03	-	4.00	18.5	0.22
DB-7367-20	W	0.93	0.45	5.09	10	-	60.2	0.13
DB-7368-08	W	0.86	3	0	8	-	13.2	0.25
DB-7368-09	W	0.57	2.2	1.9	1.3	-	6.9	0.10
DB-7369-04	W	0.97	6.4	0	10	-	12.8	0.18
DB-7369-06	W	1.79	11.4	4	4	-	92.5	0.16
DB-7369-07	D	0.32	0	0.9	-	1.38	29.0	0.28
DB-7369-11	W	0.92	0.44	1.8	4	-	40.2	0.37
DB-7370-14	D	0.72	0	5.5	-	3.17	50.9	0.24
DB-7370-16	D	0.18	0	0.5	-	1.92	29.4	0.62
DB-7467-04	D	0.15	0	0.69	-	2.00	46.2	0.35
DB-7467-06	D	0.24	0	0.48	-	3.50	21.3	0.28
DB-7467-07	D	0.40	0	3.44	-	2.59	19.2	0.50
DB-7467-12	D	0.11	0	1.3	-	1.66	26.7	0.35
DB-7467-13	D	0.44	0	2.05	-	0.53	6.7	0.51
DB-7467-14	D	0.11	0	0.44	-	0.73	6.0	0.04
DB-7467-15	D	0.26	0	3.125	-	1.61	15.1	0.04
DB-7467-16	D	0.38	0	1.73	-	1.76	23.0	0.26
DB-7468-01	W	0.37	1.2	0.8	2	-	4.2	0.15

	Detention Basin Characteristics						Watershed	
	Wet/Dry	**Area**	**Perm Pool VOLUME**	**Flood Pool VOLUME**	**Weir Length**	**Orifice Equivalent Diameter**	**Area**	**Impervious**
Basin ID	**W or D**	**ac**	**ac-ft**	**ac-ft**	**ft**	**ft**	**ac**	**Fraction**
DB-7468-06	W	2.21	9.16	8.01	10	-	161.1	0.21

Appendix C Table 4. Detention Basin Characteristics with Retrofits

		Basin									Watershed	
	Retrofit Recommendation	Area	Exist. Perm Pool VOLUME	Proposed Perm Pool AREA	Proposed Perm Pool VOLUME	Existing.Flood Pool VOLUME	Proposed Flood Pool AREA	Proposed Flood Pool VOLUME	Weir Length	Orifice Equivalent Diameter	Area	Impervious
Basin ID		**ac**	**ac-ft**	**ac**	**ac-ft**	**ac-ft**	**ac**	**ac-ft**	**ft**	**ft**	**ac**	**Fraction**
DB-6869-02	Wet Basin Retrofit	3.52	10.19			14.13			20	-	30.6	0.26
DB-6870-15	Dry to Wet Retrofit	0.34	0	0.34	0.23	1	0.34	1.00	-	0.92	5.1	0.34
DB-6870-16	Dry Detention Retrofit	0.22	0			0.88	1.14	4.57	-	0.92	16.6	0.09
DB-6871-01	None	0.38	0			1.3			-	1.49	27.8	0.65
DB-6871-03	Dry Detention Retrofit	0.27	0			1.76	0.41	2.70	-	0.86	27.3	0.66
DB-6965-01	Dry Detention Retrofit	0.44	0			1.819	0.68	2.85	-	0.83	6.7	0.13
DB-6968-02	Wet Basin Retrofit	0.76	2.1			6.636			12	-	32.9	0.21
DB-6969-02	None	0.86	3.6	0.86	0.27	4.61	2.00	4.61	15	-	10.4	0.05
DB-6969-03	None	4.63	44			0			10	-	40.9	0.10
DB-6969-04	None	1.22	1.8			3.68			5	-	35.0	0.01
DB-6969-06	Dry to Wet Retrofit	0.34	0	0.34	0.25	2	2.00	5.97	-	0.98	1.1	0.21
DB-6969-07	Dry to Wet Retrofit	0.86	0	0.86	0.27	2.044	0.86	2.04	-	1.03	8.5	0.09
DB-6969-08	Dry to Wet Retrofit	0.47	0	0.47	1.54	2.8	0.47	2.80	-	1.69	33.1	0.13
DB-6969-09	Dry Detention Retrofit	0.60	0			1.8	0.63	1.91	-	1.13	5.2	0.08
DB-6969-10	Dry to Wet Retrofit	0.39	0	0.39	1.07	2.3	0.39	2.30	-	2.26	22.0	0.13
DB-6970-03	None	5.83	32.6			0			10	-	15.3	0.17
DB-6971-08	Wet Basin Retrofit	1.27	3			14.1			20	-	24.3	0.35
DB-7065-01	Dry Detention Retrofit	0.42	0			1.82	0.45	1.95	-	2.39	1.5	0.22
DB-7065-02	Dry Detention Retrofit	0.39	0			1.9	0.39	1.92	-	0.83	1.6	0.17
DB-7065-03	Dry Detention Retrofit	0.53	0			2.1	0.54	2.13	-	0.33	4.7	0.20
DB-7065-04	Dry Detention Retrofit	0.21	0			1.4	0.42	2.78	-	0.33	197.1	0.11
DB-7065-05	Wet Basin Retrofit	2.89	6			3.5			10	-	19.5	0.15
DB-7067-01	Wet Basin Retrofit	3.31	15.8			15.1		21.10	35	-	43.5	0.54
DB-7067-02	Dry Detention Retrofit	0.42	0			3	0.36	3.45	-	0.65	56.5	0.00
DB-7069-06	Wet Basin Retrofit	0.39	114			22			3	-	116.4	0.07
DB-7069-07	Wet Basin Retrofit	0.53	6.6			0			3	-	15.1	0.24
DB-7069-08	None	0.21	2.9			0			35	-	10.6	0.24
DB-7069-10	Wet Basin Retrofit	1.54	8.5			0			10	-	43.2	0.17
DB-7069-12	Dry to Wet Retrofit	0.14	0	0.14	0.07	0.42	0.14	0.42	-	0.46	2.0	0.05
DB-7069-13	Dry to Wet Retrofit	0.63	0	0.63	0.13	4.5	0.63	4.50	-	1.13	16.4	0.13
DB-7070-03	Dry Detention Retrofit	0.19	0			1.171	0.64	3.95	-	4.00	38.1	0.52
DB-7070-10	Dry to Wet Retrofit	0.85	0	0.85	0.23	3.3	0.85	3.30	-	0.83	6.6	0.01
DB-7071-04	Wet Basin Retrofit	1.40	4.2			2.9			3.5	-	31.6	0.78

DB-7169-01	Dry Detention Retrofit	0.43	0			2.4	0.57	3.20	-	2.50	3.2	0.22
DB-7169-02	Dry to Wet Retrofit	0.16	0	0.16	0.60	0.89	0.89	5.63	-	0.63	49.1	0.37
DB-7169-04	Dry to Wet Retrofit	0.27	0	0.27	0.58	1.3	1.30	4.85	-	1.00	58.3	0.30
DB-7169-08	Wet Basin Retrofit	0.55	0.4			1.322			10	-	5.4	0.07
DB-7169-09	Dry to Wet Retrofit	0.20	0	0.20	0.19	0.53	0.20	0.53	-	0.80	5.0	0.21
DB-7169-10	Dry to Wet Retrofit	1.20	0	1.20	0.40	2.1	1.20	2.10	-	1.13	10.3	0.03
DB-7169-11	Dry to Wet Retrofit	0.14	0	0.14	0.25	0.58	0.14	0.58	-	0.56	6.5	0.07
DB-7267-04	Dry Detention Retrofit	0.37	0			0.75	0.45	0.92	-	2.75	31.6	0.29
DB-7267-14	Dry Detention Retrofit	0.44	0			4.1	0.66	6.13	-	1.50	67.9	0.36
DB-7268-04	Wet Basin Retrofit	0.84	0			1.2			-	1.38	12.5	0.24
DB-7268-06	Wet Basin Retrofit	0.90	4.3			3.2			20	-	16.4	0.29
DB-7268-07	Wet Basin Retrofit	4.38	29.2			4.5			1	-	21.1	0.12
DB-7269-01	Wet Basin Retrofit	2.13	7.6			0			2	-	65.2	0.27
DB-7270-01	Wet Basin Retrofit	1.04	3.4			1.9		3.76	1	-	12.0	0.35
DB-7270-09	None	0.63	0			2.5			100	-	37.2	0.26
DB-7270-10	Wet Basin Retrofit	1.37	14.3			0			4	-	12.2	0.52
DB-7270-15	Wet Basin Retrofit	0.92	4.1			0			-	2.00	27.2	0.43
DB-7366-01	Dry Detention Retrofit	0.35	0			3.8	0.58	6.30	-	1.00	72.0	0.37
DB-7367-04	Dry to Wet Retrofit	0.23	0	0.23	0.23	1.94	0.23	1.94	-	0.84	6.4	0.41
DB-7367-07	Dry to Wet Retrofit	0.27	0	0.27	0.26	1.07	0.27	1.07	-	2.76	6.6	0.42
DB-7367-10	Dry Detention Retrofit	0.24	0			1.08	0.28	1.26	-	4.00	12.9	0.26
DB-7367-19	Dry Detention Retrofit	0.25	0			2.033	0.30	2.40	10	-	18.5	0.22
DB-7367-20	Wet Basin Retrofit	0.93	0.4458			5.09			8	-	60.2	0.13
DB-7368-08	Wet Basin Retrofit	0.86	3			0			1.3	-	13.2	0.25
DB-7368-09	Wet Basin Retrofit	0.57	2.2			1.9			10	-	6.9	0.10
DB-7369-04	Wet Basin Retrofit	0.97	6.4			0		1.77	4	-	12.8	0.18
DB-7369-06	Wet Basin Retrofit	1.79	11.4			4			-	1.38	92.5	0.16
DB-7369-07	Dry Detention Retrofit	0.32	0			0.9	0.85	2.38	4	-	29.0	0.28
DB-7369-11	Wet Basin Retrofit	0.92	0.44			1.8			-	3.17	40.2	0.37
DB-7370-14	None	0.72	0			5.5			-	1.92	50.9	0.24
DB-7370-16	Dry Detention Retrofit	0.18	0	0.18	0.27	0.5	0.18	0.50	-	2.00	29.4	0.62
DB-7467-04	Dry to Wet Retrofit	0.15	0	0.15	1.18	0.69	0.15	0.69	-	3.50	46.2	0.35
DB-7467-06	None	0.24	0			0.48			-	2.59	21.3	0.28
DB-7467-07	None	0.40	0			3.44			-	1.66	19.2	0.50
DB-7467-12	Dry Detention Retrofit	0.11	0			1.3	0.19	2.38	-	0.53	26.7	0.35
DB-7467-13	None	0.44	0			2.05			-	0.73	6.7	0.51
DB-7467-14	Dry Detention Retrofit	0.11	0			0.44	0.15	0.62	-	1.61	6.0	0.04
DB-7467-15	Dry Detention Retrofit	0.26	0			3.125	0.29	3.53	-	1.76	15.1	0.04
DB-7467-16	Dry Detention Retrofit	0.38	0			1.73	0.48	2.17	2	-	23.0	0.26
DB-7468-01	Wet Basin Retrofit	0.37	1.2			0.8			10	-	4.2	0.15
DB-7468-06	None	2.21	9.16			8.01			10		161.1	0.21

Appendix D. Stream Classification Summary

In April and May, Black & Veatch and PBA staff joined the City to evaluate stream stability and habitat within the City limits. As a team, Black & Veatch and PBA conducted a geomorphology and stream health field survey of the 47 miles of streams in the City of St. Peters. The team applied standards developed by the Kansas City Metropolitan Chapter of American Public Works Association and various state and federal natural resource agencies. This evaluation resulted in two scores: a channel condition score and a stream asset inventory (SAI) score. This appendix summarizes the significance of each score and provides a photograph of a representative reach.

Channel Condition Score

Black & Veatch applied a Channel Condition Scoring Matrix based on the matrix developed by the Kansas City chapter of American Public Works Association to determine the stability of stream reaches throughout the City. The matrix provides a comparative score of reaches throughout the City and will be used to identify areas of significant instability and to prioritize projects. The resulting score can be divided into three groups that range between 10 and 25.

Stable Streams

A rating between 10 and 13 indicates a stream of moderate stability and may require only standard levels of protection during construction in the contributing drainage area. Figure 1 presents a good example of a stable channel in St. Peters. This stream represents a restoration project; there is a diversity of vegetation, cobble bed, and very little bank erosion.

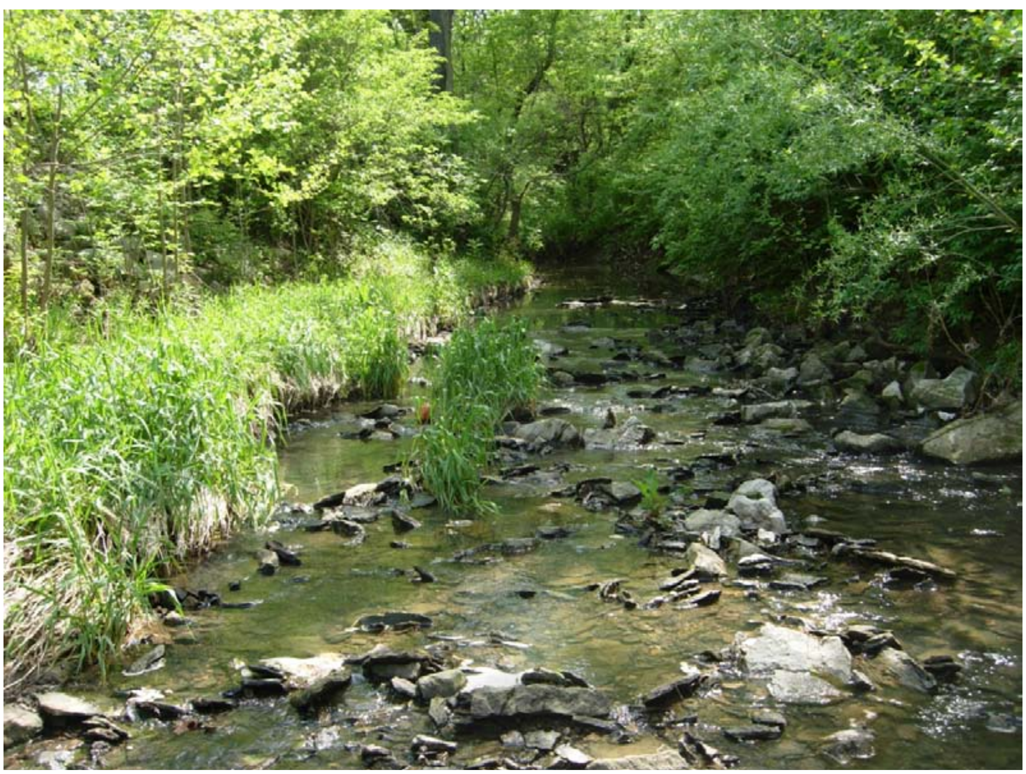


FIGURE 1. CRESCENT HILLS TRIBUTARY, SCORE: 10.2

Streams with Stability Concerns

A channel condition rating between 13 and 19 indicates that the reach may be experiencing instability and special measures may be needed to address specific issues that were rated poorly. Streams with scores in this range may have very different appearances because of the specific concern with each stream. In St. Peters, many of the channels show evidence of bank undercutting, excess sediment movement in the channel bed, debris jams, and undesirable vegetation. Figure 2 presents Spencer Creek north of Mexico Road. This reach is experiencing a transition to a wider stream after becoming incised (the channel bed material erodes and lowers the elevation). Bare soil on the banks is exposed to flow in the channel and the vegetation is mostly shrub honeysuckle, an invasive plant that out-competes native species.

FIGURE 2. SPENCER CREEK NORTH OF MEXICO, SCORE: 16

Another example of a reach with some instability is presented in Figure 3. This photograph was taken at a location along East Branch of Dardenne Creek where high banks showed evidence of active scouring. This stream channel is becoming more incised as the channel bed lowers. If not addressed, the channel will widen and many of the trees in the riparian corridor will fall into the stream.

FIGURE 3. EAST BRANCH DARDENNE CREEK, SCORE: 16

Significant Instability

A rating that is greater than 19 indicates that the stream may be experiencing significant system-wide instability. Figure 4 shows a reach of Dardenne Creek adjancent to a golf course and utility corridor. Streams in this category typically show significant erosion, active degradation, and threaten infrastructure. The vertical banks and lack of riparian corridor on this reach result in a very high score.

FIGURE 4. DARDENNE CREEK, SCORE: 22

Smaller reaches may also be scored poorly. Figure 5 was taken along a tributary to Dardenne Creek. This stream is very unstable and is actively eroding away soil on both banks.

FIGURE 5. EAST BRANCH DARDENNE CREEK, SCORE: 23

Stream Asset Inventory

PBA used the SAI procedure developed for assessing urban streams and watersheds in the Kansas City region, which incorporates the best elements of a number of accepted stream and habitat assessments. The SAI methodology provides rapid and scientifically defensible indicators of water quality, stream stability, in-stream and terrestrial habitat conditions. The assessment criteria are assigned individual weighted scores to create a composite score of stream quality at each sampled location and a relative ranking of stream quality throughout the entire watershed. Stream reaches were assigned a relative ranking from Type 1 (highest quality) through Type 5 (lowest quality) based on the relative condition of St. Peters' streams, as described and illustrated below.

Type 1 - Highest Quality

Generally described as the highest quality naturally occurring stream with little negative impact. Erosion and sedimentation is low, water quality indicators are positive and the surrounding riparian zone is healthy, mature, successional woodland or other high-quality environment.

FIGURE 6. SPENCER CREEK NEAR BIRCHWOOD DRIVE, TYPE 1

Type 2 - High Quality

This type of stream may have some down or side-cutting; however, bank and bed composition (bedrock) assist in keeping the impact low. Water quality is generally good and the riparian zone is largely intact, although vegetation may be negatively altered from that of a typical native plant association.

FIGURE 7. DARDENNE CREEK, NEAR FRONTIERS EDGE COURT, TYPE 2

Type 3 – Restorable

Deterioration of the channel and riparian corridor are more noticeable. While some remnant plant associations may be present, overall vegetative canopy cover is comprised of immature tree species. Water quality may be fair to marginal. The potential for restoration exists although erosion and sedimentation can be greater than desirable.

FIGURE 8. SPENCER CREEK, DOWNSTREAM OF MCCLAY ROAD, TYPE 3

Type 4 - Low Quality

Impacts are greater on this stream type with significant indicators of bank erosion and channel instability. The adjoining riparian corridor may be intact but vegetation is not representative of a native plant association. Water quality is typically poor.

FIGURE 9. EAST SPENCER, UPSTREAM OF OAKTREE RETIREMENT COMMUNITY, TYPE 4

Type 5 - Lowest Quality

The channel in this type is the most changed. The riparian corridor is impaired to the point of providing little protection or benefit, and erosion and sedimentation indicators are significantly high. Water quality is poor with degradation and absence of macroinvertebrates, fish, mollusks, and amphibians.

FIGURE 10. EAST SPENCER CREEK, DOWNSTREAM OF JUNGERMANN ROAD, TYPE 5

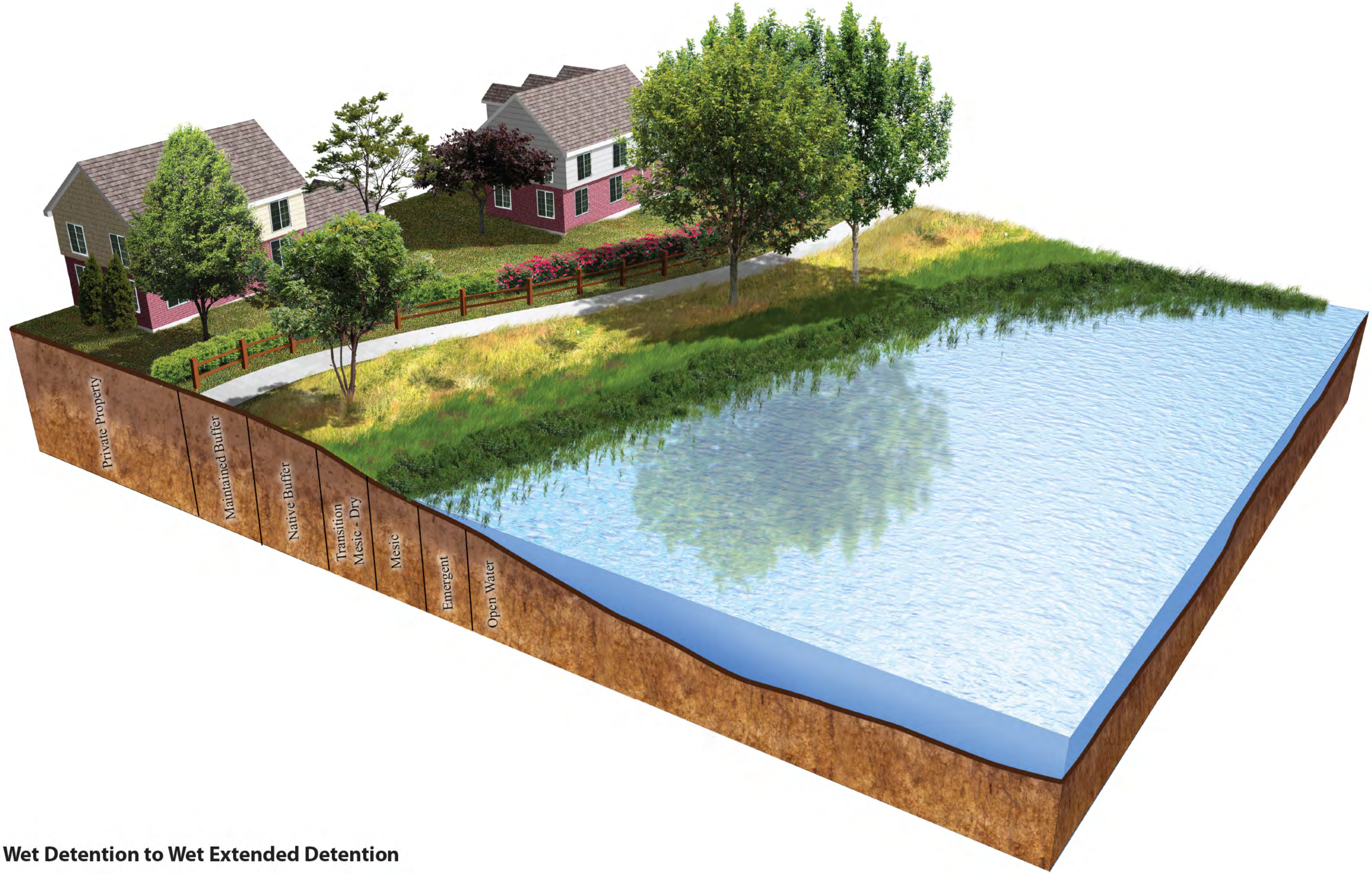
Appendix E. Detention Basin Retrofits and Stream Buffer Examples

Detention Basin Retrofit Examples

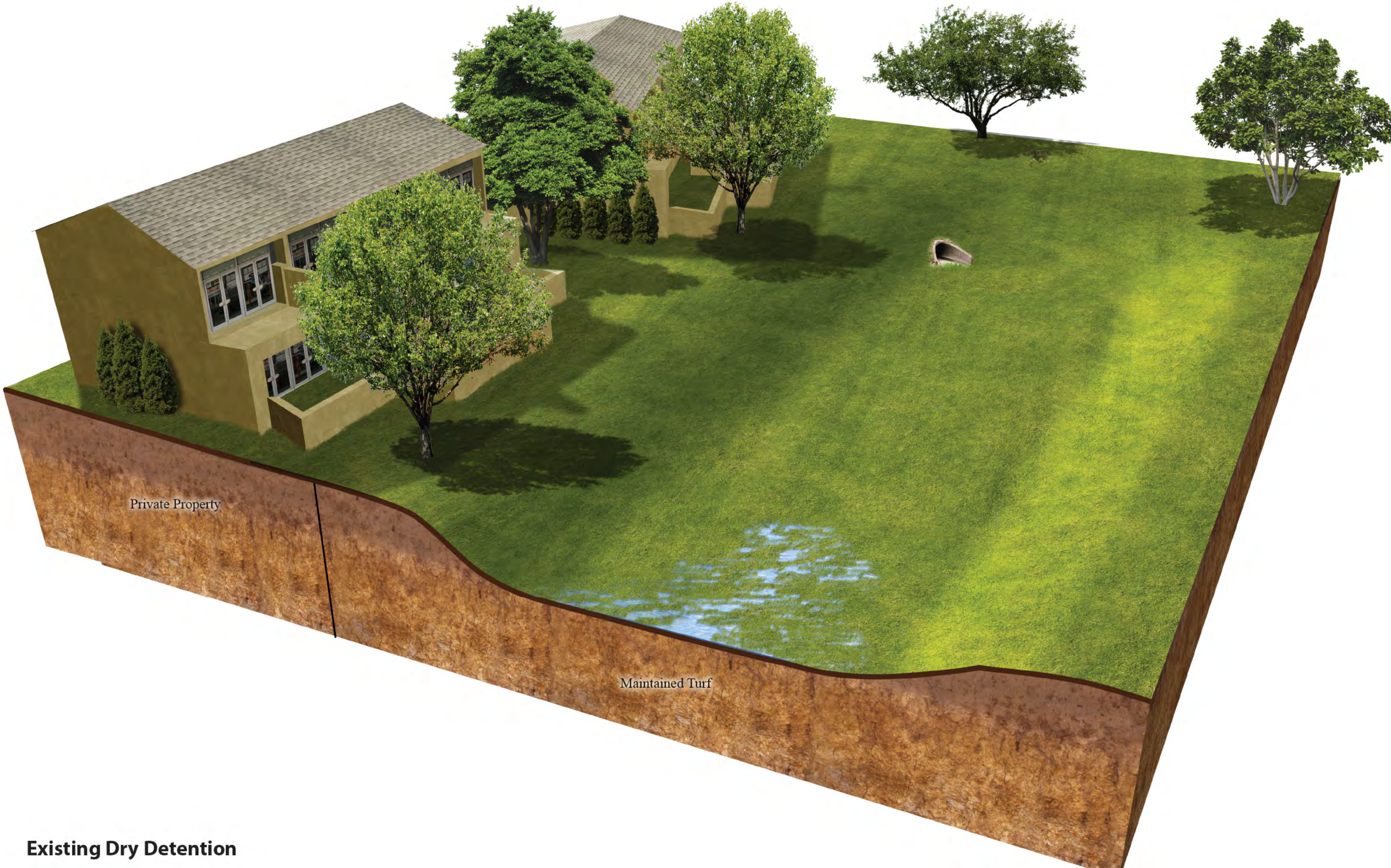
1. Wet Detention to Wet Extended Detention
2. Existing Dry Detention
3. Dry Detention to Dry Extended Detention
4. Dry Detention to Extended Wet Detention

Stream Buffer and Profile Examples

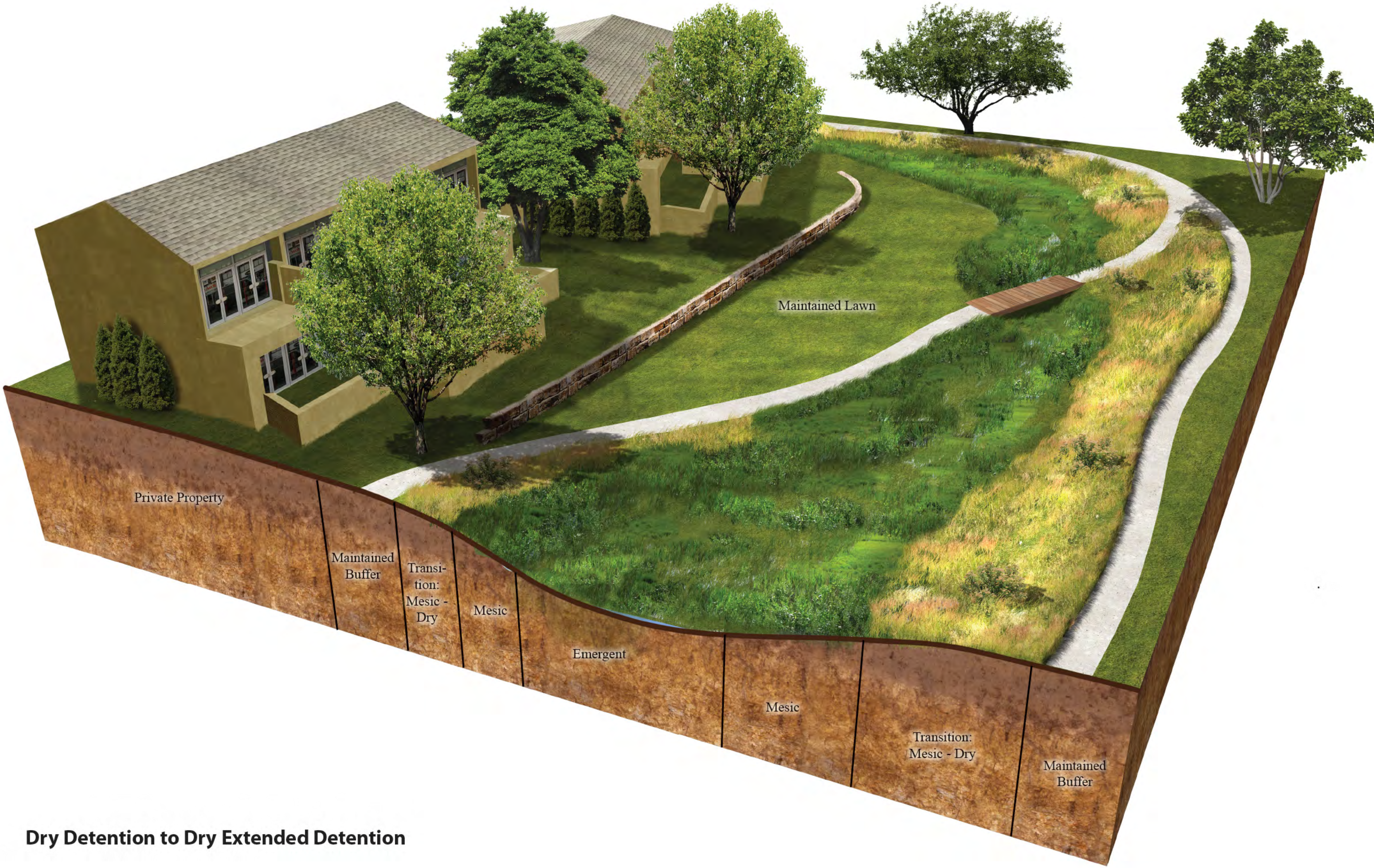
1. Stream Buffer with Recreational Trail
2. Stream Buffer with Encroaching Property Line
3. Stream Buffer with No Trail
4. Stream Profile Example for Step Pools with Grade Controls



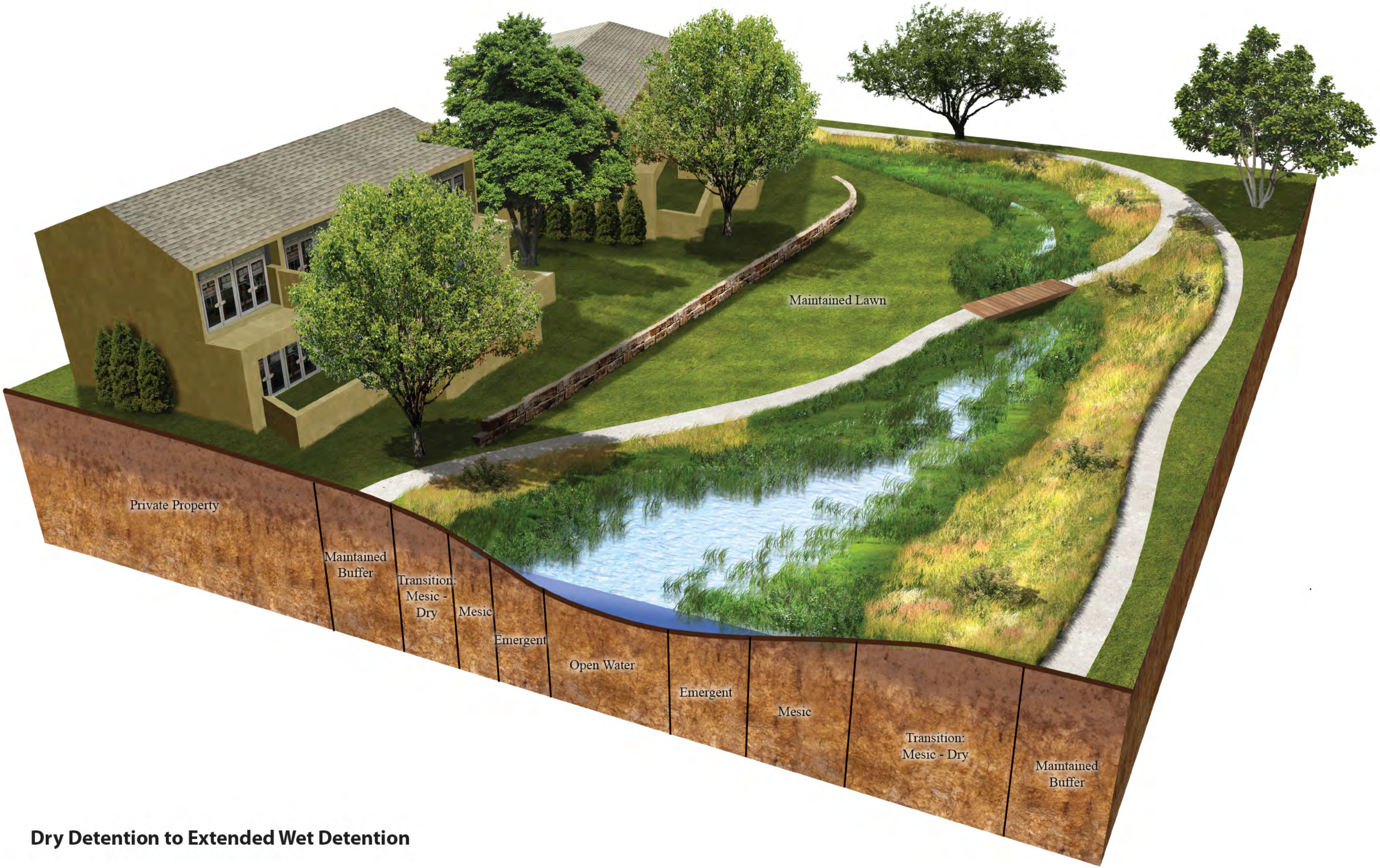
Wet Detention to Wet Extended Detention



Existing Dry Detention

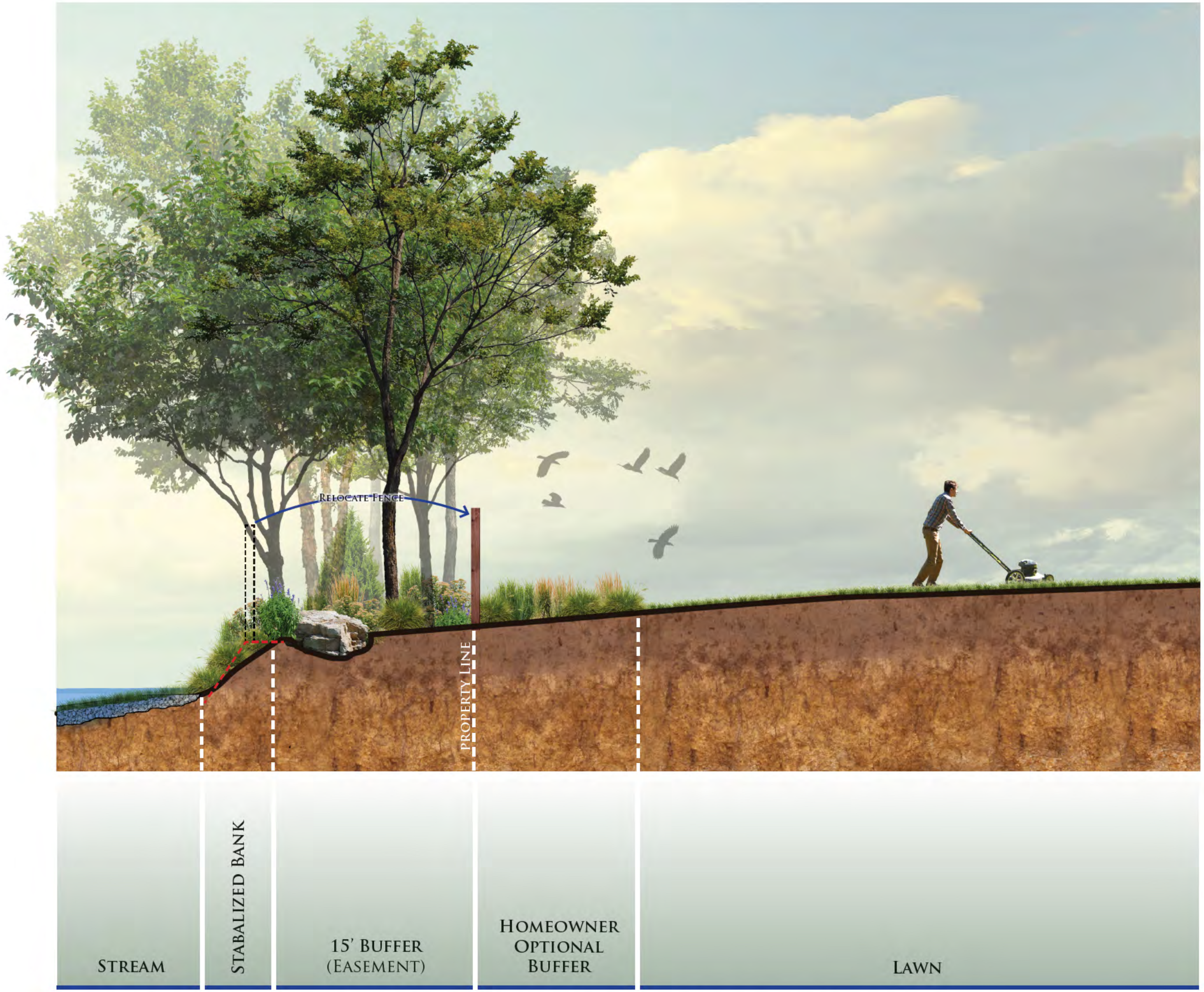


Dry Detention to Dry Extended Detention



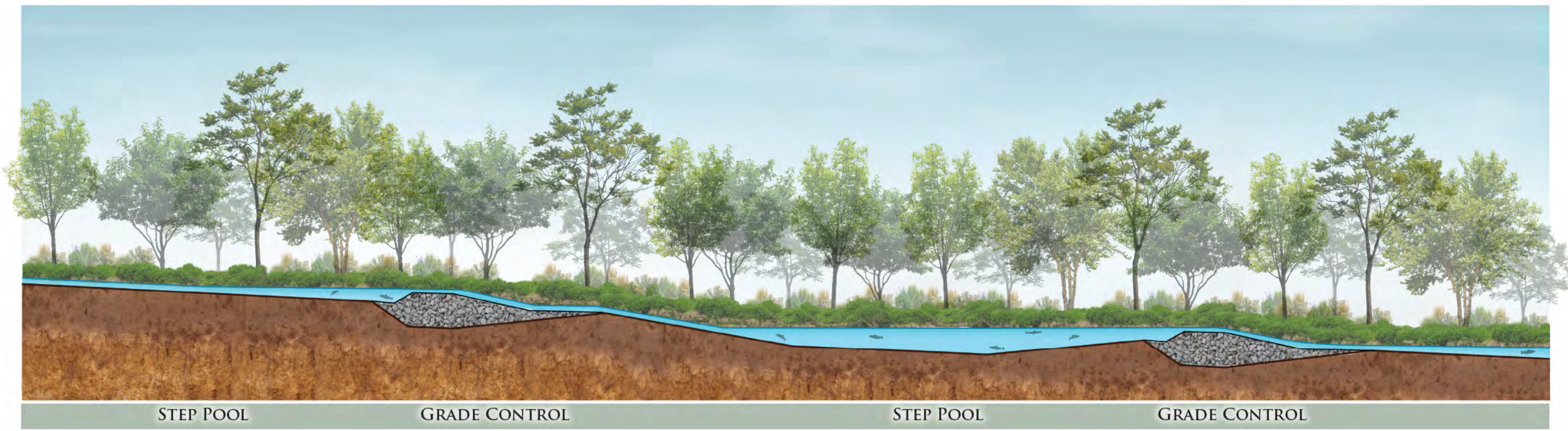
Dry Detention to Extended Wet Detention

Stream Buffer With Recreational Trail



Stream Buffer With Enchroaching Property Line

Stream Buffer With No Trail


Step Pool
Grade Control
Step Pool
Grade Control

Appendix F. Plant Palettes

Plant Palette Recommendations

This appendix includes a list of plants recommended for projects, including grasses and forbs for wet detention basins and dominant tree species, understory trees and shrubs for stream corridors.

St. Louis MSD guidance and Missouri Botanical Garden resources should also be referenced.

Plant Palette Recommendation, Wet Detention Basin

botanical name	common name	height (ft)	spacing*	water	light	comments
Upper 5 Feet						
Asclepias incarnata	Marsh Milkweed	2 to 3	18" o.c.	moist soil	full sun	
Carex grayi	Gray's Sedge	2 to 3	18" o.c.	moist soil	full to medium sun	
Carex muskingumensis	Palm Sedge	2 to 3	18" o.c.	moist soil	full to medium sun	Plant in massings for best foliage effect
Middle 10 Feet						
Acorus calamus	Sweet Flag	2 to 4	18" o.c.	moist soil to shallow water	full sun	
Carex stricta	Tussock Sedge	1 to 3	18" o.c.	moist to wet soil	full to medium sun	
Iris fulva	Copper Iris	2 to 3	18" o.c.	moist to wet soil	full sun	Plant individuals with other plant massings
Iris virginica	Southern Blue Flag Iris	2 to 3	18" o.c.	moist to wet soil	full sun	Plant in massings for best flower effect
Saururus cernus	Lizard's Tail	2 to 4	18" o.c.	moist soil to shallow water	full to medium sun	
Lower 5 Feet						
Juncus effusus	Soft Rush	2 to 3	18" o.c.	moist soil to standing water (up to 4" deep)	full sun	Good for erosion control on moist banks
Pontederia cordata	Pickerel Weed	2 to 4	18"o .c.	standing water (3"-5" deep)	full sun	Plant in massings for best foliage/flower effect
Sagittaria latifolia	Arrowhead	1 to 4	18" o.c.	wet soil to shallow water	full sun	
Scirpus validus	Softstem Bulrush	1 to 6	24" o.c.	wet soil to shallow water	full sun	

Dominant Tree Species

Silver Maple	Acer saccharinum (not recommended for yards and landscapes)
Sugar Maple	Acer saccharum
Cottonwood	Populus deltoides
Green Ash	Fraxinus pennsylvanica
Sycamore	Platanus occidentalis
Box Elder	Acer negundo
American Elm	Ulmus americana
Slippery Elm	Ulmus rubra
Hackberry	Celtis occidentalis
Sugarberry	Celtis laevigata
Black Willow	Salix nigra
Bur Oak	Quercus macrocarpa
White Oak	Quercus alba
Swamp White Oak	Quercus bicolor
Black Walnut	Juglans nigra
Bitternut Hickory	Carya cordiformis
Shellbark Hickory	Carya laciniosa
River Birch	Betula nigra
Kentucky Coffeetree	Gymnocladus dioica
Bald Cypress	Taxodium distichum

Understory Trees and Shrubs

Sandbar Willow	Salix exigua
Gray Dogwood	Cornus foemina
Swamp Dogwood	Cornus amonum
Pawpaw	Asimina triloba
Ohio Buckeye	Aesculus glabra
Red Buckeye	Aesculus pavia
Horse Chestnut	Aesculus hippocastanuum
Eastern Witch Hazel	Hamamelis virginiana
Vernal Witch Hazel	Hamamelis vernalis
Buttonbush	Cephalanthus occidentalis
Spicebush	Lindera benzoin
Blackhaw Viburnum	Viburnum prunifolium
Shrubby St. John's Wort	Hypericum prolificum
Deciduous Holly	Ilex decidua
Ninebark	Physocarpus opulifolius

Appendix G. Plant Species to be Controlled

General Species to Control

Common Name	Scientific Name	Common Name	Scientific Name
velvetleaf	*Abutilon theophrasti*	quackgrass	*Elymus repens*
Russian knapweed	*Acroptilon repens*	euonymus	*Euonymus spp.*
redtop	*Agrostis gigantea*	leafy spurge	*Euphorbia esula*
wild garlic	*Allium vineale*	fescue	*Festuca spp.*
pigweed	*Amaranthus spp.*	fescue species	*Festuca spp.*
burr ragweed	*Ambrosia grayi*	English ivy	*Hedera helix*
ragweed	*Ambrosia spp.*	pignut (Indian rushpea)	*Hoffmannseggia glauca*
burrdock species	*Arctium spp.*	kochia	*Kochia scoparia*
shallards	*Brassicaceae* - Shallard Family	prickly lettuce	*Lactuca serriola*
California brome	*Bromus carinatus*	sericea lespedeza	*Lespedeza cuneata*
ripgut brome	*Bromus diandrus*	ryegrass species	*Lolium spp.*
soft brome	*Bromus hordeaceus*	honeysuckle	*Lonicera spp.*
Japanese brome	*Bromus japonicus*	birdsfoot trefoil	*lotus corniculatus*
mountain brome	*Bromus marginatus*	purple loosestrife	*Lythrum salicaria*
downy brome, cheat	*Bromus tectorum*	sweet clover	*Melilotus spp.*
marijuana	*Cannabis sativa*	Scotch cottonthistle	*Onopordum acanthium*
hoary cress	*Cardaria draba*	reed canarygrass*	*Phalaris arundinacea*
musk thistle	*Carduus nutans*	timothy	*Phleum pratense*
lamb's quarters	*Chenopodium album*	bluegrass species	*Poa spp.*
spotted water hemlock	*Cicuta maculata*	kudzu	*Pueraria spp.*

Common Name	Scientific Name	Common Name	Scientific Name
Canada thistle	*Cirsium arvense*	multiflora rose	*Rosa multiflora*
bull thistle	*Cirsium vulgare*	common sheep sorrel	*Rumex acetosella*
poison hemlock	*Conium maculatum*	pale dock	*Rumex altissimus*
field bindweed	*Convolvulus arvensis*	curly dock	*Rumex crispus*
Canadian horseweed	*Conyza canadensis*	bitter dock	*Rumex obtusifolius*
vetch species	*Coronilla spp.*	field sowthistle	*Sonchus arvensis*
orchardgrass	*Dactylis glomerata*	spiny sowthistle	*Sonchus asper*
jimsonweed	*Datura stramonium*	common sowthistle	*Sonchus oleraceus*
Queen Anne's lace	*Daucus carota*	Johnsongrass	*Sorghum halepense*
teasel	*Dipsacus fullonum*	clover species	*Trifolium spp.*
		cocklebur	*Xanthium strumarium*
*Removal of this species from project subject to approval of the Project Representative			

Control Recommendations: Shrub Honeysuckle

This guidance is sourced from the KC Wildlands.

Basic Procedure:

Wildlands uses volunteers for labor-intensive work to cut and stump-treat honeysuckle (using Tordon RTU). Volunteers work in teams of usually three, with two cutting the shrub (loppers or handsaws) and one applying Tordon RTU (using small, twist top plastic bottles so no one person has too much chemical - bottles are available through SKS Plastics). The attached diagram is used for training volunteers. All plants must be treated properly. They have experimented and found that they get a good kill rate on cut and treat ANY TIME of year (which is counterintuitive, considering sap flow). A follow up of Roundup (5%) should be applied to any resprouts the following late October or early November (for spring and summer treatments), or the following March (for fall and winter treatments). This application is done by staff.

Wildlands occasionally uses well qualified volunteers (restorationists, biologists, naturalists) to backpack spray Roundup on euonymus and shrub honeysuckle, but collateral damage can be high if spraying thick infestations of honeysuckle (and it can be expensive!). They think the best time for foliar treatment with Roundup is in late October when natives are dormant but shrub honeysuckle is still green; or in early spring when the honeysuckle plant starts to leaf. However, they don't do much foliar treatment of honeysuckle except on resprouts.

The last-ditch approach for really thick stands or areas that aren't conducive to volunteers is to hire a professional wild land restorationist to basal treat (chemically girdle). In that case they use Pathfinder II, applied in November or early December. Cost is about $280/acre per pass. Then follow up with Roundup of resprouts the following year, although though there shouldn't be many.

Note: Wildlands is restoring habitat remnants, so all decisions are based on doing the very least harm possible to the seed banks and plants that are still hanging on. In an area where there is NOTHING under the shrubs, a more aggressive strategy could be employed.

Also: if working by water, consider using Rodeo for foliar applications. It's like round-up, but is supposed to be safer for water.

Volunteers:

Wildlands lets volunteers use Tordon because they are dropping a few drips onto a stump rather than spraying leaves; this reduces liability. Also, a stump treatment minimizes pesticide use in the environment. On the toxicity side, Tordon is more detrimental than Roundup: it can travel through wet soil and harm other plants. However , the way the volunteers are trained to use it (as a stump treatment) is safer for the surrounding area, so long as they don't treat in the rain. Volunteers never have more than 3 oz of the Tordon.

Wildlands believes that the most worthwhile part of using volunteers is that you have an opportunity to educate folks about the big picture. They become stewards and advocates when they've invested their time on the land.

Finally, Wildlands notes that a good resource for volunteers and expertise may be Missouri Master Naturalists. There are a couple of chapters near St. Peters.

Appendix H. CIP Project Summary Sheets

IP-6868-2-1

Country Crossing

Existing Description

The existing channel has very good structure but the presence of honeysuckle and other invasive vegetation needs to be addressed.

Conceptual Solution

Solution: Riparian Renovation suggested for stream corridor (1602 linear feet).

Cost of Improvements: $26,100

Figure 1. Country Crossing

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Preservation	Country Crossing		✔		✔	

IP-6869-2-1

Fawn Lake

Existing Description

The existing wet detention basin, DB-6869-02, is experiencing bank erosion and debris jams.

Conceptual Solution

Solution: This concept includes grading and vegetative establishment of basin slopes.

Cost of Improvements: $12,600

Figure 1. Fawn Lake

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Fawn Lake			✔		

IP-6869-2-2

Hollow Creek

Existing Description

This stream reach lacks a vegetated buffer and public education about dumping. About 20% of the banks along the reach need to be stabilized. Some grouted riprap exists at outfall of detention basin.

Conceptual Solution

Solution: This concept includes the limited restoration and establishment of a vegetated buffer along the entire stream reach. Bank stabilization work should occur at localized areas along about 20% of the length, estimated based on field observation. These stabilization areas are located in the upstream portion of the reach near the backyards of houses around the Hollow Creek Drive cul-de-sac. The stabilization of two outfall structures is included in the project cost.

Cost of Improvements: $198,200

Figure 1. Hollow Creek

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Hollow Creek		✔	✔		✔

IP-6870-1-1

Spanish Trails

Existing Description

The existing channel has good structure but too much shade inhibits understory growth. Riparian corridor should be restored.

Conceptual Solution

Solution: Riparian Renovation suggested for stream corridor (367 linear feet).

Cost of Improvements: $3,000

Figure 1. Spanish Trails

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Preservation	Spanish Trails		✔	✔		

IP-6870-3-1

Townes of Belleau Creek

Existing Description

This detention basin, DB-6870-16, is at The Townes at Belleau Creek. There is significant rill erosion on the basin slopes and excessive sediment deposition in the bottom of the basin. The inlet and outlet structures are new and in good condition. This basin is not part of the USACE H&H model and therefore, capacity of this structure was not modeled.

Conceptual Solution

Solution: The concept addresses rill erosion by regrading and restoring vegetation on the basin slopes. The bottom of the basin should be excavated to contain the water quality volume, soil should be amended to enhance infiltration and then, should be vegetated. The concrete swale to be removed and replaced with a vegetated swale. Source control is recommended during construction.

Cost of Improvements: $148,200

Figure 1.   Townes of Belleau Creek

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Townes of Belleau Creek			✔		

IP-6870-4-1

Child of God

Existing Description

This detention basin DB-6870-15, located along Salt Lick Road at the "Child of God Lutheran Church and School", has great visibility for a water quality demonstration project. The existing basin has sufficient capacity and there are no anecdotal reports of flooding.

Conceptual Solution

Solution: The concept includes retrofiting this basin into a wet pond by modifying the outlet structure, removing existing concrete swales, establishing a water quality ponding area with a bench, and planting wetland vegetation. Tree and shrub landscaping is included to create a more defined buffer between the Salt Lick Road and the basin.

Cost of Improvements: $435,700

Figure 1. Child of God

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Child of God			✔		✔

IP-6871-3-1

M&H Concrete

Existing Description

This detention basin DB-6871-03, located south of Veterans Memorial Parkway, accepts runoff from businesses along Industrial Park Place West. The outlet flows to a piped system, out of the watershed. This basin is not part of the USACE H&H model and therefore, capacity of this structure was not modeled.

Conceptual Solution

Solution: The concept is to replace the existing concrete swale with a wetland swale and restore the remaining basin to a dry detention basin with a forebay structure to control debris. Exposed areas around the swale will be revegetated and sediment deposition at the structure will be removed.

Cost of Improvements: $444,200

Figure 1. M&H Concrete

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	M&H Concrete			✔		

IP-6965-2-1

Wolfrum Way

Existing Description

This reach is located downstream of Wolfrum Road, downstream of the riprap protection associated with the culvert. Severe bank erosion along this incised reach may threaten homes on the north side of the channel. Rill erosion along the banks is continuous. The channel has a steep profile, dropping approximately 8 feet over a length of 625 feet.

Conceptual Solution

Solution: To address the severe bank erosion, this concept includes 3 vertical grade control structures, bank stabilization, and the use of walls on the right bank. Riparian renovation is suggested for the buffer along this entire reach. Outfalls and discharges from residential downspouts will require protection.

Cost of Improvements: $950,000

Figure 1. Wolfrum Way

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Wolfrum Way		✔	✔		

IP-6965-2-2

Deer Meadow Ct.

Existing Description

This project area, south of Hwy 94 and east of Wolfrum Road, includes a detention basin, DB-6965-01, and a small stream reach. The basin collects drainage from the Montecito Condominiums and is in good condition. The channel conveys flow that runs in swales along Hwy 94 and additional flow from a contributing drainage area outside of the City bounds. The channel is experiencing bank cutting that impacts residential backyards and some localized repairs were observed. The detention basin has sufficient capacity for 100-year event (approximately 2.5 feet of freeboard).

Conceptual Solution

Solution: This concept includes bank stabilization and uses 7 vertical grade controls to stabilize the bed profile. For the basin, the recommended concept is to excavate 2-feet of material from the base (534 to 532 ft) in order to provide additional capacity (1 acre-ft). The recommendation is to replace the concrete swales with wetland swales and amend the soil in the bottom of basin and revegetate.

Cost of Improvements: $1,379,100

Figure 1. Deer Meadow Ct.

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability, Detention	Deer Meadow Ct.		✔	✔		

IP-6968-1-1

NW Ohmes Farm

Existing Description

The project area, east of Birdie Hills and close to Ohmes Road, includes two reaches of channel and one detention basin, DB-6969-10. The existing detention basin in the Ohmes Farm residential development has been designed with sufficient capacity but has experienced significant erosion on the banks and the inlet structures are not protected. The reach directly downstream of the basin is an in-line wetland that should be maintained and preserved as a water quality feature in the City. The reach between Birdie Hills Road and Ohmes Road is lacking a healthy riparian corridor. There is a need for bank stabilization along specific areas of the reach, as documented during field reconaissance.

Conceptual Solution

Solution: This concept addresses erosion issues at the detention basin and along the channel. Additionally, it includes preservation for the in-line wetland downstream of the detention basin and riparian renovation for the stream corridor downstream of Birdie Hills Road. At the detenion basin, the recommendation is to dredge 1 foot of material from the basin and replace the outlet structure in order to convert the basin into a wet pond. The channel stabilization extends along approximately 300 linear feet of stream as needed, specifically targeting the 90 degree bend that threatens a home at 44 Arbor Shadow Court. At least 6 rock checks are included to control the bed profile.

Cost of Improvements: $388,100

Figure 1. NW Ohmes Farm

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability, Detention	NW Ohmes Farm		✔	✔	✔	

IP-6968-2-3

Country Crossing

Existing Description

This wet detention basin, DB-6968-02, is located south of Ohmes Road and discharges into a tributary of Dardenne Creek. The basin has sufficient capacity but shows evidence of erosion around inlets and lacks a buffer of vegetation. At the time of the field visit, there was algae growth in the basin.

Conceptual Solution

Solution: This concept, given the project area's high visibility on Ohmes Road, includes aeration of the basin and a 10-ft wetland bench edge treatment and vegetated filter strip buffer that will help filter nutrients from the basin. Additionally, the inlet structure should be protected and the outlet structure should be replaced to allow for flood stage storage in the basin.

Cost of Improvements: $69,700

Figure 1. Country Crossing

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Country Crossing			✔		

IP-6969-1-1

Ohmes Mitigation

Existing Description

This reach of stream, located adjacent to the mitigation site for the Ohmes Farm Development, has a good riffle pool structure but significant amount of honeysuckle that should be managed.

Conceptual Solution

Solution: Riparian renovation suggested for stream corridor (1478 linear feet).

Cost of Improvements: $20,300

Figure 1. Ohmes Mitigation

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Preservation	Ohmes Mitigation		✔	✔		

IP-6969-2-1

Ohmes-Cherry Creek

Existing Description

This new detention basin at Ohmes Farm, DB-6969-08, is located west of Cherry Creek Court. The basin has sufficient capacity, however, vegetation has not established in the basin. The channel ized reach downstream has experienced a significant amount of sedimentation from upstream sources. A narrow and sparse riparian buffer has been installed but maintenance is lacking.

Conceptual Solution

Solution: The proposed concept converts the existing basin to a wet pond and stabilizes the basin slopes. Approximately 1 foot of material is dredged from the bottom of the channel (adding 0.8 acre-ft of storage) and the low flow opening on the outlet structure is modified. Bank slopes are stabilized and vegetated. A wetland buffer is installed around the perimeter of the permanent pool. This improvement directly benefits the channel reach downstream where additional improvements are recommended. In the channel, riparian renovation is recommended along the entire reach. Source controls must be implemented in the contributing drainage area during residential development.

Cost of Improvements: $155,300

Figure 1. Ohmes-Cherry Creek

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability, Detention	Ohmes-Cherry Creek		✔	✔		

IP-6969-2-2

Hope Drive

Existing Description

This tributary reach of Dardenne Creek is located within the 100-year area of inundation. The overall health of this channel system is in good condition. There is a good pool and riffle sequence and some vegetation on bank slopes. The turbid water observed during the field visit is a result of upstream residential development that lacks erosion and sediment control. However, the profile may be too steep and is resulting in incision and lateral bank movement. Localized sections of the adjacent trail are threatened by the bank stability issues.

Conceptual Solution

Solution: This concept addresses further incision of the tributary with the use of two vertical grade control structures. Riparian renovation is included for the entire length of the project (1493 linear feet). Localized bank protection is recommended where the channel erosion threatens the trail (along 500 feet).

Cost of Improvements: $261,100

Figure 1. Hope Drive

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Hope Drive		✔			✔

IP-6969-2-4

Ohmes-Baytree

Existing Description

This new detention basin, DB-6969-06, is located at the north end of the Ohmes Farm development, west of Dardenne Creek. The basin has sufficient capacity but may have accumulated sediment due to recent construction activities in the contributing drainage area.

Conceptual Solution

Solution: The proposed concept converts the existing basin to a wet pond and stabilizes the basin slopes. Approximately 1 foot of material is dredged from the bottom of the channel (adding 0.23 acre-ft of storage) and the low flow opening on the outlet structure is replaced. A wetland planting buffer is installed around the ponding elevation and the remaining banks are revegetated. Source controls must be implemented in the residential development that contributes drainage to this basin.

Cost of Improvements: $135,400

Figure 1. Ohmes-Baytree

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Ohmes-Baytree			✔		

IP-6969-3-1

Ohmes-Dogwood Meadwow Ct.

Existing Description

This new detention basin, DB-6969-09, is located at the west end of the Ohmes Farm development, between Dogwood Meadow Court and Evergreen Forest Drive. The basin has sufficient capacity, however, rill erosion is creating unstable basin slopes. Material that has sedimented in the basin may be blocking the low flow outlet and water is pooling in the basin. Tree saplings have established throughout this wet area and may compromise the capacity.

Conceptual Solution

Solution: The proposed concept includes stabilization of basin slopes, amendment to the base to increase infiltration, and revegetation of the basin. Limited riprap material may be necessary to protect against erosion at the structures. Source controls must be implemented in the residential development that contributes drainage to the basin.

Cost of Improvements: $490,800

Figure 1. Ohmes-Dogwood Meadwow Ct.

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Ohmes-Dogwood Meadwow Ct.					

IP-6970-1-1

Calwood

Existing Description

The existing channel reach is a small tributary within the Dardenne Creek watershed. During the field visit, excessive debris in the channel and invasive vegetation on the banks were noted. The channel profile is too steep for the bed materials to stay in equilibrium. During high events, flow in this channel may be influenced by Dardenne Creek.

Conceptual Solution

Solution: Riparian renovation is recommended for this stream corridor (791 linear feet). Debris jams should be removed. Additionally, 5 rock checks should be installed to stabilize the channel bed.

Cost of Improvements: $54,300

Figure 1. Calwood

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Calwood		✔	✔		

IP-6970-1-2

Richmond

Existing Description

The existing wet detention basin, DB-6971-08, is upstream of a commercial development west of Salt Lick Road and south of I-70. The basin is in good condition and has sufficient capacity.

Conceptual Solution

Solution: The proposed improvements are limited to the detention basin. A vegetated buffer should be added to this basin. Erosion around inlets should be addressed by limited regrading and placement of riprap to protect the structures. During preliminary engineering of the solutions to address Dardenne Creek flooding, this portion of the revised inundation map should be further studied with bathymetric data of Dardenne Creek incorporated in the model. The flooding associated with this project is addressed in IP-6970-4-3.

Cost of Improvements: $13,500

Figure 1. Richmond

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Richmond			✔	✔	✔

IP-6970-4-1

Calwood

Existing Description

This project area includes a long reach of channel that extends through a residential area, parkland, and a golf course, before joining Dardenne Creek. The most upstream section of this project is adjacent to apartment buildings and has been stabilized with geocells. The reach through the parkland area is very incised within continuous bank cutting. The bed material in this area is unconsolidated, indicating that a lot of sediment is deposited in this channel. The section of reach in the golf course is mowed to the edge and then piped (HDPE) to Dardenne over a short distance. Riprap protection of the bank around this confluence is lacking, although a rock riffle directly downstream has prevented excessive scour development. There is a short tributary that is included in this project as well. This tributary is a channelized reach within a very narrow easement, conditions are similar to project IP-6970-1-1. Flooding is caused by the water surface elevation in Dardenne Creek.

Conceptual Solution

Solution: This concept is limited to stream stability. The flooding associated with this project is addressed in IP-6970-4-3. The concept includes riparian renovation along the 515 linear feet of geocell bank stabilization in the upstream portion. In the wooded reach which extends 1706 linear feet, this concept includes renovation of the corridor and limited bank improvement projects to areas where infrastructure is threatened or where bank heights are actively contributing sediment to the channel. Bank stabilization should be prioritized in the reach of the main channel, upstream of the golf course and at any outfall . Areas of encroachment should be re-established as riparian corridor and storage structures should be removed. In the golf course, the tributary and small adjacent contributing drainage ways should be buffered with a vegetated filter strip and the confluence should be stabilized with riprap on the bank of Dardenne Creek.

Cost of Improvements: $661,400

Figure 1. Calwood

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Calwood		✔	✔		✔

IP-6970-4-2

Dardenne b/t Mexico Rd & I-70

Existing Description

This reach of Dardenne Creek extends between Mexico Road and I-70. The reach is experiencing severe bank erosion and potential channel bed degradation. The LIDAR information shows an estimated slope of 0.0009 ft/ft, however, this may not reflect accurate conditions because it represents the water surface elevation in Dardenne Creek.

Conceptual Solution

Solution: The proposed improvements include bank stabilization along this reach and the development of a riparian corridor along the golf course bank (approximately 7,000 linear feet of the project). Riparian renovation is recommended for the right bank. A series of 4 rock checks are included but may not be necessary depending on the actual bed slope. The flooding associated with this project is addressed in IP-6970-4-3.

Cost of Improvements: $15,134,400

Figure 1. Dardenne b/t Mexico Rd & I-70

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Dardenne b/t Mexico Rd & I-70		✔	✔		✔

IP-6970-4-3

Dardenne at Mexico Rd & I-70

Existing Description

The project area is located at the Mexico Road and I-70 crossings of Dardenne Creek. These bridges may cause constrictions for high flows in Dardenne Creek and flooding upstream may be attributed to these constrictions.

Conceptual Solution

Solution: Address flooding with improvements at Mexico Road and the I-70 tunnel to remove some houses from the 100-year floodplain. Improvements include widening the Dardenne Creek channel along 2000 linear feet and installing a new Mexico bridge with a higher low steel.

Cost of Improvements: $4,914,700

Figure 1. Dardenne at Mexico Rd & I-70

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Flooding	Dardenne at Mexico Rd & I-70	✔	✔	✔	✔	✔

IP-7065-1-1

Montecito

Existing Description

This existing wet detention basin, DB-7065-05, is mainly a water feature for the surrounding neighborhood. It appears that the water may be dyed to appear more blue. The basin is well landscaped and maintained by mowing. There is an existing fountain that provides aeration. The inlet structure is an exposed RCP that drains into the basin. A shoreline edge is ripraped. The existing basin has sufficient capacity.

Conceptual Solution

Solution: The concept recommendation includes the addition of a filter strip around the existing basin. Riprap should be placed at the detention basin structures to protect from erosion. Recommendations should be made to the homeowners association to avoid adding chemicals to the water and stop mowing a grass strip around the riprap.

Cost of Improvements: $13,300

Figure 1. Montecito

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Montecito			✔		

IP-7065-1-3

Highlands

Existing Description

This project includes four existing detention basins, DB-7065-01, DB-7065-03, DB-7065-02, and DB-7065-04, and three reaches of stream in the Highlands subdivision. Each of the dry detention basins is mowed with a concrete flume conveying low flows. The basins have various levels of landscaping but each one shows evidence of fertilizer application (algae), sediment deposition, or localized erosion. The stream reaches show evidence of localized erosion. Invasive vegetation is present in the riparian corridor. The property lines in this area extend to include the creek in some cases.

Conceptual Solution

SOLUTION: Four detention basins should be retrofitted to retain the water quality volume and use vegetated swales instead of concrete flumes. Additional capacity is provided for DB-7065-01 and DB-7065-04. (Assuming 1 foot of excavation in both basins) There are three stream segments that are included in this conceptual improvement as well. The first segment, south of Deer Meadow Court, includes 375 linear feet of bank stabilization. The outfall structure of the detention basin into this reach should be stabilized. The second reach, 400 linear feet, is located east of Wolfrum Glen Court. On this reach, the recommended improvement is to stabilize banks and develop 4 grade controls. The third segment, 932 linear feet, is located parallel to Castle Douglas Drive and banks should be stabilized. All reaches should have the existing riparian corridor renovated.

Cost of Improvements: $1,739,100

Figure 1.   Highlands

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability, Detention	Highlands		✔	✔		

IP-7066-1-1

Home Depot

Existing Description

This reach along Baltic Creek, directly downstream of MO-94 and extending to Central School Road, shows evidence of incision and lateral bank movement. An existing off-line detention area on the east side of the channel could be further developed to be effective during higher flows. This detention basin is not included in the City's GIS database currently. A power utility easement on the west side of the channel prevents the establishment of a riparian corridor.

Conceptual Solution

Solution: The conceptual recommendation is to maintain the same alignment, enhance the east riparian corridor, and stabilize the west bank with shrubs and grasses. The hydraulic model shows velocities of 6-10 fps in this reach and therefore, a riprap toe protection would be critical to hold the bank in place. This proposed recommendation also includes grading and riprap improvements to increase the effectiveness off the eastern off-line detention. This concept does not include improvements on the upstream tributary located between MO-94 and parking lots. The existing profile (estimated by LIDAR contours) drops 6 feet over the length of the reach. The Central School Road culvert may provide the necessary grade control and therefore no additional vertical controls are included.

Cost of Improvements: $2,487,300

Figure 1. Home Depot

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability, Detention	Home Depot		✔	✔		

IP-7066-4-1

Pittman Hill Road

Existing Description

Pittman Hill Road is overtopping in the hydraulic model. Two structures are shown within both the FEMA floodplain and this study's refined area of inundation during the 100-year event. There was one tall shear bank noted on the downstream side of Pittman Hill Road. Owners on the adjacent property said that this bank was eroding quickly. Upstream of Pittman Hill Road, the riparian corridor is in fair condition but very narrow on the west side. The main channel banks showed evidence of continuous scouring. Debris jams were noted in the field study.

Conceptual Solution

Solution: The concept includes replacment of the Pittman Hill Road culverts with a bridge to address overtopping. Additionally, bank stabilization of the 24-ft tall shear bank downstream of Pittman Hill Road is recommended. This bank is upstream of the area that was protected as part of the Hwy 94 construction project. This project also includes vegetative and riprap toe protection of the reach upstream of the culvert crossing where shorter banks show evidence of continuous scouring. The corridor upstream of Pittman Road should be renovated. The corridor downstream of Pittman Road will require the establishment of a new riparian corridor and limited stream widening.

Cost of Improvements: $1,453,300

Figure 1. Pittman Hill Road

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Flooding, Stream Stability	Pittman Hill Road	✔	✔		✔	

IP-7067-1-1

Baltic Creek, downstream of Central School Roa

Existing Description

This project area includes two detention basins, DB-7067-01 and DB-7067-02, and the reach of Baltic Creek that extends between Central School Road and the confluence with Dardenne Creek, crossing Dye Club Drive. The outfall channel to the creek for both detention basins is unstable and contributing sediment to the stream. The wetland basin is lacking a regulated outfall structure. The channel reach runs parallel to an existing power utility corridor and therefore, the riparian corridor on the west side is limited. Any flooding in this reach is controlled by the water surface elevation of Dardenne Creek, which backs up all the way to Central School Road during flooding events.

Conceptual Solution

Solution: The proposed concept is to provide an outfall structure for DB-7067-01 and improve vegetation management in the basin. For the second basin in the project area, DB-7067-02, the recommendation is to addess the outfall erosion and connection to Baltic Creek. This basin does not have sufficient capacity and additional capacity is proposed (6 acre feet). On the reach of Baltic Creek, the concept is to stabilize the banks and maintain the same alignment. A series of 4 rock checks are included to stabilize te bed profile. The east riparian corridor, buffering the creek from the golf course should be enhanced and the west bank should be stabilized with shrubs and grasses. The hydraulic model shows velocities of 6-10 fps in this reach and therefore, a riprap toe protection would be critical to hold the bank in place.

Cost of Improvements: $6,850,100

Figure 1. Baltic Creek, downstream of Central School Road

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability, Detention	Baltic Creek, downstream of Central	✔	✔	✔		✔

IP-7067-2-3

Old Hickory GC

Existing Description

This channel reach extends through the golf course before reaching a confluence with Dardenne Creek. The reach is very incised with a narrow riparian corridor. Steep drainage ways from the golf course are headcutting and contributing more sediment and bank stability issues. The downstream 1000 feet of the reach is completely lacking a riparian corridor and shows evidence of mass bank wasting.

Conceptual Solution

Solution: The proposed concept is to stabilize the bank and construct 2 vertical grade controls. On the entire project, a vegetated filter strip should be established to treat runoff from the golf course. On the downstream 1000 feet, a corridor should be established after benching and developing a low flow channel.

Cost of Improvements: $2,205,200

Figure 1. Old Hickory GC

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Old Hickory GC		✔	✔		✔

IP-7068-2-1

Bruns Place

Existing Description

This stream reach extends through a neighborhood at Bruns Place Court, under Mid Rivers Mall Drive and then confluences with Dardenne Creek. The channel has a very steep profile in the reach upstream of Mid Rivers Mall Drive (0.024 slope) and then becomes a braided channel before flowing to Dardenne Creek. A section of the channel has been piped through the backyard of the residence at 109 Bruns Place Court - the pipe entrance has become blocked and is therefore not functional.

Conceptual Solution

Solution: The proposed concept includes the installation of 7 grade control structures and riparian renovation of the corridor (along 1592 linear feet). The piped system at 109 Bruns Place Court should have the inlet structure replaced to allow appropriate drainage of the upstream channel. No additional bank stabilization is recommended at this time.

Cost of Improvements: $88,900

Figure 1. Bruns Place

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Bruns Place		✔	✔	✔	✔

IP-7068-4-1

Dardenne Creek at Fairfax

Existing Description

This reach of Dardenne Creek extends between the confluence with Tributary 7 and the Mid Rivers Mall Drive crossing. Although Dardenne Creek is analyzed as a system, this reach is of particular importance because adjacent homeowners have reported backyard bank erosion that may threaten homes. The Mid Rivers Mall Drive crossing shows adequate conveyance for all events analyzed in this study, up to the 500-year. While there are not flooding concerns, residents on the right bank are concerned about bank failures on their property. The bank toe appeared to be more stable than elsewhere on Dardenne Creek - an exposed ledge of cobble and limestone. The upper bank, however, has slid in some areas to form a flood bench. This sliding has encroached on the right bank structures. The profile of this channel should be further investigated because the LIDAR data shows a flat water surface elevation in this reach (Elevation: 446 ft).

Conceptual Solution

Solution: This proposed concept addresses areas of bank slides on the right bank and areas of mass wasting on the left bank. Bank stabilization will include installation of a wall along 1533 linear feet of the right bank, sloping and vegetating the bank in the low flow area. On the left bank, a bench should be graded to allow for higher flows to spread into a larger conveyance area. One rock check is recommended at the downstream boundary of the project to ensure that the bed profile stays in place. Stream corridor restoration is recommended along the downstream section of the project reach. Installation of a new corridor is included for the upstream section of the project reach, on both banks. The total length of riparian restoration work is approximately 1682 linear feet.

Cost of Improvements: $11,461,300

Figure 1. Dardenne Creek at Fairfax

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Dardenne Creek at Fairfax		✔	✔	✔	✔

IP-7069-1-1

Crystal Lake Detention

Existing Description

This area, located east of Dardenne Creek in Rabbit Run Park, experiences flooding from Dardenne Creek. The project area includes two detention basins, DB-7069-06 and DB-7069-07, as well as the East Branch tributary to Dardenne Creek. There are some anecdotal erosion issues at the wet detention basin and the need for improved sediment management was noted. The existing basin capacity, however, is sufficient. The secondary wet basin, DB-7069-07, is protected with concrete chunks along the perimeter but lacks a vegetative buffer. The outfall structures appear to be cobbled together and not well designed. The downstream section of the stream shows evidence of deep incision and the confluence with Dardenne Creek is actively eroding. The area of inundation in the refined HEC-RAS model indicates that 14 structures are impacted by the 100-year event in Dardenne.

Conceptual Solution

Solution: This proposed concept addresses stream stability and water quality associated with detention. The flooding associated with this project is addressed in IP-6970-4-3. At the main detention basin, a forebay should be constructed to help maintain sediment. A vegetated buffer should be established around the perimeter of both basins for water quality benefit. This project has great visibility from backyards, the trail, and the adjacent park. The outfall to the stream should be protected. Two grade controls should be installed on the downstream end of the channel (along 1848 linear feet). In areas where the stream corridor is lacking (1848 linear feet), benching should be established on at least one bank. The corridor that is in good condition (3977 linear feet) should be renovated.

Cost of Improvements: $1,678,100

Figure 1. Crystal Lake Detention

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability, Detention	Crystal Lake Detention		✔	✔		✔

IP-7069-1-2

Crystal Lake

Existing Description

This project includes a reach of the East Branch tributary to Dardenne Creek. This reach extends between the South Church Street crossing and the confluence with the Rabbit Run channel. There are a significant number of homes (>100) in the area of inundation as the water surface elevation of Dardenne Creek backs up into this channel during high flow events.

Conceptual Solution

Solution: This proposed concept addresses stream stability. The flooding associated with this project is addressed in IP-6970-4-3. The proposed concept along this reach is to restore the riparian corridor. Based on the field study, the bank slope should be restored to a stable slope and revegetated along approximately 25% of the reach. Two rock checks are included to provide stabilization of the bed profile. This bank stabilization is located in the downstream section of the project reach.

Cost of Improvements: $587,200

Figure 1. Crystal Lake

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Crystal Lake		✔			✔

IP-7069-2-3

Parkdale

Existing Description

This project, located west of Mid Rivers Mall Drive and south of Grand Teton Drive, includes two reaches. During field reconaissance, the north reach was documented as an ephemeral vegetated swale. Anecdotally, this channel carries significant flow during storm events and may cause flooding to the adjacent homeowners. The second channel, in the south half of the project area, conveys more flow. This channel has an existing concrete flume along the channel bed in most areas and there is typically erosion on either side of this flume. There was significant algae in the water and the stream lacks a riparian buffer. The existing slope of this channel was estimated at 0.0055 ft/ft.

Conceptual Solution

Solution: This concept routes excess flows from Mid Rivers Mall Drive to the main channel within the project area, stabilizes all erosion areas and uses vegetative buffer strips to help filter nutrients. The north inlets on Mid Rivers Mall Drive should be connected to a new 48-inch RCP that extends south to the main channel. On the north channel, the 1,035 linear feet of swale should be graded and vegetated with native vegetation. For the main channel, 1,450 linear feet, the following is recommended: 1) Remove concrete flume, replace this bed profile control with 4 rock checks, 2) Lay back slopes to stable slope and vegetate, and 3) Develop vegetated filter strip buffer to stream, limited tree plantings.

Cost of Improvements: $1,610,700

Figure 1. Parkdale

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Parkdale		✔	✔	✔	✔

IP-7069-3-1

Savannah

Existing Description

This wet detention basin, DB-7069-10, is located in residential backyards, between Creekside Drive and North Hillview Drive. The basin has sufficient capacity and does not show overtopping during the 100-year event. It has approximatley 0.9 feet of freeboard during this event. There is limited landscaping around the basin and a riprap shoreline protection that works well to control most erosion. There was evidence of some cattail growth during the field visit. Excessive algae growth was observed around the inlet structure.

Conceptual Solution

Solution: The recommended concept is to add a buffer planting to the edge of this basin. Additionally, 500 square feet of wetland plantings are recommended for the south swale inlet area to help improve water quality in the basin. Riprap should be placed at structures within the basin to protect from erosion. Source controls for nutrients would also be recommended.

Cost of Improvements: $411,100

Figure 1. Savannah

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Savannah			✔		

IP-7069-3-2

Woodlands GRG

Existing Description

This project includes a tributary of Dardenne Creek, close to Woodlands Park and a small drainage way. The GRG trail along Dardenne Creek crosses this tributary close to the confluence. The existing slope of the main tributary was estimated at 0.004 ft/ft. This steep profile shows that further incision may occur in the channel. The existing channel is incised with significant exposure of roots. A gravelly sand deposition is on the channel bed, likely washed downstream from the installation of the upstream culvert. The smaller drainage way is a dumping ground for lawn clippings and trash that can be carried downstream during higher flows.

Conceptual Solution

Solution: The recommended concept is to develop 4 grade controls, preserve the riparian corridor and stabilize approximately 50% of the banks in the main channel by grading an appropriate slope, stabilizing the toe, and vegetating. This bank stabilization should occur in the downstream half the project reach.

Cost of Improvements: $1,001,700

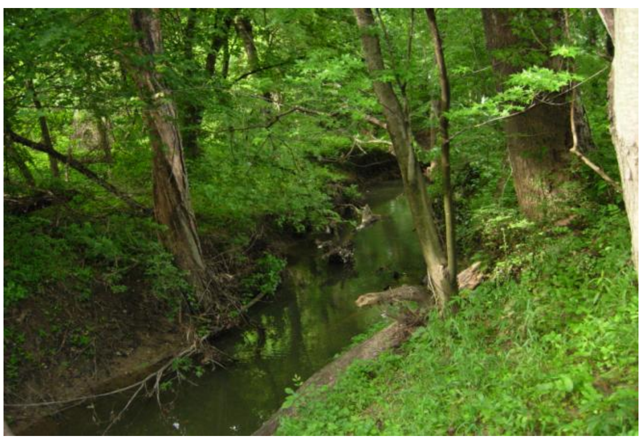


Figure 1. Woodlands GRG

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Woodlands GRG		✔	✔		✔

IP-7069-3-3

Ohmes Farm/Woodland

Existing Description

This project includes a series of three basins, DB-6969-02, DB-6969-04, DB-6969-07, located on the southern edge of the Ohme's Farm residential development and the north side of Woodland's Park. The existing basins have already experienced problems and present an opportunity for a community resource that doubles as a demonstration of successful water quality management. The ongoing development of Ohme's Farm has contributed significant sediment loads to the system of basins. The outlet structure of the third basin has failed and all of the basins show evidence of bank erosion and rill erosion.

Conceptual Solution

Solution: The concept is to integrate these 3 basins to better manage water quality and volume. The first basin will be restored to an extended dry detention basin. The exposed pipe between the first and second basins will be replaced with an open channel to connect the buried pipe and second basin. The second basin will become a functional fishing pond with a boardwalk that connects two docks and a walking trail. The pipe system between the second and third basins will be restored to an open channel with two bridges, one pedestrian and one for maintenance traffic. The third basin will be established as a polishing wetland connected to the boardwalk and trail. Additionally, the stream reach downstream of the GRG trail crossing should be stabilized with a grade control to prevent further headcut migration from Dardenne Creek.

Cost of Improvements: $2,475,000

Figure 1. Ohmes Farm/Woodland

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Ohmes Farm/Woodland			✔		✔

IP-7069-3-4

Ohmes Farm-1

Existing Description

This project includes an existing dry detention basin, DB-7069-13, at the Ohmes Farm residential development. The basin was not finished after structures were placed and has accumulated substantial sediment from the surrounding development work. Additionally, the basin slopes show evidence of rill erosion and are not protected by vegetation.

Conceptual Solution

Solution: This concept includes retrofit of the existing wet detention basin by modifying the outfall, addressing rill erosion on the banks by grading and revegetating, and removing material that has sedimented in the basin (assuming a depth of 1 foot). Additionally, riprap should be added to the basin structures to protect from erosion.

Cost of Improvements: $301,500

Figure 1. Ohmes Farm-1

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Ohmes Farm-1			✔		✔

IP-7069-4-1

Country Hill Manor

Existing Description

This existing dry detention basin DB-7069-02, located northeast of the intersection of Willott Road and Mid Rivers Mall Drive, was not selected by the screening process but the City requested evaluation of a detention opportunity at this location. The contours show that the basin may be acting as an offline storage of channel overflow rather than regulating discharges.

Conceptual Solution

Solution: This proposed concept is to expand the capacity of the detention basin to reduce the impact on the downstream channel. Approximately 1500 cubic feet of storage is added by grading modifications on the west side of the basin. The berm on the east side, extending 185 linear feet, should be raised approximately 4 feet to elevation 504-ft. A vegetated buffer is included for the perimeter and amendment of soil is recommended for the base of the basin.

Cost of Improvements: $186,100

Figure 1. Country Hill Manor

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Country Hill Manor			✔		

IP-7070-4-1

Crown Colony

Existing Description

This existing detention basin, DB-7070-03, runs parallel to Villa Circle Drive, west of Mid Rivers Mall Drive. The basin is located in a multi-family area and represents an important green space for the neighborhood. The existing basin has a concrete flume and several outfall structures contributing flow from the parking areas and street.

Conceptual Solution

Solution: The proposed concept is to replace the concrete flume with a wetland swale, develop a vegetated filter strip buffer between the basin and the parking lot, and modify the outlet structure to retain the water quality volume in the basin. The remaining area of the basin should be amended with appropriate soils that enhance infiltration and planted with dry detention vegetation. This basin shouldn't be modeled as a basin because it functions as an open channel. In order for the 25-year event to be contained in the channel, an additional 15 ac-ft of storage would be needed, requiring excavation of approximately 5 acres. This is not likely feasible.

Cost of Improvements: $172,600

Figure 1. Crown Colony

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Crown Colony			✔		

IP-7070-4-3

Schnucks/HS-1

Existing Description

This reach is located upstream of South Church Street and extends across the west side of Schnuck's Grocery Store on Mid Rivers Mall Drive. The upstream portion of the reach is bounded by concrete walls. Sediment has deposited in this channel and reed canary grass has become the dominant species. On the lower two thirds of the reach, the bed profile is very flat and channel incision is not anticipated to continue. Extensive root systems provided bank stabilization in this reach. The stream corridor should be restored and protected.

Conceptual Solution

Solution: This proposed concept addresses restoration of the riparian corridor on the downstream section of the project reach. The flooding associated with this project is addressed in IP-6970-4-3. In the reach behind Schnuck's Grocery Store, the recommendation is to develop a wetland swale through this area. An access point should be developed to ease maintenance of harvesting wetland plants. A wetland swale should also be developed in the marshy area north of the channel to help retain sediments with establishment of vegetation.

Cost of Improvements: $103,900

Figure 1. Schnucks/HS-1

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Schnucks/HS-1		✔	✔		

IP-7071-3-1

Dardenne Creek, downstream of I-70

Existing Description

This project area extends along Dardenne Creek, downstream of I-70 until the levee system begins. Some bank sliding is beginning to create benches. The outside bends along this reach are very steep and tall (>20 feet in some locations). The downstream portion of this reach is in more stable condition than the section directly downstream of I-70.

Conceptual Solution

Solution: This proposed concept addresses stability of the channel reach by incorporating 10 rock checks, bank stabilization with low flow flood benches, and renovation of the riparian corridor.

Cost of Improvements: $11,580,600

Figure 1. Dardenne Creek, downstream of I-70

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Dardenne Creek, downstream of I-70		✔	✔	✔	✔

IP-7071-4-1

Shrine

Existing Description

This existing wet detention DB-7071-04, located between I-70 and Suemandy Drive and west of Mid Rivers Mall Drive, has sufficient capacity. The basin is located in a commercial area.

Conceptual Solution

Solution: The proposed concept is to install a vegetative buffer around the basin perimeter to improve water quality and help stabilize the shoreline. Riprap should be placed around structures to protect from erosion.

Cost of Improvements: $17,000

Figure 1. Shrine

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Shrine			✔		✔

IP-7071-4-2

Old Town

Existing Description

The existing Old Town pump station is undersized to address local drainage in Old Town. Some pipes within the area are also undersized. The hydraulic model shows levee overtopping and inundation of Old Town as well but the USACE has certified these levees and the City does not plan to retrofit the levees.

Conceptual Solution

Solution: Some pipes should be replaced to avoid local surcharging. The pump station does not have sufficient capacity but would require a very significant retrofit to address flooding at the same level of protection required elsewhere. There was not sufficient detail at this study level to determine the exact recommendation for the pump station upgrade.

Cost of Improvements: $0

Figure 1. Old Town

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Flooding	Old Town	✔	✔	✔	✔	✔

IP-7166-1-1

Old Farmhouse Rd./Community Park

Existing Description

This channel reach was characterized to have shear banks and a good riparian corridor downstream of Central School Road. Excessive deposition has blocked the Central School Road culvert and may result in flooding issues. The existing slope on this channel is 0.0023 ft/ft. Tall banks are exposed along this channel (14-16 feet in height) and the right bank is particularly steep.

Conceptual Solution

Solution: This concept includes the bank stabilization, vertical grade control, and addresses the functionality of the Central School Road culvert crossing by adding a silt wall on the upstream side of the culvert array. Two rock checks are included in the proposed concept. Due to the health of the existing corridor, stabilization of the banks downstream of Central School Road is not recommended at this point; instead, riparian renovation is recommended on this reach. For a section extending 500 feet upstream of Central School Road, banks should be stabilized and a low flow bench should be established.

Cost of Improvements: $483,300

Figure 1. Old Farmhouse Rd./Community Park

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Old Farmhouse Rd./Community Park		✔	✔	✔	✔

IP-7166-2-1

Harvestowne

Existing Description

The existing channel, south of Hwy 94, has very good structure, with stable sloped banks and a diverse riparian corridor but the presence of invasive vegetation should be addressed.

Conceptual Solution

Solution: Riparian renovation suggested for stream corridor (788 linear feet). Additionally, the buffer on the east side should be enhanced.

Cost of Improvements: $6,400

Figure 1. Harvestowne

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Preservation	Harvestowne		✔			

IP-7168-1-1

Athens Drive

Existing Description

This existing channel, in Pegasus Farms, is formed by a pipe outlet from Morningside Drive. This pipe discharges to a steep ravine and re-enters a piped system to Kenworth Drive. This very steep channel has an average slope of 0.054 ft/ft with bank heights up to 12 feet. Active bank erosion and dumping of lawn waste was noted in the upstream portion of this reach. The existing woodland corridor should be preserved on this upstream portion. On the downstream portion of the project reach, the corridor is lacking. Access for construction may be difficult because the channel is located in backyards and there are not street crossings in the project area.

Conceptual Solution

Solution: This concept utilizes a series of 13 rock checks to stabilize the invert elevation of the channel. The upstream corridor (200 feet) should be preserved and a downstream corridor, along 315 linear feet, should be enhanced. Large debris should be removed from the channel (shopping cart, old truck).

Cost of Improvements: $81,100

Figure 1. Athens Drive

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Athens Drive		✔	✔		

IP-7169-1-1

Bellemeade Subdivision Detention

Existing Description

This project includes six detention basins in the Bellemeade residential development: DB-7169-09, DB-7069-12, DB-7169-08, DB-7169-10. DB-7169-11, DB-7070-10. Additionally, the project area includes a reach of channel that runs between Nashville Street and Cashmere Lane. Sediment loads to the basins have not been controlled and there is excessive sedimentation in each basin.

Conceptual Solution

Solution: The concept recommendation includes a vegetated shoreline buffer around each basin, wetland benching, improvements to the landscaping. A wet pond retrofit is recommended for DB-7169-11 and 7169-10.

Cost of Improvements: $1,217,800

Figure 1. Bellemeade Subdivision Detention

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability, Detention	Bellemeade Subdivision Detention		✔	✔		✔

IP-7169-1-2

Dubray Middle School

Existing Description

This project, located east of Mid Rivers Mall Drive, includes one detention basin, DB-7169-02, and a stream reach. There are two locations within the project area that have been highlighted for additional detention opportunity, however the model shows that this basin has sufficient capacity with approximately 1.5 feet of freeboard during the 100 year event. The existing basin has great visiblity and is located adjacent to a school. It has sufficient capacity but could be augmented to improve water quality. The channel reach has a stable structure, meandering with overflow benches but debris and presence of invasive vegetation was documented in the field. In some areas, the stream bank has been cleared of vegetation and is used as recreational area for the church.

Conceptual Solution

Solution: The concept project is to retrofit the existing detention basin to a wet pond and add buffer along top of basin. For the stream reach, 10 grade controls, benching, and vegetation is recommended. Riparian renovation is recommended for the reach. This stream project and the proposed wet detention basin could be great educational opportunities and signage is included in project.

Cost of Improvements: $186,900

Figure 1. Dubray Middle School

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability, Detention	Dubray Middle School		✔	✔		✔

IP-7169-2-1

Carrington Place

Existing Description

This project includes a detention basin, DB-7169-01, with high visibility along a trail, and a reach of stream. This main reach in this project extends between Wilott Road and Colby Drive. South of Willott Road, two contributing tributaries are also included in the project area. The field work documented bank erosion and bank cutting, debris jams, and a lack of corridor along this stream. The contours show a bed profile average slope of 0.008 ft/ft along the main channel. The slopes of the tributaries range between 0.01 and 0.03 ft/ft. At the detention basin, settling on top of the pipe was noted.

Conceptual Solution

Solution: This concept includes recommendations for the detention basin and channel stability. For the basin, 1-ft of material should be excavated from the bottom to add capacity. Additionally, the grading on the channel side should be refined with a berm that reaches elevation 488 (along 100 total feet). Signage should be used because of high visibility along trail. The existing concrete swales should be retrofitted using vegetation and settling around the pipe structure should be addressed with grading and riprap protection. For the channel, the entire riparian corridor should be renovated because it is contributing to the stability benefits of this system. This concept addresses bank erosion and shear banks in the main reach (downstream of Willott Road) by installing stable slopes, vegetation, and riprap toe protection on 50% of the slopes (typically the outside of a bend). A series of 6 grade control structures is recommended downstream of Willott. Upstream of Willott, 4 grade control structures should be installed on the east

Cost of Improvements: $3,023,700

Figure 1. Carrington Place

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability, Detention	Carrington Place		✔	✔	✔	

IP-7169-3-1

Pegasus Farms/Willott Square

Existing Description

This project area, south of Willott Road, includes two detention basins. The east basin, DB-7169-04, has a grouted riprap bank and low flow channel. There was water in the channel during the field visit and the bottom of the basin was not quickly infiltrating. This basin is undersized although there are no anecdotal complaints. The west detention basin, DB-7169-06, does not retain any volume, an observation and concern raised by the City. This basin was not selected during the screening process for this study.

Conceptual Solution

Solution: This concept increases the capacity and functionality of the east basin by excavating 1-foot of the basin bed, retrofitting to a wet basin, and providing new maintenance practices for DB-7169-04. Additionally, the north side should be raised with a 2-foot berm extending 150 linear feet (to elevation 510). In the west basin, the outlet structures should be modified so that more flow is retained during typical rain events. The concrete swale should be replaced with vegetated swale and the remaining area on the base should be amend with soil that enhances infiltration, then vegetated.

Cost of Improvements: $234,700

Figure 1. Pegasus Farms/Willott Square

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Pegasus Farms/Willott Square	✔		✔		

IP-7170-2-1

Eldorado

Existing Description

The project is located on West Spencer Branch and includes the reach that extends through the El Dorado Estates, between Mexico Road and Executive Center Parkway. The trapezoidal concrete channel, located at the Mid Rivers Mall along SueMandy Drive is represented in this project reach but not included in the concept. Good pool riffle structure was observed on this reach between Mexico and Executive Center Parkway. Cobble and gravelly sand bed on a hard clay layer was documented. This reach has high banks and a significant amount of debris. The profile of this reach was estimated at 0.0044 ft/ft.

Conceptual Solution

Solution: This proposed concept includes stream stabilization along West Spencer between Mexico and Executive Center Drive. Walls are included in the bank stabilization along the reacah due to the constrained nature of the channel. The proposed concept includes 5 rock checks.

Cost of Improvements: $11,061,400

Figure 1. Eldorado

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Eldorado		✔	✔		

IP-7170-2-2

Police Justice Centre

Existing Description

This project is an existing parking lot retrofit to include bioswales. The majority of the project has been constructed and may need slight modification to ensure success.

Conceptual Solution

Solution: This proposed concept includes evaluation of the existing parking lot design function and vegetation of the bioswales.

Cost of Improvements: $26,400

Figure 1. Police Justice Centre

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Water Quality	Police Justice Centre			✔		✔

IP-7170-4-2

Brookmount Apts.

Existing Description

This project area, located just south of the Brookmount Apartments, includes a stretch of open channel that was recently routed through a CMP array. The system may not have been correctly designed and may not have sufficient capacity. There have been complaints registered with the City of flooding at a nearby residence.

Conceptual Solution

Solution: To determine if a new culvert array would be necessary to address the flooding complaint upstream, the system that was installed should be further studied. This recommendation includes replacing the culvert array with 4 40-inch RCP pipes and stabilizing the entrance and outlet to ensure that the banks are protected.

Cost of Improvements: $1,179,100

Figure 1. Brookmount Apts.

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Piped Conveyance	Brookmount Apts.		✔	✔		✔

IP-7171-2-1

Old Town I-70 Service Rd. North

Existing Description

Swale draining east Old Town toward regional detention basin along Iffrig Road is flooding Old Town.

Conceptual Solution

Solution: This system should be studied in more detail to verify elevations of swale. From the information provided and a rough model of the drainage system, the following recommendations have been developed. Reduce the amount of vegetation in the swale to reduce roughness (ongoing maintenance not included in capital cost). Replace pipes with 48" RCP, set lower.

Cost of Improvements: $764,800

Figure 1. Old Town I-70 Service Rd. North

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Flooding	Old Town I-70 Service Rd. North	✔				✔

IP-7267-4-1

Walmart

Existing Description

This existing dry detention DB-7267-14, located east of Jungermann Road, and south of Hwy 94, is maintained by Walmart. The basin is in overall good condition with some localized erosion.

Conceptual Solution

Solution: This proposed concept includes installation of diverse vegetation in the swale area and recommendations to change mowing and fertilizer maintenance practices. Riprap should be added at basin structures to protect from erosion.

Cost of Improvements: $108,200

Figure 1. Walmart

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Walmart			✔		

IP-7267-4-3

Park Ridge Estates

Existing Description

The existing detention basin, DB-7267-04, is an extension of the surrounding backyards and currently mowed and likely fertilized. This basin has sufficient capacity. The field reconaissance documented concrete swales and debris around the outlet and localized erosion along the concrete swale. Both stream segments have existing riparian corridors that could be improved and significant debris in the channel. There are localized areas, such as downstream of Centre Pointe Court, where active bank erosion was noted.

Conceptual Solution

Solution: On the channel reach, localized bank stabilizations are recommended on 75 linear feet downstream of Centre Pointe Court and riparian renovation is recommended for the entire reach. One rock check is included in the concept to help stabilize the bed of the channel. In the basin, the outlet structure should be replaced to manage flows, erosion should be addressed in an area adjacent to the concrete swale. Maintenance practices for the basin should include reduced mowing and fertilization.

Cost of Improvements: $114,400

Figure 1. Park Ridge Estates

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability, Detention	Park Ridge Estates		✔	✔		

IP-7268-1-1

Enwood

Existing Description

This existing wet detention DB-7268-06, located west of Spencer Road has sufficient capacity. The basin is well landscaped and an amenity for the surrounding residences.

Conceptual Solution

Solution: The concept recommendation includes planting a shoreline buffer around the basin to help stabilize this area.

Cost of Improvements: $10,900

Figure 1. Enwood

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Enwood			✔		

IP-7268-2-1

Country Creek

Existing Description

This existing wet detention DB-7268-04, located just upstream of Margaret Brown Court, does not have sufficient capacity. Additionally, algae was noted in the basin during the field visit, indicating that a filter strip may be beneficial. The shoreline did not have any live vegetation, although it appeared that some wetland vegetation may have established in the past.

Conceptual Solution

Solution: The concept recommendation includes planting a shoreline buffer around the basin to help stabilize this area. This basin may be evaluated in the future as part of a regional detention study to alleviate flooding at Jungermann Road.

Cost of Improvements: $60,000

Figure 1. Country Creek

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Country Creek			✔		

IP-7268-2-2

Wood Path

Existing Description

This project area, located in the Springwood subdivision, extends along two tributaries to the Crescent Hill tributary. Mass wasting, the failure of previous projects, backyard inlet erosion, and undercutting of structures should be addressed. There are a variety of stream stabilization strategies employed on these reaches: concrete slabs, milk crates, guardrails, gabions, are railroad ties are examples. Several of the outfall structures are not properly protected and may contribute to further bank scour.

Conceptual Solution

Solution: The recommended stream stabilization concept includes 8 rock check vertical grade control structures, riparian renovation, and bank stabilization along specific reaches within the project area. Bank stabilization shall extend 400 linear feet along the south branch of the Springwood Tributary, 1,035 linear feet along Springwood Tributary (the reaches upstream of Wood Path Lane), and 510 linear feet along Crescent Hills tributary (at least one bank the entire reach of 1,021 linear feet).

Cost of Improvements: $811,100

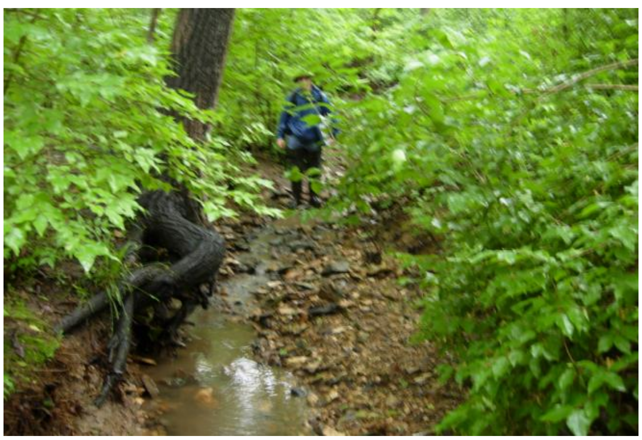


Figure 1. Wood Path

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Wood Path		✔	✔		

IP-7268-4-1

Hidden Lake

Existing Description

This existing wet detention basin, DB-7268-07, is located at Hidden Lake Drive in the Hidden Lake Estates subdivision. The presence of algae was documented during the field visit. The shoreline was protected in some places by decaying railroad ties or a low concrete wall. The basin is used for recreational boating. This basin is an amenity for the surrounding homes but not very accessible to the public. There is an opportunity to address nutrient water qualilty issues.

Conceptual Solution

Solution: This concept recommendation is to replace the existing concrete drainage flume with a vegetated riprap swale and stabilize confluence with basin. Wetland plantings should be installed in local benched areas within the wet basin and a vegetative buffer should be planted around most of basin, allowing access points for public use. There should be a public education effort regarding fertilier applications around the basin.

Cost of Improvements: $93,400

Figure 1. Hidden Lake

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Hidden Lake			✔		

IP-7269-1-1

Colby Drive

Existing Description

This reach of channel extends from Sutters Mill Road to Shadow Ridge Drive, just west of Spencer Road. The project reach has one crossing: Shadow Creek Drive. In some areas of the reach, there is concrete rubble material or riprap in the bottom of the channel. The home at 430 Spencer Road may be threatened by high bank stability issues.

Conceptual Solution

Solution: This concept addresses localized bank stability on 650 linear feet of the channel (about 25% of the channel within the project area). This bank stabilization work is located in the middle of the downstream reach, upstream of the area protected by riprap. The concept includes use 21 vertical grade controls over the entire reach. Riparian renovation and honeysuckle management is recommended for the entire project area and debris jams should be cleared.

Cost of Improvements: $606,400

Figure 1. Colby Drive

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Colby Drive		✔	✔	✔	✔

IP-7269-1-2

Penny Lane

Existing Description

This existing wet detention basin, DB-7269-01, is located between Spencer Road and Revolution Drive. Overall, the basin is in good condition but lacks a vegetative buffer. Small riprap protection edges the shoreline and a fountain in the middle of the basin provides aeration. There is a potential capacity issue that may be addressed by modifying the outlet structure.

Conceptual Solution

Solution: This concept includes increasing the basin capacity by modifying the outlet structure. Riprap should be placed at all basin structures to protect from erosion. Additionally, a vegetative buffer strip should be installed around the basin perimeter.

Cost of Improvements: $431,300

Figure 1. Penny Lane

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Penny Lane			✔		✔

IP-7269-2-1

Spencer Crossing

Existing Description

This reach of the Oak Creek Park Tributary was documented as a meandering sandy, cobble bed channel with bank cutting around bends, scour under TRM, riprap on some bank toes. Generally, the reach was characterized with moderate stability and good floodbench structure.

Conceptual Solution

Solution: The recommendation is to renovate the riprarian corridor (1164 linear feet).

Cost of Improvements: $22,700

Figure 1. Spencer Crossing

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Preservation	Spencer Crossing		✔		✔	✔

IP-7269-4-1

Oak Creek Park

Existing Description

This reach of incised channel lacks floodbenches and evidence of mass wasting was documented during field reconaissance. In some sections, the channel bed was characterized with bedrock. Some homemade gabion structures were documented. The riparian buffer was not sufficiently wide. The detention basin outfall structure into the channel should be replaced and protected (at the upstream end of the reach).

Conceptual Solution

Solution: This concept addresses bank stability issues along the entire reach of the channel with walls (along one side of the channel), vegetative protection, and 12 vertical grade control structures. The existing riparian buffer should be renovated and widened. New riparian buffer should be implemented in any area where it has been removed by homeowners (estimated at 20% of the reach).

Cost of Improvements: $3,383,900

Figure 1. Oak Creek Park

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Oak Creek Park		✔	✔		✔

IP-7270-1-1

St. Peters Executive Centre

Existing Description

This project area, located close to Executive Centre Parkway and west of St. Peters Center Boulevard, includes two existing wet detention basins, DB-7270-01 and DB-7270-10, and a reach of stream that extends between Veteran's Memorial Parkway and its confluence with Spencer Creek. The south detention basin has a sink hole at the outfall structure and an oil sheen was noted on the basin. This basin has sedimented in and the outlet pipe is 80% full of sediment. The north detention basin appears to be undersized and the outfall structure is not functional. Continuous overtopping of the spillway has led to rill erosion on the berm. The downstream channel is deeply incised below this basin with a dense canopy that prevents the establishment of vegetation. The channel reach north of Executive Centre Parkway is also incised and contributing significant sediment to the watershed. A braided channel and wetland swale was documented in the channel reach extended downstreamm of Executive Centre Parkway.

Conceptual Solution

Solution: This concept addresses erosion at both detention basins and the stability of the stream reach as needed. At the south detention basin, approximately 2 feet of material should be dredged. A vegetated filter strip, small pockets of wetlands, and new outlet structure are included. At the north basin, the existing outfall structure should be replaced and a spillway should be stabilized. A vegetated filter strip and wetland bench should be established. The short reach between the north basin and the confluence with Spencer Creek should be stabilized. The stream reach, upstream of Executive Centre Parkway, should be be stabilized. Ten rock checks should be used to control the bed slope and outfall structures should be protected. A narrow riparian corridor and filter strips would be established along the top of bank. There is a potential to include additional upstream BMPs in this project area to treat water from hot spots such as the car dealership parking lots.

Cost of Improvements: $1,512,200

Figure 1. St. Peters Executive Centre

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability, Detention	St. Peters Executive Centre		✔	✔	✔	

IP-7270-1-2

Executive Centre

Existing Description

This project includes a reach of Main Spencer Creek that extends between Executive Center Parkway and Spencer Road. The right bank has failed and will continue to change as the bank consists of silt loam soils without armoring. The reach downstream of Spencer Road has shown that riprap armoring in the trapezoidal channel is a successful solution for this reach. However, the channel shape in this reach has already started to form a bench that reconnects the reach with a wider floodplain. The water surface elevation was completely flat when LIDAR data was taken and therefore, the bed profile should be studied more in depth to determine the necessary grade controls. The stability of this channel does not impact infrastructure at this time but may be contributing substantial sediment to the system.

Conceptual Solution

Solution: This stream stability approach incorporates benching, 1 grade control structure, and vegetation management along the main channel of Spencer Creek at this location.

Cost of Improvements: $476,400

Figure 1. Executive Centre

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Executive Centre		✔	✔		

IP-7270-2-1

I-70 Executive Centre

Existing Description

This project is located directly north of City Hall and includes approximately 1250 feet of stream and the DB-7270-09 detention basin. The area is associated with flooding of Mexico Road, noted by the City during a 2011 storm event. The City noted that steps have been taken to modify the outlet structure of the detention basin to better control low flow events and create a functional dry detention basin. Additionally, the open channels have experienced severe erosion and contribute significant sediment loads to the system downstream.

Conceptual Solution

Solution: The concept includes stream stabilization along approximately 1250 linear feet with new riparian corridor. Stream reaches on the upstream and downstream sides of the detention basin should be stabilized by establishing a stable slope and vegetation. The channel toe should be protected with riprap and 2 rock check riffle structures are used to control the bed slope on these steep incised channels. The inlet to a pipe upstream of Mexico Road should be modified to include wingwalls and a headwall, reducing entrance losses at this transition. A narrow riparian corridor and filter strips should be established along the top of bank. To address sediment issues in the contributing drainage area, the rill erosion of the slope north of Executive Center Parkway should be addressed by developing a stable slope and establishing vegetation.

Cost of Improvements: $879,300

Figure 1. I-70 Executive Centre

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability, Detention	I-70 Executive Centre		✔	✔	✔	✔

IP-7270-3-1

Spencer Rd. Storage

Existing Description

This project includes the downstream portion of the Spencer Place Tributary, located between Spencer Road and the confluence with main Spencer Creek in the Avemco subdivision. Three storage structures are located within the area of inundation during the 100-year event in Spencer Creek.

Conceptual Solution

Solution: Construct 300-foot berm, 2-4 feet tall around north and east side of storage facilities, bringing elevation up to 462.

Cost of Improvements: $22,000

Figure 1. Spencer Rd. Storage

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Flooding	Spencer Rd. Storage	✔	✔	✔		✔

IP-7270-3-2

City Centre

Existing Description

This project includes a wet detention basin, DB-7270-15, and the downstream reach of East Spencer Creek, extending between the bridge crossing to Rec-plex South and the confluence with the main channel of Spencer Creek. The existing wet detention basin is an aesthetic feature for the park.

Conceptual Solution

Solution: The concept includes stabilizing the channel reach to improve sediment management. A series of 4 rock checks are included to stabilize the bed profile of the channel. To establish a successful restoration project, this channel should be reconnected with a wider floodplain on at least one side. This concept includes relocating the trail to be within the floodplain bench and excavating a wide bench along most of the south side of the channel. At the detention basin, some wetland plants and benching should be incorporated.

Cost of Improvements: $1,980,800

Figure 1. City Centre

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability, Detention	City Centre		✔	✔		✔

IP-7270-4-1

Carrington Estates

Existing Description

This project includes a reach of main Spencer Creek that extends between a tributary confluence downstream of Boone Hills Drive and Mexico Road. The channel was characterized by cobble bed material at riffle locations and deep pools with hard clay. The banks, consisting of silt loam, are slumping and contributing sediment to the watershed.

Conceptual Solution

Solution: This concept includes bank stabilization of the project reach and repair of mass wasting areas. Additionally, the concept incorporates the installation of 4 rock checks to control the bed profile elevation and prevent further degradation. Riparian renovation of the stream corridor is included.

Cost of Improvements: $3,707,900

Figure 1. Carrington Estates

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Carrington Estates		✔	✔		✔

IP-7366-2-1

Canyon Creek

Existing Description

This existing detention basin. DB-7366-01, has not been adequately maintained and excessive debris was noted in the basin during field reconaissance. The outfall structure should be redesigned.

Conceptual Solution

Solution: This concept recommendation includes retrofiting the dry detention basin to an improved dry basin. The outfall structure should be replaced and erosion areas should be stabilized with riprap. The concrete swale should be removed and vegetated. The surrounding area should be amended with soils that enhance infiltration, then seeded.

Cost of Improvements: $183,100

Figure 1. Canyon Creek

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Canyon Creek			✔		

IP-7367-1-1

Triad Center Dr. & Queens Ct.

Existing Description

This project includes two dry detention basins, DB-7367-04 and DB-7369-07, that are close to Queensbrook Court and Jungermann Road.

Conceptual Solution

Solution: The concept includes retrofitting the existing dry detention basins into wet basins for improved water quality. All structures are replaced and the concrete flumes are removed. Wetland and perimeter plantings should be installed after some excavation and grading work. Riprap should be placed to protect each new structure from erosion.

Cost of Improvements: $412,100

Figure 1. Triad Center Dr. & Queens Ct.

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Triad Center Dr. & Queens Ct.			✔		

IP-7367-2-1

Bella Vista Subdivision (1)

Existing Description

This project area, located south of McClay Road in the Bella Vista subdivision includes an existing wet detention basin, DB-7367-20, and a channel reach that was modified during a previous stabilization project. The channel area is impacted by the upstream detention basin and very turbid water was documented in the field.

Conceptual Solution

Solution: This concept includes improvements to the detention basin and riparian renovation of the stream corridor with some spot fixes for areas with erosion. Wetland plantings and a vegetated buffer should be established around the perimeter of the detention basin. A forebay structure should be added to control sediment in runoff from the contributing drainage area which is currently under development. Additional volume should be considered to prevent overtopping.

Cost of Improvements: $156,400

Figure 1. Bella Vista Subdivision (1)

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability, Detention	Bella Vista Subdivision (1)	✔	✔	✔		✔

IP-7367-3-1

Ashleigh Estates

Existing Description

This existing detention basin, DB-7367-10, is located northeast of the intersection of Triad Center Drive and Jungermann Road. The existing basin has concrete flumes to convey low flows and is traditionally maintained by mowing. The existing basin is undersized.

Conceptual Solution

Solution: The proposed concept includes replacing the existing concrete swales with riprap vegetated swales. This project requires approximately 5 more ac-ft of storage to address capacity concerns and provide water quality benefit. Riprap should be installed at all structures to protect from erosion.

Cost of Improvements: $287,200

Figure 1. Ashleigh Estates

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Ashleigh Estates					

IP-7367-3-2

Queensbrooke Village

Existing Description

This existing wet detention basin, DB-7367-19, is located northeast of the intersection of North St. Peters Parkway and Woodstone Drive. Rill erosion was observed on the banks during the field visit. The basin has sufficient capacity.

Conceptual Solution

Solution: The proposed concept includes a filter strip buffer between the roadways and basin. Additionally, grading and vegetative establishment on the basin slopes should be completed to address existing erosion. The water quality volume should be developed and revegetated. Riprap should be placed at all structures to protect from erosion.

Cost of Improvements: $37,700

Figure 1. Queensbrooke Village

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Queensbrooke Village			✔		

IP-7368-1-1

Millwood

Existing Description

This project includes the preservation and enhancement of a high-quality (SAI Type 1 and 2) riparian corridor on Spencer Creek betwen Jungermann Road and Millbrook Court/Mill Run Lane. The project intent is to maintain the corridor's existing health and function, and to demonstrate how vegetative plantings on residential properties that border riparian corridors can protect and enhance stream health. The figure below highlights the location of proposed riparian buffer preservation and enhancements.

Conceptual Solution

Solution: The recommendation is to renovate the riprarian corridor (2579 linear feet).

Cost of Improvements: $45,800

Figure 1. Millwood

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Preservation	Millwood		✔			✔

IP-7368-1-2

Crescent Hills (SC-3)

Existing Description

This reach of the Crescent Hills Tributary was characterized with good structure and vegetation.

Conceptual Solution

Solution: The recommendation in this project reach is to preserve the existing corridor through riparian renovation (1313 linear feet).

Cost of Improvements: $10,700

Figure 1. Crescent Hills (SC-3)

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Preservation	Crescent Hills (SC-3)		✔	✔		✔

IP-7368-1-3

Jungermann Road at Spencer Creek

Existing Description

The Jungermann Road Bridge project is located along the main channel of Spencer Creek. This has been an area of concern during each of the significant 2011 storm events. The existing hydraulic model does not show flooding in this area during events as large as the 25-year however the City has documented roadway ponding several times in 2011. There are two possible causes for this difference between modeling and reality: 1) the open channel provides sufficient conveyance but local drainage infrastructure is inadequate to convey flow from the street, 2) the USACE hydrologic analysis for the area is not representative of contributing drainage area and the open channel does not have sufficient capacity. Also, the conveyance capacity of the downstream channel may be the cause of flooding at Jungermann Road.

Conceptual Solution

Solution: Several options were evaluated at this location. The modeling approach used in the USACE models and assumed for the updated study did not produce overtopping of Jungermann Road at this crossing. A more conservative assumption was applied in the HECRAS model routing a higher flow through the bridge and this produced overtopping. Upstream detention should be considered when the hydrology of this contributing basin is further refined. Potential detention locations are indicated in the CIP report. To address overtopping that resulted from the conservative modelling approach, the existing culvert at Jungermann should be replaced with a bridge. The sump area along Jungermann should be filled - impacting approximately 800 linear feet of this road. Additionally, a berm should be constructed on the north side of the channel, downstream of Jungermann Road.

Cost of Improvements: $2,347,100

Figure 1. Jungermann Road at Spencer Creek

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Flooding, Stream Stability	Jungermann Road at Spencer Creek	✔	✔	✔	✔	✔

IP-7368-1-4

Tanglewood

Existing Description

This existing stream reach, located between Autumn Leaf Drive and Jungermann Road, is in the Tanglewood subdivision. An unnecessary culvert crossing may be creating a constriction in flow. Bank cutting was evident and invasive vegetation in a narrow riparian corridor was noted.

Conceptual Solution

Solution: This concept includes stabilization of each bank by sloping and vegetating. Management of riparian corridor is another feature of the recommendation. Two rock checks are included to control the bed profile elevation.

Cost of Improvements: $555,300

Figure 1. Tanglewood

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Tanglewood		✔	✔		

IP-7368-2-1

Burning Leaf Drive

Existing Description

The crossing of Burning Leaf Drive in the Tanglewood subdivision is currently overtopping. Six structures are impacted by the 100-year inundation area.

Conceptual Solution

Solution: The low area at Burning Leaf Drive should be raised along approximately 300 linear feet and 3 10x10 culverts should replace the existing bridge crossing. One rock check is included to help stabilize the bed profile of the channel. Additionally, 150 linear feet of channel improvements will be necessary as part of the culvert installation. One other option evaluated was new regional detention upstream, however, there was not sufficient land available to add the capacity needed to reduce peak 100-year discharge.

Cost of Improvements: $258,100

Figure 1. Burning Leaf Drive

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Flooding	Burning Leaf Drive	✔	✔	✔		✔

IP-7368-2-2

Laurel Park

Existing Description

The existing wet detention basin, DB-7368-09, is located at a City Park in the Huntleigh Estates subdivision. Erosion was noted around the perimeter of the basin, particularly at the location of an existing asphalt trail. Failure at the outfall structure was also noted.

Conceptual Solution

Solution: The concept proposed includes utilizing this accessible, City-owned detention basin as a water quality project. Erosion issues should be addressed along the bank with riprap shoreline protection. A buffer that includes wetland vegetation should be established around the perimeter with breaks to maintain access to the water.

Cost of Improvements: $61,800

Figure 1. Laurel Park

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Laurel Park			✔		✔

IP-7368-2-3

Kelly Leaf

Existing Description

This stream reach along the Tanglewood tributary was characterized as slightly incised with sharp meanders, significant debris jams, and good cobble bars. The buffer on the left bank was documented to be in good condition.

Conceptual Solution

Solution: The recommendation for this project reach is to preserve the corridor through riparian renovation. Six rock checks are included for vertical grade control.

Cost of Improvements: $48,900

Figure 1. Kelly Leaf

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Kelly Leaf		✔	✔		

IP-7368-3-1

Jungermann Office Center

Existing Description

This project stream reach is located on the Hidden Lake tributary in the Jungermann Office Center subdivision and extends between Hermana Lane and McClay Road. The outfalls along this reach are not protected and could lead to significant bank erosion. In some reaches, the bank failure threatens existing concrete retaining walls that have a fractured limestone base.

Conceptual Solution

Solution: Stream stabilization is recommended for this reach and due to the close proximity of structures, the use of walls will be necessary along portions of the reach. This very incised channel should be reconnected with a floodplain and therefore, the recommendation is to remove potions of the existing bank to create a wider bench. These areas will need to be established with new riparian corridor (assumed to be at least half of the entire reach). Six grade control structures will be used to stabilize the bed profile.

Cost of Improvements: $1,719,600

Figure 1. Jungermann Office Center

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Jungermann Office Center		✔	✔		

IP-7368-3-2

Hidden Pine Estates

Existing Description

This stream reach is located in the Hidden Pine Estates subdivision, to the west of Jungermann Road and south of Briarwick Trail.

Conceptual Solution

Solution: Stream stabilization concept recommendation includes establishing a stable slope and vegetation on the banks and renovating the existing corridor. Eight rock checks are included to stabilize the bed profile.

Cost of Improvements: $1,580,600

Figure 1. Hidden Pine Estates

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Hidden Pine Estates		✔	✔		

IP-7368-4-1

Country Lake Estates

Existing Description

This existing wet detention basin, DB-7368-08, is located in the Country Lake Estates subdivision, north of Country Lake Court.

Conceptual Solution

Solution: This concept recommendation includes a vegetated buffer surrounding half of the perimeter of the basin. Riprap should be placed around structures to protect from erosion.

Cost of Improvements: $7,800

Figure 1. Country Lake Estates

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Country Lake Estates			✔		

IP-7368-4-3

Spencer Creek in Millwood Subdivision

Existing Description

This project reach is along both the main channel of Spencer Creek and the Millwood tributary in the Millwood subdivision. Minor flooding, stream stability, debris jams, and backyard erosion were documented in the study. Significant amount of riprap already present in the main channel of Spencer Creek, however in localized areas bank protection is needed (such as the high bank threatening the existing trail along Spencer Creek).

Conceptual Solution

Solution: The proposed solution addresses flooding of 2 residences by adding fill in the floodplain downstream of Millwood Drive and completing channel improvements along Spencer Creek. Additionally, IP-7368-2-1, a project that includes improvements to Burning Leaf Drive, must be completed to address flooding. Limited stream stabilization approaches are included along 25% of the Spencer Creek main channel (the most upstream reach within project boundary) and riparian renovation is included in the entire project area. Seven rock checks are included to stabilize the bed profile. Upstream regional detention was evaluated as an alternative, however, it was determined that insufficient area was available to add a level of detention that would significantly reduce the 100-year water surface elevation.

Cost of Improvements: $520,000

Figure 1. Spencer Creek in Millwood Subdivision

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Flooding, Stream Stability	Spencer Creek in Millwood Subdivision	✔	✔		✔	✔

IP-7369-1-1

Spencer b/t Sutters Mill and Boone Hills

Existing Description

This project reach is along the main channel of Spencer Creek between Sutters Mill Road and Boone Hills Drive. There is a section in the middle of the reach, close to Showboat Circle cul-de-sac, where concrete chunks have been used as toe protection and the banks have successfully vegetated (although vegetation was not diverse). The reach upstream of this stabilized area showed evidence of significant bank erosion and debris jams which should be addressed to reduce sediment loading into the channel.

Conceptual Solution

Solution: The proposed solution addresses flooding by replacing the existing culvert array at Boone Hills Drive with 4 12x15 boxes and filling floodpain areas just north of Showboat Circle Drive on both sides of channel to raise floodplain grade by 2 feet. This project also includes imited stream stabilization approaches are included along the upstream 2414 linear feet of this project reach. Four rock checks are included to stabilize the bed profile of the channel. Riparian renovation is included in the entire project area (3597 linear feet).

Cost of Improvements: $3,186,400

Figure 1. Spencer b/t Sutters Mill and Boone Hills

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Flooding, Stream Stability	Spencer b/t Sutters Mill and Boone Hills	✔	✔	✔		✔

IP-7369-1-2

Applewood

Existing Description

This existing wet detention DB-7369-04, located in the Applewood subdivision, is south of Bartley Street. The basin does not have sufficient capacity and is overtopping Bartley Street.

Conceptual Solution

Solution: The concept recommendation includes replacement of the outfall structure, implementing a shoreline buffer of vegetation and riprap, and increasing capacity by excavating additional 2 feet from the bed of the basin. The basin is borderline on 25-year capacity and this additional storage will prevent street flooding.

Cost of Improvements: $97,400

Figure 1. Applewood

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Applewood	✔		✔		

IP-7369-2-1

Boone Hills Drive and Jungermann Road

Existing Description

This project area includes a stream reach along East Spencer Branch, existing detention at DB-7369-11, and a proposed detention location. These improvements may be related to potential flooding at the intersection of Boone Hills Drive and Jungermann Road. The existing aerated wet detention basin is well landscaped and the shoreline protected with a stacked stone wall and tree buffer on the west. Very turbid water was documented during the field visit. The stream has good overall structure in the upstream section, although an excessive amount of debris associated with brush and dumping at the Tieman Property was noted. This dumping has also compromised bank stability along 400 feet of the reach. The existing corridor has a significant amount of honeysuckle brush that is preventing the growth of a diverse riparian corridor.

Conceptual Solution

Solution: This concept includes improvements to the existing detention basin, development of a new dry detention basin west of Jungermann, and channel improvements. At the existing basin, the outfall structure should be further studied. A forebay structure should be added to better manage debris in this basin. A vegetative buffer should be established along the street that runs adjacent to the basin. In the upstream reach, the left bank should be repaired with a 5-ft wall and sloped/vegetated section. Three rock check structures are included to stabilize the bed profile of the channel. The riparian corridor should be renovated along along the entire reach. To the west of Jungermann Road behind 410 Jungermann Road, a new dry detention facility is proposed with the addition of a 70-ft long berm that raises the grade 4 feet.

Cost of Improvements: $491,900

Figure 1. Boone Hills Drive and Jungermann Road

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability, Detention	Boone Hills Drive and Jungermann Road	✔	✔	✔	✔	✔

IP-7369-3-1

Novella Court

Existing Description

This project area includes a reach of the main channel of Spencer Creek where there is localized flooding of backyards to the east. The channel shows limited bank cutting and poor vegetation. There is a good cobble bottom, good bar development and toe stabilization along the majority of the reach.

Conceptual Solution

Solution: Riparian renovation of the entire reach is recommended. The backyard flooding should be addressed by grading in backyards rather than channel improvements. The cost of grading at this project location is not included in the 2012 cost estimate.

Cost of Improvements: $66,700

Figure 1. Novella Court

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Flooding, Preservation	Novella Court	✔	✔	✔		✔

IP-7369-3-2

Spencer Trail

Existing Description

This stream reach, located north of Willott Road, is along the main channel of Spencer Creek. Each backyard condition is different and high banks were observed along portions of the reach. Much of the channel was characterized as a long riffle run, stable channel bed, banks were armored with concrete slabs in some areas. There was limited scour around drainage structures

Conceptual Solution

Solution: This concept includes limited bank stabilization to address bank cutting observed in the field. This bank stabilization is recommended for the middle 575 linear feet of the reach along Spencer Creek Park and upstream of the crossing. The riparian corridor along the entire length of channel should be renovated. Two rock checks are included to stabilize the bed profile.

Cost of Improvements: $480,900

Figure 1. Spencer Trail

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Spencer Trail		✔	✔		✔

IP-7369-3-3

St. Peters Condos Detention

Existing Description

This dry detention basin, DB-7369-07, is located north of Willott Road in the St. Peters Condos subdivision. Erosion was noted around the outfall but the structure was in good condition. This basin is located along an existing trail and has good visibility.

Conceptual Solution

Solution: The proposed concept includes a retrofit to improved dry detention. The high percentage of impervious drainage area to the basin makes the location a good candidate for water quality improvement. Wetland plantings, removal of the concrete flume, and a meandering low flow are all included in the concept. Additional storage volume (1 acft) is excavated.

Cost of Improvements: $521,600

Figure 1. St. Peters Condos Detention

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	St. Peters Condos Detention	✔		✔		✔

IP-7369-4-1

West Drive

Existing Description

This project area includes a wet detention basin, DB-7369-06, and stream reaches in the contributing drainage area. The basin is currently used for recreation (i.e. fishing) and is owned by the City. There are three contributing tributaries that drain into the basin: Elm Tree Tributary is at the far west, Hi Pointe Tributary is the center tributary, and Peach Street Tributary is at the far east of the project area. The upstream two thirds of Elm Tree Tributary was characterized as a farily incised channel with unconsolidated leaf litter debris and loose sediment bed material. The Hi Pointe Tributary was characterized as an incised channel with debris dumping in the downstream half. In the upstream half it is a meanding intermittent channel with poor understory vegetation. The Peach Street Tributary flows through backyards and has been associated with flooding problems at Peach Street.

Conceptual Solution

Solution: This concept includes improvements to the basin and each of the contributing tributaries. At the detention basin, the capacity should be increased by raising West Drive and replacing the outlet structure. Wetland benching should be established on the southwest and a vegetated buffer should be installed around the entire perimeter. The Hi Pointe tributary entrance to the basin should be regraded to enter on the upstream end (reducing the stream length by 529 linear feet). Ripairan renovation is recommended throughout the remaining reach. Stabilization of the Peach Street Tributary includes two strategies, 1) stabilization and vegetation downstream of Peach St., 2) narrow riparian corridor re-established upstream of Peach St. A total of 6 rock check structures are included to stabilize the bed profiles of these streams.

Cost of Improvements: $990,000

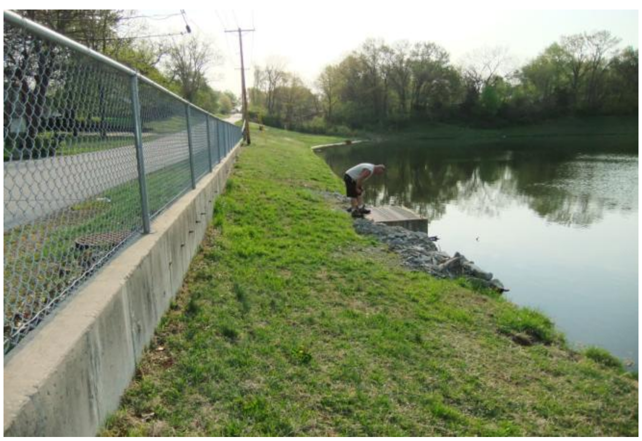


Figure 1. West Drive

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability, Detention	West Drive	✔	✔	✔		

IP-7370-3-1

Koenig Orchard

Existing Description

Thix existing reach of East Spencer Creek/Koenig Tributary was characterized as having a bedrock bottom, some bank cutting, and good rock material on most banks. The channel is located in an agricultural area without buffers and significant invasive vegetation in the riparian corridor was documented during field reconaissance.

Conceptual Solution

Solution: Riparian renovation is recommended for this stream corridor. Additionally, a vegetated filter strip should be added to all agricultural buffers that are adjacent to this reach. Debris on culvert face should be removed.

Cost of Improvements: $54,200

Figure 1. Koenig Orchard

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Koenig Orchard		✔	✔	✔	✔

IP-7370-3-2

Fort Zumwalt East HS

Existing Description

This existing dry detention basin DB-7370-16, located at the Fort Zumwalt High School, just north of Boone Hills Drive and west of First Executive Avenue, was characterized with limited erosion around the concrete flume. The basin has sufficient capacity but the City requested that this study evaluate additional capacity in this area. There is great visibility at this location and a connection to school and public related education. All structures in this basin are very new. Based on the layout of the basin, most small storm events bypass this basin and flow moves quickly, moving 6-12" riprap.

Conceptual Solution

Solution: The concept recommendation is to retrofit the existing dry detention basin to an improved dry detention and use a silt wall at the downstream end to control flow leaving the basin during small storm events. The concrete flume should be replaced with a vegetated swale and the bottom of the basin should be revegetated to enhance infiltration. Additional capacity at this location does not address improvements on Spencer Creek. The basin has sufficient capacity for the 100-year event.

Cost of Improvements: $105,100

Figure 1. Fort Zumwalt East HS

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Fort Zumwalt East HS			✔		✔

IP-7370-4-1

E. Spencer Creek d/s of Jungermann Rd

Existing Description

This existing reach of East Spencer Creek/Koenig Tributary is located downstream of the intersection of Jungermann Road and Boone Hills Drive. The stream was characterized with continuous bank erosion and deposition on the channel bed. A riparian corridor or buffer was lacking.

Conceptual Solution

Solution: The recommended concept is to stabilize the existing channel by sloping and vegetating. Five rock checks are included to stabilize the channel bed. Additionally, the concept includes establishment of a riparian buffer.

Cost of Improvements: $962,800

Figure 1. E. Spencer Creek d/s of Jungermann Rd

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	E. Spencer Creek d/s of Jungermann Rd		✔	✔	✔	✔

IP-7467-1-1

Bella Vista Subdivision (2)

Existing Description

This existing project reach is located south of McClay Road and north of the Bella Vista subdivision. It extends from the detention basin at Mattina Court, DB-7467-14, to the confluence with the McClay Village Tributary.

Conceptual Solution

Solution: At the detention basin, sediment deposition needs to be managed (particularly during development) and rill erosion should be stabilized. The recommendation is to remove the existing conrete flumes and replace with vegetated swales. A section (approximately 240 linear feet) of the stream should be stabilized with bank grading and vegetation. The riparian corridor for the entire reach should be renovated.

Cost of Improvements: $273,100

Figure 1. Bella Vista Subdivision (2)

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability, Detention	Bella Vista Subdivision (2)		✔	✔	✔	✔

IP-7467-1-2

Bella Vista Subdivision

Existing Description

This project includes two detention basins in the Bella Vista subdivision: DB-7467-15 and DB-7467-16. One basin is at Mattina Cort and one is at Hemsath Way Drive.

Conceptual Solution

Solution: The recommended concept is to replace the existing concrete swale with vegeation, revegetate the dry detention area and incorporate amended soil in the base, establish vegetation on side slopes, riprap around structures to reduce erosion, reduce mowing, address some rill erosion.

Cost of Improvements: $213,400

Figure 1. Bella Vista Subdivision

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Bella Vista Subdivision					

IP-7467-1-3

Sun River Village

Existing Description

This project area includes a channel reach and detention basin, DB-7467-04, in the Sun River Village subdivision. The existing outfall is buried. The stream reach was characterized with diverse vegeation that should be managed. Field notes documented a cobble bed system and some localized bank erosion that should be stabilized.

Conceptual Solution

Solution: The proposed recommendation includes reconstruction of the detention basin into a wet basin and the development of a pocket park. Stabilization is recommended on downstream reach (very incised channel with unconsolidated bed material and soft material on high banks). Stabilization should include benching. Riparian renovation is recommended for the entire project reach.

Cost of Improvements: $411,900

Figure 1. Sun River Village

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability, Detention	Sun River Village	✔	✔	✔		

IP-7467-3-1

Windwood

Existing Description

This project includes a dry detention basin, DB-7467-12, in the Villages of Windwood subdivision, located south of Windwood Trails Drive. The basin drains outside of USACE model, however, it appears that existing capacity should be sufficient for at least the 25-year.

Conceptual Solution

Solution: The proposed recommendation includes replacing the concrete swale with a vegetated swale to enhance infiltration. Riprap should be placed around structures to protect from erosion.

Cost of Improvements: $68,600

Figure 1. Windwood

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Windwood			✔		

IP-7467-3-2

Villages of Windwood

Existing Description

This existing reach showed evidence of polluted water and is too shaded for a healthy riparian corridor.

Conceptual Solution

Solution: Riparian renovation is recommended for this stream corridor. (686 linear feet).

Cost of Improvements: $5,600

Figure 1. Villages of Windwood

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Preservation	Villages of Windwood		✔	✔		

IP-7467-4-1

Magnolia Manor

Existing Description

This project area includes a reach directly west of Magnolia Manor Court. The field notes documented headcutting at the 90 degree bend behind the residence at 1343 Magnolia Manor Court. A twin CMP discharge in the right bank may have been abandoned. Invasive vegetation was present in this channel and preventing the establishment of a diverse corridor.

Conceptual Solution

Solution: This concept includes 5 vertical grade control structures and renovation of the riparian corridor. There will be significant grading and clearing to establish a stable slope and remove debris in the channel.

Cost of Improvements: $37,400

Figure 1.   Magnolia Manor

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Magnolia Manor		✔	✔		

IP-7467-4-3

Pointe of Heritage Crossing

Existing Description

This reach, directly east of Kings Crossing church on Hwy 94 was characterized as a meandering incised channel through a heavily wooded area.

Conceptual Solution

Solution: This concept includes 6 vertical grade control structures and vegetation management to develop a more stable channel system. Benching was considered but excluded because of the established trees in this reach and the downstream detention that slows flow. A high wall behind the properties on Calvert Place should be further investigated.

Cost of Improvements: $80,000

Figure 1. Pointe of Heritage Crossing

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Pointe of Heritage Crossing		✔	✔		✔

IP-7467-4-4

Heritage Manor (PC-1)

Existing Description

This project area, located south of Hwy 94 and east of Jungs Station Road, is highlighted as an educational opportunity. There is some grading at one residence along Plantation Manor Court that should be addressed to prevent standing water in the backyard

Conceptual Solution

Solution: This large BMP should continue to be maintained. The concept recommendation is to develop this area into a more educational and public park with a boardwalk, educatoinal signage. Limited grading is included to address standing water in the backyard along Plantation Manor Court.

Cost of Improvements: $83,000

Figure 1.   Heritage Manor (PC-1)

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Heritage Manor (PC-1)		✔	✔		✔

IP-7468-1-1

Huntleigh Estates

Existing Description

This existing wet detenion basin, DB-7468-01, is located in Huntleigh Estates, south of Wyatt Drive. The basin structures are old and the edge needs to be stabilized. Additional capacity is needed because the existing basin is overwhelmed with flows. The basin may not have sufficient capacity.

Conceptual Solution

Solution: The concept recommendation at this project location includes addressing erosion along bank, incorporating wetland plants and a vegetative buffer. An additional 0.5 acft of storage is recommended.

Cost of Improvements: $133,500

Figure 1. Huntleigh Estates

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	Huntleigh Estates			✔		✔

IP-7468-3-1

Laurel Park, McClay Valley Blvd

Existing Description

The existing channel has very good structure but the presence of honeysuckle and other invasive vegetation needs to be addressed.

Conceptual Solution

Solution: Riparian renovation suggested for stream corridor (904 linear feet).

Cost of Improvements: $7,400

Figure 1. Laurel Park, McClay Valley Blvd

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Preservation	Laurel Park, McClay Valley Blvd		✔	✔		✔

IP-7468-3-2

McClay Valley /Woodstream

Existing Description

This existing channel was identified as a potential linkage between two channels in good condition.

Conceptual Solution

Solution: Riparian renovation suggested for stream corridor (2086 linear feet).

Cost of Improvements: $17,000

Figure 1. McClay Valley /Woodstream

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Linkage	McClay Valley /Woodstream		✔	✔		✔

IP-7468-3-3

McClay Valley Detention Basin

Existing Description

The McClay Valley Detention Basin, DB-7468-06, receives a significant amount of debris and flow from upstream sources and presents a unique demonstration opportunity as a larger detention basin in the watershed. Additionally, the City noted that the contributing storm sewer infrastructure is not designed to adequately drain the surrounding area to the basin.

Conceptual Solution

Solution: The conceptual solution is focused on addressing the issues at the McClay Valley detention basin and restoring a second detention upstream of the large basin. A berm embankment and outlet works should be constructed for the upstream detention basin. At the main basin, a forebay should be developed with wetland plantings and the outlet structure may be modified. Local drainage infrastructure to the main detention basin should be replaced to allow functional drainage. Edge treatment may include a vegetative buffer, wetland bench, or combination established on the perimeter of the main basin.

Cost of Improvements: $1,650,000

Figure 1. McClay Valley Detention Basin

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Detention	McClay Valley Detention Basin	✔	✔	✔		✔

IP-7470-3-1

Venture Dr.

Existing Description

This project area includes a short reach of open channel between piped systems. The channel has a good corridor and very tall steep slopes. Rill erosion was noted, likely from parking lot drainage on the east.

Conceptual Solution

Solution: Stabilize banks and rill erosion with the use of walls, grading, and vegetation.

Cost of Improvements: $1,120,500

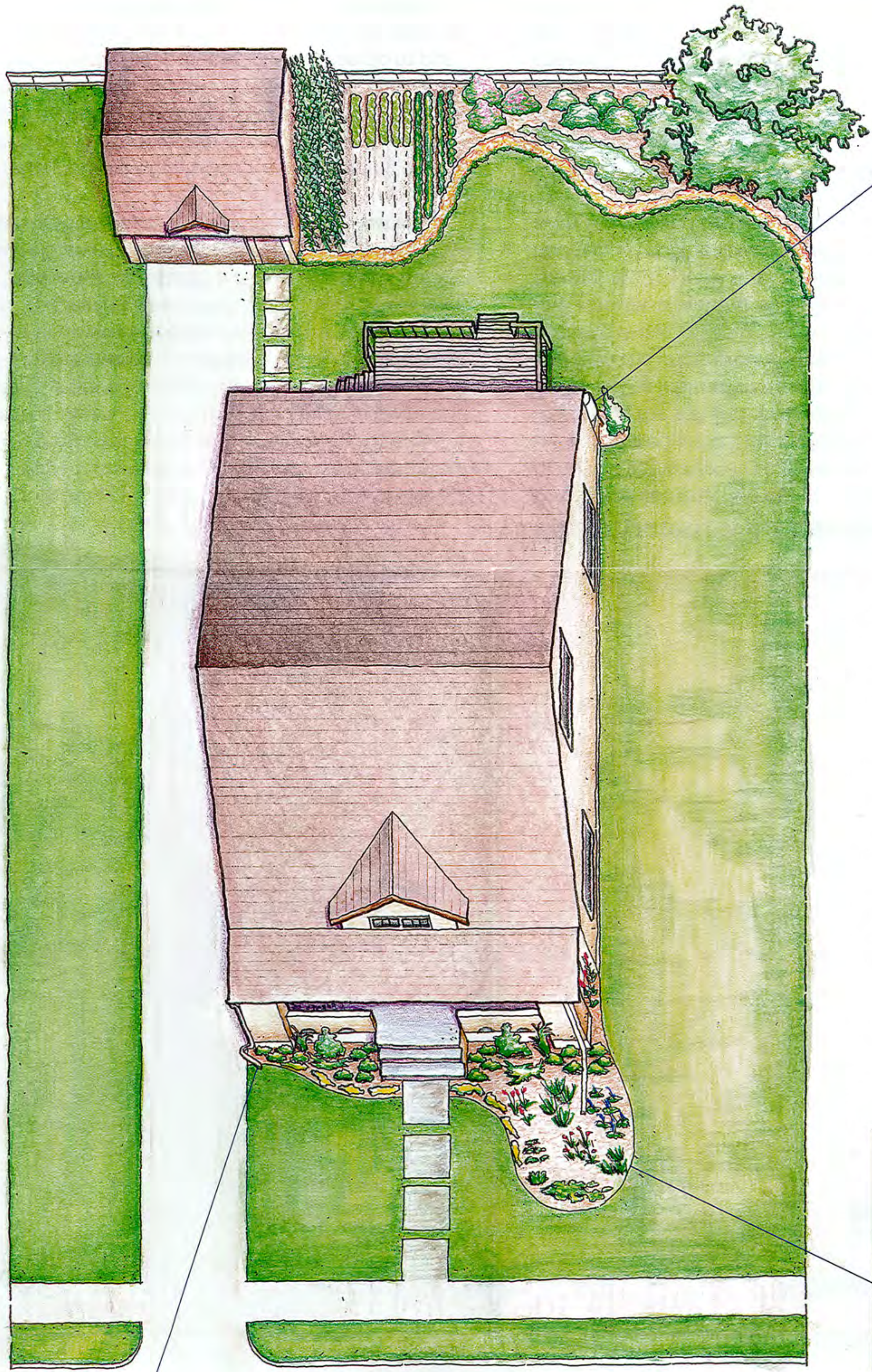
Figure 1. Venture Dr.

Project Type	Project Location	Flooding	Stream Stability	Water Quality	Visibility	Educational
Stream Stability	Venture Dr.		✔	✔		

Appendix I. Example Educational Materials

Get the most out of rain

Ideas for creating a rain-friendly yard



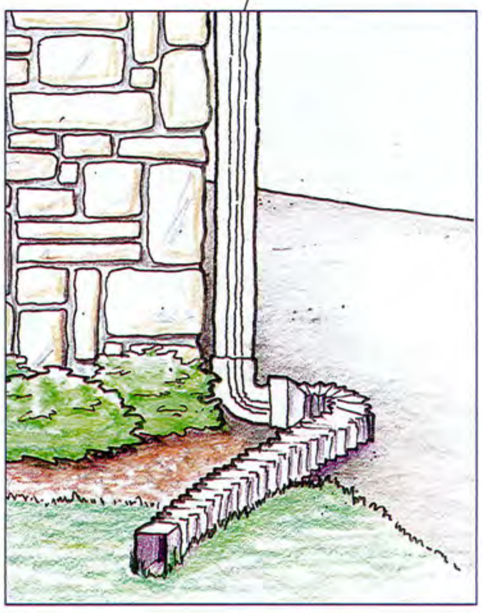
Save water with rain barrels

A rain barrel is a container that collects and stores rainwater from downspouts and rooftops for future use watering lawns and gardens. Generally a rain barrel is made using a 55-gallon drum, a vinyl garden hose, PVC couplings, a screen grate to remove debris and keep insects out, and other materials found at neighborhood hardware stores.

Rain barrels can be constructed in a number of ways, but they all serve the same purpose — to collect rainwater and decrease the amount of stormwater runoff that leaves your property.

During the summer months it is estimated that nearly 40 percent of household water is used for lawn and garden maintenance. A rain barrel collects water and stores it for those times that you need it most — during the dry summer months. Using rain barrels potentially helps homeowners lower water bills, while also improving the vitality of plants, flowers, trees, and lawns.

For more information about rain barrels, please visit **www.marc.org/rainbarrels.htm**



Redirect downspouts

Take full advantage of the rain that comes off your roof by making sure that your downspouts deposit rainwater where it can be put to good use. Redirect downspouts to gardens, grassy areas, rain barrels — places where water can infiltrate the ground and roots of plants, decreasing the amount of water that goes down storm drains.

Rain is naturally soft and devoid of minerals, chlorine, fluoride, and other harmful chemicals. The chemicals and hard water from many of our municipal water systems can add to chemical imbalances in soil and damage sensitive plants. Rainwater from the roofs of houses picks up very little contamination, and is very healthy for plants.

Use extension gutters or splash blocks to help direct the flow of water if your downspout isn't long enough. If directing stormwater to a yard, try to discharge the water at least five feet from foundations to prevent potenial leakage into the house.

Build a rain garden

A great way to complement your rain barrel and increase your property's ability to absorb runoff is through a rain garden. Rain gardens can be a fun and easy way to learn about beautiful native plants as well as help to improve water quality and reduce flooding.

Rain gardens typically absorb much more water than the same size area of lawn. They are drought resistant, winter hardy and less prone to destructive insects and diseases. Rain gardens create a preferred habitat for birds, butterflies and dragonflies. These specialty gardens are versatile; they can be any size or shape imaginable, but to maximize their benefit you should build them in an existing low spot or near the drainage area of your rain barrel or downspout.

For more information on rain gardens visit **www.marc.org/water/raingardens.pdf**

MARC
Mid-America Regional Council

For more information please visit www.marc.org/water, or call 816/474-4240.

Why disconnect your downspout?

Downspouts that connect directly to sewer pipes increase the risk of sewer overflow and flooding. Disconnecting your downspout from a sewer intake pipe (standpipe), then redirecting the flow of water to a grassy area or garden is a simple process that makes a big difference to the environment.

Supplies

- Hacksaw
- Cordless drill
- Tape measure
- Pliers
- Sheet metal screws
- Downspout elbow
- Downspout extension
- Standpipe cap

There are different types, lengths and sizes, of standpipe caps, so be sure to take measurements before shopping. Capping the standpipe prevents water from going in while keeping pests (such as rodents) from entering/exiting the pipe.

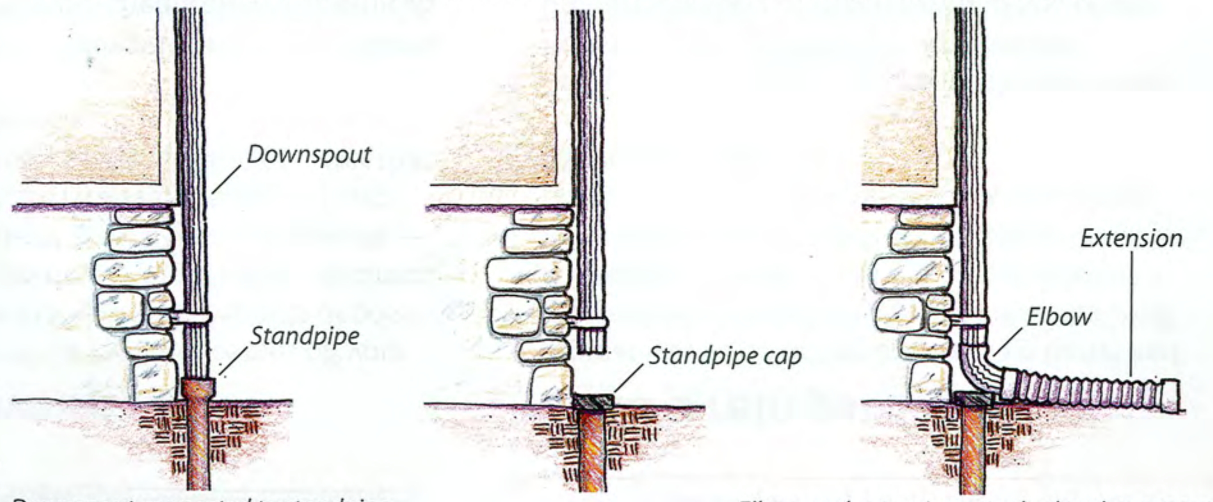
Instructions

1. Cut the existing downspout approximately 9 inches above the sewer standpipe with a hacksaw.

2. Cap the sewer standpipe.

3. Attach elbow by crimping the downspout with pliers to ensure a good fit. Connect elbow to downspout using sheet metal screws. It may be necessary to pre drill holes.

4. Attach the elbow INTO the extension and secure with sheet metal screws. Water should drain at least five feet away from the house, so direct the extension accordingly. A splash block may help direct water further away from the house.



Downspout connected to standpipe. *Elbow and extension attached to downspout.*

www.marc.org/water

MARC
Mid-America Regional Council

Rain, roofs and runoff

Did you know that each downspout on a house can drain approximately 12 gallons of water per minute during a one-inch rainfall? If managed properly, the water that flows off rooftops can help keep lawns and gardens green while lowering utility bills during spring and summer months. However, most downspouts send rainwater down driveways, sidewalks, and underground pipes that lead to storm drains or sanitary sewer lines. This **"stormwater runoff"** picks up pollutants from motor oil, lawn chemicals, and pet waste along the way, before entering lakes and streams — **untreated.**

The large amount of untreated water entering the storm sewer system — and eventually our streams and lakes — has lasting health, safety, environmental and economic impacts on communities. Fortunately, there are many things that property owners can do to put rainwater to good use while reducing the amount of stormwater runoff that ends up in local waterways.

For more information, visit www.marc.org/water

The problem with pavement

During the construction of homes, roads and office buildings vegetation is often removed and replaced by large paved areas. These surfaces keep rain from infiltrating the soil and recharging groundwater supplies. The infiltration process helps clean water and feed the underground springs that supply drinking water. Paved surfaces also increase the speed and amount of water that rushes into streams, causing stream bank erosion and harming wildlife habitats. Direct the flow of water from downspouts away from paved surfaces whenever possible.

Combined sewer overflows

Combined sewers are older systems that carry both stormwater and wastewater to treatment plants. When rainstorms fill combined sewers beyond capacity, the result is a Combined Sewer Overflow — a discharge of untreated wastewater and stormwater into local waterways. Combined sewers are costly to replace and still used in older areas of the region. Residents are encouraged to disconnect downspouts from sewer pipes or redirect downspouts to grassy areas or gardens to reduce the rain that enters sewers.

Disconnect or Redirect Your Downspout

Did you know?

Plants act as filters to clean stormwater runoff before it enters the stream. Notice the native plants along the banks of the stream.

Can you see...


Cardinal Flowers


Tall Bellflowers


Green Bulrush


Mash Milkweed


Ohio Buckeyes


Sycamore Trees

A healthy stream, like a city, is a bustling

place with plants, insects, fish and wildlife each doing their job to help the "city" grow. Trees, shrubs and groundcover on the banks of the stream stop erosion and provide important **habitat**, food and hiding places **for insects** and wildlife. **Plants** and animals use the nutrients in the water for food. **Fish** eat the plants **and** recycle the nutrients back into the system. **Birds**, mammals, amphibians and reptiles use the land surrounding the stream for nesting and breeding.

Notice this stream and many other natural streams in the area. They wind through the landscape. Deep pools form on the outside of bends and shallower, rockier sections called riffles form in between. Fish find shelter in the pools, where the water is deeper and moves slowly. Water moves through riffles more quickly, bubbling over the rocks, picking up oxygen, insects and other nutrients. This is an ideal environment for fish to feed and spawn.

The Shape of a Stream is Important Too

Stream Ecology

Lenexa KANSAS

www.raintorecreation.org

The Floodplain get connected

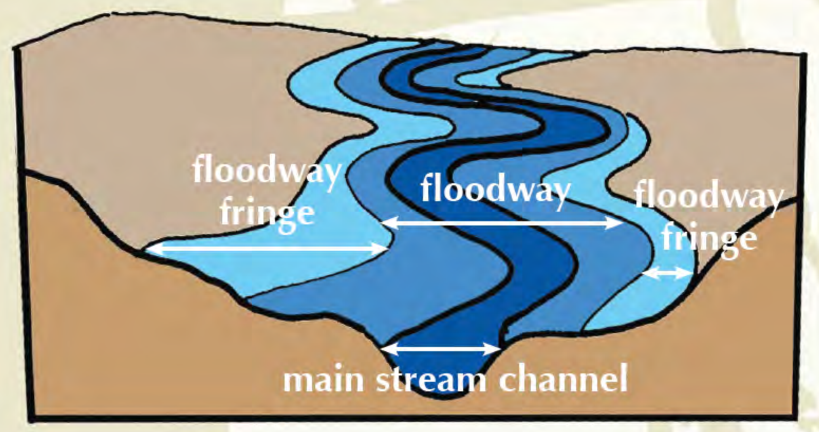
Safety tips

Flooding is the most common of all natural disasters and can happen in all parts of the United States.

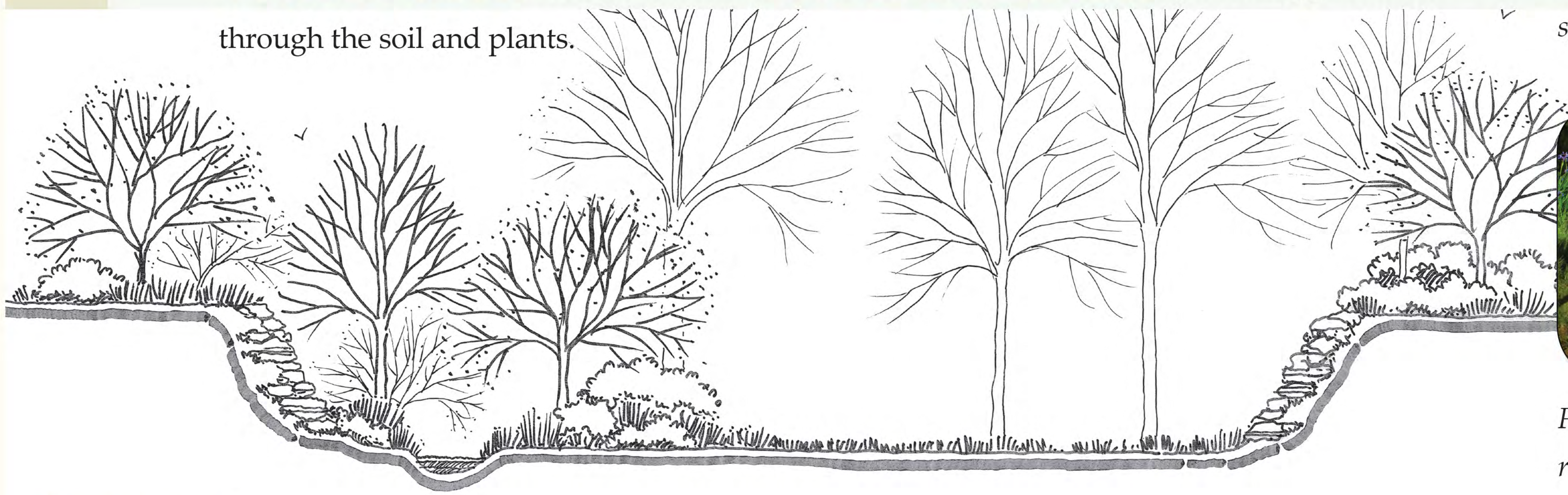
Some floods happen slowly and with warning. Flash floods can happen very quickly, without warning and can be very dangerous.

During a flood, do not walk through moving water because you could fall and be quickly washed away.

Do not drive into flooded areas. A small car can float away in 7 inches of water over a roadway.



Part of the Rain to Recreation initiative is to **reconnect floodplains to their streams**. Streams connect communities while floodplains provide important wildlife travel corridors and are home to uniquely adapted trees and plants. The floodplain is the flat area of land adjacent to a river that can be covered with water when the river overflows its banks following a heavy rain. As a natural part of the landscape, the floodplain plays an important role in **maintaining the quality of our water and** the health of the **environment** by filtering pollutants through the soil and plants.



Floodplains provide important habitat and breeding sites for many species of birds and mammals.

Floodplains are suitable for recreational activities such as hiking, bird watching and fishing.

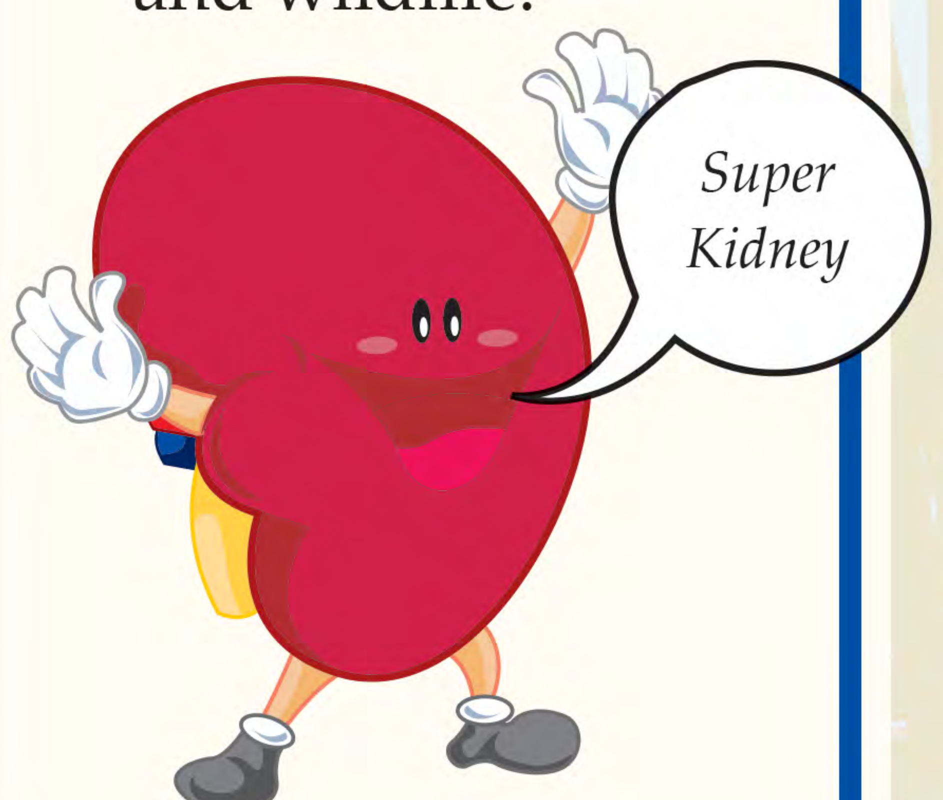
Lenexa KANSAS

www.raintorecreation.org

Why save the Wetlands?

Did you know?

Just like your kidneys filter toxins and waste from your body, wetlands filter waste from stormwater runoff, leaving clean healthy water for fish, birds, and wildlife.



Wetlands are one of the most important ecosystems in nature. They store and slowly release excess stormwater into the ecosystem, help to stop flooding and erosion, and filter out pollutants and sediments. They are also home to thousands of species of both plants and animals.

What do you see?

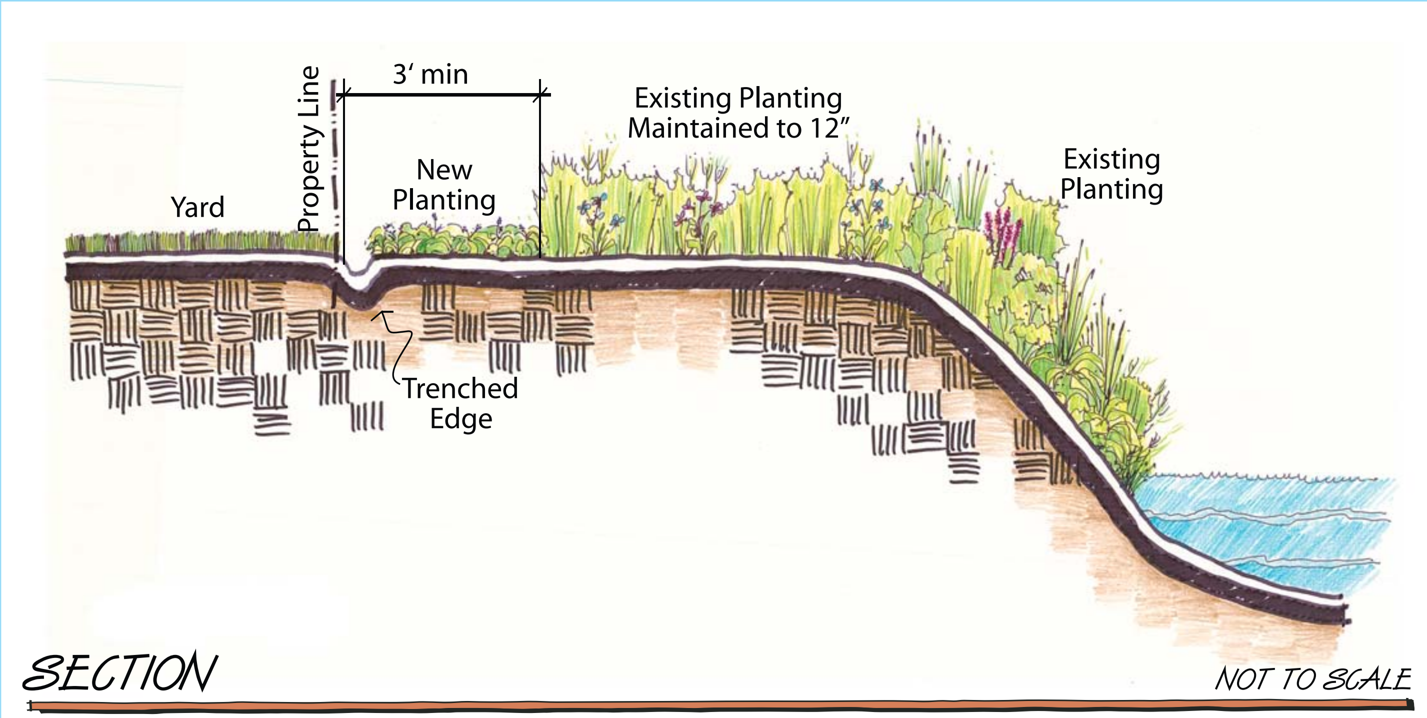
Lenexa KANSAS

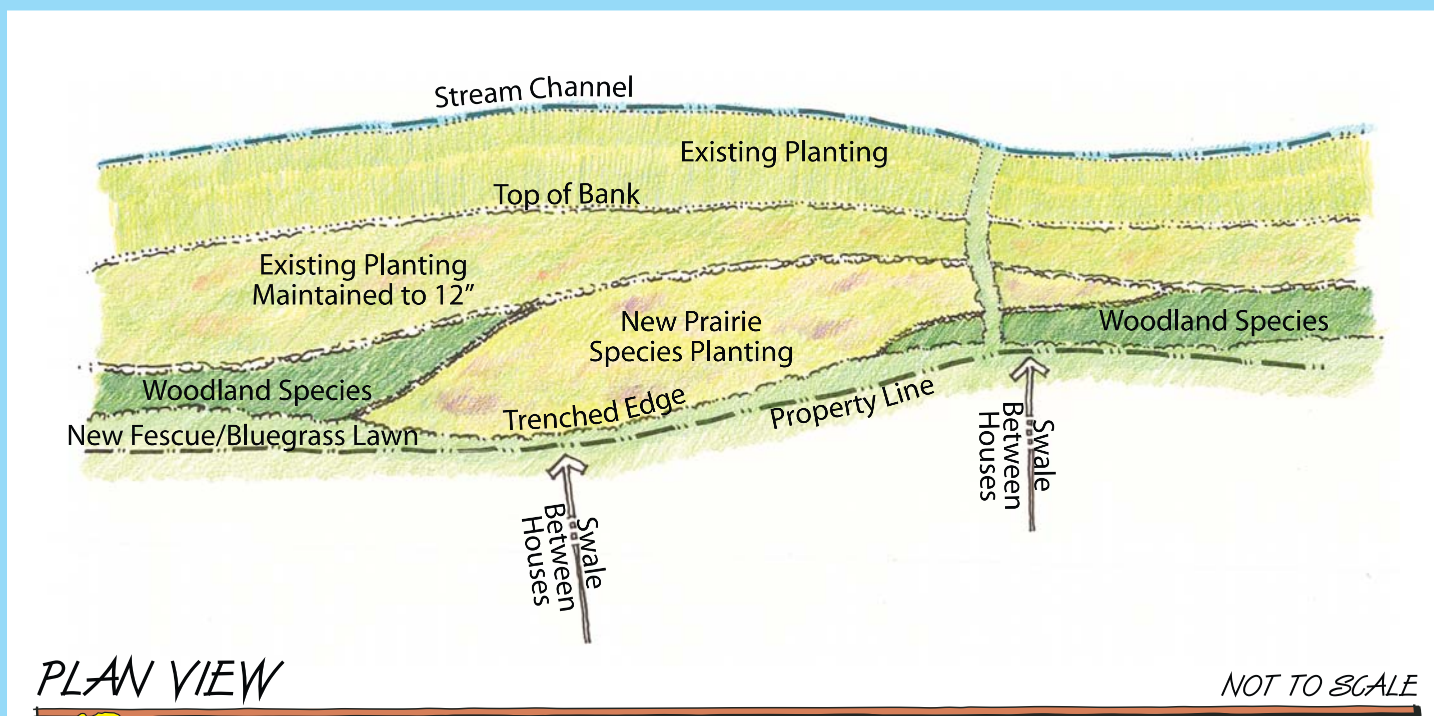
www.raintorecreation.org

Funded in part by: U.S. EPA SECTION 319 GRANT & KANSAS WATER PLAN FUNDS Provided by KANSAS DEPT OF HEALTH AND ENVIRONMENT

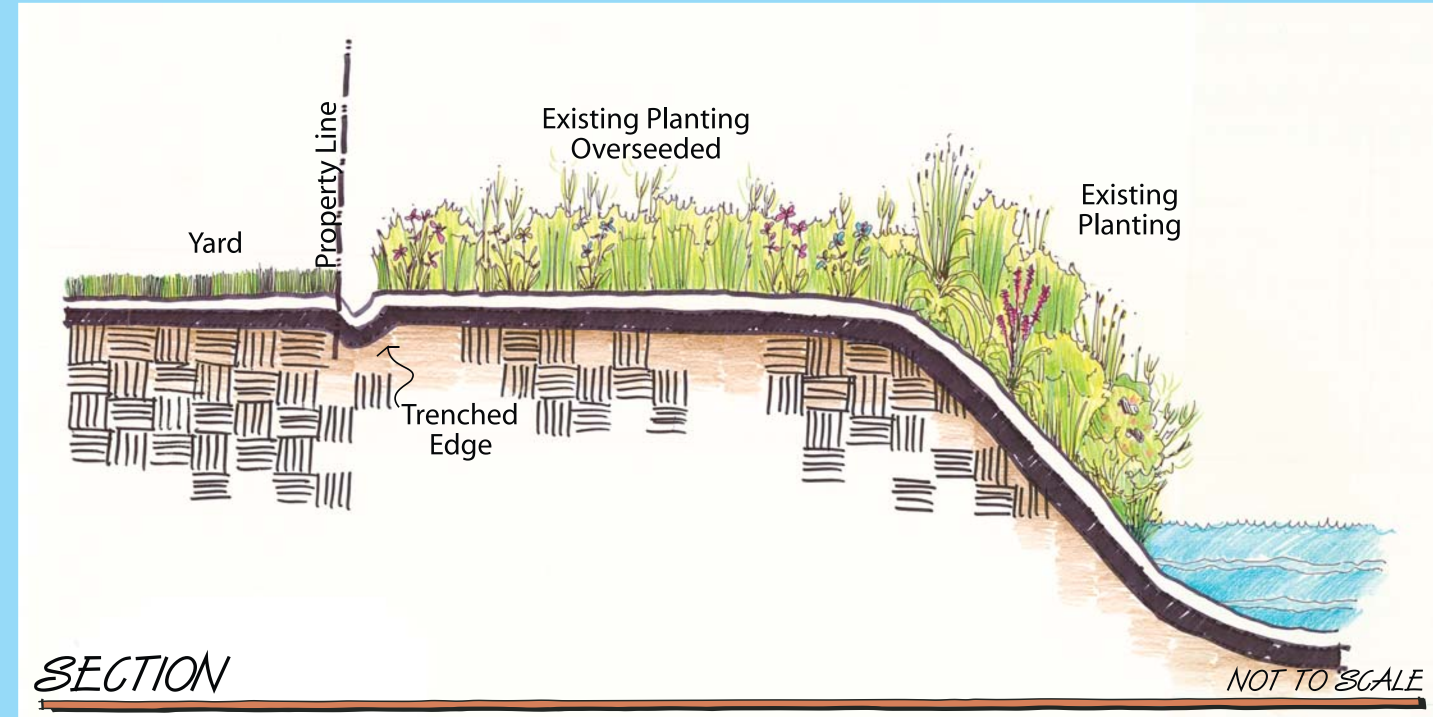
83rd Terrace Stormwater

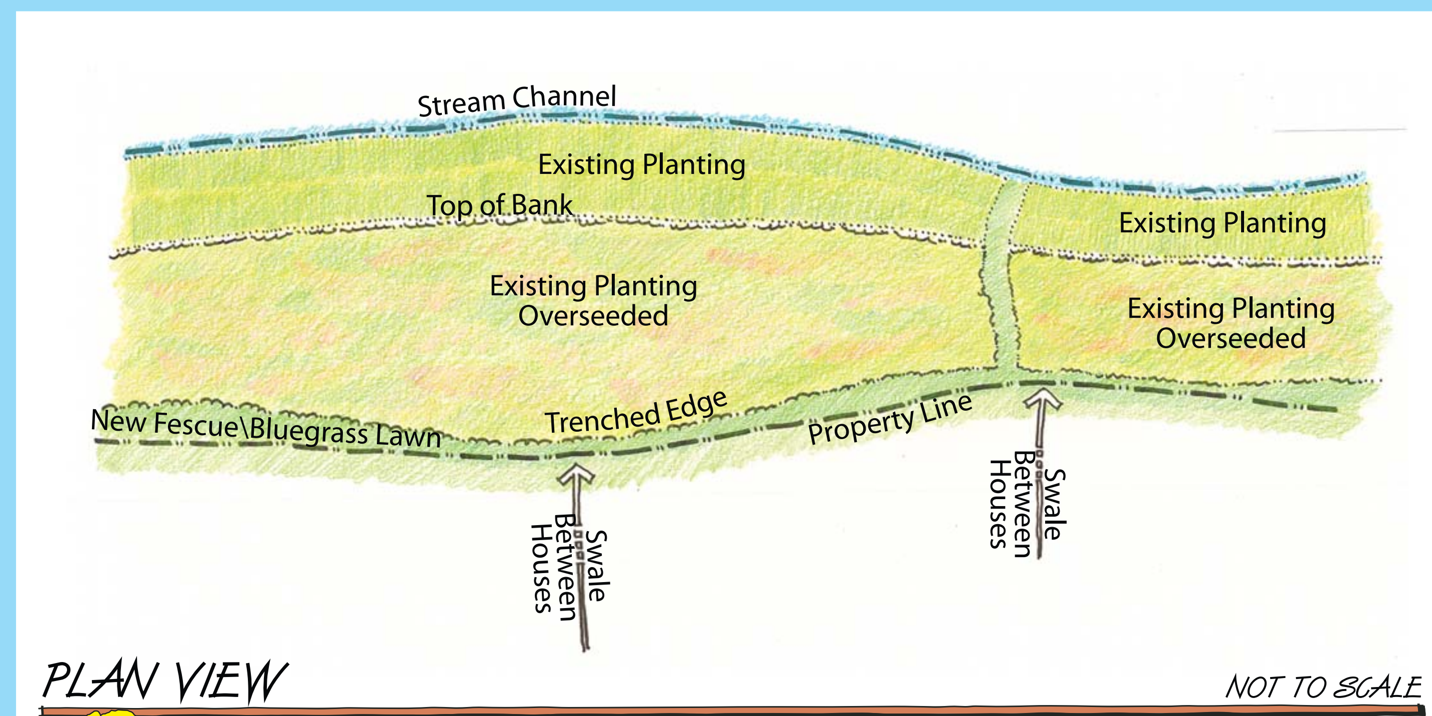
Option 1





Option 2





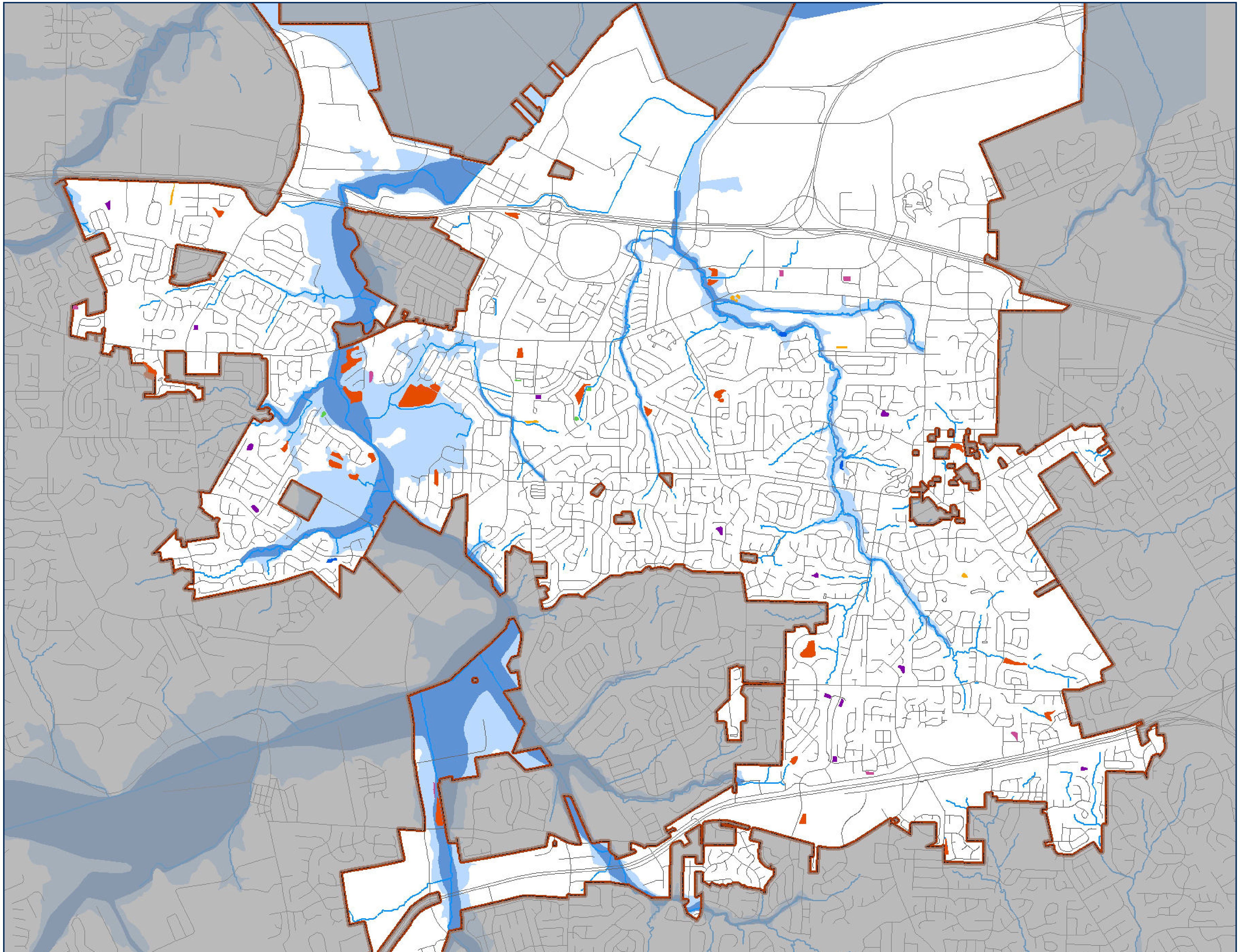
Lenexa KANSAS

PBA

Appendix J. Maps

Maps

1. General Map
2. FEMA Floodplain and Revised Inundation Area Map
3. Selected Detention Basin Map
4. Stream Stability, Existing Conditions Map
5. Stream Asset Inventory, Existing Conditions Map
6. Project Location Map
7. Water Quality Monitoring Map
8. General Watershed Impairment Map
9. General Watershed Protection Map
10. Figure 5 from Report



Selected Detention Basins

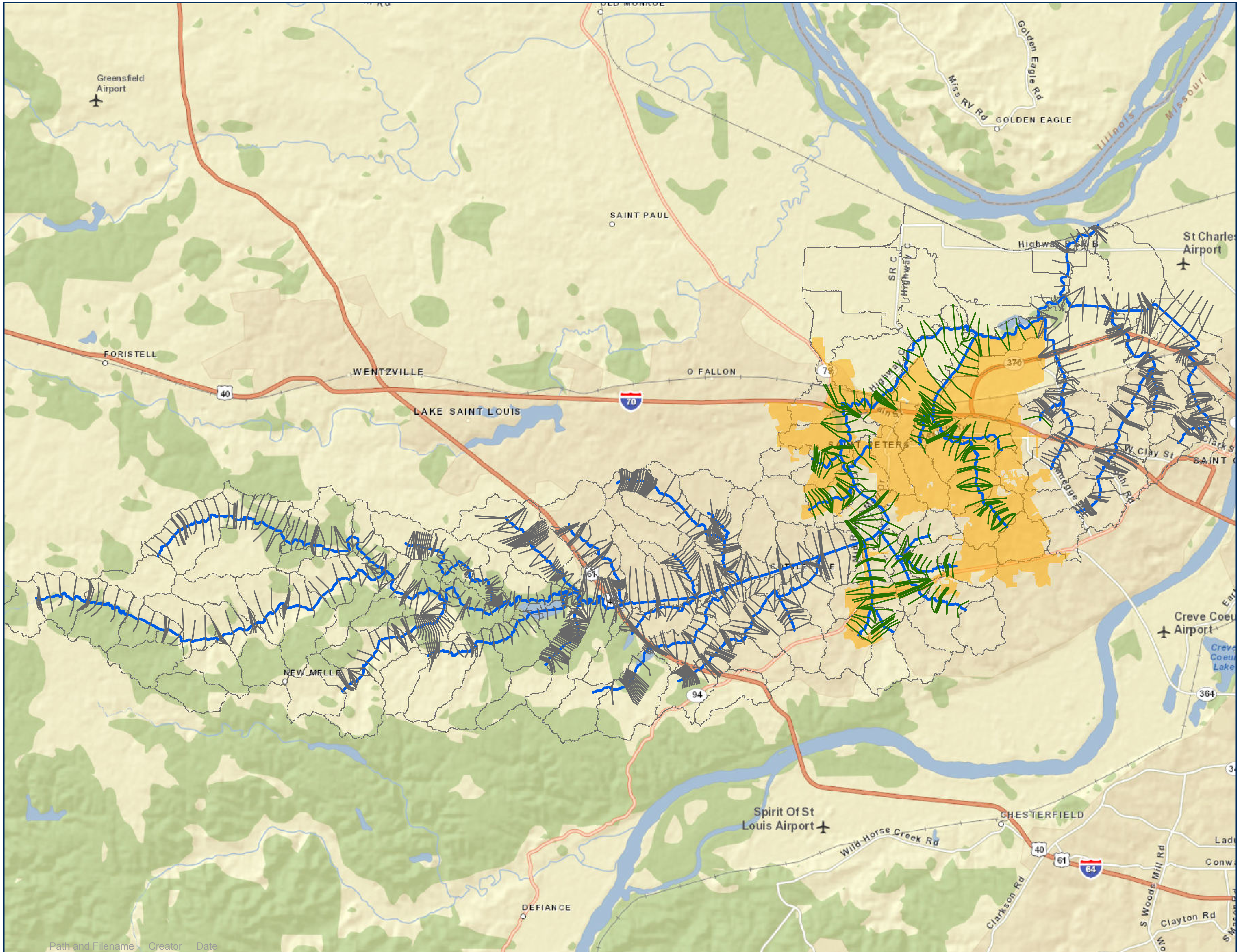
St. Peters, MO

LEGEND

Screened Detention Basins

- Floodplain Detention
- New Subdivision
- Public Land Zoning
- Surface area > 1 acre
- Surface>5% of CDA
- Vacant Land Zoning

1 inch = 3,000 feet



Dardenne Creek Watershed

HEC-RAS Model Extents

St. Peters, MO

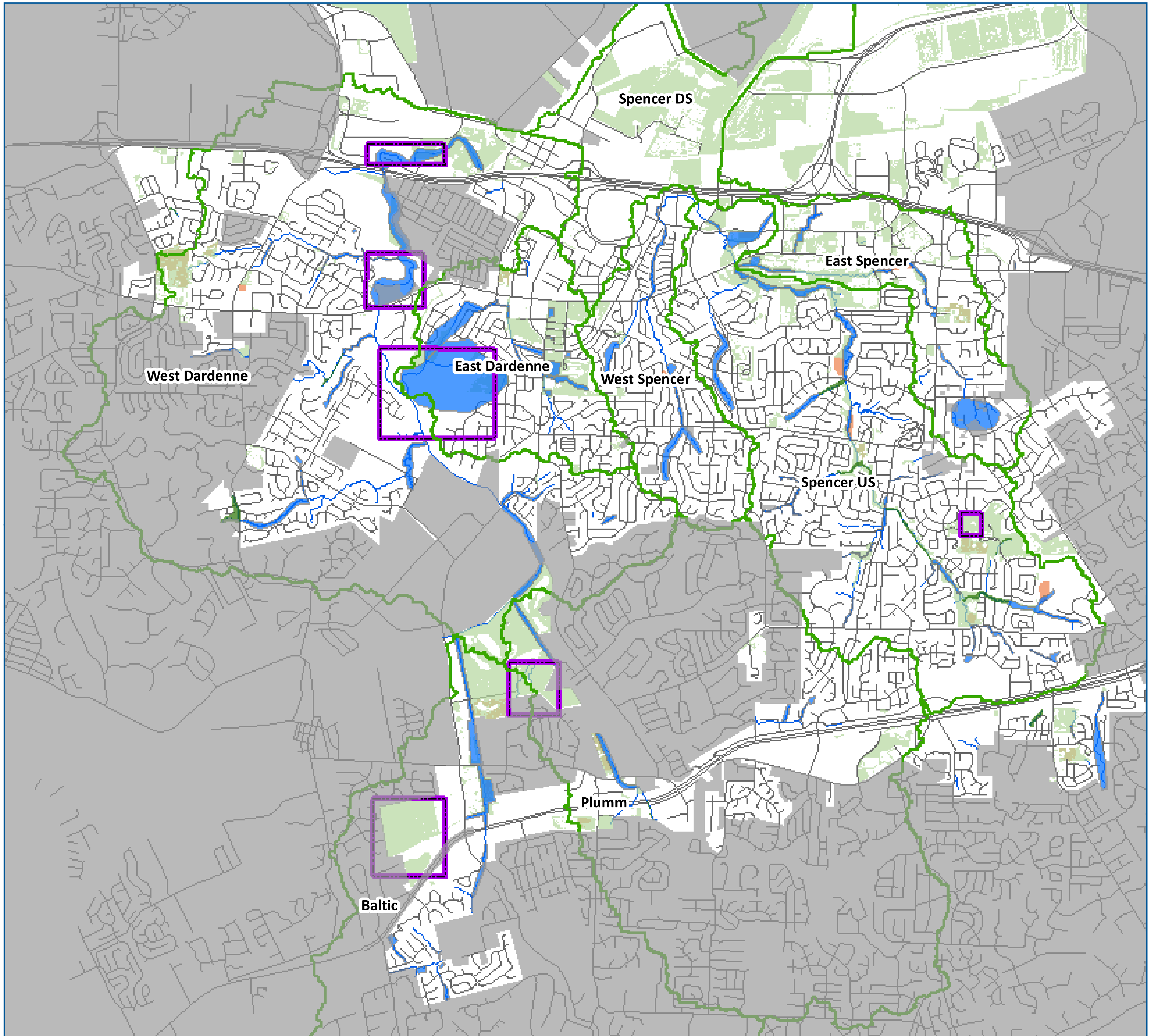
LEGEND

- HECRAS XS within City
- HECRAS XS, Dardenne
- HECRAS Streams
- City Limits
- Subshed Boundaries
- World Street Map

N
W E
S

0 5,500 11,000
Feet

1 inch = 11,000 feet



General Watershed Protection Areas

St. Peters, MO

N
W E
S

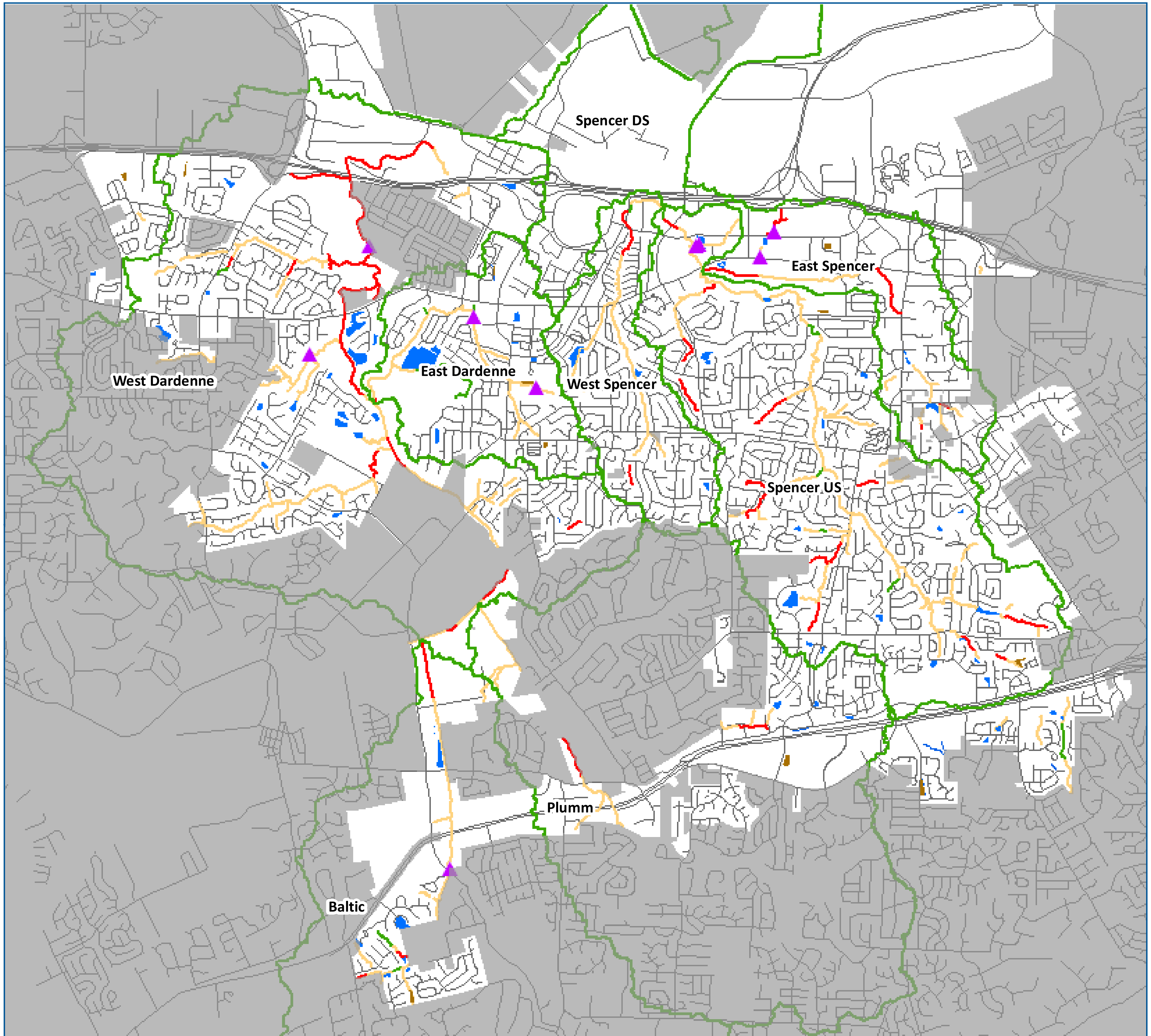
0 1,800 3,600
Feet
1 inch = 3,600 feet

LEGEND

Watersheds
Protection Zones

Projects

Preservation
Stream Stability
Locations with BMP Suitability
Regional Detention Opportunities
Stream Network
Street Network



General Watershed Impairment Areas

St. Peters, MO

N
W E
S

0 1,800 3,600
Feet
1 inch = 3,600 feet

LEGEND

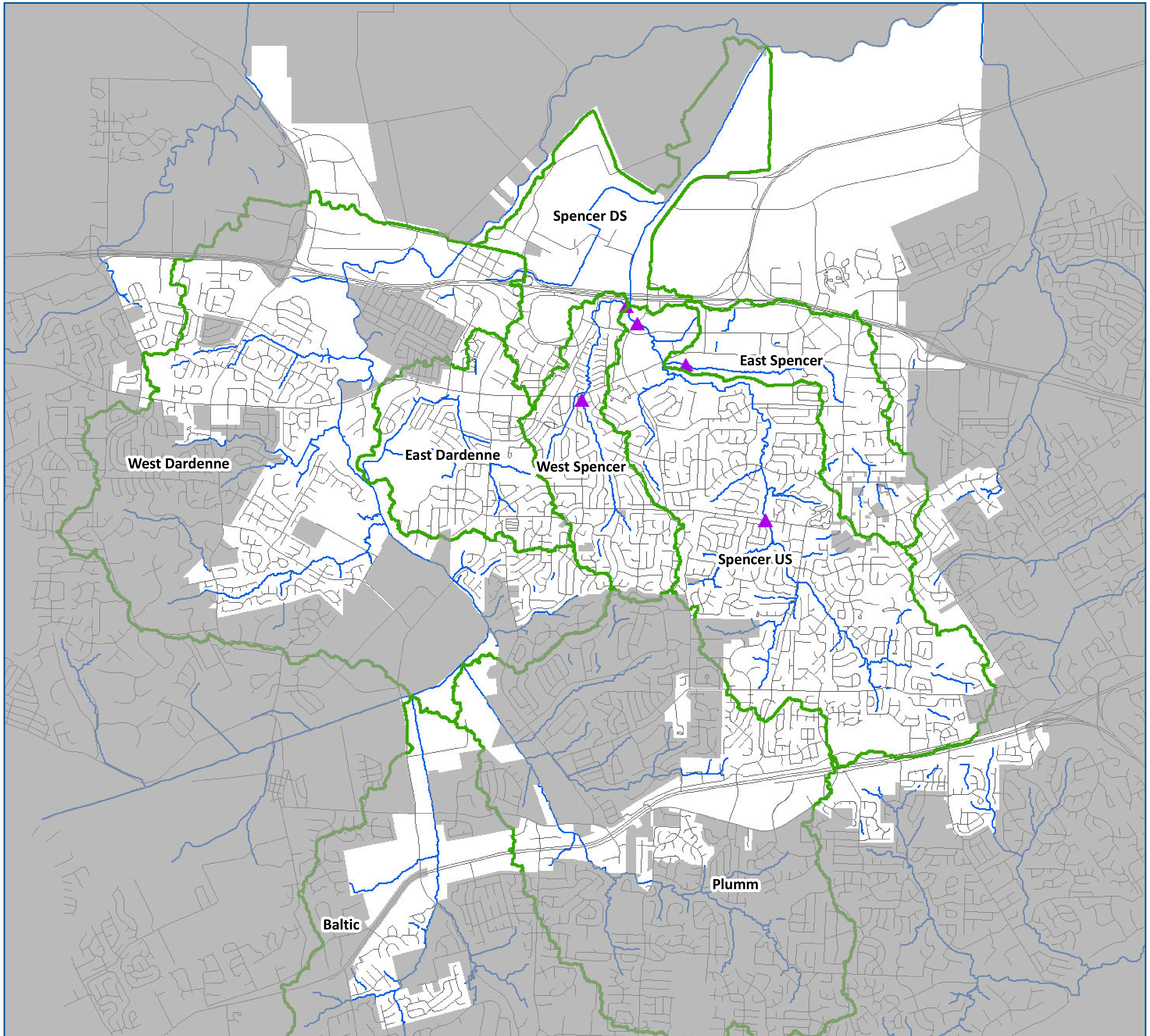
- Watersheds
- Water Quality Concern Points

Selected Detention

- Other Basins
- High TSS Discharge (>1000 lbs/yr)

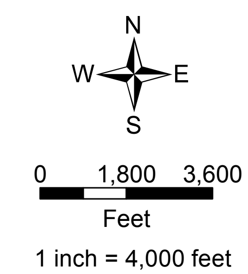
Stream Network

- 10-13
- 13-19
- 19-24
- Stream Network
- Street Network



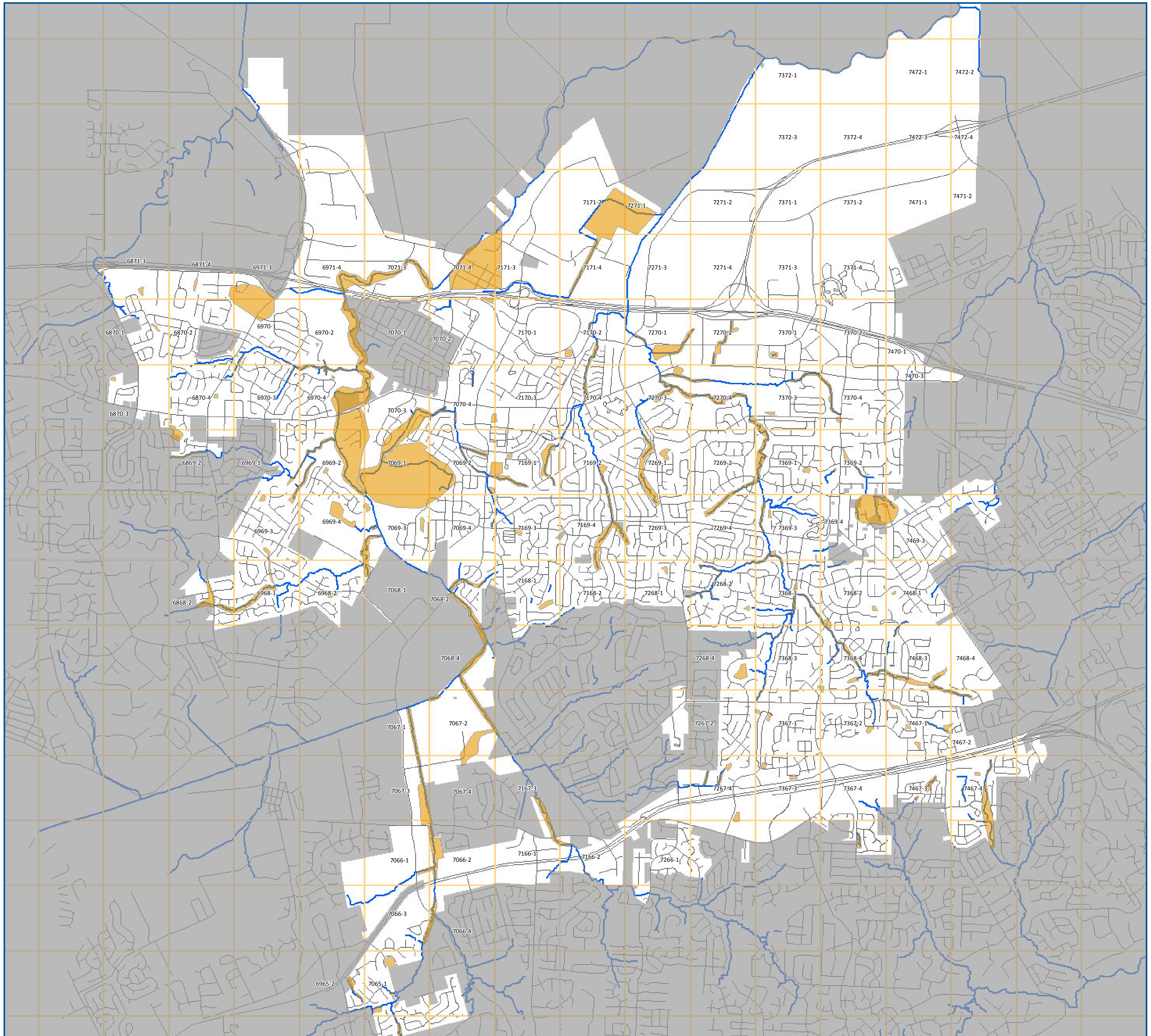
Water Quality Monitoring Locations

St. Peters, MO



LEGEND

- Watersheds
- Monitoring Locations
- Stream Network
- Street Network



Recommended Project Locations (2011 CIP)

Spencer Creek Watershed

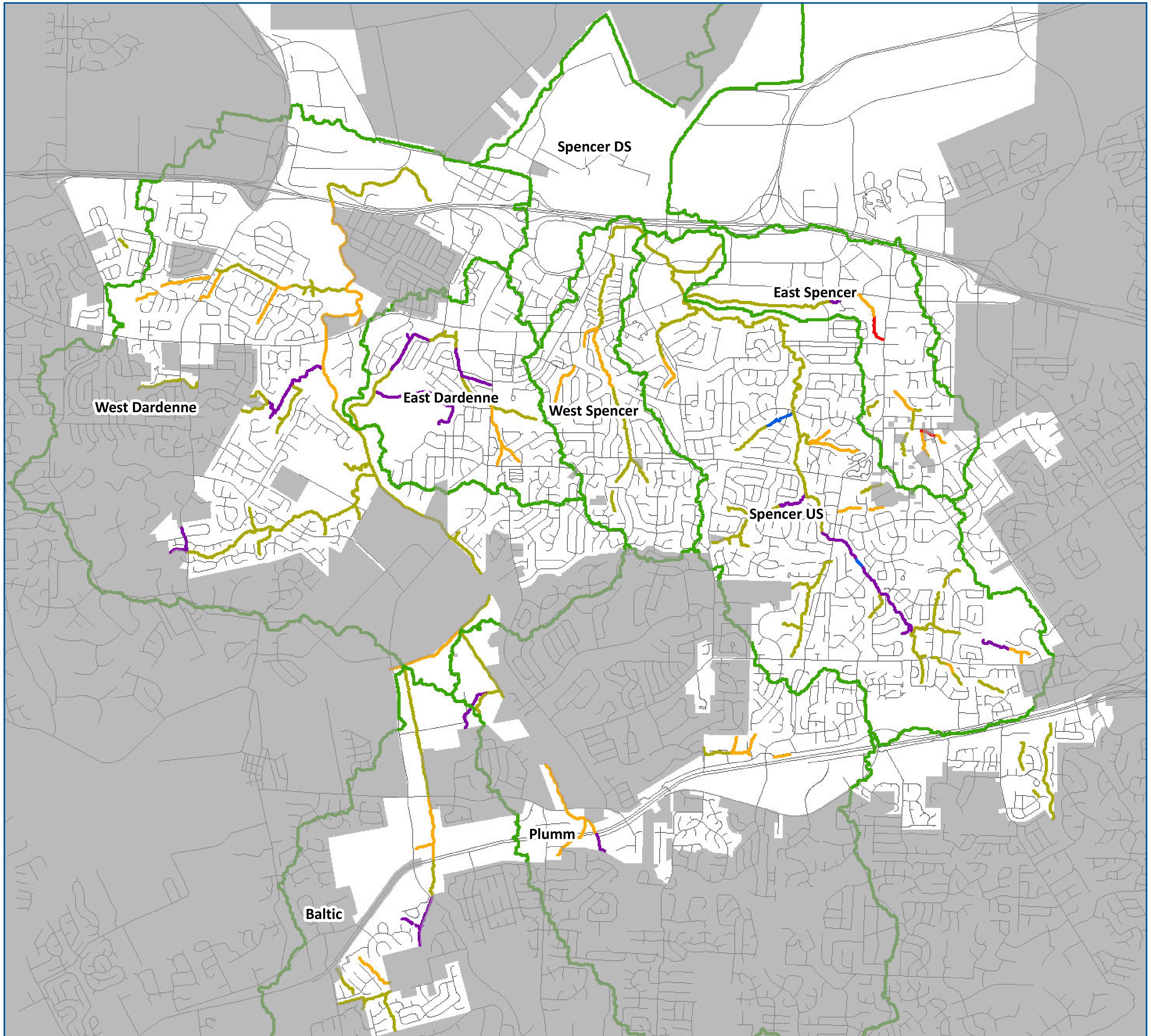
St. Peters, MO

N
W E
S

0 2,000 4,000
Feet
1 inch = 4,000 feet

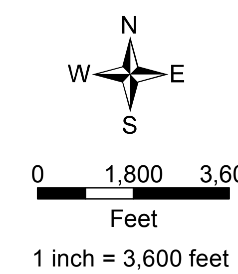
LEGEND

CIP Project Locations
Grid for Project ID
Stream Network
Street Network



Stream Assets (SAI Scores)

St. Peters, MO



LEGEND

Watersheds

Stream Network

1 (1% of network)

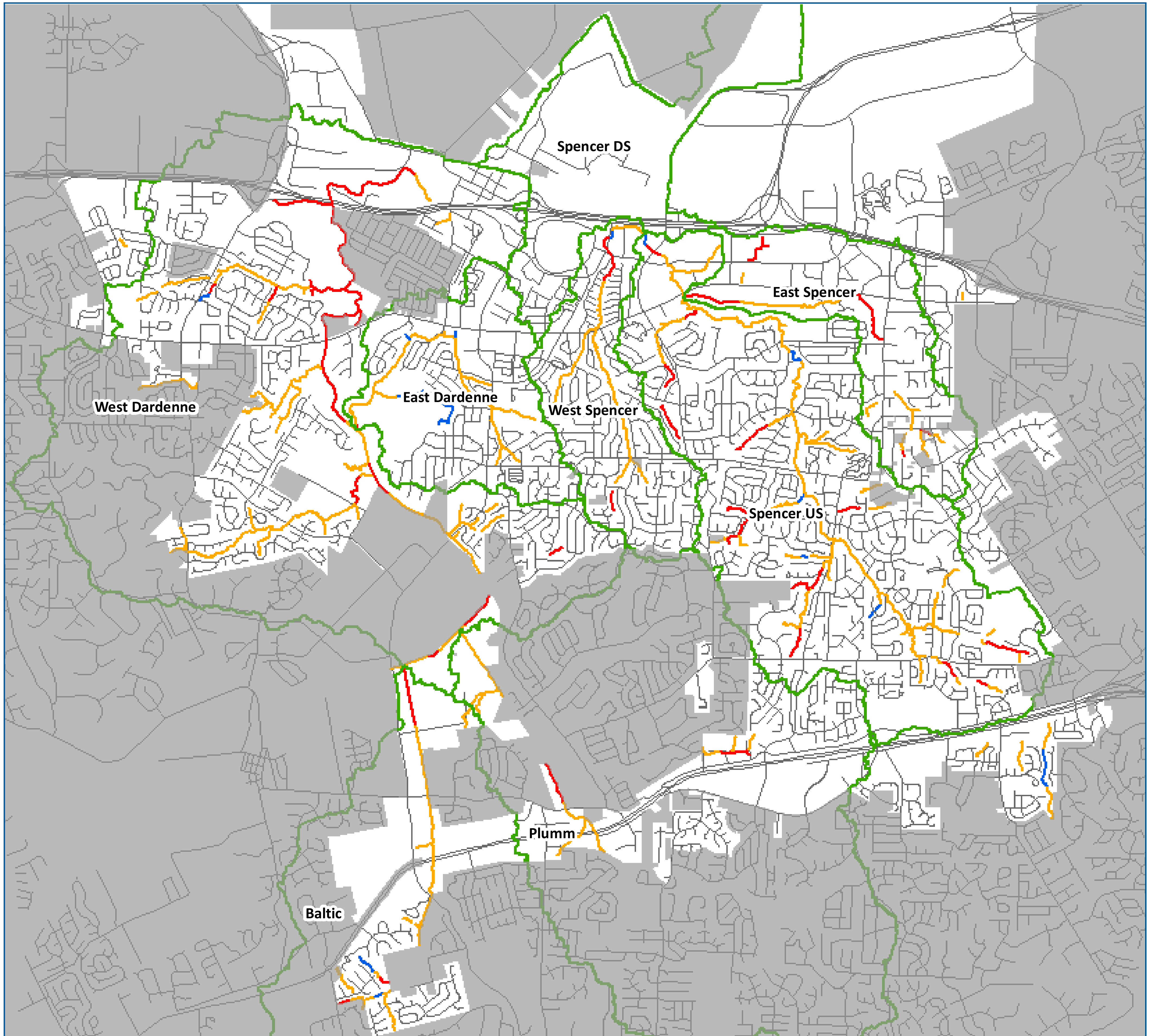
2 (12% of network)

3 (63% of network)

4 (23% of network)

5 (1% of network)

Street Network



Stream Stability (CCSM Scores)

St. Peters, MO

N
W E
S

0 1,800 3,600
Feet
1 inch = 3,600 feet

LEGEND

Watersheds

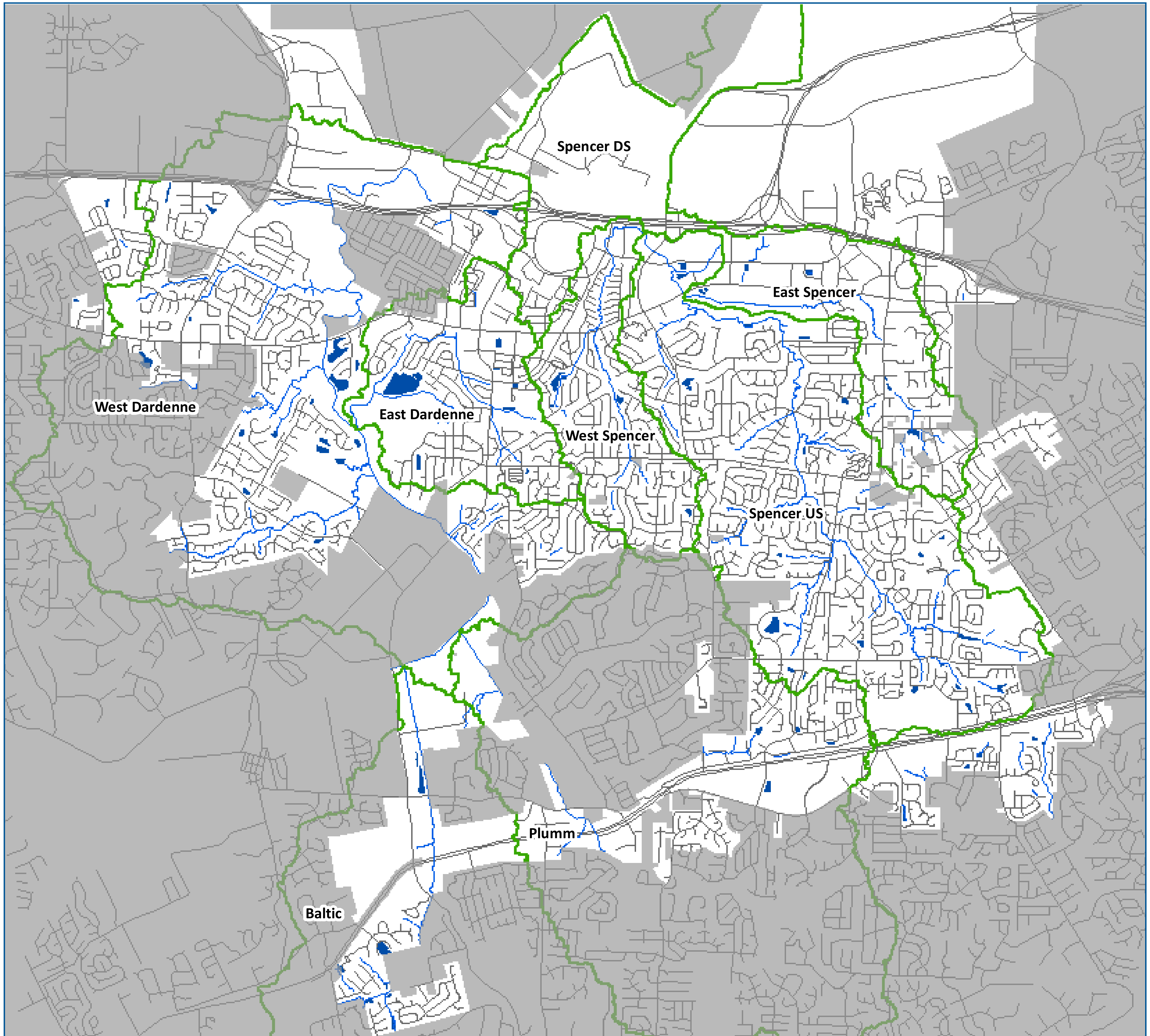
Stream Network

10-13, Stable

13-19, Stability Concerns

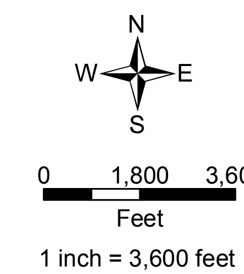
19-24, Significant Instability

Street Network



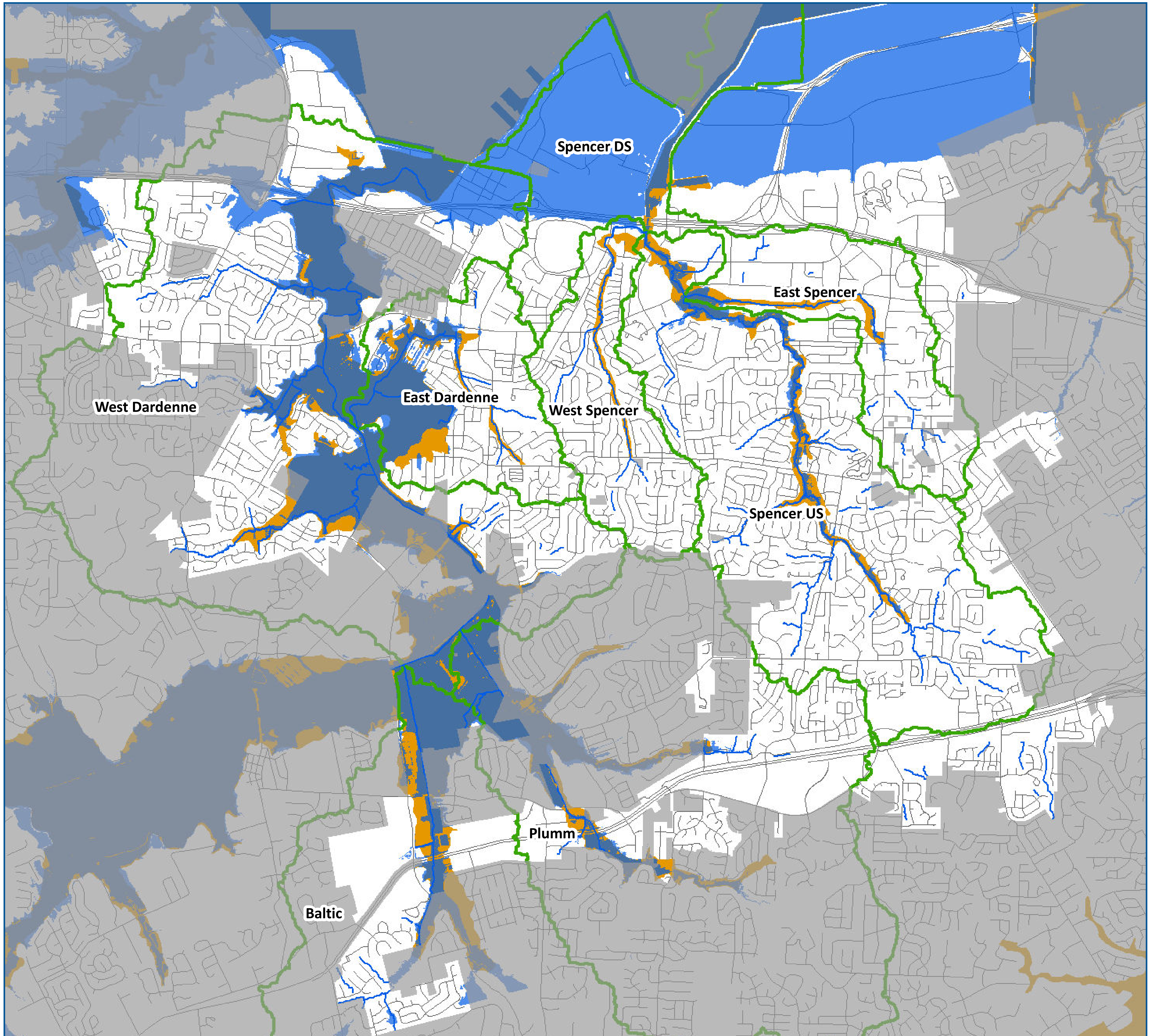
Selected Detention Basins

St. Peters, MO



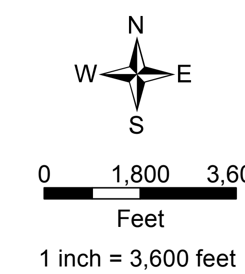
LEGEND

- Watersheds
- Stream Network
- Street Network
- Selected Detention



FEMA Floodplain and Revised Inundation Area

St. Peters, MO



LEGEND

- Stream Network
- Watersheds
- Revised Inundation Area
- FEMA Floodplain (May 1996)
- Street Network

General Map

St. Peters, MO

LEGEND

- Stream Network
- Street Network

N
W E
S

0 1,800 3,600

Feet

1 inch = 3,600 feet