Columbia Wastewater and Stormwater IMP

# Attachment H

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Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

# Technical Memorandum 4 *Stormwater System Evaluation*

Columbia Wastewater and Stormwater Integrated Management Plan

*Columbia, Missouri*
February 16, 2017

HDR

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# Table of Contents

## List of Tables



## List of Figures



## List of Attachments

# Section 1. Introduction and Objectives

The City of Columbia, Missouri (City) is working to develop an Integrated Management Plan (IMP) for the City's wastewater and stormwater utilities. The goal of the IMP is to develop an adaptable and affordable long-term plan that addresses the City's wastewater and stormwater management needs and meets Clean Water Act requirements. The IMP will be developed based on guidance presented in US Environmental Protection Agency's (EPA) *Integrated Municipal Stormwater and Wastewater Planning Approach Framework* (Stoner 2012).

A critical step in the IMP includes evaluating the City's environmental resources and infrastructure assets to better define the existing condition, performance, and needs of its systems. This evaluation is important because it forms the basis for identifying priorities and developing alternatives in subsequent phases of the IMP. To develop a comprehensive understanding of existing conditions, the City and their project team compiled and evaluated existing surface water, wastewater, and stormwater data. These data, as well as current operation and maintenance practices and procedures, were then reviewed and discussed in a series of workshops. Results from these efforts are documented in the following technical memoranda:

- Technical Memorandum 1 – Surface Water Quality and Biological Conditions
- Technical Memorandum 2 – Wastewater Collection System Assessment
- Technical Memorandum 3 – Wastewater Treatment System Assessment
- Technical Memorandum 4 – Stormwater System Assessment

This purpose of this memorandum is to summarize findings from the stormwater system assessment. Effective management and efficient implementation of the stormwater program is necessary for meeting important environmental and public safety goals such as improving water quality, minimizing flooding impacts, and reducing property damage. To develop a better understanding of the City's existing stormwater assets, representatives from HDR Engineering, Inc. (HDR), met with City staff on August 10 to discuss these goals and identify the City's priorities and level of service (LOS) expectations. HDR, Geosyntec Consultants, Inc. (Geosyntec), and other members of the project team also compiled relevant data and worked with the City to inventory the existing system, review its performance, and evaluate capacity. Results from the evaluation are documented in the sections that follow.

# Section 2. Stormwater System Inventory

The City has collected an impressive amount of data on their stormwater system, the majority of which are entered into their Geographic Information System (GIS) database. There are nearly 14,000 City-owned storm structures in the database including manholes and inlets (**Table 1**). Curb inlets and end structures make up the majority of the system structures.

**Table 1. Stormwater Structure Inventory by Installation Date.**

| Installation Date | Structure Type | | | | |
|---|---|---|---|---|---|
| | Area Inlet | Curb Inlet | End Structure | Junction | Other* |
| Pre-1960 | 105 | 241 | 153 | 73 | 1 |
| 1960-1970 | 110 | 576 | 405 | 92 | 9 |
| 1970-1980 | 63 | 349 | 372 | 63 | 4 |
| 1980-1990 | 162 | 1,006 | 828 | 197 | 3 |
| 1990-2000 | 229 | 1,445 | 1,030 | 230 | 7 |
| 2000-2010 | 484 | 2,135 | 1,334 | 514 | 7 |
| 2010-Present | 246 | 752 | 367 | 287 | 9 |
| **Total** | **1,399** | **6,505** | **4,488** | **1,457** | **40** |

*31 Structures are of unknown type.

Of the nearly 14,000 structures, approximately 7% have a condition rating associated with them (**Table 2**). Approximately 96% of the structures with condition ratings are considered to be in either fair or good condition.

**Table 2. Stormwater Structure Condition Assessment Summary.**

| Type | Number of Structures with Condition Scores | | | | | |
|---|---|---|---|---|---|---|
| | No Score | Critical | Failing | Poor | Fair | Good |
| Area Inlet | 1,337 | 0 | 0 | 1 | 13 | 48 |
| Curb Inlet | 6,043 | 2 | 2 | 6 | 65 | 387 |
| End Structure | 4,173 | 1 | 7 | 10 | 77 | 221 |
| Junction | 1,411 | 0 | 1 | 0 | 5 | 41 |
| Other* | 39 | 0 | 0 | 0 | 1 | 0 |
| Total | 13,004 | 3 | 10 | 17 | 161 | 707 |
| **% of Total Rated** | **--** | **0.3%** | **1.1%** | **1.9%** | **17.9%** | **78.7%** |

Notes:
Only 7% of all structures in the database have a condition assessment associated with them.
*31 structures are of unknown type.

The database also lists pipe material types, pipe size and age of the system installed. The City populated the system by reviewing past construction plans and entering the information. A visual condition assessment of curb inlets has been performed sporadically, but less than 1% of the piping system has been inspected. The GIS database includes approximately 930,000 feet of stormwater pipes that are under municipal control (**Table 3**). This estimate excludes private stormwater systems and systems within the Missouri Department of Transportation (MoDOT) right of way. Approximately 89% of the system has the pipe type identified and corrugated metal pipe (CMP) is the most common (**Table 3, Attachment A**).

**Table 3. Stormwater Pipe Inventory Itemized by Material Types and Sizes.**

| Pipe Material | Pipe Length (ft.) | | | | | |
|---|---|---|---|---|---|---|
| | **< 18 inch diameter** | **18-36 inch diameter** | **36-54 inch diameter** | **> 54 inch diameter** | **Unknown** | **Total** |
| Corrugated Metal (CMP) | 78,306 | 202,950 | 53,208 | 10,313 | 9,534 | **354,310** |
| High Density Polyethylene (HDPE) | 56,706 | 67,020 | 13,283 | 1,234 | 123 | **138,367** |
| Reinforced Concrete (RCP) | 65,966 | 134,722 | 49,143 | 12,090 | 4,816 | **266,737** |
| Polyvinyl Chloride (PVC) | 2,095 | - | - | - | - | **2,095** |
| Vitrified Clay (VCP) | 9,738 | 8,311 | 770 | - | - | **18,819** |
| Bitunimous Coated Corrugated Metal (BCCMP) | 1,492 | 3,186 | 98 | - | 268 | **5,044** |
| Corrugated Polyethylene (CPEP) | 548 | 1,792 | - | - | - | **2,340** |
| Corrugated Polypropylene (CPP) | 268 | 82 | - | - | - | **350** |
| Other | 540 | 945 | - | 415 | 1,946 | **3,846** |
| Reinforced Concrete Box (RCB) | - | - | - | - | 229 | **33,678** |
| Unspecified/ Unknown | 4,255 | 5,461 | 1,831 | - | 91,717 | **103,264** |
| **Total** | **219,914** | **424,470** | **118,334** | **24,051** | **108,403** | **928,850** |

The GIS database also contained the age of the stormwater pipes for approximately 70% of the pipes. The City frequently updates information when new segments of storm pipe are installed on retrofit and roadway projects, but has not yet estimated the age of for the remaining 30% of missing records. To develop a more holistic understanding of the system and potential future needs, age was estimated by assuming that storm pipe age would approximately equal the age of the nearest adjacent sanitary sewer pipes. Aging of the sanitary lines was based on subdivision age, pipe material type, and other methods as described in Technical Memorandum 2. Results of the age assessment show that nearly 50% (431,020 feet) of the stormwater pipes in the City have been installed since the year 2000 (**Table 4, Attachment B**).

**Table 4. Stormwater Pipe Inventory by Age.**

| Pipe Material | Pipe Length (ft.) by Installation Date | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Pre-1960** | **1960-1970** | **1970-1980** | **1980-1990** | **1990-2000** | **2000-2010** | **2010-Present** |
| CMP | 9,251 | 35,948 | 28,866 | 54,079 | 99,927 | 105,356 | 20,884 |
| HDPE | 1,739 | 3,016 | 40 | 629 | 8,623 | 70,670 | 53,650 |
| RCP | 9,288 | 12,258 | 7,883 | 50,856 | 64,738 | 86,708 | 35,006 |
| RCB | 3,096 | 3,306 | 2,760 | 6,358 | 5,268 | 6,889 | 6,002 |
| PVC | - | 14 | - | 235 | 314 | 666 | 866 |
| VCP | 5,405 | 2,614 | 77 | 1,328 | 853 | 4,555 | 3,987 |
| BCCMP | 119 | 4,499 | - | 42 | 287 | 98 | - |
| CPEP | - | 130 | - | - | 986 | 1,224 | - |
| CPP | 130 | - | - | 28 | - | 193 | - |
| Other | 1,230 | 152 | 444 | 230 | 466 | 999 | 323 |
| Unknown | 14,102 | 9,903 | 9,904 | 14,802 | 21,607 | 22,074 | 10,872 |
| **Total** | **44,359** | **71,841** | **49,974** | **128,588** | **203,068** | **299,432** | **131,588** |

Notes:
70% of pipe age based on existing database construction year values.
30% inferred based on assessed sanitary pipe age based on neighborhood age and other analysis.

Similar to the stormwater structures, less than 1% (approximately 7,000 feet) of the stormwater pipe length has been assigned a condition assessment rating in the database (**Table 5**). Of the structures with a rating, 76% (approximately 5,300 feet) are rated as good and 16% (approximately 1,700 feet) are rated as either critical, failing or in poor condition.

**Table 5. Stormwater Pipe Condition Assessment Summary.**

| Pipe Material | Pipe Length (feet) with Condition Scores | | | | | |
|---|---|---|---|---|---|---|
| | **No Score** | **Critical** | **Failing** | **Poor** | **Fair** | **Good** |
| CMP | 351,188 | 221 | 172 | 225 | 397 | 2,107 |
| HDPE | 136,455 | - | - | - | - | 1,912 |
| RCP | 265,872 | - | 51 | - | - | 815 |
| RCB | 33,606 | - | - | 52 | - | 20 |
| PVC | 2,095 | - | - | - | - | - |
| VCP | 18,687 | 101 | - | - | - | 31 |
| BCCMP | 4,990 | - | - | - | - | 54 |
| CPEP | 2,340 | - | - | - | - | - |
| CPP | 350 | - | - | - | - | - |
| Other | 3,760 | - | 85 | - | - | - |
| Unknown | 102,488 | - | - | 234 | 178 | 364 |
| **Total** | **921,832** | **322** | **309** | **511** | **575** | **5,302** |

Since a large portion of the system has not been inspected, an assumed design life was estimated. The life span of the material types will vary widely based on induced stresses, installation methods, proximity to groundwater and soil corrosiveness. For example, in recent years the City has experienced several structural failures of CMP due to corrosion. In general, the CMP has an average lifespan of 30-years before it rusts and leads to structural deficiencies that cause sink holes, flooding, or pavement failures (**Figure 1**). According to the data reviewed as part of this evaluation, approximately 128,000 feet of CMP is more than 30 years old and would be expected to have sections of structurally deficient pipe. In the next 10 years, the length of CMP beyond the useful life will approach 225,000 feet (**Table 4**).


**Figure 1. Example of CMP Corrosion and Failure.** CMP typically rusts along the bottom of the pipe until the corrosion compromises the structural integrity of the pipe. As a consequence of the corrosion, soil may wash into the pipe causing sink holes to develop or the pipe may collapse causing upstream flooding or pavement failure.

# Section 3. Stormwater System Performance

As part of the system performance evaluation, the project team evaluated frequency, location, and severity of reported flooding issues; system capacity; and progress towards meeting water quality goals as defined in the City's municipal separate storm sewer system (MS4) permit. Results from these evaluations are outlined in the following sections.

## 3.1 Flooding Evaluation

The City has recorded storm drainage and flooding issues in a database since the early 1970's. The database records were developed from flooding reports and a community survey. The database includes 2,670 total reports classified as street flooding, house flooding, yard erosion and yard flooding. Some of the database entries were inconsistent, had data formatting issues, incomplete records, or missing addresses that could not be geocoded. The following sections discuss the reported flooding locations by type of flooding reported for the database records that were available to analyze using GIS (2,332 records).

### 3.1.1 Riverine Flooding

Flooding reports that fell within the 500-year FEMA floodplain were considered to be riverine flooding or at least significantly influenced by backwater elevations in the stream. Within the study area, there are 228 riverine flooding records (**Table 6, Attachment C**) and several locations with a high concentration of flooding reports (**Figure 2**). The City does not yet have the FEMA Risk-Map products so information on the depth, velocity and frequency of flooding can not be directly evaluated. Flooding reports from properties within the regulatory floodway will likely be more frequent and severe than flooding reports outside the floodplain. This assumption should be re-evaluated as more data becomes available.

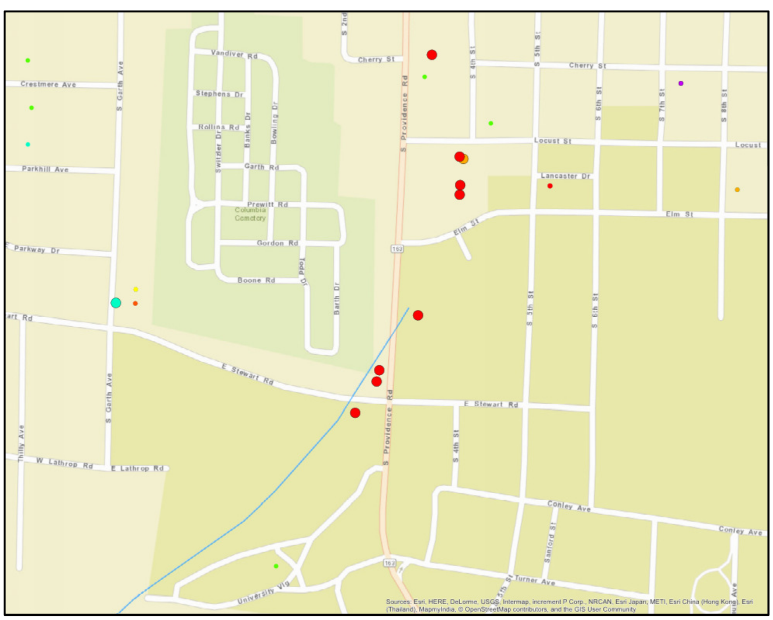


**Figure 2. Example of Concentrated Flooding Reports.**

**Table 6. Riverine Flooding Reports.**

| Flooding Location | Number of Reports |
|---|---|
| Floodway | 46 |
| Floodplain | 50 |
| 500 Yr. Annual Chance | 132 |
| **Total** | **228** |

### 3.1.2 Street, House and Yard Flooding

Flooding reports were also analyzed outside of the floodplain. The flooding reports were recorded through questionaries initiated by the City and by individual citizens contacting the City (**Table 7**). Areas such as South West Blvd. and Ridge Road, Morningside Drive, and Gillespie Bridge Road have severe flooding reports and are likely more problematic than private property considerations alone. Reports which included house, yard and street flooding are coded as red on **Attachment D**.

**Table 7. Reported Street, House and Yard Flooding Outside of the Regulatory Floodplain.**

| Flooding Location | Number of Reports |
|---|---|
| House, Yard, & Street | 30 |
| House & Street | 18 |
| Street Only | 198 |
| Yard & Street | 68 |
| House & Yard | 131 |
| House Only | 92 |
| Yard Only | 638 |
| **Total** | **1,175** |

### 3.1.3 Depression Areas and Flooding Reports

Street and structure flooding is usually most severe in depression areas. Once the surface flows reach the roadway sumps, the depth and duration of exposure to the traveling public is increased. Likewise, houses and other structures adjacent to the depression areas may see additional basement flooding and flows in the side yards as the water depth increases. In order to help identify the most severe flooding areas from the large number of flooding reports, a depression map was superimposed on the flooding reports map. The MSDIS-published Boone County bare earth DEM, previously derived from LiDAR collected in 2009, was filled and then subtracted from the original DEM to produce depression areas. Flooding reports within 50 feet of these depression areas were then calculated. As expected, many of the persistent yard and street flooding reports occur near low depression areas (**Attachment E**).

### 3.1.4 Other Reports

Other flooding reports in the City are related to open channel flooding and yard erosion issues (**Table 8, Attachment F**). The City does not own or maintain natural channels (streams and creeks). The stormwater network contains eight engineered open channels that are actively maintained.

**Table 8. Other Reports within the Flooding Database.**

| Description | Number of Reports |
|---|---|
| Open Channel Flooding | 946 |
| Reported Yard Erosion | 769 |
| **Total** | **1,715** |

## 3.2 Conveyance System Capacity

Many of the new stormwater systems in residential and commercial subdivisions are installed by private land developers. Private developers are required to design and build the stormwater conveyance system to meet municipal requirements (ordinance 12A-95) and once built, the system is owned and operated by the City. The City's stormwater design standards are presented in the Stormwater Management & Water Quality Manual (Columbia 2009), which was approved by the public works director in February 2009 (Chapter12-A of the City Code of Ordinances) and recently updated in January 2015. The current design standards require adequate conveyance features and the routing of runoff to detention ponds prior to flow being released to downstream properties (**Table 9**). The detention ponds are intended to slow the runoff to match the rates experienced prior to development in order to prevent increasing downstream flooding.

**Table 9. Summary of Key Stormwater Conveyance System Features Level of Service.**

| Stormwater Drainage Element | Street Classification | | |
|---|---|---|---|
| | **Local** | **Collector** | **Arterial** |
| Street Spread Width | One 10 ft. lane open during 10 yr. | One 12 ft. lane open during 25 yr. | One Lane in each direction open during 25 yr. |
| Storm Pipes | 10 yr. | 25 yr. | 100 yr. |
| Storm Pipes at Street Crossings | 10 yr. | 25 yr. | 100 yr. |
| 100-yr. Maximum Street Ponding Depth | 14 in. at gutter<br>7 in. at crown | 14 in. at gutter<br>7 in. at crown | 14 in. at gutter<br>7 in. at crown |
| Open Channel | 100 yr. plus 1 ft. of freeboard<br>10 yr. stability requirements | | |
| Detention | 1-, 2-, 10-, 100-yr. flows must not exceed greenfield or existing.<br>1 yr. used for stream protection flows. | | |
| Water Quality Storm | 1.3 inches in 24 hours. Reduction allowance for disconnected impervious areas. | | |
| Rainfall Depth Duration Sources | TP-40, NRCS Type II, Bulletin 71 (Huff) | | |

Notes:
For complete design criteria see the Stormwater Management & Water Quality Manual (Columbia 2009).

The current design standards also include designing detention ponds for a "stream protection flow". Stream protection flows are intended to prevent increased erosion of the stream channel. These protections are needed because detention ponds are not able to reduce the overall volume of runoff, just the rate that leaves a property. Since the area upstream of a detention pond is usually covered with impervious areas like parking lots or buildings, less rainfall will soak into the ground and ultimately result in an increased volume of runoff. Increases in flow volume can lead to an increase in stream erosion. The City's current design standards do not require developers to mitigate for the increase in volume, just the peak rate of runoff.

The current design standards also use the Natural Resources Conservation Service (NRCS) Type II storm temporal distribution. This storm distribution is important when designing detention cells. The Type II storm distribution has a very intense rainfall pattern within the middle of the storm. When used, the NRCS Type II distribution generally predicts very high runoff rates for existing undeveloped conditions and for the future flows. Based on this method, a large detention cell outlet pipe is needed to convey the flows to downstream areas. This method may result in the detention ponds not holding back runoff from very intense storms and downstream flooding could result.

In contrast to the NRCS Type II distribution, the Bulletin 71 (Huff) temporal distribution will predict more moderate rates of existing runoff (Huff and Angel 1992). As a result, smaller pipe sizes are needed to convey flows to downstream areas. Detention pond outlets sized using this Bulletin 71 (Huff) method will generally hold runoff more frequently and tend to not pass large flows to downstream areas. Allowing both methods within the design manual may allow for contradictions in design and uncertainty in performance. Therefore to maintain consistency, only one temporal distribution should be used.

Recently, NRCS released a draft version of the National Engineering Handbook, *Chapter 4: Storm Rainfall Depth and Distribution* (2015). In this draft document, NRCS recommends not using a Type II distribution but rather using the updated rainfall depths and temporal distribution from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 (Perica et al. 2013). The NOAA Atlas 14 temporal distribution generally results in a less intense storm than the NRCS Type II but more intense than a Bulletin 71 (Huff) distribution for Columbia. The City may want to consider eliminating the NRCS Type II distribution from the list of approved storm temporal distributions since NRCS is no longer recommending its use.

## 3.3 Stormwater Quality Performance

The City, Boone County (County), and University of Missouri (MU) are permitted together as co-permittees under a Phase II MS4 permit (Permit No. MO-0136557) issued by the Missouri Department of Natural Resources (MDNR). The three entities are collectively responsible for compliance with their MS4 permit, which was recently reissued on June 1, 2016 (MDNR 2016). Federal (40 CFR 122.34) and state (10 CSR 20-6.200(5)(A)1-6)) regulations stipulate that MS4 permits include provisions for developing, implementing, and enforcing a stormwater management program and plan (SWMP) to reduce pollutant discharges to the maximum extent practicable (MEP).

The City's ability to fulfill its commitments to the other co-permittees and maintain compliance with the requirements of the MS4 permit is an important consideration for the IMP. The following summarizes an assessment of the co-permittees compliance with the MS4 permit requirements. The assessment was conducted through a review of the MS4 permit; the SWMP; the Collaborative Adaptive Management (CAM) Implementation Schedule and Agreement for

Hinkson Creek TMDL, dated March 2012; and MS4 Phase II Stormwater Annual Reports for 2011 through 2015. Additional information about the City's Stormwater Program was also obtained from the City's website.

### 3.3.1 Stormwater Quality Evaluation Objectives

To fulfill their MS4 permit requirements, the co-permittees have developed a Joint SWMP, which was also recently updated, in December 2015 (Boone County/Columbia/MU 2015). This SWMP states that the co-permittees "…have developed and implemented this program in order to protect water quality and effectively reduce stormwater pollutant runoff within their respective jurisdictions to the maximum extent practicable (MEP)."

The SWMP reflects federal (40 CFR 122.34) and state (10 CSR 20-6.200(5)(A)1-6)) regulations which require six (6) minimum control measures (MCMs) to meet the MEP standard. The six MCMs are:

1. **Public Education and Outreach –** Permittees are required to conduct outreach activities to communicate the impacts of stormwater and provide steps that the public can take to reduce pollutants in stormwater runoff.
2. **Public Involvement and Participation –** Permittees are required to provide opportunities for citizens to participate in program development and implementation.
3. **Illicit Discharge Detection and Elimination (IDDE) –** Permittees are required to develop and implement a plan to detect and eliminate illicit discharges to the storm sewer system.
4. **Construction Stormwater Runoff Control –** Permittees are required to develop, implement and enforce an erosion and sediment control program for construction.
5. **Post-Construction Stormwater Management in New Development and Redevelopment –** Permittees are required to develop, implement and enforce a program to address discharges of post-construction stormwater runoff from new development and redevelopment areas.
6. **Pollution Prevention and Good Housekeeping for Municipal Operations –** Permittees are required to develop and implement a program with the goal of preventing or reducing pollutant runoff from municipal operations.

The co-permittees are responsible for developing, implementing, and maintaining best management practices (BMPs), as well as measurable goals, for each of the six MCMs. The MS4 permit requires compliance with plans for any Total Maximum Daily Loads (TMDLs) in effect within the jurisdictions. The MS4 permit also requires the co-permittees to revise their SWMP within one year of receiving their operating permit (by June 1, 2017), if necessary, and to prepare and submit progress reports to MDNR every odd year during the life of the permit.

EPA (2001) defines measurable goals as "…BMP design objectives or goals that quantify the progress of program implementation and the performance of…BMPs." EPA further "…strongly recommends that measurable goals include, where appropriate, the following three components:

- The activity, or BMP, to be completed;
- A schedule or date of completion; and
- A quantifiable target to measure progress toward achieving the activity or BMP."

According to EPA, measurable goals that include these three components and are easy to quantify and allow the permittee and regulatory agencies to assess progress at reducing pollutants to the MEP. The City and their co-permittees include 33 BMPs and 46 measurable goals in the Joint SWMP (Table 10).

**Table 10. Number of BMPs and Measurable Goals in the Joint SWMP.**

| Minimum Control Measure | | Number of BMPs | Number of Measurable Goals |
|---|---|---|---|
| MCM 1: | Public Education and Outreach | 6 | 8 |
| MCM 2: | Public Involvement and Participation | 4 | 7 |
| MCM 3: | Illicit Discharge Detection and Elimination | 5 | 8 |
| MCM 4: | Construction Stormwater Runoff Control | 7 | 7 |
| MCM 5: | Post-Construction Stormwater Management in New Development and Redevelopment | 6 | 10 |
| MCM 6: | Pollution Prevention and Good Housekeeping for Municipal Operations | 5 | 6 |
| | **Total** | **33** | **46** |

### 3.3.2 MCM Assessment Summaries

The aim of this assessment was to evaluate the City's recent and on-going efforts with respect to maintaining compliance with the MS4 permit requirements. Although the County and MU play a vital role in meeting the obligations of the MS4 permit, the sections that follow primarily focus on the efforts undertaken by the City. Summaries of the findings of the assessment for each of the six MCMs are provided in the following sections. Each of the summaries also includes additional information on EPA's goals and guidance for the respective MCM.

**MCM1 – Public Education and Outreach**

EPA suggests that permittees inform individuals about steps that can be taken to reduce stormwater pollution by developing outreach and communication strategies that are tailored to the community. Example strategies include brochures or fact sheets, public service announcements, interactions with community groups, implementing educational programs, and leading community-based projects such as storm drain stenciling, and watershed cleanups. EPA also recommends that some of the materials or outreach programs be directed toward targeted groups of commercial, industrial, and institutional entities likely to have significant storm water impacts.

Based on review of the recent annual reports, the City, in collaboration with the County and MU, has completed several outreach and education activities in compliance with the permit requirements, including: identification of pollutants of concern, development of numerous brochures, webpages, workshops, stream cleanups, special projects, TMDL demonstration/education, grant-funded stormwater retrofits with related education, partnership meetings, and education visits to concrete companies. Measures of success include quantification of litter cleaned up and the number of volunteers participating in clean-up events. The City appears to significantly engage in activities that reach multiple audiences. For example, the 2012 annual report states that over 4,000 citizens had some type of direct contact with the Stormwater Outreach program during nearly 100 separately documented events. As previously noted, the City also maintains a website for the City's Stormwater Program and is active on social media.

**MCM2 – Public Involvement/Participation**

Public involvement is a key component of storm water management programs. Ideally, this public involvement should include engaging individuals from a variety of economic and ethnic groups to provide input in developing, implementing, and reviewing storm water management programs. There are many options to include citizen stakeholders as part of the process. These can range from participation in public hearings, serving on local storm water management panels, assisting to coordinate the local program to activities such as volunteer monitoring or stream clean-up efforts.

The City, along with MU and the County, have completed numerous public involvement and participation events related to public education, such as stream team stream/road clean-ups that have involved thousands of volunteers and several tons of trash removed from the watershed. The following are some additional examples of activities reported under this MCM:

- The CAM process for the Hinkson Creek TMDL began in April 2012.
- The City met twice in 2012 with a Stormwater Advisory Board to address redevelopment in a local ordinance and design manual.
- Stakeholders are involved in the Bonne Femme Watershed Management plan to address bacteria.
- Public Notice requirements for construction projects appear to be in place.

In regard to the CAM, the annual reports indicate the establishment of three specific teams, including a 15-member stakeholder committee, an action team, and a science team. Each team meets six to 10 times per year, and the action team has led the completion of a Geographic Information System (GIS) habitat assessment for Hinkson Creek and its subwatersheds, as well as the implementation of a level spreader[1] BMP performance study.

[1] A level spreader is an erosion control device designed to reduce water pollution by mitigating the impact of high-velocity stormwater surface runoff.

**MCM3 - Illicit Discharge Detection and Elimination**

EPA recommends that a storm water management program include an illicit discharge detection and elimination component. This component should include procedures such as visual inspections of outfalls during dry weather and field tests of selected pollutants to determine priority illicit discharge areas. Once priority areas are determined a plan for tracing the source of the illicit discharges as well as procedures to eliminate the discharge is needed. The illicit discharge detection and elimination program should be periodically reviewed and revised. This component of a storm water management program can also include education activities such as storm drain labeling and stenciling, public reporting or illicit discharges, and distribution of related outreach materials.

The City has completed GIS mapping of all known outfalls and continues to update this dataset. In accordance with the MS4 permit, the City has adopted ordinances or other administrative controls to deem illicit discharges as illegal and undertake enforcement action, if necessary. The City also has a public reporting hotline for illicit discharges. The reporting of illegal discharges has increased over the first few years of the permit cycle.

Additionally, the City has an active inspection program. Specifically, the City inspects areas where illicit discharges have been reported and also randomly inspects areas when field staff are attending other matters. The City also continues a grease-trap inspection program. The City has embarked on an extensive Sanitary Sewer Evaluation Study (SSES) to detect and eliminate illicit connections to the sanitary sewer, which should also identify cross connections with the storm drainage system or defects adjacent to creeks and streams that have the potential to cause a discharge. The City has completed this work in three basins. Additionally, all building construction and remodeling is inspected to evaluate plumbing and wastewater connections.

In the City, building inspectors are expected to visually inspect for illicit discharge detections when evaluating structures. An opportunity for improvement in this area is to dedicate resources for IDDE and a more strategic proactive visual inspection program through watershed and stream inspections, given the numerous points of potential discharges that cannot be captured through existing pipe inspections or report responses.

**MCM4 – Construction Site Runoff Control**

Areas undergoing new development or redevelopment should have procedures in place for construction site inspection and enforcement of the necessary control measures. Site inspections can be prioritized based on the type of construction occurring, the local topography, soil and water quality. These inspections should also include an evaluation of consistency with local sediment and erosion control requirements. Requiring construction site storm water pollution prevention plans, for sites in the jurisdiction, can also be included as part of the program. Another option is to provide additional training to local construction site operators as to the appropriate management of storm water runoff from the site.

The City has established required ordinances with enforcement capacity and mechanisms, BMP requirements, Stormwater Pollution Prevention Plan (SWPPP) requirements, site plan review, inspection requirements and related written procedures for all regulated construction projects. Consideration is given to special features such as karst geology. At the City, all private construction and development is handled through the Community Development Department. Four City inspectors and one City engineer became certified in erosion and sediment control inspection. All City public improvement projects are inspected by City personnel.

**MCM 5: Post-Construction Stormwater Management in New Development and Redevelopment**

By considering water quality impacts in the initial stages of a new development or a redevelopment project, more opportunities for water quality protection can be identified. EPA recommends that the planning process for new development or redevelopment identifies the goals of the municipal storm water management program, implementation strategies, operation and maintenance policies and procedures, and enforcement procedures while considering existing ordinances, policies, programs and study results that address storm water runoff quality. Selection of BMPs for a new or redeveloped sites should be appropriate for the local community, improve water quality, and attempt to maintain pre-development runoff conditions. Locally-based watershed planning efforts which involve a diverse group of stakeholders including interested citizens can aid in the selection of appropriate BMPs for such sites.

Both structural and non-structural BMPs should be considered. Structural BMPs include storage, filtration and infiltration practices. To determine the appropriate implementation of such practices, EPA recommends pre-construction review of BMP designs, inspections during construction to verify BMPs are built as designed, post-construction inspection and maintenance of BMPs, and penalty provisions for the noncompliance with design, construction or operation and maintenance.

Non-structural BMPs (preventative measures that involve management and source controls) should also be evaluated. These non-structural BMPs could include local policies and ordinances focused on directing growth to identified areas (infill development in higher density urban areas and areas with existing infrastructure), protection of sensitive locations, maintaining or increasing available open space, and providing buffers along sensitive water bodies. Other non-structural BMPs can seek to minimize impervious surfaces and the disturbance of soils and existing vegetation.

EPA also recommends that post-construction storm water management programs should include education programs for developers and members of the public regarding ways to design projects to minimize water quality impacts and impervious area. As storm water technologies are continually improving the post-construction stormwater management programs should have a mechanism to be responsive to these changes.

Nationally, this area of the MS4 program, being focused on stormwater quality, has required a stormwater management paradigm shift (for all stakeholders) that is still occurring and ripe for refinement in the goal of significant water quality protection. The approach in the industry has changed from a faster to a slower discharge more like that of the natural processes, while still achieving flood protection. While the co-permittees have amended their stormwater ordinances, policies, BMPs, and processes to incorporate requirements for water quality, discussions continue across the country regarding understanding and implementing strategies and standards that could be most effective for a given region and/or watershed. These discussions include the definition and applicability of design storms, diversity of geological features, effective standards and whether a standard should even exist.

The annual reports include information on retrofit projects and indicate that each of the co-permittees have also modified their manuals and ordinances/policies to expand options for post-construction BMPs. Project review and approval processes are changing to consider water quality in the project-planning stage. Additional and continued BMP performance monitoring specific to this region will inform the continued discussion on effective performance standards and state-of-the-practice.

The City of Columbia Stormwater Management and Water Quality Manual that was adopted in March 2007 allows for stormwater management plans to be tailored to specific conditions in the City's watersheds for both development and redevelopment projects. The manual is continually reviewed and updated as necessary. Additionally, the City's Community Development Department enforces the City's Stream Buffer Ordinance and stormwater quality management for new developments and also records covenants and maintenance agreements for post-construction BMPs.

The City receives and tracks annual inspection information for the post-construction BMPs and maintains this information in a GIS database. The database includes 412 records of known BMPs throughout the City, approximately 50% of which are categorized as bioretention, detention, or ponds (**Figure 3, Attachment G**). Approximately 14% of the BMPs in the database are unknown or not identified and many records are missing basic information such as the owner, descriptions, date of last inspection, and links to pictures. One potential opportunity for improvement is for the City to update the GIS database to reflect the most recent annual inspection information available. These updates would improve the City's ability to track and report progress towards meeting post-construction management requirements.

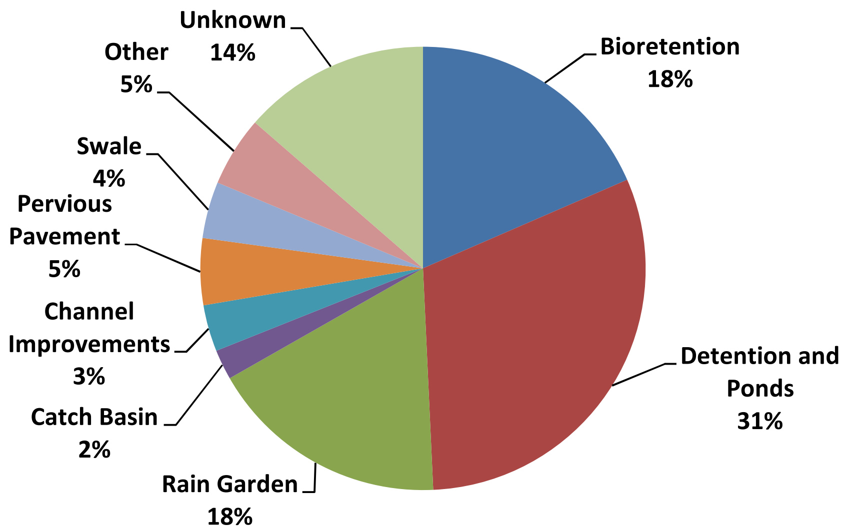


**Figure 3. Categories of Structural BMPs (412 Individual Records).**

In addition to the activities described above, the 3M wetland and Katy Place trail detention retrofit projects were implemented to treat over 140 acres of upstream development before it enters into Hinkson Creek (Figure 4). The Forum Nature Area Level Spreader Monitoring Project was established through the CAM to assess BMP effectiveness. Additionally, demonstration projects have also been implemented in the City and on the MU campus.


**Figure 4. The 3M Wetland and Katy Place Trail Detention Retrofit Projects Treat Over 140 Acres of Stromwater Runoff from Upstream Development.**

## MCM 6: Pollution Prevention/Good Housekeeping for Municipal Operations

EPA recommends that to reduce the risk of water quality problems, municipal operations and maintenance should be a key component for all municipal storm water management programs. Effective operations and maintenance based pollution prevention programs should consider schedules and activities to ensure limited impacts on water quality. Pollution prevention programs can evaluate existing projects to determine if additional water quality practices are needed, as well as evaluate new flood management projects to assess the impacts on water quality.

Effective and efficient programs should include long-term inspection procedures for both structural and non-structural controls to result in reductions of floatables and other pollutants, controls to reduce or eliminate the discharge of pollutants from roadways, parking lots, storage yards, maintenance shops or yards, salt and/or sand storage locations, snow disposal operations and waste transfer stations. Pollution prevention plans should also contain procedures for the disposal of waste such as dredge spoils, accumulated sediments, floatables, and other debris removed from separate storm sewers and any of the areas listed above.

All co-permittees have staff training and inspection requirements. Existing spill prevention programs have been incorporated. Quantification of street sweeping and staff training is evident in the annual reports.

### 3.3.3 Stormwater Quality Performance Summary

The assessment of the City's MS4 permit compliance efforts reveals that the City has dedicated a significant amount of resources to maintain compliance with the permit requirements. While opportunities for improvements and increased efficiencies exist, the City's efforts, as represented by the previous annual reports, are fulfilling the requirements of the permit.

- **MCMs 1: Public Education and Outreach and MCM2: Public Involvement and Participation –** The City develops and implements publications, events, and training, and has added awareness and involvement through the Hinkson Creek Urban Retrofit Project and CAM process, as well as other watershed groups and special projects.
- **MCM 3: IDDE –** The City has mapped their known outfalls, adopted ordinances or other administrative controls to reduce illicit discharges, and has an active inspection program. One opportunity for impromement includes pursuing a more strategic and proactive visual inspection program.
- **MCM 4: Construction Stormwater Runoff Control –** The City has established ordinances with enforcement capacity and mechanisms, performs erosion and sediment control inspections, and provides project oversight.
- **MCM 5: Post-Construction Stormwater Management in New Development and Redevelopment –** The City has completed several retrofit projects, enforces ordinances and development requirements, and tracks BMPs. Opportunities exist with respect to further refining standards and BMP design requirements and improving BMP data management.
- **MCM 6: Pollution Provention/Good Housekeeping for Municipal Operations –** The City incorporates staff training requirements, inspection requirements, spill prevention programs into their program. Additional consideration might be given to a more dynamic and inclusive inspection program with independent quality checks (including government/MU construction projects).

# Section 4. Existing Stormwater Utility Needs

To develop a better understanding of funding needs relative to the existing system condition and performance, the project team broadly reviewed planned capital improvement program (CIP) projects, costs, and current funding levels. Results are summarized in the following sections.

## 4.1 Current Stormwater Capital Improvement Program Funding

The City's fiscal year (FY) 2017 capital improvement program (CIP, Columbia 2016) stormwater projects include infrastructure asset management, flood reduction projects and stormwater runoff water quality improvements. It is anticipated that with the large amount of CMP in the system, asset management needs will increase over the next 20 years and exacerbate the stormwater funding issues already facing the City. For example, the 2008 Stormwater Utility Assessment identified an annual expenditure of $5.8 million for CMP replacements starting in year 2010 and continuing for approximately 10 years until the asset management portion would drop to approximately $2.8 million (CH2MHill 2008). The current level of asset management investment is less than 10% of what was projected by the 2008 Stormwater Utility Assessment report (CH2MHill 2008). It is clear that with the resources currently available, necessary system replacement and renewal activities must be deferred. This deferment will result in a reduction in system reliability and an increase in emergency repairs. To help address these issues, more detailed renewal costs and alternatives will be evaluated in the next phase of the IMP process.

## 4.2 Current Stormwater Prioritization Method

Due to budget shortfalls outlined in the previous section, there are multiple flood and erosion reduction needs that cannot currently be addressed. As a result, City staff uses a holistic approach to prioritize funding expenditures which is generally based on public safety and impacts to infrastructure (**Table 11**). The prioritization method is weighted to promote projects that reduce the flooding risk exposure to the traveling public. For instance a failing CMP below a highly traveled street would rate much higher than flooding damages to a single residence. If the CMP was also undersized, then the points available would include Safety (150 pts), Street Flooding (80 pts) and Maintenance (40 pts). A single structure flooding problem would be eligible for 10 pts plus the years waiting points.

There are multiple challenges when developing and applying a prioritization method. It is suggested that the prioritization method closely align with community priorities which will shift over time and after major events such as a system failure in a well traveled street. It is recommended that the City periodically request community input and revise the existing prioritization methodology appropriately. Community input could be obtained through individual outreach events or through a more structured approach like a Stormwater Utility advisory board.

**Table 11. Existing Stormwater Project Prioritization Approach.**

| Criteria | Points Available | Weighting | Decision Criteria |
|---|---|---|---|
| Years Waiting | 30 | 8% | Up to 5 years of waiting scores zero points. 30 or more years of waiting will score the highest points. |
| Safety | 150 | 38% | Related to a structural failure leading to safety concerns. |
| Structure Flooding | 10 | 3% | Water in doors and windows will score the highest points. Basement flooding scores 1 point. Each flooded structure will receive points. |
| Street Flooding | 80 | 20% | Based on size of roadway and depth in street. 100 pts is added if a car can be swept from the road or the road is the single point of access for a neighborhood. |
| Yard Flooding | 5 | 1% | Maximum score when it threatens house or garage. |
| Erosion | 40 | 10% | Maximum score if the erosion will impact house, utilities or street. Add 50 pts if the erosion also impacts the stormwater system. |
| Maintenance | 40 | 10% | Higher points are awarded if a sinkhole is forming. |
| Permitting | 40 | 10% | Scores 40 or zero based on additional agreements and permits being needed. |

# Section 5. Summary

The stormwater system evaluation findings and summary points are as follows:

- The City records a significant amount of data on their stormwater lines and pipes in their GIS system. The database indicates that the City owns and maintains approximately 175 miles of pipes and 14,000 structures. Approximately 50% of both the pipes and structures have been installed in the last 15 years.

- The overall condition of the stormwater system is largely unknown; approximately 1% of the pipes and 7% of the structures have been inspected and assigned a condition rating.

- According to the data, CMP makes up more than 33% of the system. Approximately 128,000 feet of CMP is more than 30 years old and would be expected to have sections of structurally deficient pipe. In the next 10 years, the length of CMP beyond the useful life will approach 225,000 feet.

- Flooding reports (2,670 total) are widespread throughout the City and the severity and impact of the flooding varies. There are several areas in the City with a relatively high concentration of flooding reports.

- The City's Stormwater Management & Water Quality Manual (Columbia 2009) is robust, has been recently updated, and is easily accessible for the public and private land developers. The City may want to consider reevalutating key design standards, such as assumed temporal storm distributions, to increase stream channel protection during wet weather.

- The City's stormwater management efforts indicate that they are protecting water quality through the application of BMPs and measureable goals to the maximum extent practicable, as is required by the MS4 permit. Specific conclusons for each MCM and opportunities for improvement are outlined in Section 3.3.3.

- The current level of asset management investment is less than 10% of what was projected by the 2008 Stormwater Utility Assessment report (CH2MHill 2008). It is clear that continued underfunding and deferment of system replacement and renewal activities will result in a reduction in system reliability and an increase in emergency repairs.

- The City relies on a project prioritization approach that is generally based on public safety and impacts to infrastructure. The City could potentially improve the methodology by periodically requesting community input through individual outreach events or through a more structured approach like a Stormwater Utility advisory board.

A number of data gaps and limitations were also identified while reviewing the stormwater system database. Addressing these gaps will help improve future stormwater system planning, maintenance, and performance. The City is aware of many of these issues and is currently working to improve their data collection, tracking, and maintenance procedures.

- **Flooding Report Database Formatting –** To improve mapping and analysis efficiency, consistent data formatting is needed throughout the report database. In particular, addresses or other coordinates should be entered for each per report report and a standard format (e.g., house number followed by street name) should be applied. Flooding reports that are associated with specific locations will aid in capital improvement planning, risk assessment and other analyses of flooding, erosion, and city-wide observations.
- **Stormwater Maintenance Database –** Currently, the City's stormwater system includes very little cleaning, maintenance, or condition information. Collecting, analyzing, and maintaining this type of information would help the City work to efficiently maintain existing stormwater assets and proactively address vulnerable areas rather than respond reactively system failures and emergency situations. Keeping a database and system that includes stormwater line information such as cleaning dates, line conditions; completed closed circuit television inspections (CCTV) and other inspection data would support the necessary planning and analysis efforts. Stormwater CCTV inspections are an annual unfunded request.
- General missing attribute information of the Stormwater database includes:
    - Approximately 30-percent of the stormwater lines and structures have an unknown construction year.
    - Approximately 12-percent of the records have an unknown pipe size
    - 99-percent of the records are missing invert information.

# Section 5. References

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Technical Memorandum 4

Attachments

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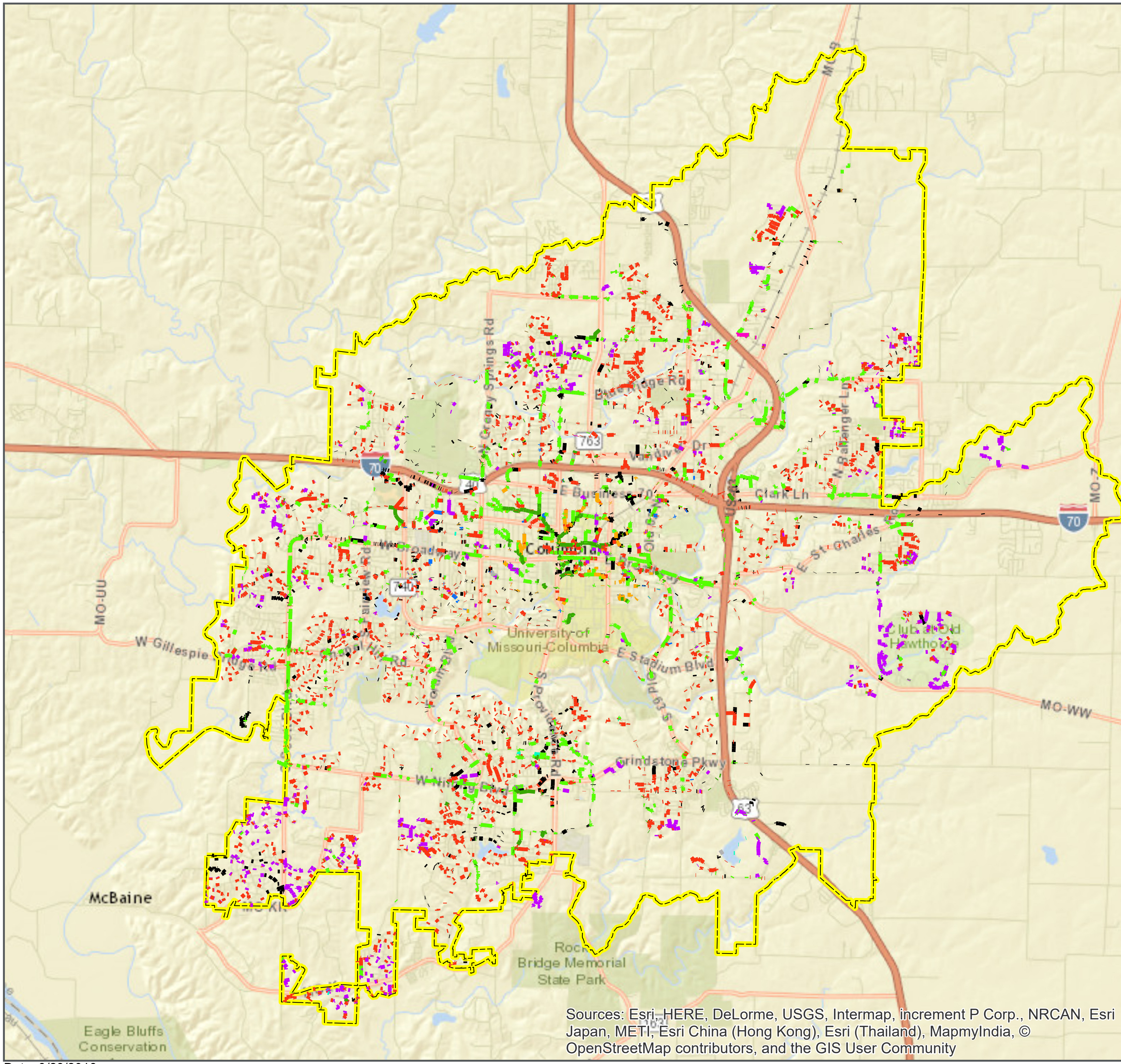


Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

## Legend

Urban Service Area

**Material**

- CMP
- CPEP
- CPP
- HDPE
- BCCMP
- PVC
- RC
- RCP
- VCP
- Unknown

**ATTACHMENT A**
**STORMWATER PIPE INVENTORY**

**CITY OF COLUMBIA MISSOURI**

**WASTEWATER & STORMWATER INTEGRATED MANAGEMENT PLAN**

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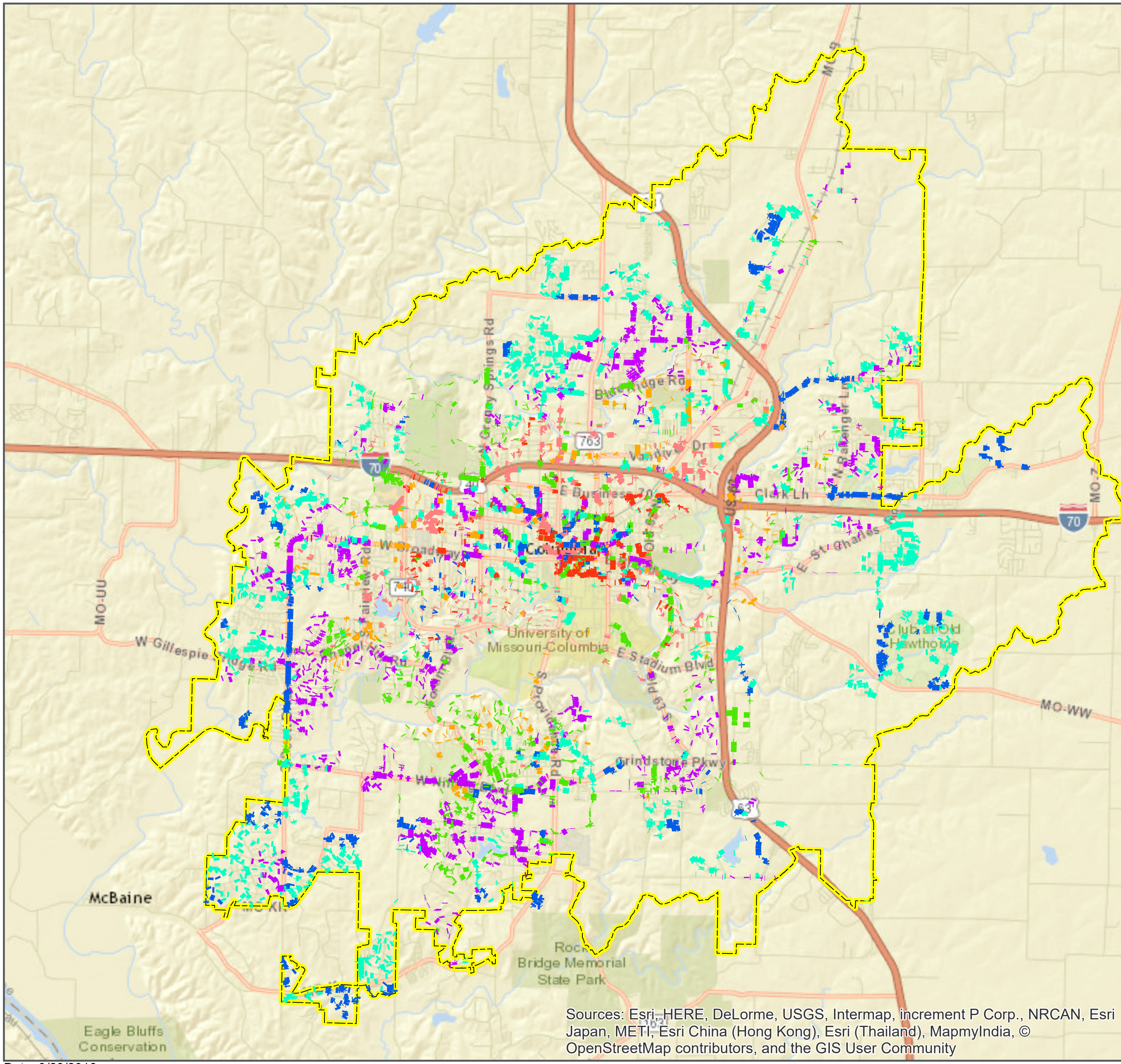


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Integrated Management Plan
Wastewater & Stormwater

## Legend

Urban Service Area

### Construction Year

- Pre-1960
- 1960-1970
- 1970-1980
- 1980-1990
- 1990-2000
- 2000-2010
- 2010-Present

# ATTACHMENT B STORMWATER PIPE INVENTORY BY AGE

**CITY OF COLUMBIA MISSOURI**

**WASTEWATER & STORMWATER INTEGRATED MANAGEMENT PLAN**

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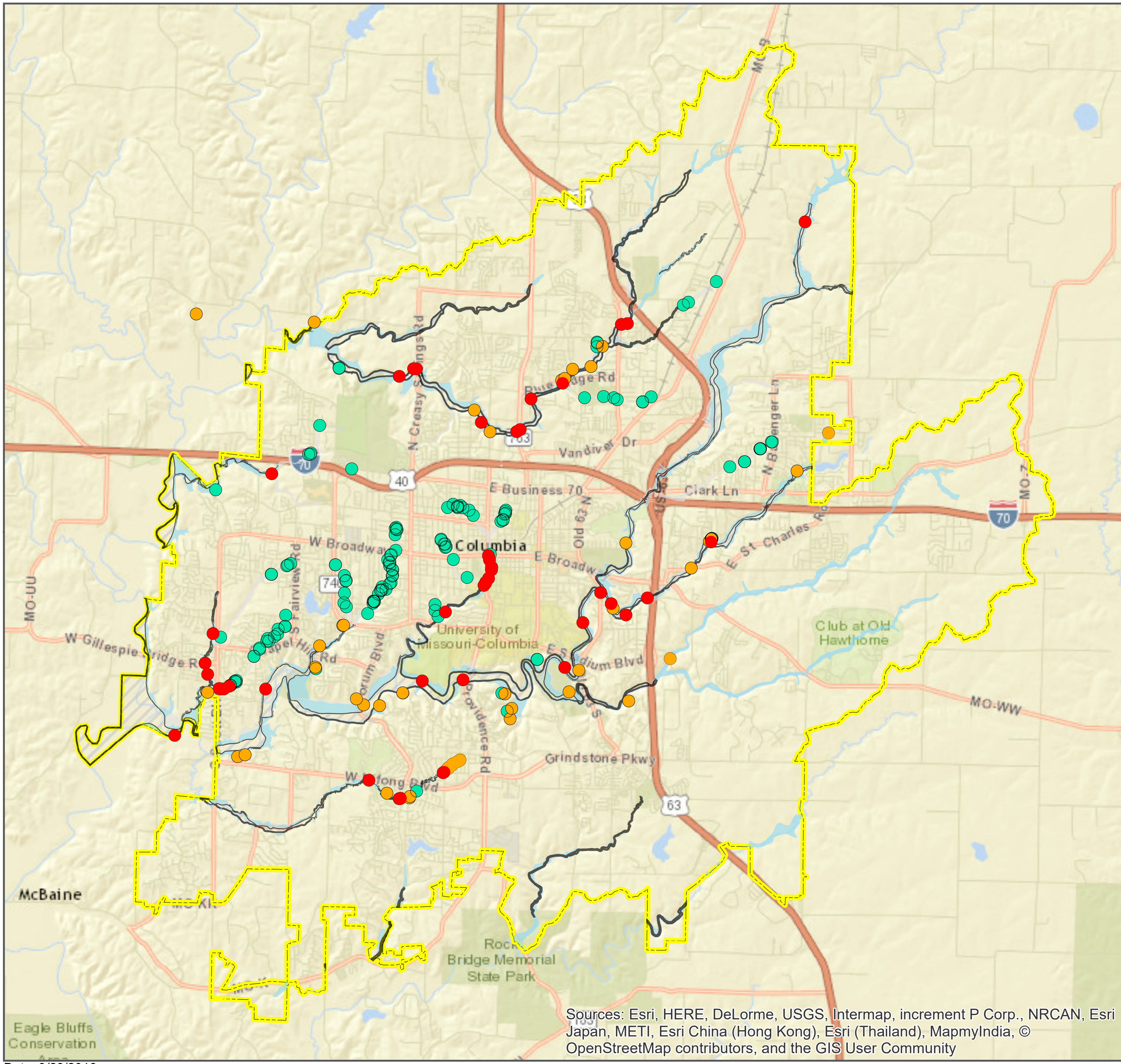


Date: 9/23/2016

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Integrated Management Plan
Wastewater & Stormwater

## Legend

Urban Service Area

**Reported Flooding Locations**

- Floodway
- Floodway Fringe
- 500 Yr. Annual Chance Flood Hazard

**Regulatory Floodplain**

- Floodway
- Floodplain

## ATTACHMENT C
## RIVERING FLOODING

**CITY OF COLUMBIA MISSOURI**

**WASTEWATER & STORMWATER INTEGRATED MANAGEMENT PLAN**

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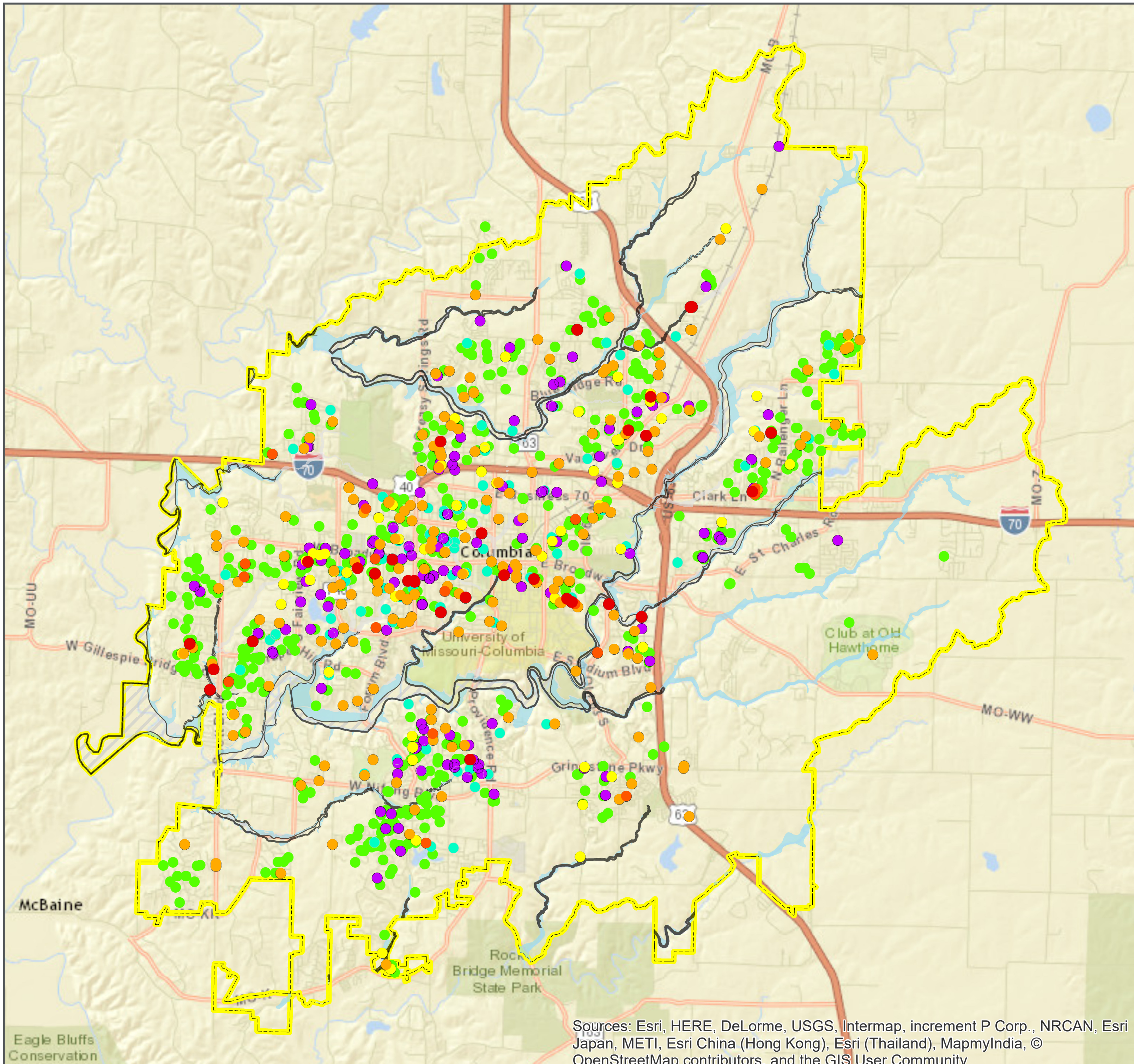


## Legend

Urban Service Area

**Regulatory Floodplain**

Floodway

Floodplain

**Reported Flooding Locations**

- House, Yard, & Street
- House & Street
- Street Flooding Only
- Yard & Street
- House & Yard
- House Only
- Yard Only

**ATTACHMENT D**
**STREET, HOUSE & YARD FLOODING**

**CITY OF COLUMBIA MISSOURI**

**WASTEWATER & STORMWATER INTEGRATED MANAGEMENT PLAN**

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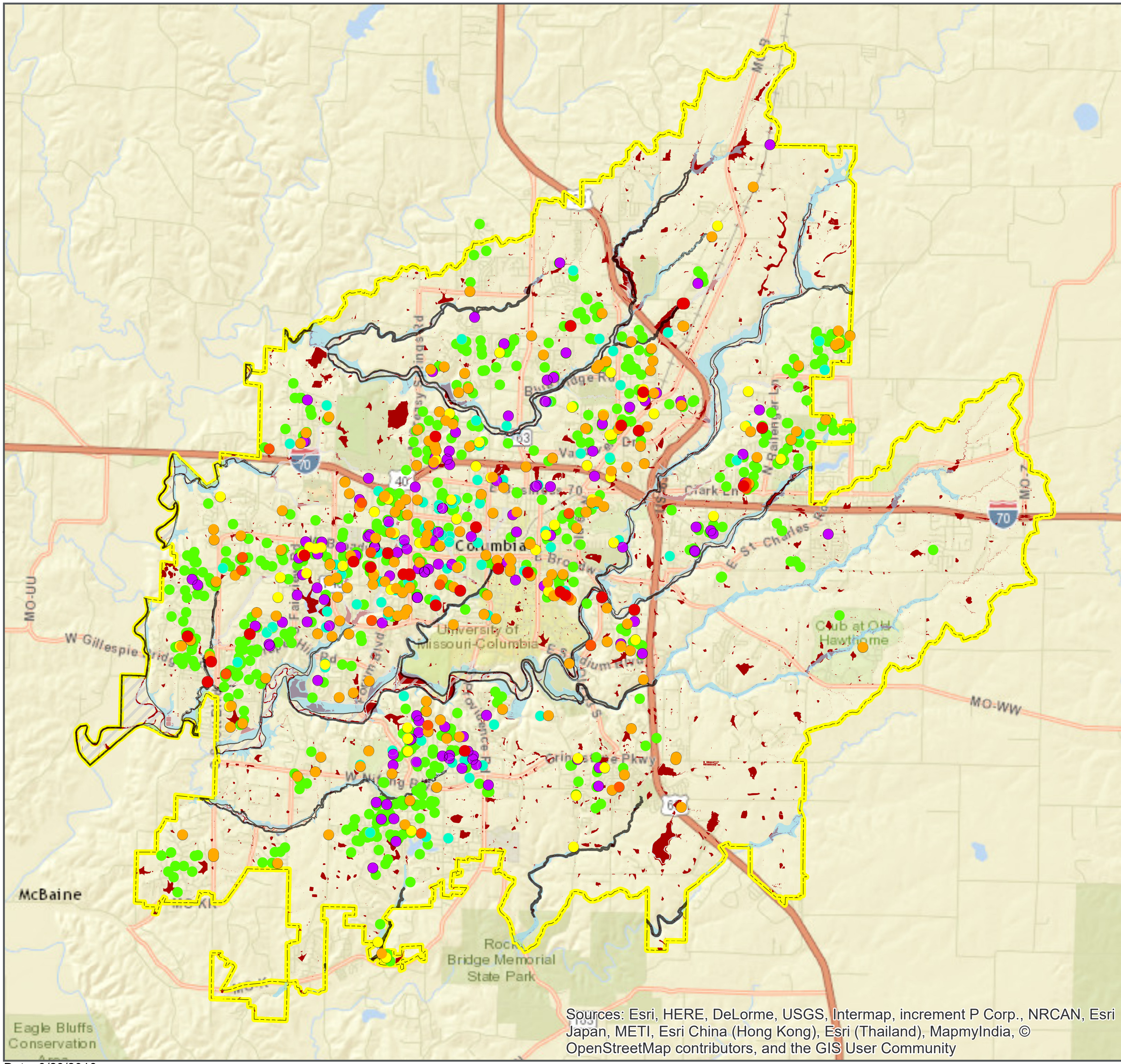


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## Legend

- Urban Service Area
- Depression Areas

**Regulatory Floodplain**

- Floodway
- Floodplain

**Reported Flooding Locations**

- House, Yard, & Street
- House & Street
- Street Flooding Only
- Yard & Street
- House & Yard
- House Only
- Yard Only

# ATTACHMENT E DEPRESSION AREAS & REPORTED FLOODING LOCATIONS

**CITY OF COLUMBIA MISSOURI**

**WASTEWATER & STORMWATER INTEGRATED MANAGEMENT PLAN**

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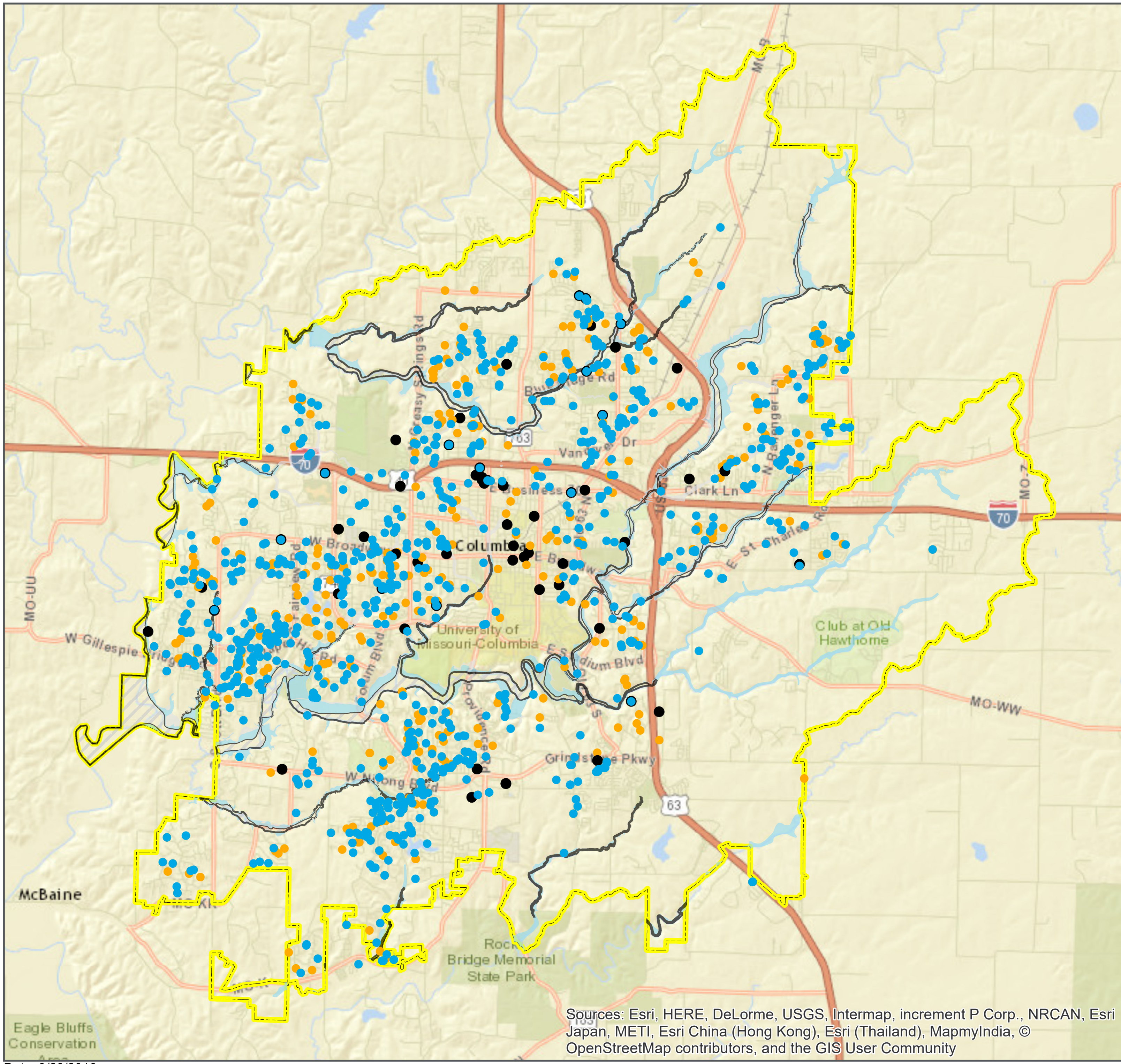


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**Legend**

- Urban Service Area
- Depression Areas

**Regulatory Floodplain**

- Floodway
- Floodplain

**Reported Locations**

- Open Channel
- Failing System
- Reported Yard Erosion

**ATTACHMENT F**
**OTHER CITIZEN REPORTS**

**CITY OF COLUMBIA MISSOURI**

**WASTEWATER & STORMWATER INTEGRATED MANAGEMENT PLAN**

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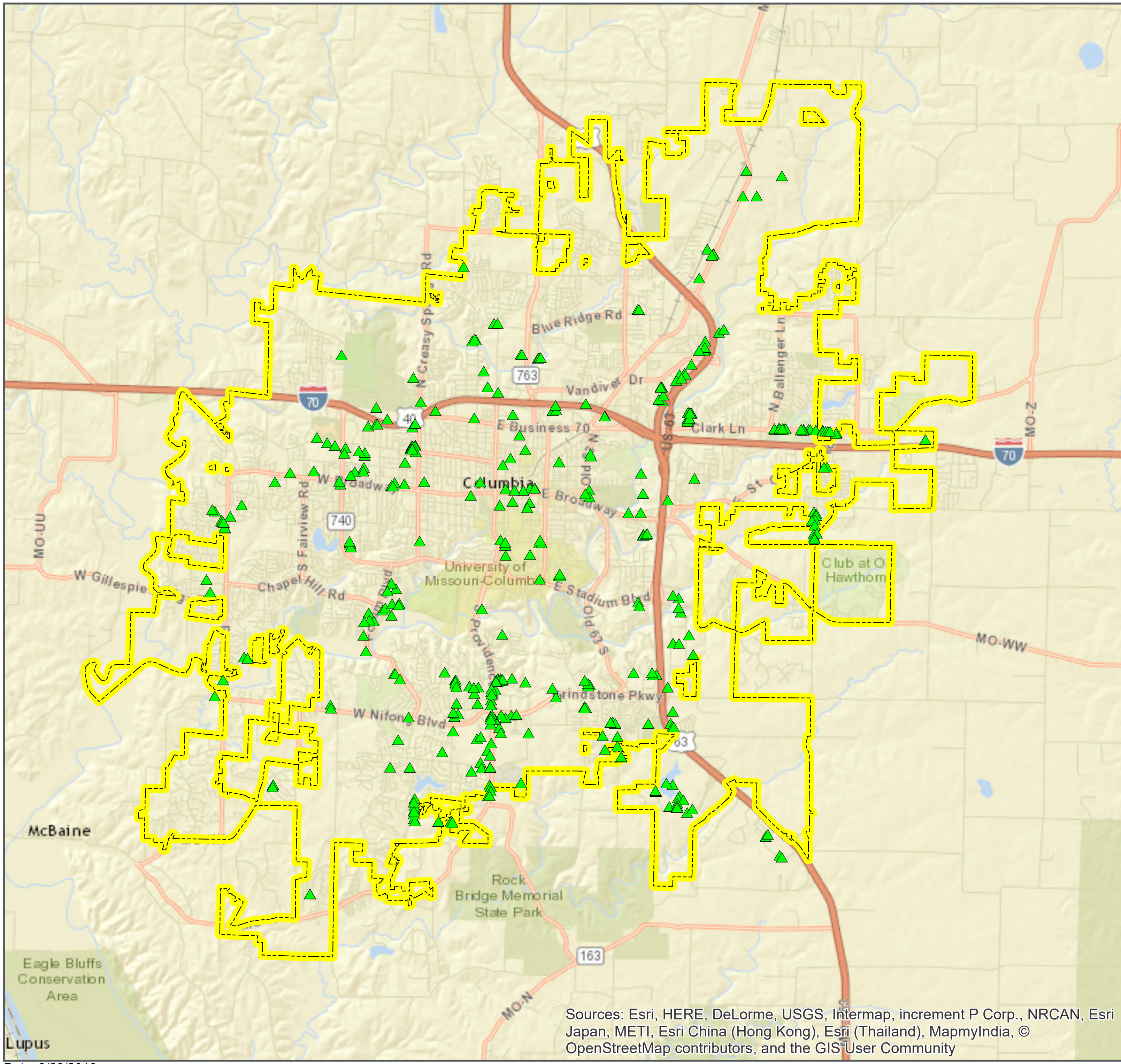


Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

## Legend

- Stormwater BMP
- Columbia City Limit

**ATTACHMENT G**
**STORMWATER BMP LOCATIONS**

**CITY OF COLUMBIA MISSOURI**

**WASTEWATER & STORMWATER INTEGRATED MANAGEMENT PLAN**

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