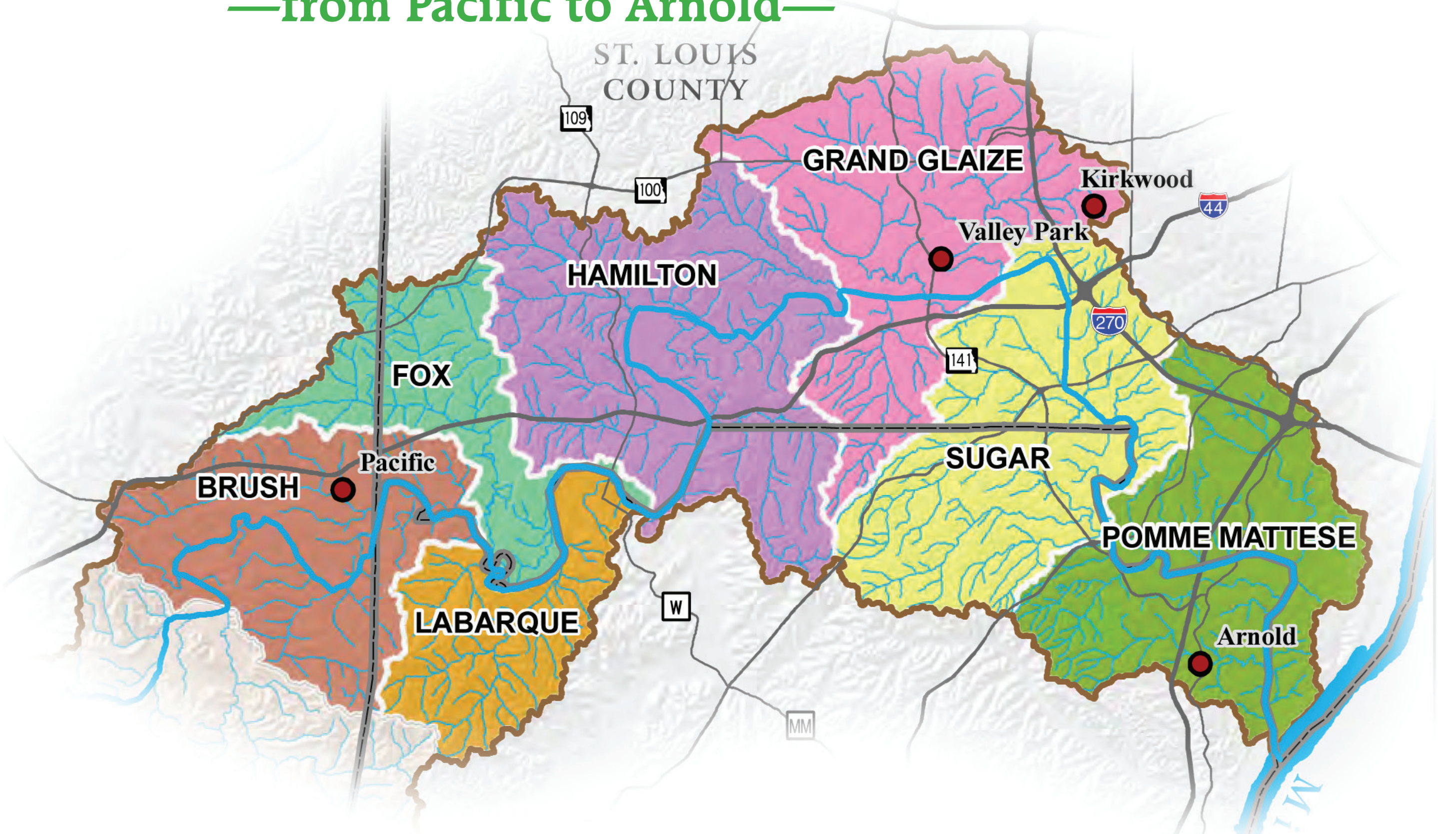
Lower Meramec Watershed Management Plan

FINAL

September 2017

Lower Meramec Watershed Plan

—from Pacific to Arnold—



This project has been funded in part by the U.S. Environmental Protection Agency, Region7, through the Missouri Department of Natural Resources under assistance agreement G16-NPS-05 to East-West Gateway Council of Governments. Other funders include Great Rivers Greenway, Missouri Department of Conservation and The Nature Conservancy. The contents of this document do not necessarily reflect the views and policies of the Environmental Protection Agency, or other partners, nor does the mention of trade names or commercial products constitute endorsement or recommendation for use.

EAST-WEST GATEWAY
Council of Governments

Creating Solutions Across Jurisdictional Boundaries

2017

Lower Meramec Watershed Management Plan 2017 Update: Including Mattese/Pomme, Sugar/Fenton, Grand Glaize/Fishpot/ Williams, Hamilton/Kiefer, Fox/LaBarque, and Brush Creeks

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Prepared by East-West Gateway Council of Governments
September 2017

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Chapter I. Introduction

A. Introduction

The lower Meramec River extends 109 miles from Meramec State Park at Sullivan to the confluence with the Mississippi River at Arnold. It lies wholly within the East-West Gateway region and the three counties of Franklin, Jefferson, and St. Louis. In 2012, East-West Gateway Council of Governments (EWG) completed a watershed management plan for the Lower Meramec River and its tributaries in Jefferson and St. Louis counties, from Pacific to Valley Park, covering four 12-digit Hydrologic Unit Code, or HUC, watersheds.[1]

Water quality problems in the lower Meramec watershed are largely the result of non-point sources of pollution. Over the past few decades point sources of pollution from wastewater treatment plants and industries have been regulated and require permits to discharge into receiving waters. These permits specify effluent limits so the discharge still allows receiving waters to meet water quality standards. Non-point sources are mostly stormwater runoff from urban development. Cities with over 10,000 people are now (since 2000) required to obtain permits through the municipal separate storm sewer system, or MS4, program. While regulations on point source discharges to waterbodies will continue to improve water quality over time, polluted runoff still makes its way into streams and rivers. Past development practices that were not subject to the permitting process, through overland flow outside of MS4 systems and also from failing on-site wastewater treatment systems (septic systems) are major contributors of pollutants. The 2012 Lower Meramec Watershed Plan (2012 Plan) outlined goals, objectives, and projects for improving water quality through the use of green infrastructure to address these unpermitted, non-point sources.

B. Implementation Progress Since 2012

As of 2016, segments of seven streams in the 2012 Plan are still listed as impaired for pollutant loads that exceed water quality standards. Additionally, in 2016, a segment of the Meramec River has now been listed as polluted by bacteria. More significantly, the tributaries east of LaBarque Creek all exhibit serious loss of aquatic habitat as shown by fish populations studies conducted by the Missouri Department of Conservation (MDC) in 2015. The Lower Meramec River remains a prime recreational asset for the region, and water quality improvement and protection are critical to maintaining this resource.

[1] See *Lower Meramec Watershed Plan, from Pacific to Valley Park: Water Quality, Green Infrastructure and Watershed Management for the Lower Meramec Watershed,* (January 2012) Herein called 2012 Plan. http://www.ewgateway.org/lowermeramec/lowermeramecwatershedplan-final.pdf. It includes the 12 digit HUC watersheds of 1) Brush Creek; 2) Fox and LaBarque Creeks; 3) Hamilton, Antire, Carr, Flat, Forby and Kiefer Creek; and 4) Grand Glaize, Williams and Fishpot Creek.

The 2012 Plan recommended that Kiefer Creek[2] and other sub-watersheds would each require specific watershed-based management plans. It highlighted Kiefer Creek as a priority sub-watershed because it flows through popular Castlewood State Park. Several key projects and initiatives have taken place or are underway in the sub-watershed since the plan was developed, and are described below:

- The production and distribution of a Lower Meramec watershed brochure, an on-site wastewater system management brochure, and informational maps and brochures on septic tank management and rainscaping projects in the region. (EWG, 2013 and 2014)[3]
- A comprehensive analysis of Kiefer Creek watershed which identified key sources of pollution and decline of habitat (Missouri Coalition for the Environment, or MCE, 2015).[4]
- The Open Space Council for the St. Louis Region (OSC) and St. Louis County Parks implemented a number of small scale projects that had been identified in the plan.
- The Nature Conservancy (TNC) completed a Conservation Action Plan (CAP) for the Meramec watershed[5].
- Great Rivers Greenway (GRG) District acquired property in the floodplain of the Lower Meramec watershed for the purpose of open space preservation, habitat restoration, and riparian corridor enhancement. These activities will provide opportunity to engage volunteers in these efforts while improving water quality and over all watershed health. In addition, GRG has been a long-time partner of the OSC Operation Clean Stream program which supports citizen involvement in the stewardship of the Meramec River and its tributaries.

C. 2017 Plan Update

The 2017 Lower Meramec Watershed Plan (2017 Plan) updates the 2012 Plan with two additional 12 digit HUC watersheds – Sugar /Fenton Creeks and Mattese /Pomme Creeks. This extends the plan from Pacific to the Mississippi River and identifies new projects and watersheds for the planning area (see Map 1). Building on the framework for addressing non-point sources of pollution and past development practices, established in the 2012 Plan, the 2017 Plan identifies new partners and projects, as well as a timeline for projects aimed at achieving goals in the plan.[6] The 2017 Plan also references several other plans that have previously set priorities for the area.[7]

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[2] The official name listed in the Geographic Names Information System (GNIS), which serves as the names repository for all Federal agencies, is spelled Keifer Creek, however East-West Gateway finds no local use of this spelling. Since residents, county roads, subdivisions all spell the creek's name Kiefer, East-West Gateway spells it the way the citizens in the community spell it, since this is a plan for the community.

[3] http://www.ewgateway.org/lowermeramec/lowermeramecbrochure-090711.pdf , http://www.ewgateway.org/pdffiles/library/wrc/septictankbrochure.pdf and http://www.ewgateway.org/pdffiles/library/wrc/RAINSCAPINGBROCHURE.PDF

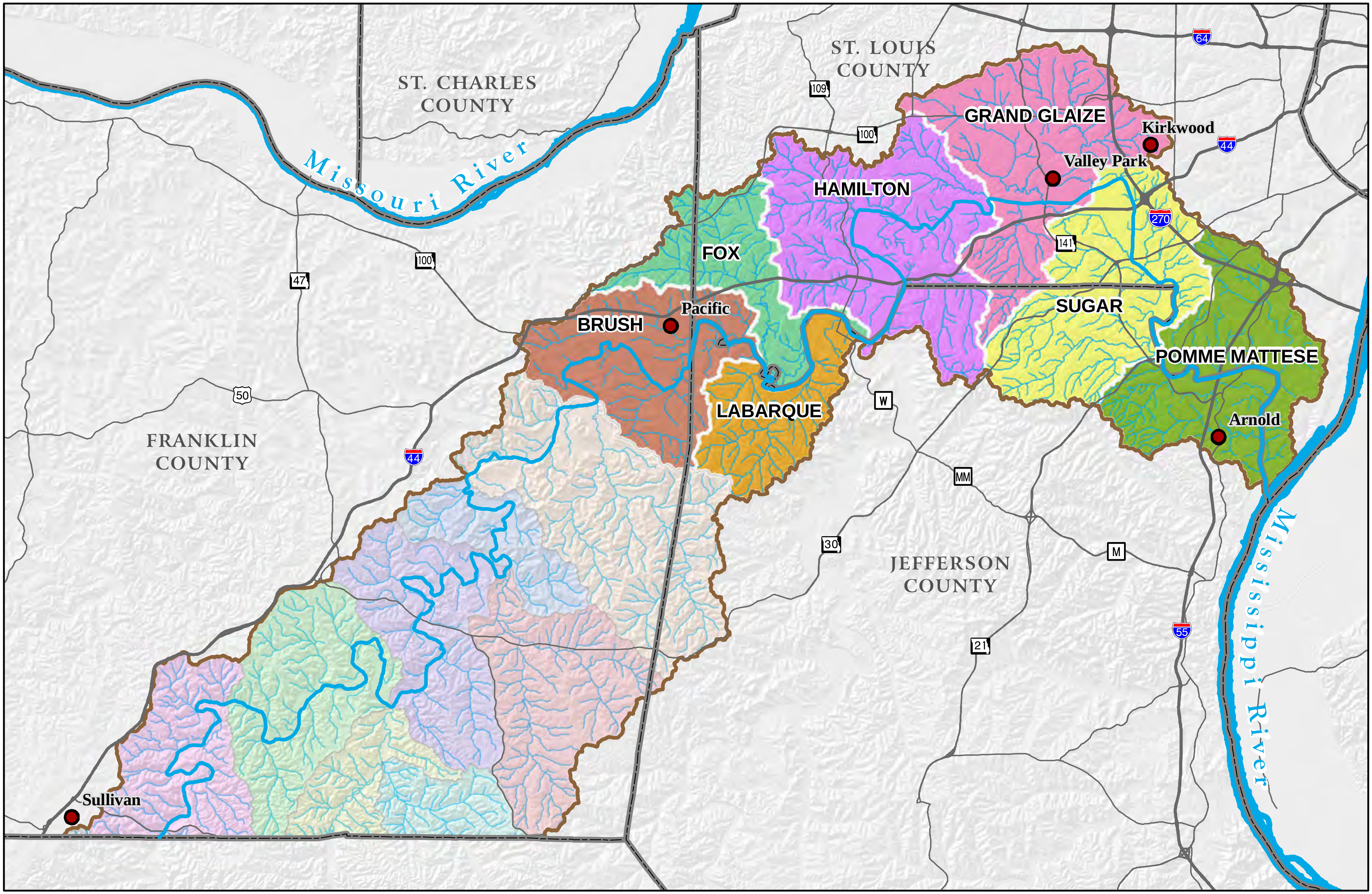
[4] http://moenvironment.org/11-clean-water-program/96-kiefer-creek-water-quality-bacteria

[5] https://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/missouri/meramec-river-conservation-action-plan-2014.xml?redirect=https-301

[6] See 2012 Plan, Table 41.

[7] "*Water Quality Futures: Watershed Planning for the Lower Meramec River*" (July 2005); The recognized need to focus on the Meramec River Basin and the Lower Meramec Watershed dates back to the original *208 Water Quality Management Plan* (208 Plan), completed in 1979 to meet requirements of section 208 in the Federal Clean Water Act . Also referenced in this plan are several studies that address specific streams. Links to plans are at http://www.ewgateway.org/environment/waterresources/WRCProducts/wrcproducts.htm

Map 1
Lower Meramec River Watershed



Watersheds (12-digit HUC)

Selected Watersheds

Other Watersheds

Meramec River Watershed (8-digit HUC)

River or Stream

Major Road

County Boundary

0 1 2 3 4 5 Miles

Sources: USDA/NRCS via MSDIS,
East-West Gateway Council of Governments
August 2011

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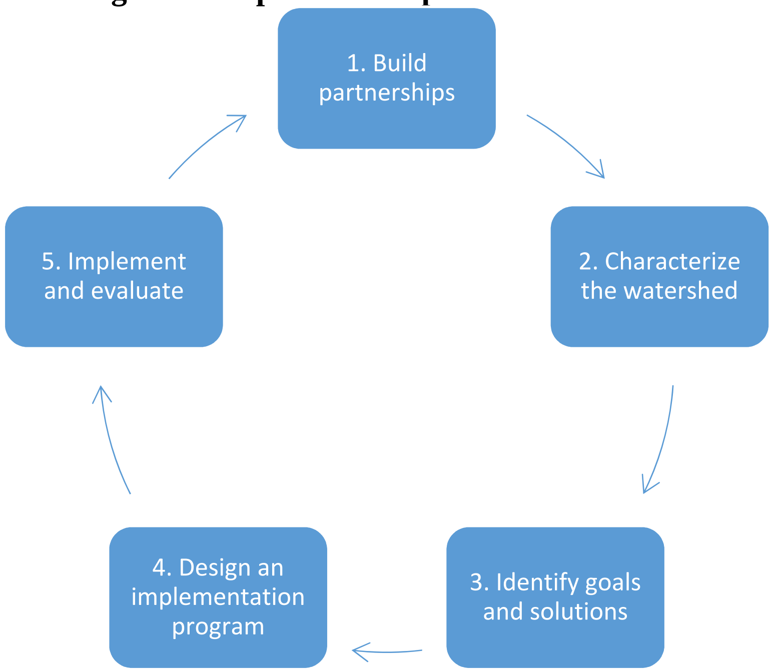
The 2017 Plan followed the steps to develop a watershed plan as recommended by the U.S. Environmental Protection Agency (EPA)[8], shown in Figure 1. It is an ongoing planning, implementation, and evaluation process. As projects and programs are implemented and monitored, they can be revised and enhanced to be more effective. In this chapter the partners involved in this planning effort are described. In Chapter Two, information about the lower Meramec watershed and the HUC 12 watersheds is presented. In the remainder of the 2017 Plan, Nine Element Plans have been prepared for three critical sub-watersheds in the planning area as well as discussion about projects to occur along the main stem of the Meramec River.

Figure 1. Steps to Develop a Watershed Plan



Nine Elements refers to the "Nine Key Elements Critical to the Watershed Management Plan" that meet the requirements of the EPA - Section 319 grant program. These elements include:

A. An identification of causes and sources of pollution that will need to be controlled to achieve load reductions
B. An estimate of load reductions expected for the management measures
C. Description of non-point source measures needed and areas implemented
D. Technical and financial assistance and lead implementers
E. Education component that will be used to enhance public understanding
F. Schedule for implementing the non-point source measures identified in the plan
G. A description of interim, measurable milestones for determining non-point measures are being implemented

[8] https://www.epa.gov/nps/handbook-developing-watershed-plans-restore-and-protect-our-waters -- the figure is based on but modified from the EPA.

H. Set of criteria to determine whether loading reductions are being achieved over time to attain water quality standards.
I. A monitoring component to evaluate effectiveness of implementation efforts over time

D. Public Involvement, Outreach and Engagement

EWG has been engaged in planning activities in the lower Meramec River watershed since 2002. EWG staff first focused on the healthy LaBarque, Fox, and Calvey Creeks in the three counties of the lower Meramec River watershed, organized the 2007 Meramec Summit, and then developed the Lower Meramec Watershed Plan in 2012. In each planning initiative, EWG staff have involved numerous stakeholder organizations. Through these organizations the planning efforts have reached many individuals.

For the 2017 Plan, EWG again has engaged many partners, including cities along the river, federal and state agencies and non-profit organizations involved in activities in the area. Throughout 2015-2016, EWG was contracted by Missouri Department of Natural Resources (MoDNR) to facilitate community engagement meetings within the entire Meramec River watershed. Through these meetings, EWG met with local stakeholders and gathered information that has helped to inform this effort. Local residents have become engaged when there has been a focus on their sub-watershed. Public involvement in the development of this plan is critical since this plan calls for active involvement of the public through volunteer activities and educational programs, and holding meetings and events to assist in bringing more people into the planning process and to engage more individuals in improving water quality.

1. Building Partnerships

Prior to beginning work on this plan, EWG engaged a broad team of agency and organization partners who have a stake in the lower Meramec River watershed, inviting them to participate in the planning process. The core partners involved with developing the plan are presented in Table 1.

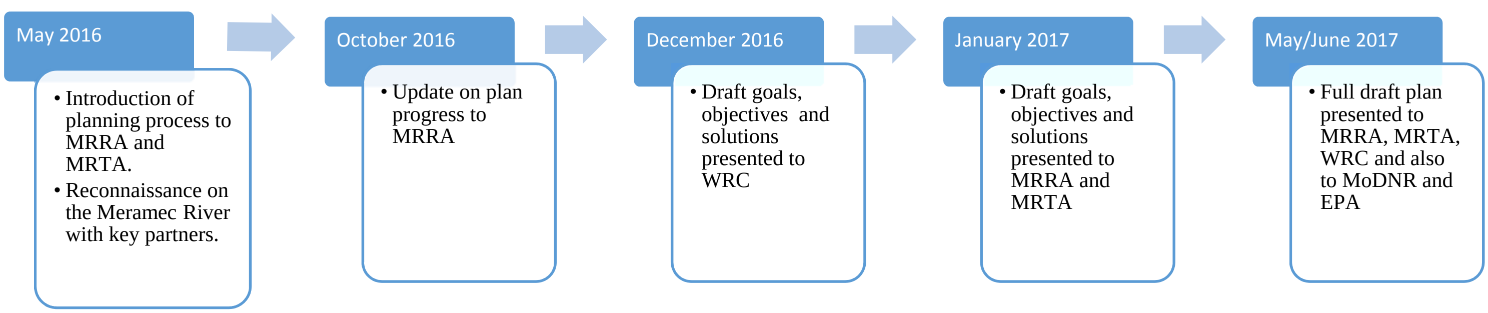
Table 1. Lower Meramec River Watershed Plan Update Core Partners

Partners	Partners
East-West Gateway Council of Governments (EWG)	St. Louis County Parks Department
The Nature Conservancy (TNC)	Open Space Council of the St. Louis Region (OSC)
Missouri Department of Conservation (MDC)	U.S. Geological Survey (USGS)
Missouri Department of Natural Resources (MoDNR)–Environmental Quality Program	Metropolitan St. Louis Sewer District (MSD)
Missouri Department of Natural Resources – Missouri State Parks	U.S. Army Corps of Engineers (USACE)– St. Louis District
Great Rivers Greenway District (GRG)	U.S. Environmental Protection Agency (EPA) – Urban Waters Division

Many of the partner agencies own significant parcels of land in the watershed or are undertaking notable plans, projects, and initiatives in the watershed that could have an impact on water quality (See Appendix for more information). All core partners contributed funding to the plan development and/or provided important technical support. The partners were able to assist with information necessary to characterize the watershed, identify goals and solutions, and develop an implementation program as well as monitoring strategy. The partners also have the interest and resources necessary to implement the plan. Any partner may seek funding to implement any of the key elements of the plan and the partners are committed to sharing information resources where appropriate. The core partners will meet on an ongoing basis (at minimum twice a year) to evaluate the progress of implementation activities and achieving load reductions, and to identify any implementation problems. When any course corrections are to occur, the associated schedule and project focus will be revised to address issues noted.

Feedback from the Meramec River Recreation Association (MRRA), the Meramec River Tributary Alliance (MRTA), and the EWG Water Resources Committee (WRC) was also obtained, (See Figure 1). Early in the process these organizations contributed background insights and recommendations. As the early stages of the draft plan were developed, EWG provided updates and preliminary goals and objectives, and then sought additional feedback which helped to shape the draft plan. Finally these organizations and their constituent members were invited to comment on the draft plan.

Figure 2. Outreach and Engagement



The MRRA was formed by Governor Bond in 1975 in order to promote recreation, tourism and a coordinated approach to the lower Meramec River. The MRRA board is made up representatives from cities located adjacent to the Meramec River, Franklin County, Jefferson County, St. Louis County and agencies that own or manage conservation lands along the Meramec River. Cities participating include: Arnold, Fenton, Sunset Hills, Kirkwood, Valley Park and Eureka. In 2016, the MRRA members voted to become the Watershed Advisory Committee for the Lower Meramec. The MRRA brings initiatives occurring in a watershed together under one umbrella to strengthen collaboration and coordinate planning efforts. The organization helps to focus available resources to address priorities. The MRRA supports recreational use of the river and its environments. As a result, the by-laws of the organization emphasize the importance of clean water and a healthy watershed system. The MRRA has agreed to be an information sharing and project review body.

The MRTA is an informal organization of federal, state and local agencies, non-profit organizations, and others interested in the Meramec watershed. The group meets at least twice per year to share project information, success stories, and other resources. The MRTA was formed following the 2007 Summit on the Meramec River watershed to provide a collaborative approach to watershed wide issues and opportunities. The Open Space Council (OSC) has facilitated the meetings of the MRTA since 2007. In 2009, the MRTA and OSC worked in partnership with the U.S. Forest Service, Trust for Public Land, EWG, and representatives of the water and sewer districts and cities to analyze opportunity to protect source drinking water in the Meramec watershed.

The WRC is a standing committee of EWG. It meets two to four times per year to address regional and sub-regional issues related to rivers, floods, watershed planning, stormwater management, and floodplain protection. Membership includes representatives from local government, business, academia and non-profits from the EWG region in Missouri and Illinois, along with representatives of federal and state agencies. The WRC was formed in 2001 and over the years it has addressed issues related to flooding, flood plain development, levee construction and maintenance, watershed planning, and habitat protection and improvement.

Although there is some overlapping membership, these three organizations – MRRA, MRTA, and WRC, together provide a broad cross section of community interest and expertise. These groups also include all of the stakeholders who were engaged in the development of the 2012 Plan. Early in in the planning process, the team also met with stakeholders interested in the Kiefer Creek watershed, including America's Confluence and the Wildlife Rescue Center, situated on Kiefer Creek. Outside of the MRRA, the cities of Pacific and Valley Park have participated in the 2017 Plan development, which has involved all of the cities on the river.

As the 2017 plan is completed, EWG will share the plan with stakeholders to obtain additional input. Following review by MoDNR and EPA, as well as the stakeholders, the 2017 Plan will be completed by September 2017, then revised as needed, at minimum, once every five years.

2. Other Watershed Initiatives

The core partner agencies are also engaged in their own planning initiatives. (See Table 2 for a brief summary of activities underway as of January 2017.) As a result, this plan also incorporates references where appropriate to the activities, actions, initiatives and plans of the partners. They are being described as a way to increase the understanding of all activities occurring in the watershed. With this increased understanding, organizations may find new partners and recognize how their work may relates to other projects. More importantly, organizations can align their work to the overall goals of the plan to improve water quality by 2038 and increase public awareness of water quality issues and challenges. Although this plan is primarily focused on water quality, these other plans and initiatives include the following:

- In 2016, St. Louis County Parks began to develop an update it its master plan, and EWG staff contributed to stakeholder discussions related to that plan.[9]
- TNC developed a CAP for the whole basin in 2014. TNC is now involving most of the same partners in an update to that plan in 2017. This CAP addresses the Meramec, Big River, and Bourbeuse River watersheds, and will make use of extensive modeling being conducted by St. Louis University to identify critical areas in the whole watershed.[10]

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[9] http://www.stlcountyparksmasterplan.com/

[10] https://www.nature.org/media/missouri/meramec-river-conservation-action-plan.pdf

- U.S. Geological Survey (USGS) has developed a flood inundation mapping study for the lower Meramec watershed and will complete an interactive map late in 2017. The river cities from Pacific to Arnold, along with the Metropolitan St. Louis Sewer District (MSD) and the U.S. Army Corps of Engineers (USACE), have participated in funding this mapping project which will be a valuable resource both for planning and for emergency response.[11]
- MoDNR, the USACE and TNC have partnered on a Joint Feasibility Study (FS) for natural resource improvement on the Big River and Meramec River in Jefferson and St. Louis counties. The FS will be completed by 2019.[12]
- MSD has developed plans for reducing sewer overflows as part of Project Clear[13] and has also identified key stream bank stabilization projects in the lower Meramec tributaries.
- Great Rivers Greenway District (GRG) has a plan for an interconnected set of trails, and is now developing plans for how to manage property that it acquires as a part of the trail network.[14]
- OSC has plans to expand its volunteer programs in the lower Meramec River to include more people in volunteer activities to clean up trash and refuse, and to complete more habitat improvement projects.[15]

This plan will serve all of these partners, facilitate cooperation and coordination, and provide both background information and a strategy for returning our tributary streams to health. The success of this plan will depend on continued collaboration of the many partners.

E. Goals and Solutions

The overall goal of the 2017 Plan is to restore the Meramec River and its tributary streams to water quality standards, and to maintain healthy streams throughout the lower watershed. Strong partnerships can establish the long-term framework for restoring the streams that are designated as impaired and protect the healthy sub-watersheds. While point sources, especially constructed sanitary sewer overflows (SSOs), have been a problem in the past, the efforts of the MSD should successfully address this problem within the next decade.[16] Therefore, the 2017 Plan focuses on non-point source runoff, including stormwater, which will be an on-going area-wide source of pollution. It is necessary to have a long-term strategic approach to building awareness and support to improve stormwater management practices in local government and the

[11] https://dnr.mo.gov/env/meramecfloodingproposal.htm
[12] http://www.mvs.usace.army.mil/Missions/Programs-Project-Management/Plans-Reports/MeramecFeasibilityStudy/
[13] http://www.projectclearstl.org/
[14] www.greatriversgreenway.org
[15] www.openspacestl.org
[16] Per John Lodderhose with MSD, any reference to implementation of a supplemental environmental project shall include the following reference: This project was undertaken in connection with the settlement of an enforcement action, *United States of American and the State of Missouri, and Missouri Coalition for the Environment Foundation v. Metropolitan St. Louis Sewer District, No. 4:07-CV-1120-CEJ*, taken on behalf of the U.S. Environmental Protection Agency, State and the Coalition under the Clean Water Act. MSD is currently working under a consent decree with USEPA to eliminate sewer overflows, http://www.projectclearstl.org/about/

private sector. To achieve the water quality goals, the 2017 Plan has identified willing and interested partners who have funds to begin work within the next few years to address significant problems. Voluntary demonstration projects in the first five years of this plan should raise awareness and expand public interest in more complete action to achieve water quality goals in the subsequent years.

Table 2. Other Projects Underway in Lower Meramec Watershed

Project or Initiative	Lead Organization	Description	Years
St. Louis County Parks Master Plan review	St. Louis County Parks	St. Louis County Parks Department owns significant parcels of park land in the lower watershed. Twenty seven County Parks covering a total of 6,344.55 acres of land occur within the Meramec watershed. Ten of those parks have permanent year round creeks that either drain directly into the Meramec or a tributary. The remaining 17 parks have dry creek beds that flow directly to the Meramec or feed one of the tributaries. Twelve parks have Meramec River frontage representing 2,196.35 acres. Out of the 12 parks directly along the Meramec River there are 87,925 feet or 16.65 miles of river bank within the park system. The department has started a review of their Master Plan to plan for capital works projects. www.stlcountyparksmasterplan.com	2017
Great Rivers Greenway Plan	GRG	Great Rivers Greenway is creating a network of greenways to connect people to some of the region's best assets – rivers, parks and communities. Specifically, GRG is acquiring land to build recreational trails in the Meramec watershed to connect people to this valuable water resource. GRG currently owns more than 300 acres of land, most of which is along the main stem of the river in St. Louis County. This provides opportunity to improve watershed health by implementing projects that restore and enhance natural habitats while engaging volunteers in these efforts. https://greatriversgreenway.org	Ongoing
Joint Feasibility Study-Meramec River Basing Ecosystem Feasibility Study	USACE MoDNR	MoDNR, TNC and the USACE entered into a joint agreement to conduct a Feasibility Study (FS) to assess potential projects to improve aquatic habitat in the lower Meramec River. This study promises to address larger scale stream bank problems and improve the riparian buffers on the Meramec. www.mvs.usace.army.mil/Missions/Programs-Project-Management/Plans-Reports/MeramecFeasibilityStudy/	2017-2018
Flood Inundation Mapping	USGS	Following the December 2015 Meramec River flood, the USGS worked with local governments in the Meramec watershed to develop an interactive flood inundation map, which will enable communities to identify areas at risk when storms are predicted. The program should also assist communities to determine what properties are most at risk and therefore highest priority for buy out or other flood mitigation strategies.	2017-2018

Project or Initiative	Lead Organization	Description	Years
Valley Park Levee flood study	USGS	USGS is working with the USACE to determine what impact the recently constructed levee in Valley Park may have had on flooding in December 2015. https://mo.water.usgs.gov	2017-2018
Flood Recovery Planning	Federal Emergency Management Agency (FEMA)	FEMA has encouraged communities to develop comprehensive flood planning and preparation, and this initiative may encourage protection of the riparian buffer especially in the floodway. The City of Pacific is one candidate for flood preparation planning. www.fema.gov/national-disaster-recovery-framework/community-recovery-management-toolkit	2017- Ongoing
Regional All Hazard Mitigation Plan	EWG	This regional (five county) plan is updated every five years and provides general guidance for communities to conduct pre-disaster mitigation planning and project implementation. www.ewgateway.org/ProgProj/Emergency-Response/HazMit/hazmit.html	2019-2020
Stormwater projects	MSD	MSD has stormwater projects on the following streams in the lower Meramec River watershed: Fenton, Fishpot, Grand Glaize, Mattese, Sugar and Williams Creeks; bank stabilization projects in Fishpot and Mattese Creeks and channel improvements in Grand Glaize and Williams Creek. www.stlmsd.com/what-we-do/stormwater-management	2018-2028
Operation Clean Stream	OSC	The OSC organizes and annual clean up on the Meramec River, and will celebrate the 50th anniversary of its annual cleanup event in 2017. More than 2,000 volunteers participate annually in this single event. OSC also organizes a variety of volunteer efforts to remove trash, plant native plants and trees and remove honeysuckle and other invasive species in the lower Meramec River watershed, and it has played a key role in acquisition of land for parks in the lower Meramec River watershed. These volunteer initiatives also enable more cost effective improvements to public lands. www.openspacestl.org/ocs/	Annually
LaBarque Creek watershed plan	Friends of LaBarque Creek /MDC	Nine agencies worked with the citizens in the watershed to develop a plan to protect water quality and aquatic habitat. The Citizen organization Friends of LaBarque Creek has the primary oversight of the plan. www.friendsoflabarquecreek.org	Ongoing

Project or Initiative	Lead Organization	Description	Years
Watershed Advisory Committee	MRRA	Established in 1975 by act of the Governor, the MRRA has played a role in recreation planning for the lower watershed in Franklin, Jefferson and St. Louis Counties, and the board represents, cities, counties and citizens in the watershed. MRRA can facilitate communication, collaboration and planning for the lower Meramec and its sub-watersheds with all partners. In 2016, the board agreed to function as a watershed advisory committee for projects in the lower Meramec watershed. https://www.facebook.com/MeramecRecreation	2017-Ongoing
Interagency communication	MRTA	Informal organization of organizations interested in the Meramec River watershed that facilitates inter-agency communication on river related issues. MRTA may provide a planning role for the upper watershed and involve other organizations in planning in the Lower Meramec Watershed. www.openspacestl.org/meramec-river-tributary-alliance	2017-Ongoing
Meramec River Conservation Action Plan	TNC	In 2014, TNC completed a *Meramec River Conservation Action Plan*[17] (CAP) for the entire Meramec watershed. A plan update is underway with completion expected by 2018. As a part of this study St. Louis University, in partnership with TNC, the USACE and MoDNR, is modeling pollutants, as well as, BMPs and potential climate and land use changes in the watershed. This should provide guidance for future project work. All of the partners of the lower Meramec watershed plan have been engaged in the CAP. www.nature.org/Missouri	2017-2018
Sewer Overflow projects	MSD	MSD is working under a Consent Decree to eliminate sanitary sewer overflows in the watershed. This may quickly improve bacteria loading in affected streams. www.projectclearstl.org	2017-2028

[17] http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/missouri/meramec-river-conservation-action-plan-2014.xml

F. About the Lower Meramec Watershed

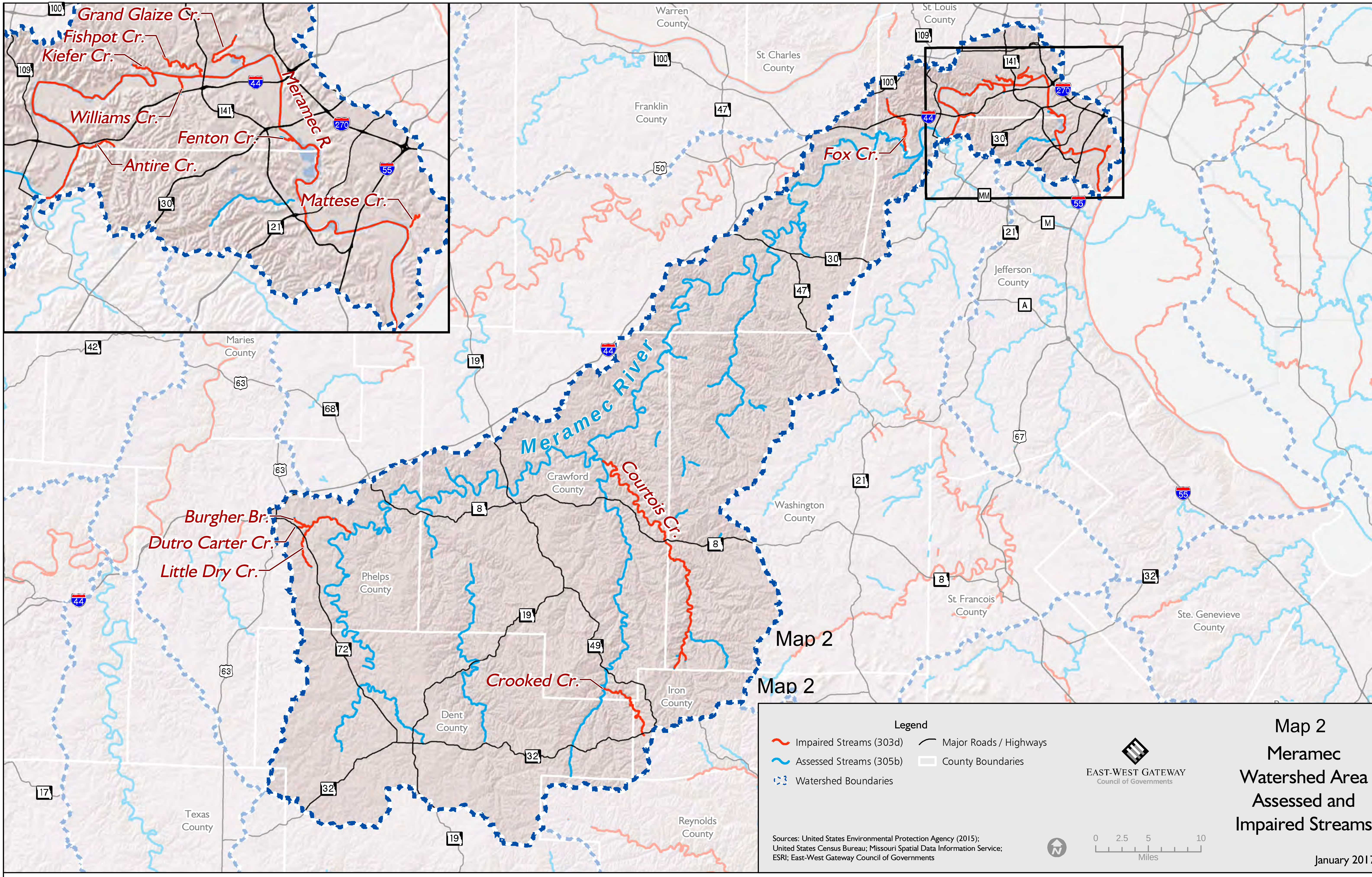
1. Impaired Streams

MoDNR undertakes water quality monitoring to assess if rivers, streams and lakes meet water quality standards. Table 3 shows the waterbodies in the Lower Meramec watershed that do not meet water quality standards for designated uses and are considered impaired.[18] These waterbodies were listed in the 2012 Plan, with the exception of Mattese and Fenton Creeks which have been added to the 2017 Plan, and a segment of the Meramec River which was recently added to the impaired streams list for bacteria. Urban stormwater runoff is the main source of each pollutant. See Map 2 for locations and extent of the impaired streams.

Table 3. Impaired Streams in the Lower Meramec Watershed as of 2016

Lower Meramec Watershed Streams	Impairment
Antire Creek	Bacteria and pH
Fishpot Creek	Bacteria and chloride
Fox Creek	Unknown (decline in aquatic life)
Grand Glaize Creek	Bacteria, chloride, mercury in fish tissue
Kiefer Creek	Bacteria and chloride
Williams Creek	Bacteria
Bee Tree Lake	Mercury in fish tissue
Meramec River	Lead in sediment; Bacteria in a 22.8 mile segment
Mattese Creek	Bacteria and chloride
Fenton Creek	Bacteria and chloride

[18] As required by the Clean Water Act, the state completes an assessment of state waters to determine if they are meeting water quality standards. Biennially, on even numbered years, the department develops an Integrated Report that discusses the overall health of Missouri's waters and provides a list of streams that are not currently meeting water quality standards and/or its designated uses. http://dnr.mo.gov/env/wpp/waterquality/303d/303d.htm



Map 2
Meramec Watershed Area Assessed and Impaired Streams
January 2017
Legend
Impaired Streams (303d)
Assessed Streams (305b)
Watershed Boundaries
Major Roads / Highways
County Boundaries
East-West Gateway
Council of Governments
Sources: United States Environmental Protection Agency (2015);
United States Census Bureau; Missouri Spatial Data Information Service;
ESRI; East-West Gateway Council of Governments
0 2.5 5 10
Miles
Map 2
Map 2
Grand Glaize Cr.
Fishpot Cr.
Kiefer Cr.
Williams Cr.
Fenton Cr.
Antire Cr.
Mattese Cr.
Meramec R.
Fox Cr.
Meramec River
Courtois Cr.
Burgher Br.
Dutro Carter Cr.
Little Dry Cr.
Crooked Cr.
Warren County
St Charles County
St Louis County
Franklin County
Jefferson County
Maries County
Crawford County
Washington County
Phelps County
St Francois County
Ste. Genevieve County
Iron County
Dent County
Texas County
Reynolds County

MoDNR has an EPA-approved Total Maximum Daily Load (TMDL) for bacteria in Fishpot Creek. Other TMDLs will be developed over time and this plan will be updated as TMDLs are completed. In the meantime, this plan uses available data to identify target reductions in bacteria load in priority streams. EWG worked closely with the MoDNR TMDL staff to develop appropriate load duration curves in focus area streams. Elsewhere, Simple Modeling of best management practices (BMPs) has been used to provide a clear set of recommended practices to reduce bacteria and chloride from streams in the lower Meramec.

Because the lower Meramec watershed planning area includes a healthy stream, LaBarque Creek, at river mile 42, it is important to recognize that efforts should also be placed on protecting and preventing degradation of healthy streams (see 2012 Plan, pages 101-111). The partners recognize the importance of on-going work to maintain stream health and aquatic habitat in healthy tributaries to the Meramec. The MDC, Jefferson County, and local residents have worked collaboratively to develop and maintain a watershed protection plan for LaBarque Creek[19]. TNC and local partners are currently leading a streambank stabilization project for LaBarque Creek.

Fox Creek is the site of another stream bank mitigation project[20]. Fox Creek has been added to the 303d Impaired Water List for unknown pollutants because of a decline in aquatic life. These streams remain a priority for streambank stabilization, and riparian buffer zone protection. Public education programs for land owners and developers should be a high priority. Further study is needed to determine the cause of problems in Fox Creek. MoDNR has completed a biologic study along with a stressor study[21].

2. Priority Streams

Development has had an impact on the Meramec River and all of its tributaries in the plan area. To mitigate the impact of this development, the 2017 Plan calls for improving the riparian buffer zone along the main stem and the tributaries. Working with key partners in county and state parks, local governments, and not-for profit partners, including TNC and OSC, on a series of projects on public land in the watershed will provide significant improvements to the riparian zone, engage the public in volunteer activity, demonstrate that progress is being made, and provide a baseline for evaluating the effectiveness of the strategy.

[19] http://www.jeffcomo.org/uploads/Stormwater/Manuals/LaBarque%20Creek%20Watershed%20Conservation%20Plan%209-03-09%20kjm.pdf

[20] http://ascelibrary.org/doi/abs/10.1061/40581(2001)25

[21] http://dnr.mo.gov/env/esp/wqm/docs/FoxCreekbioreportFy14.pdf

Kiefer Creek stands out as a priority sub-watershed for development of a watershed management plan because it flows through Castlewood State Park, which had more than 750,000 visitors in 2015. Children, adults, and pets all can be found wading in the creek near the park entrance just a quarter mile upstream from its confluence with the Meramec River. The small size of the Kiefer Creek watershed, and the fact that pollutants come from non-point sources, also makes it a good site both to demonstrate voluntary best management practices (BMPs) to achieve water quality goals within twenty years, as well as to measure the water quality impact that result from those projects. The impaired section of the stream extends 1.2 miles upstream from the mouth of the creek where it meets the Meramec River. Most of the impaired section lies in Castlewood Park and the Wildlife Rescue Center. Finally, Kiefer Creek has a draft watershed management plan, prepared by the Missouri Coalition for the Environment (MCE) and several partner organizations with matching funds necessary to implement voluntary water quality projects. EWG has worked with the MoDNR staff to develop a load duration curve for the recreational season for Kiefer Creek, so that BMPs can be evaluated in terms of percent of load reduction goal.

Fishpot Creek and Mattese Creek are a second priority in the 2017 Plan, because these streams are bordered by numerous subdivisions and the opportunity for human exposure is particularly high. In these two streams, there is some limited interest in water quality projects, and therefore the 2017 Plan recommends demonstration projects that will serve to raise public awareness of both the problem and potential solutions. Fishpot Creek has a TMDL approved by EPA in 2016, and the 2003 Geomorphic Study,[22] which provides baseline direction for stream improvement. As partners bring projects forward, Fishpot Creek should also become a priority for reduction in bacteria and chloride. Some subdivisions in Mattese Creek have an opportunity to implement BMPs on subdivision land, which can treat and reduce stormwater runoff, reduce erosion and sedimentation, stabilize stream banks and improve the riparian corridor to improve stream health. In addition, MSD has several projects funded, including the removal of a constructed sanitary sewer overflow in Fishpot Creek, and more projects identified once additional funding becomes available, which will stabilize the channel and improve stormwater runoff.

While bacteria and chloride are listed as the impairments for these three creeks, the Nine Element Plans for each creek only address the bacteria impairment for a number of reasons. First, bacteria is considered a priority to address because there is a high risk of human exposure to bacteria in these creeks since they are in residential areas as well as a State Park where hundreds of thousands of people recreate each year. Second, more data and information is needed to adequately quantify the contribution of chloride to the creeks. The application of road salt is the likely source of the chloride impairment, so more data is needed from private contractors as well as public transportation agencies about the use of road salt. There is much more information available about best management practices to reduce bacteria loading that informed the management measures of this plan. Third, bringing together a different set of stakeholders is required to address the application of road salt which can be a sensitive matter since liability and safety is an important factor in any decisions about the use of road salt. The intent is to update this plan at a minimum every five years. Further data and information gathering and discussion with stakeholders about the chloride impairment will take place in the interim in order to inform chloride load reduction goals and management measures in the next update to this plan.

[22] http://www.ewgateway.org/pdffiles/library/wrc/meramecriverwatershedsrpt/fishpotwatershed.pdf

Chapter II. Characterize the Watershed

A. Planning Area Overview and Description

The lower Meramec River extends 109 miles from Meramec State Park near Sullivan in Franklin County to the confluence with the Mississippi River at Arnold. It lies entirely within the EWG region in Franklin, Jefferson and St. Louis counties. The 2012 Plan addressed four watersheds draining approximately 116,000 acres (182 square miles), extending from Pacific in Franklin County to Valley Park in St. Louis County. The Hydrologic Unit Code12 (HUC) watersheds addressed in this plan were Brush Creek, Fox/LaBarque Creeks, Hamilton Creek, and Grand Glaize Creek.

The 2017 Plan area has been extended from Valley Park east to the confluence of the Meramec River and the Mississippi River. Sugar/Fenton Creeks, (HUC 071401021003) and Pomme/Mattese Creeks (HUC 071401021004) watersheds have been included. (See Map 1) Information about these watersheds (incorporated units, creeks, size) is presented in Table 4 below.

Table 4. Lower Meramec River Watersheds

12-Digit Hydrologic Unit	County	Acres	Square Miles	Creeks	Municipalities
Brush Creek 071401020902	Franklin St. Louis Jefferson	23,584	36.9	Brush, Winch Brush, Segment draining to Meramec* Segment draining to Meramec	Pacific
Fox Creek 071401020903 Fox Creek sub-watershed LaBarque Creek sub-watershed	Franklin St. Louis Jefferson	28,201 14,691 13,510	44.1 23.0 21.1	Little Fox Little Fox, Fox, Segment draining to Meramec McFall, LaBarque, Segment draining to Meramec	Pacific Wildwood, Eureka Lake Tekakwitha
Hamilton Creek 071402021001	St. Louis Jefferson	34,956	54.6	Hamilton, Carr, Forby, Flat, Kiefer Segment draining to Meramec Antire, Little Antire	Wildwood, Eureka, Ellisville, Ballwin Byrnes Mill, Peaceful Village
Grand Glaize Creek 0714010021002	St. Louis Jefferson	29,895	46.7	Fishpot, Grand Glaize, Segment draining to Meramec Williams, Segment draining to Meramec	Ellisville, Ballwin, Chesterfield, Town & Country, Twin Oaks, Winchester, Manchester, Country Life Acres, Des Peres, Kirkwood, Fenton, Valley Park Parkdale

12-Digit Hydrologic Unit	County	Acres	Square Miles	Creeks	Municipalities
Sugar/Fenton Creeks 071401021003	Jefferson	28,851.0	45	Sugar, Saline, Romaine, Segment draining to Meramec	Parkdale
	St. Louis			Fenton, Segment draining to Meramec	Fenton, Kirkwood, Sunset Hills
Pomme/Mattese Creeks 071401021004	Jefferson	27,974.1	43.7	Pomme, Segment draining to Meramec	Arnold
	St. Louis			Mattese, Segment draining to Meramec	Sunset Hills, Green Park
Total		173,461.1	270.9		

* Refers to that portion of HUC12 watershed which does not drain directly into the identified creeks and on to the Meramec River.
Source: Center for Applied Research and Environmental Systems (CARES) for acreage, University of Missouri-Columbia and East-West Gateway Council of Governments

B. Socio-Economic Background - Updated

In 2015, the population in the planning area was estimated to be 296,953 (see Table 5). The St. Louis County portion of the Hamilton, Grand Glaize Creek, Sugar/Fenton Creeks and Pomme/Mattese Creeks watersheds contains approximately 73.5 percent of the planning area population. The Fox Creek and LaBarque Creek watersheds together contain about two percent of the total watershed population.

Table 5. Lower Meramec Watershed: 2015 Population by Sub-Watershed

Watershed	2015 Estimated Population	Percent Share
Brush Creek	11,581	3.9
Fox Creek	2,269	0.8
LaBarque Creek	3,358	1.1
Hamilton Creek	29,071	9.8
Grand Glaize Creek	107,687	36.3
Sugar/Fenton Creeks	57,197	19.3
Pomme/Mattese Creeks	85,789	28.8
Total	296,953	100

2015 5 Year American Community Survey

The median household income by watershed ranges from $46,900 in the Brush Creek watershed to $98,100 in the Hamilton Creek watershed. The median for the entire planning area is $72,200 (see Table 6).

Table 6. Median Household Income by Watershed

Watershed	Estimated 2015 Households	Estimated Median Household Income
Brush Creek	4,428	$46,900
Fox Creek	905	$74,400
LaBarque Creek	1,085	$91,600
Hamilton Creek	10,077	$98,100
Grand Glaize Creek	41,665	$82,100
Sugar/Fenton Creeks	21,481	$65,800
Pomme/Mattese Creeks	34,648	$64,200
Lower Meramec Planning Area	114,289	$72,200

Source: 2015 Year American Community Survey, US. Bureau of the Census

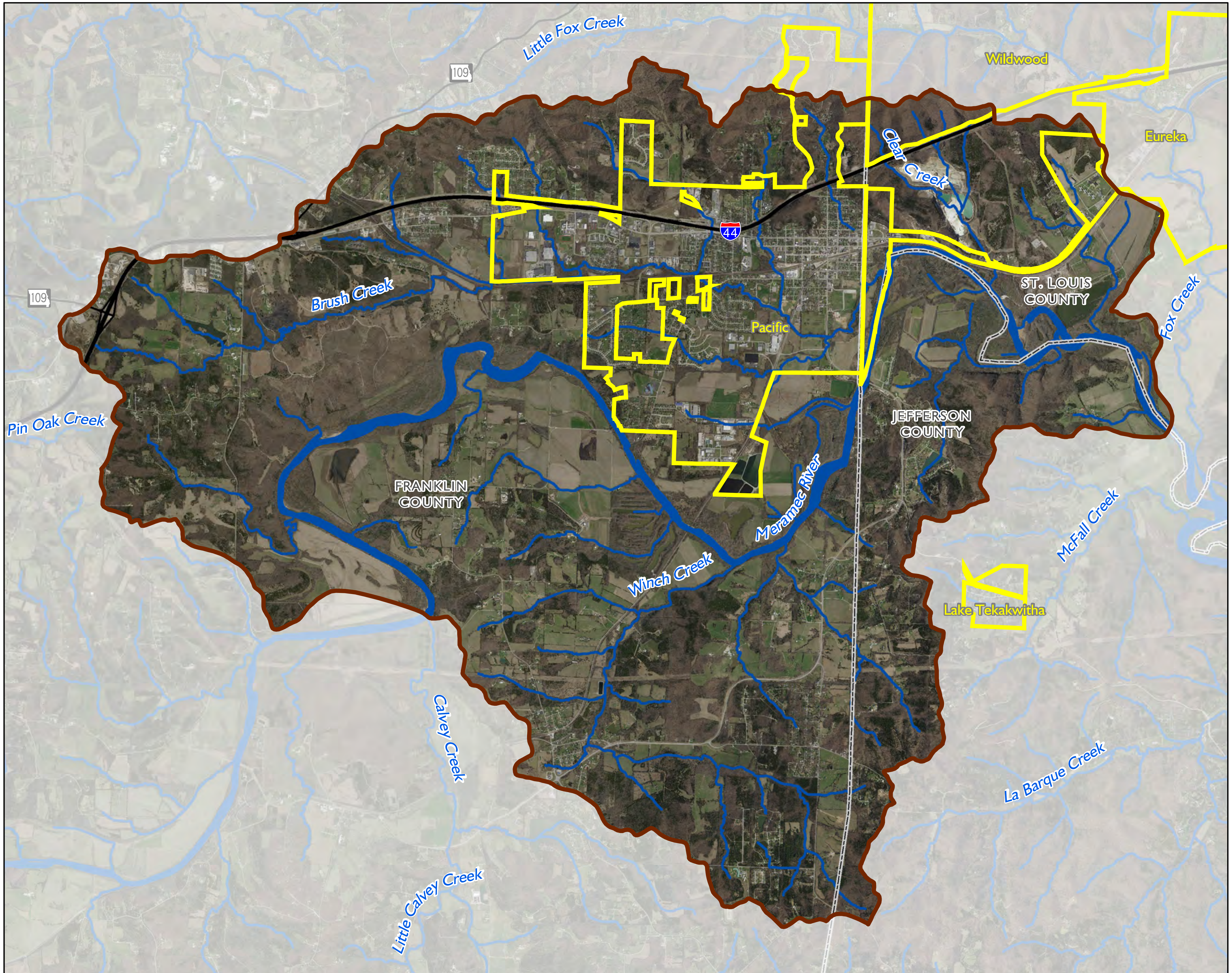
C. Watershed Descriptions

This section gives a general overview of each of the HUC12 watersheds in the lower Meramec watershed planning area. The overview begins with Brush Creek sub-watersheds in Franklin County and moves east to the Pomme/Mattese Creeks subwatershed.

- **Brush Creek**

The Brush Creek sub-watershed, 23,606 acres is located in the western part of the study area. The majority of the watershed is in east central Franklin County with the remainder in southwest St. Louis County and northwest Jefferson County. (See Map 3) Brush Creek, north of the Meramec River, and Winch Creek to the south are the major streams in this watershed. There are also tributaries to these creeks and smaller streams and land areas which drain directly to the Meramec River. Brush Creek enters the Meramec River at Pacific, 51 miles upstream of the confluence with the Mississippi River. Winch Creek enters the Meramec River at the Catawissa Conservation Area. All of the city of Pacific is within the Brush Creek watershed. A small portion of Wildwood is in the northeast section of the watershed along I-44. North and west of Pacific is unincorporated Gray Summit. Unincorporated Catawissa is in the southern part of the watershed.

Approximately 20 percent of the land area in this watershed can be considered developed or built up. Concentrated residential areas can be found in Pacific, Gray Summit and Catawissa. There are freestanding subdivisions adjacent to Highway F in Jefferson County and Highways O, NN and AP in Franklin County, Individual residences are dispersed throughout the watershed, with commercial uses primarily found along Interstate 44, Old Route 66 and in Pacific. Industrial activity (manufacturing and extraction) makes up four percent of the land area, while recreational areas include the Shaw Nature Reserve, the Catawissa Conservation Area and the Pacific Palisades Conservation Area. Both conservation areas are adjacent to the Meramec River. The majority of the land in the watershed is in crop, grass/pasture and forested land. Much of the agricultural land is found in the Meramec River valley and the side valleys of the major streams.



Map 3

Brush Creek Watershed

Aerial Photograph (2015)

Basemap Elements

- Watershed Boundary
- Municipal Boundaries
- County Boundary
- Major Road
- Interstate Highway
- River or Stream

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Miles

Sources: County GIS Departments,
East-West Gateway Council of Governments
March 2017

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- **Fox Creek**

Fox and LaBarque Creek watersheds are a part of the same 12-digit watershed, but for the purposes of the 2012 Plan, EWG separated the two. They enter the Meramec from opposite sides of the stream, sit in different counties, and have different characteristics. The Fox Creek sub-watershed, 14,691 acres, is located in the western part of the planning area. The majority of the watershed is in southwest St. Louis County with the remainder, adjacent to Little Fox Creek, in East central Franklin County (see Map 4). Fox Creek and Little Fox Creek are the major streams in this watershed. There also are tributaries to these creeks and land area in Eureka, which drains directly to the Meramec River. Fox Creek enters the Meramec River 44.4 miles upstream of the confluence with the Mississippi River. In Franklin County, a portion of the city of Pacific as well as unincorporated Gray Summit are in the Fox Creek sub-watershed. The majority of the sub-watershed lies within the cities of Wildwood and Eureka in St. Louis County

Approximately 15 percent of the land area in this watershed can be considered developed or built up. Residential development is found along the creek valleys and the northern drainage divide. There are freestanding subdivisions adjacent to State Highway 100 in Franklin and St. Louis counties and Fox Creek Road, Model Realty Road and Hencken Road. Commercial uses primarily can be found along Interstate 44 and Old Route 66. Recreation areas make up 12 percent of the land area and include the MDC Rockwoods Range Conservation Area and a portion of the St. Louis County Greensfelder Park. The majority of the land in the watershed is in crop, grass/pasture and forested land. Much of the agricultural land is in the Meramec River valley, in that portion of the Fox Creek valley, south of Old Route 66 and adjacent to Little Fox Creek.

- **LaBarque Creek**

Part of the Fox/LaBarque watershed, the LaBarque Creek Sub-watershed, 13,510 acres or 21.1 square miles, is located in the southwest part of the study area. This entire watershed is located in northwest Jefferson County, (See Map 5). LaBarque Creek and McFall Creek are the major streams in this watershed. There also are tributaries to these creeks and smaller streams and land areas which drain directly to the Meramec River. LaBarque Creek enters the Meramec River 41.9 miles upstream of the confluence with the Mississippi River. The LaBarque Creek sub-watershed has been the focus of a major watershed planning effort that involves the residents and local government along with agencies in developing strategies to protect this healthy stream. McFall Creek enters the Meramec near the Swiftwater Bend Access Point (approximately 45 miles from the mouth of the Meramec River). In the northwest portion of this sub-watershed is the recently incorporated village of Lake Tekakwitha.

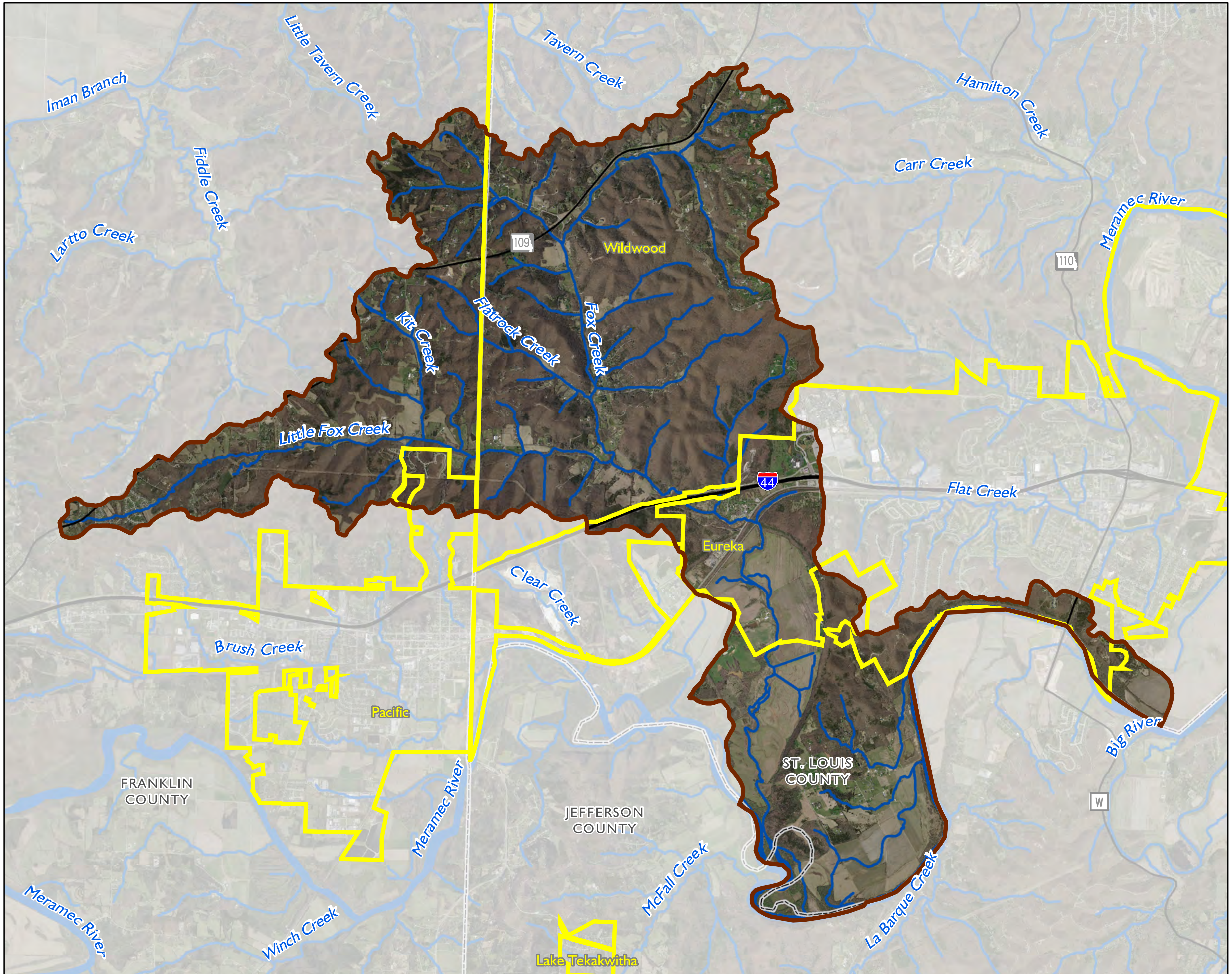
Approximately 22 percent of the land area in this sub-watershed can be considered developed or built up. Individual residences are dispersed throughout the watershed, especially along or adjacent to State Highway FF and State Highway F. Publicly owned recreation land includes: LaBarque Creek Conservation Area in the upper portion of the watershed; Young Conservation Area near the mouth of LaBarque Creek; Glassberg Family Conservation Area; and Don Robinson State Park. Institutional land in this sub-watershed is primarily forested/open space. Additionally, as this plan is being developed, the MDC is working to acquire several hundred additional acres. Over 75 percent of the watershed is in crop, grass/pasture and forest. Much of the agricultural land can be found in the Meramec River valley and McFall Creek.

Map 4
Fox Creek Watershed

Aerial Photograph (2015)

Basemap Elements

- Watershed Boundary
- Municipal Boundaries
- County Boundary
- Major Road
- Interstate Highway
- River or Stream



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Miles

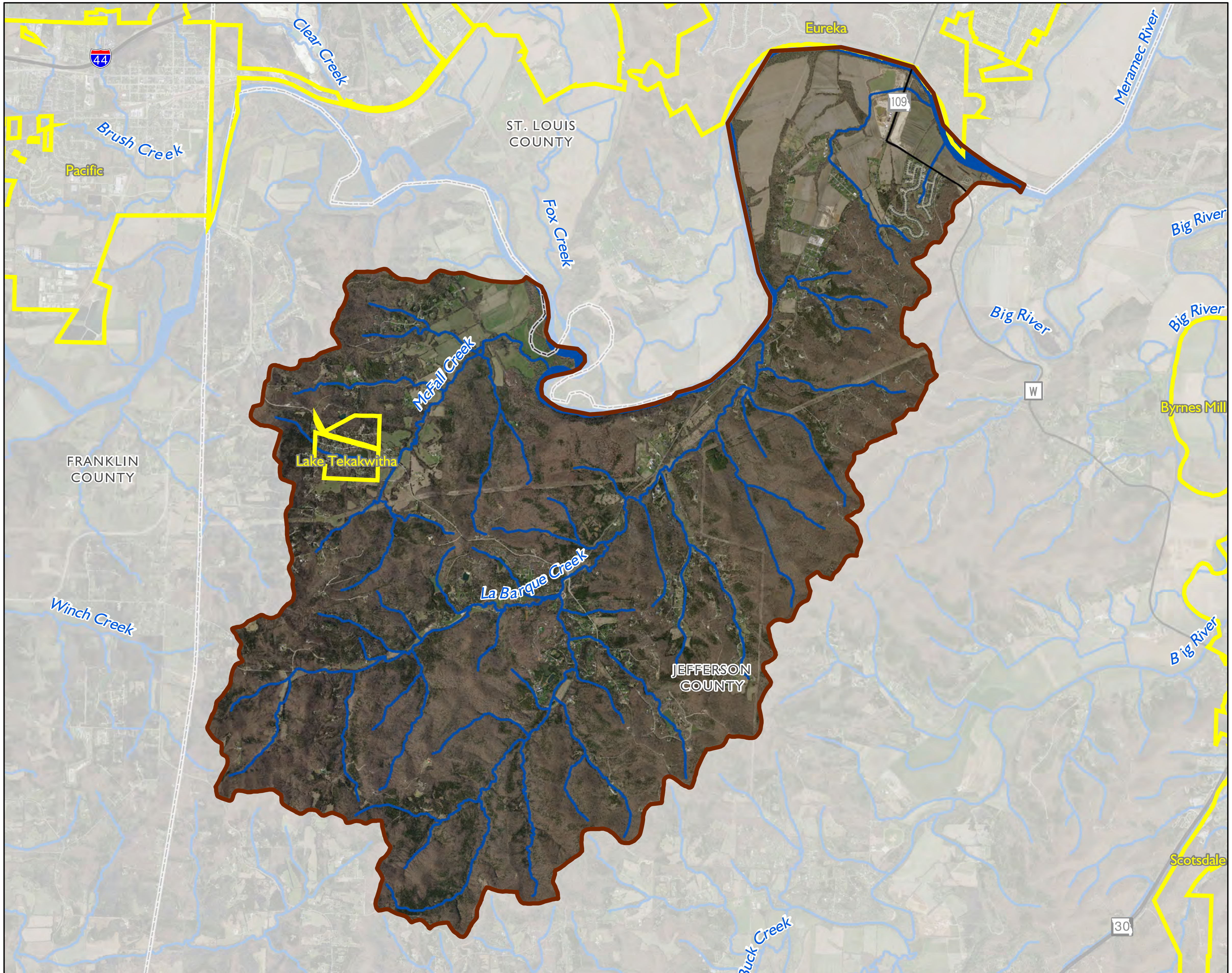
Sources: County GIS Departments,
East-West Gateway Council of Governments
March 2017

EAST-WEST GATEWAY
Council of Governments

Map 5

LaBarque Creek Watershed

Aerial Photograph (2015)



Basemap Elements

- Watershed Boundary
- Municipal Boundaries
- County Boundary
- Major Road
- Interstate Highway
- River or Stream

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Miles

Sources: County GIS Departments,
East-West Gateway Council of Governments
March 2017

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- **Hamilton Creek**

The Hamilton Creek watershed, 34,956 acres, is located in the western part of the study area, (see Map 6). The majority of the watershed is in southern St. Louis County and the remainder is in north central Jefferson County. Hamilton, Carr, Flat, Forby and Kiefer Creeks are north of the Meramec River. Carr Creek is a tributary of Hamilton Creek. Antire Creek is on the southern side of the Meramec River. There also are tributaries to these creeks and smaller streams and land areas which drain directly to the Meramec River. Kiefer Creek enters the Meramec River in Castlewood State Park, 24 miles upstream of the confluence with the Mississippi River, Hamilton Creek enters the Meramec near the Glencoe area of Wildwood, 30 miles upstream, Flat Creek enters the Meramec in Eureka approximately 31 miles upstream, and Antire Creek enters the Meramec River near Route 66 State Park. Portions of Eureka, Wildwood, Ellisville, Ballwin and Byrnes Mill are in the Hamilton Creek watershed. Peaceful Village in Jefferson County is completely within this watershed. Unincorporated High Ridge is in the southern part of the watershed

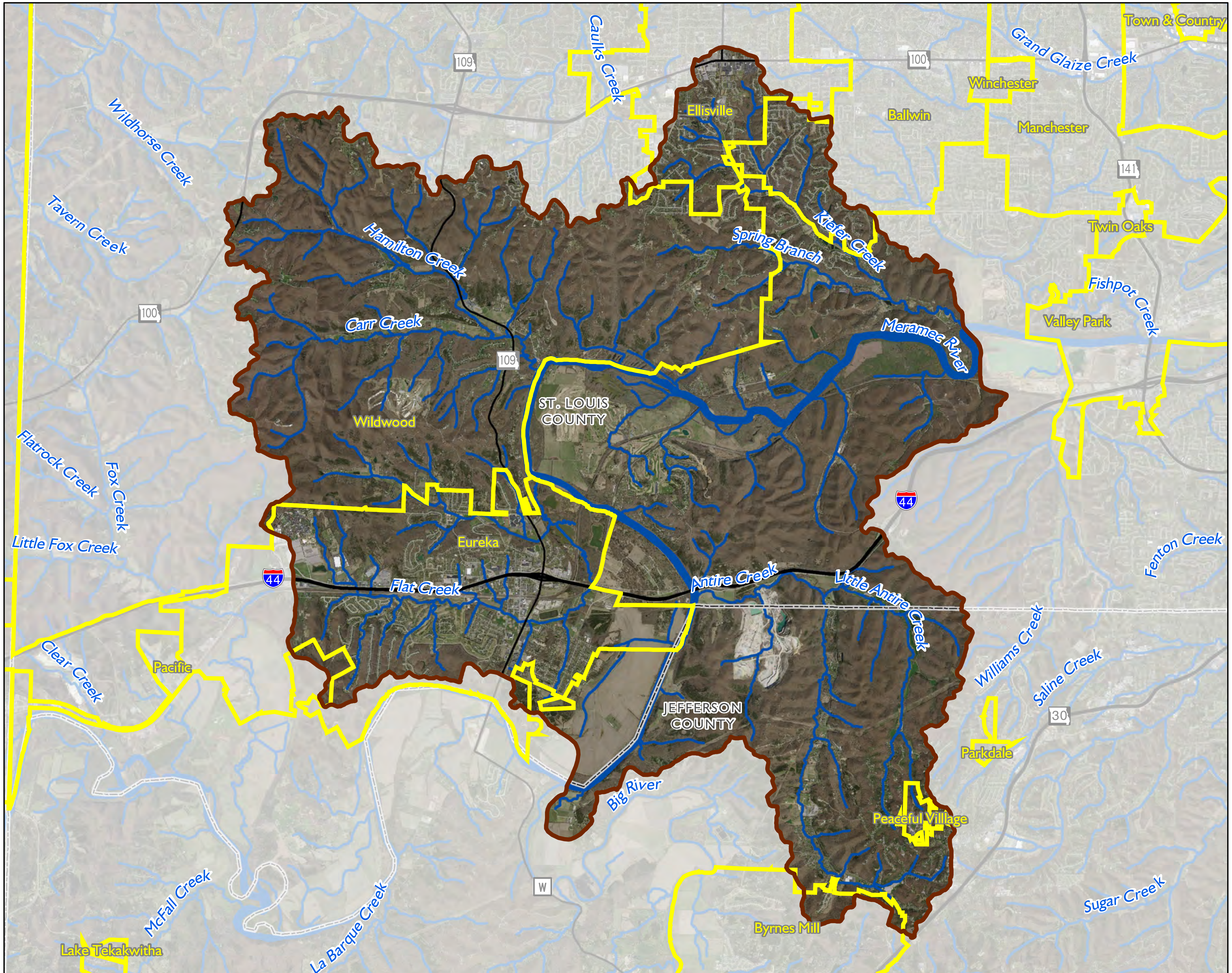
Approximately 28 percent of the land area in this watershed can be considered developed or built up. Concentrated residential areas can be found in Eureka, Wildwood, Ellisville and Ballwin. There are freestanding subdivisions adjacent to Highway 109, Old State Road and Kiefer Creek Road in St. Louis County and Antire Road and Beaumont Scout Road in Jefferson County. Individual residences are located throughout the watershed primarily along the major ridgelines. Commercial uses are concentrated along Interstate 44 in Eureka and Manchester Road in Ellisville. Lands in recreation use make up approximately one-third of the total acreage in the Hamilton Creek watershed. There are a number of municipal and St. Louis County and Jefferson County parks in this watershed as well as Castlewood State Park and Route 66 State Park. MDC properties in this watershed include the Rockwoods Reservation, the Klamberg Woods Conservation Area and a portion of the Forest 44 Conservation Area, south of the Meramec River. Agricultural land can be found in the Meramec River valley and the side valleys of the major streams. The remainder of the land in the watershed is in grass/pasture or forested land.

- **Grand Glaize Creek**

The Grand Glaize Creek watershed, 29,895 acres, is located in the central part of the study area. The majority of the watershed is in south central St. Louis County with a small portion in northern Jefferson County, (see Map 7). Grand Glaize Creek and Fishpot Creek, north of the Meramec River, and Williams Creek to the south are the major streams in this watershed. There are also tributaries to these creeks and smaller streams and land areas which drain directly to the Meramec River. Grand Glaize Creek and Fishpot Creek enter the Meramec River at Valley Park, 20.1 and 22.1 miles, respectively, upstream of the confluence with the Mississippi River. Williams Creek flows into the Meramec upstream of the Highway 141 Bridge. All or parts of 12 incorporated units in St. Louis County are located in the Grand Glaize Creek watershed. The village of Parkdale is located in the Jefferson County portion of the watershed.

Map 6
Hamilton Creek Watershed

Aerial Photograph (2015)



Basemap Elements

- Watershed Boundary
- Municipal Boundaries
- County Boundary
- Major Road
- Interstate Highway
- River or Stream

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Miles

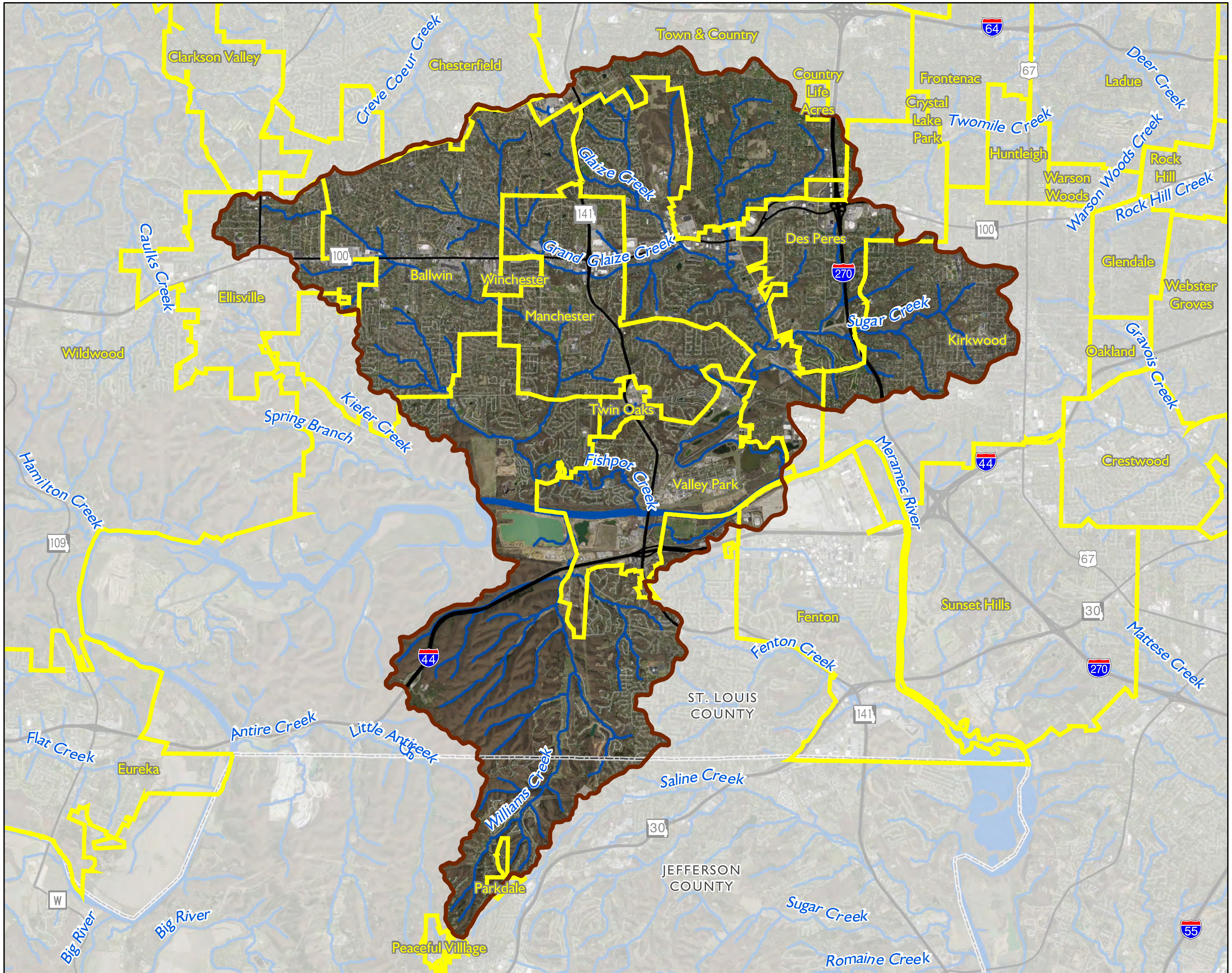
Sources: County GIS Departments,
East-West Gateway Council of Governments
March 2017

East-West Gateway
Council of Governments

Map 7

Grand Glaize Creek Watershed

Aerial Photograph (2015)



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Miles

Sources: County GIS Departments,
East-West Gateway Council of Governments
March 2017

East-West Gateway
Council of Governments

Over 62 percent of the land area in this watershed can be considered developed or built. The majority consists of single family and multi-family residential uses and are concentrated in the municipalities. Freestanding subdivisions are adjacent to Highway 141 in St. Louis County south of I-44. Commercial uses primarily can be found along Interstate 44, Highway 141 and Manchester Road. Industrial activity, including sanitary and construction and demolition landfills, makes up five percent of the land area. Approximately 14 percent of the land area is in use for recreation. This includes municipal and county parks and the Forest 44 Conservation area.

- **Sugar/Fenton Creeks**

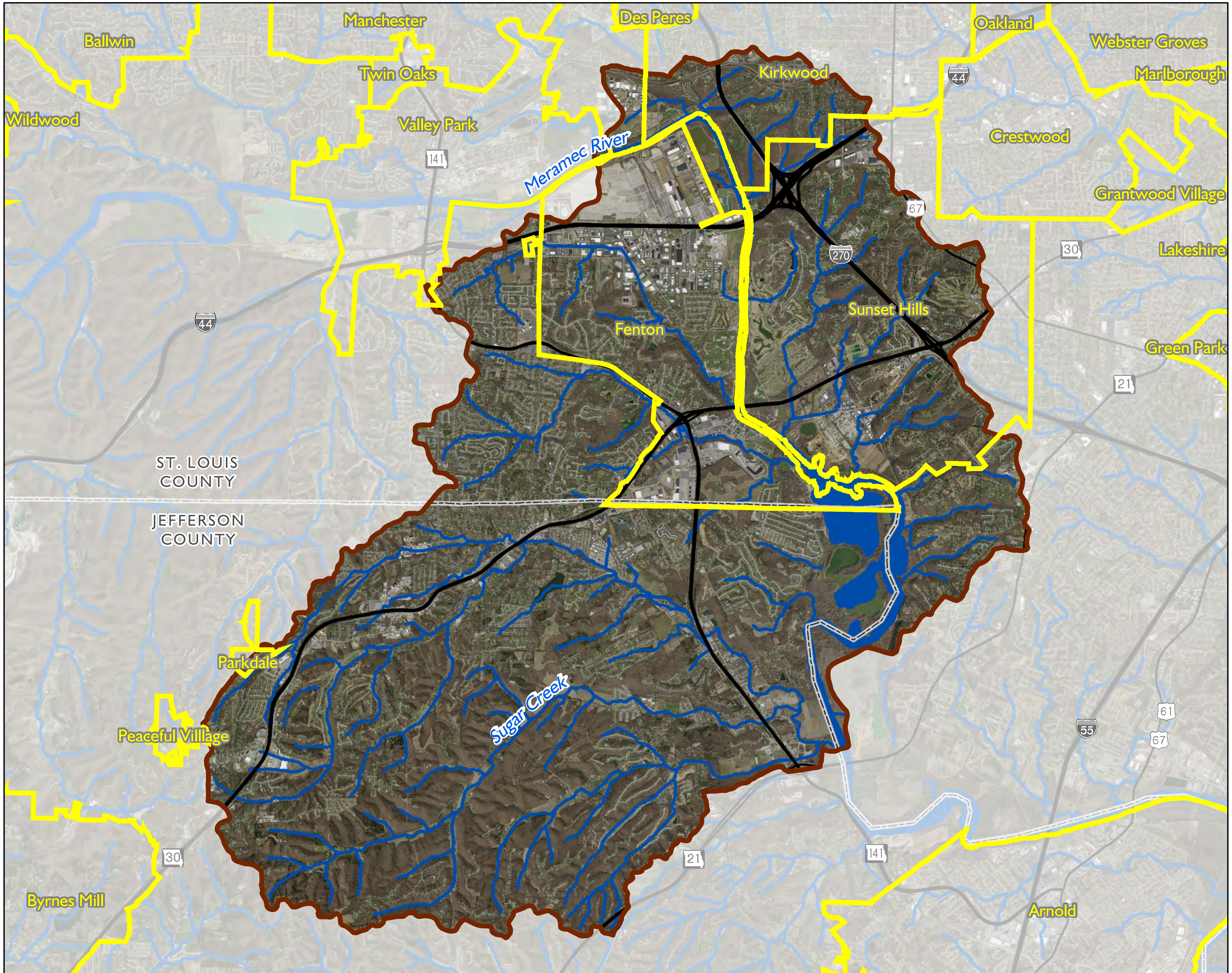
The Sugar/Fenton Creeks watershed is 45 square miles in size and is located in the eastern part of the planning area, between Valley Park and Sunset Hills. It is divided between southern St. Louis County and northern Jefferson County (see Map 8). The major streams in this sub-watershed are Sugar Creek which is7.7 miles in length and located in Jefferson County, and Fenton Creek which is 4.6 miles in length and located in St. Louis County. Both are located west of the Meramec River. There also are two tributaries of Sugar Creek, Saline and Romaine, Creeks, as well as smaller streams and land areas which drain directly into the Meramec River. Sugar Creek enters the Meramec River at river mile 10.2, north of the Highway 21 Bridge over the Meramec River. Fenton Creek enters the Meramec River in the city of Fenton, 14.8 miles upstream of the confluence with the Mississippi River. Part or all of three cities in St. Louis County are located in this watershed, which includes all of the city of Fenton, the majority of Sunset Hills, and a small portion of Kirkwood. In Jefferson County, the eastern section of the village of Parkdale is in this watershed. The unincorporated areas of Murphy and High Ridge along State Highway 30 are in the center of Sugar/Fenton Creeks watershed in Jefferson County.

Approximately 57 percent of the land area in this watershed can be considered developed. The majority of this is multi and single-family residential use found throughout the sub-watershed. Commercial uses are primarily along Interstate 44, State Highway 30, State Highway 141 and Gravois Road in Sunset Hills. Industrial activity (manufacturing and extraction) makes up seven percent of the land area. Recreation areas open to the public include county and municipal parks along the Meramec River and the MDC Powder Valley Conservation Nature Center in Sunset Hills. Most of the land identified as agricultural is found in the Jefferson County. Approximately 24 percent of the land is in the vacant/undeveloped (no structures) or unassigned category and can be found throughout the watershed. Vacant/undeveloped land is land void of structures and could be forest, grass, pasture or land being prepared for development.

- **Pomme/Mattese Creeks**

The Pomme/Mattese Creeks watershed, 43.7 square miles, is located in the eastern part of the planning area. The watershed is divided between northeast Jefferson County and south St. Louis County (see Map 9). The major streams in the watershed are Pomme Creek, 6.3 miles in length, located in Jefferson County south of the Meramec River, and Mattese Creek, 7.5 miles in length, located in St. Louis County. Also in this watershed are tributaries to these creeks and smaller streams and land areas which drain directly into the Meramec River. Pomme Creek enters the Meramec River in the city of Arnold, 1.8 miles upstream of the confluence with the Mississippi River. Mattese Creek enters the Meramec River in St. Louis County, 4.5 miles upstream of the confluence. All of the city of Arnold is in the Jefferson County portion of this watershed.

Between I-270 and State Highway 30 to the north, is a small portion of Sunset Hills in St. Louis County. Unincorporated St. Louis and Jefferson Counties makes up the majority of this watershed.



Map 8
Sugar Creek Watershed

Aerial Photograph (2015)

Basemap Elements

- Watershed Boundary
- Municipal Boundaries
- County Boundary
- Major Road
- Interstate Highway
- River or Stream

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Miles

Sources: County GIS Departments,
East-West Gateway Council of Governments
July 2016

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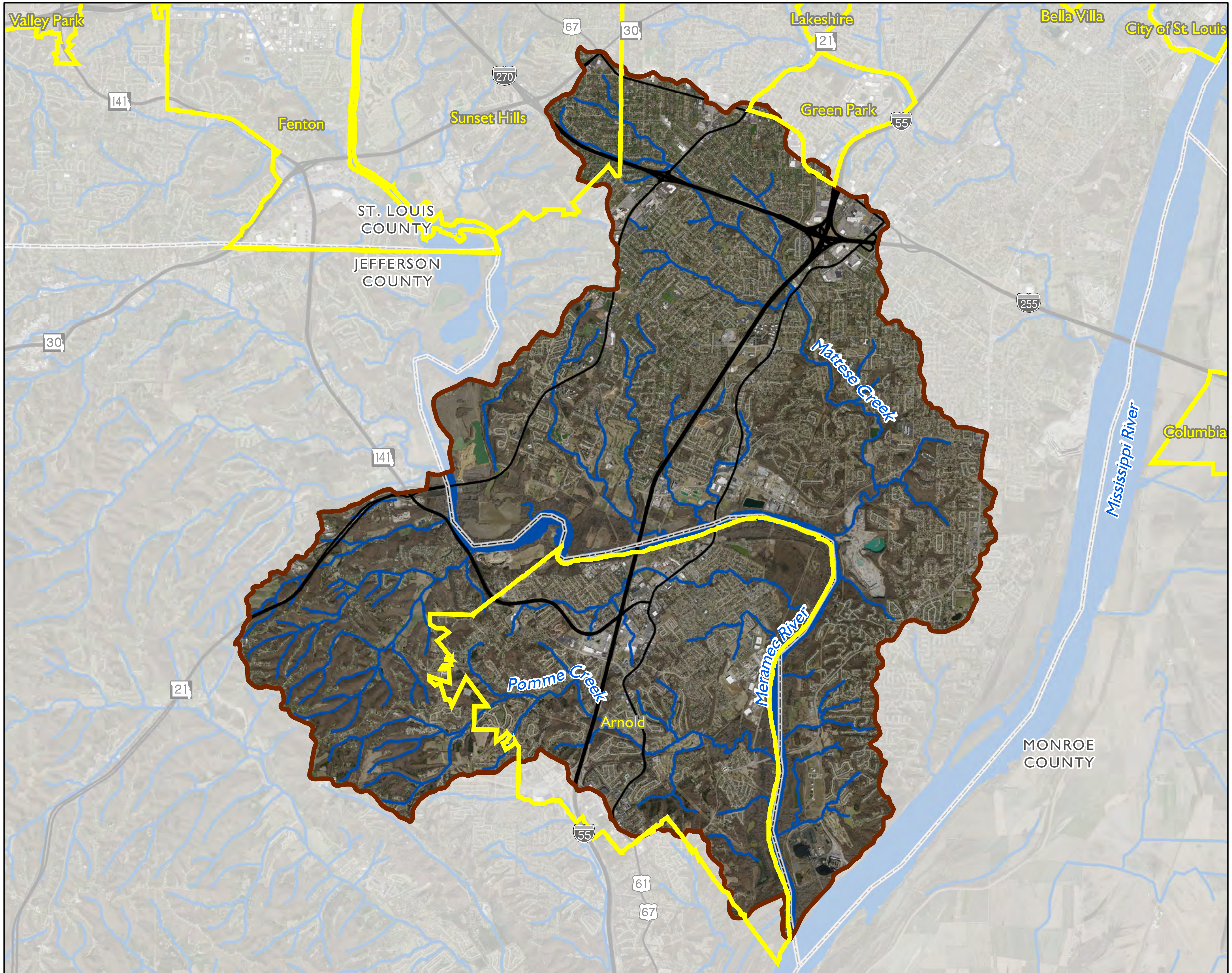

Map 9

Pomme-Mattese Watershed

Aerial Photograph (2015)

Basemap Elements

- Watershed Boundary
- Municipal Boundaries
- County Boundary
- Major Road
- Interstate Highway
- River or Stream

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Sources: County GIS Departments, East-West Gateway Council of Governments
June 2016

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Council of Governments

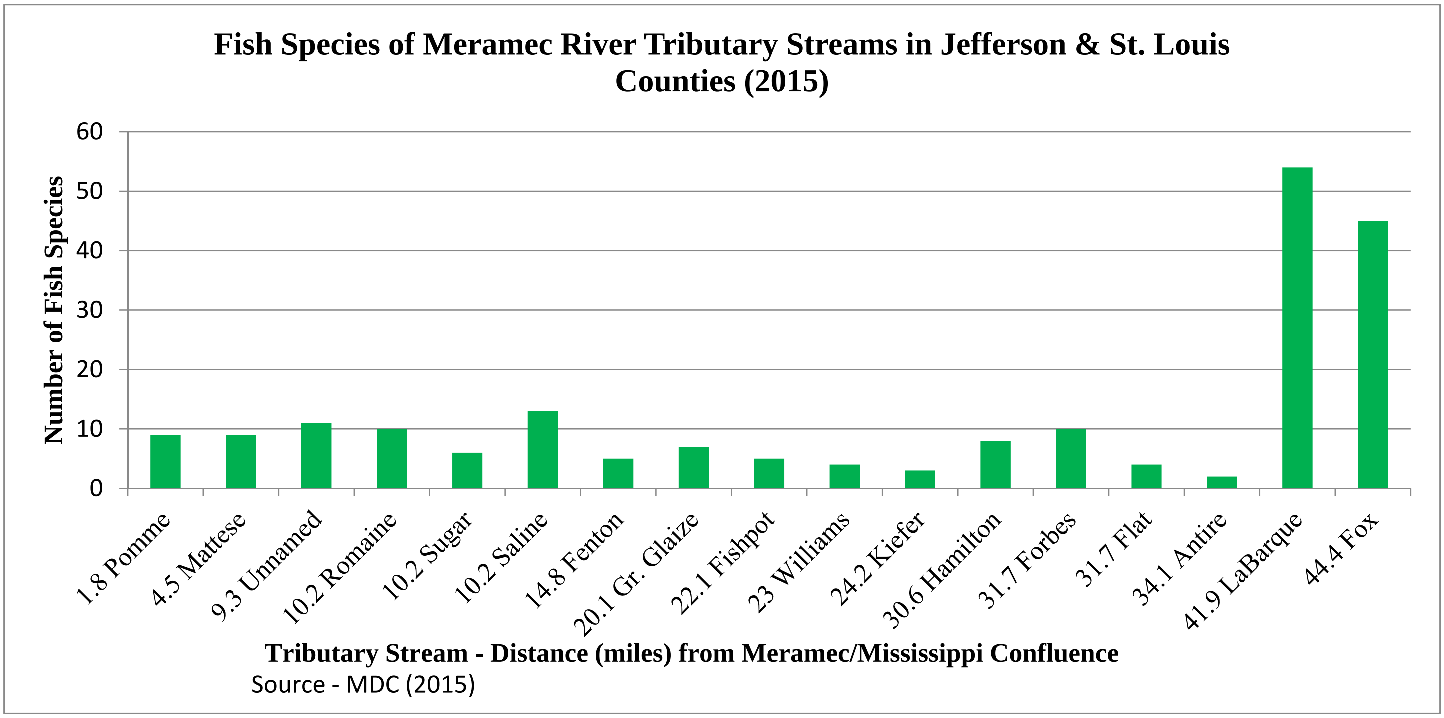
In the Pomme/Mattese Creeks watershed, approximately 60 percent of the land can be considered developed with the majority of it being multi and single-family residential areas found throughout the watershed. Commercial uses primarily can be found along Highways 61-67 in the city of Arnold in Jefferson County, Baumgartner Road in St. Louis County, State Highway 21/Tesson Ferry in Jefferson and St. Louis counties, and adjacent to the I-55/I-270 and I-255 interchange at the northern edge of the watershed in St. Louis County. Industrial activity (manufacturing and quarry operations) makes up six percent of the land area (see Table 25) and include the Ameren Meramec power plant, the MSD Meramec wastewater treatment facility and the MAWC Meramec drinking water treatment plant. Recreation areas in Jefferson County open to the public include the Strawberry Creek Nature Area, Arnold and Flam City parks, and the MDC Teszars Wood Conservation Area. There are five parks in the St. Louis County portion of the watershed. Only 2.7 percent of the land is classified as agricultural. Approximately 27 percent of the land has been assigned to the vacant/undeveloped (no structures) or unassigned category. A large portion of the unassigned category is in the city of Arnold, where buyouts of flood-impacted structures have occurred. In these areas, where Federal Emergency Management Agency (FEMA) funds were used to purchase property, development or redevelopment of the land will be restricted and parks or green space will be the permitted land use.

D. Aquatic Biodiversity

The Meramec River is an outstanding example of unique aquatic biodiversity, emblematic of certain river systems in the interior highlands of the Ozark Mountains. The Meramec River's rich mussel and crayfish fauna include several species not found in any other watershed on earth and equals or exceeds that of any other Ozark river. Indeed, the Meramec River's mussel fauna is one of the most diverse and unique in North America. The river supports one of the highest levels of biodiversity of any river in the United States, being home to more than 125 species of fish, 45 species of mussels, and 32 species of crayfish. The pink mucket mussel (*Lampsilis abrupta*), which is on the federal endangered species list, is found in the area. Mussel population monitoring indicates that reproduction in some mussel species is not occurring to maintain that diversity over time.

Fish population studies conducted by MDC on the lower Meramec River (109 miles from Sullivan to mouth) have revealed an unexpected finding; while the Meramec River itself has recovered in the last thirty years and currently supports 125 species of fish, its tributaries are in decline. None of the smaller tributaries between the mouth at the Mississippi River and mile 41.9 near Eureka supports a broad diversity of fish species (see Figure 3). LaBarque Creek in Jefferson County, with 54 fish species, and Fox Creek in St. Louis County, with 45 fish species, at miles 41.9 and 44.4 respectively, are considered healthy streams. None of the 15 comparably sized tributaries to the east have more than 13 species (Saline Creek in Jefferson County) and most have fewer than 10. More research is needed to understand changing habitats and population declines, but it appears likely that the declining fish species is a direct result of the suburban development patterns in the lower Meramec River watershed.

Figure 3. Fish Species in Meramec River Tributary Streams



E. Impaired Streams

Eight tributary streams, one lake, and two sections of the Meramec River have been identified by MoDNR as not meeting water quality standards protecting specific uses (see Table 7). In fact, all but two of the tributary streams in the lower Meramec River watershed planning area are considered degraded in terms of their ability to host a full complement of fish species. Erosion, sedimentation, the decline of year-round flow and habitat degradation may also contribute to the aquatic life impairment in those streams (see Map 2). However, LaBarque Creek, south of Eureka in Jefferson County, and Fox Creek, north and east of Pacific in Franklin and St. Louis counties, have adequate fish populations and are considered healthy streams.

MoDNR has established a schedule to develop TMDL studies for these impaired streams which will delineate the maximum amount of the identified pollutant (load) a stream can receive in order to meet state water quality standards.[23] In addition to a TMDL, implementation strategy will also be developed. The implementation strategy document will describe what best management practices could be utilized, the potential participants, and pollutant reduction calculations which can show how the waterway will be restored to unimpaired status. The bacteria TMDL for Fishpot Creek was approved by EPA in 2016. An implementation plan for Fishpot Creek was also prepared[24].

[23] https://dnr.mo.gov/env/wpp/tmdl/wpc-tmdl-progress.htm
[24] https://dnr.mo.gov/env/wpp/tmdl/docs/2186-fishpot-ecoli-tmdl-final.pdf

In the lower Meramec watershed, stream impairment have been identified for bacteria, chloride, mercury (atmospheric deposition) and lead (in sediment). NPS urban runoff into these streams has contributed to high levels of bacteria and chloride. The presence of *E. coli* is an indicator that a potential health risk exists for individuals exposed to this water. *E. coli* may occur as a result of inadequate on-site wastewater treatment systems, the overflow of domestic sewage, or non-point sources of human and animal waste. Chloride in surface waters can be toxic to aquatic life. Chloride in ground and surface water comes from the use and storage of salt for de-icing roads, on-site waste water systems, water softening, animal waste, fertilizers, discharges from landfills, natural sources of salt and brine in geologic deposits and from natural and human sources in precipitation.

Mercury occurs in the environment through natural processes and industrial activity, (through atmospheric deposition), and because it can vaporize, mercury can enter the atmosphere and is deposited in waterways through precipitation and runoff. Mercury can accumulate in fish muscle tissue (filets) of commercial and recreational bottom-feeding fish. In the Missouri portion of the St. Louis region, coal-fired electric generation facilities operated by Ameren Missouri can be found in northeastern Franklin County, southern Jefferson County, eastern St. Charles County and far south St. Louis County. The Meramec Energy Center is located in lower Meramec watershed planning area and it is scheduled to be retired in 2022.

Starting where the Big River enters the Meramec River and eastward to the mouth of the Meramec, sediment has become contaminated with lead. It is the result of erosion of lead mine tailing piles in the southern portion of the Big River watershed in St. Francois County. The contamination of stream sediment has resulted in the contamination of fish and other aquatic life.

a. Applicable Water Quality Criteria

The Missouri Water Quality Standards can be found at 10 CSR 20-7.031[25]. The numeric criteria to protect a designated use for a waterbody by specific pollutant are found in Table 20 below. According to these standards, the whole body contact recreation designated use is divided into three categories which refer to recreation in and on the water. Category A includes those waters established by a property owner as public swimming areas and waters with documented existing whole body contract recreational use(s) by the public. Examples include public swimming beaches and property which is open to and accessible to the public through law or written permission. Category B encompasses those waters designated for whole body contact recreation not covered by Category A. Secondary Contact Recreation includes waters where physical contact with the water is not likely to result in exposure of the eyes, ears, nose or mouth. For protection of waters designated for Category A use, bacteria (*E. coli*) are not to exceed 126 counts per 100 milliliters (mL) of water, measured as a geometric mean, for the recreational season. For waters designated for Category B use, *E. coli* counts are not to exceed 206 counts/100 mL of water. The standards define the recreational season as running from April 1 through October 31. For the protection of aquatic life from chloride, the chloride criteria are dependent upon water hardness and sulfate concentrations. Since this criteria was not approved by the EPA, MoDNR used Missouri’s previous chronic chloride criterion of 230 milligrams per liter in the assessment and impairment identification concerning Kiefer, Fishpot, Grand Glaize, Fenton and Mattese Creeks.

[25] http://www.sos.mo.gov/cmsimages/adrules/csr/current/10csr/10c20-7a.pdf

Table 7. 2016 Section 303(d) Impaired Waters List for the Lower Meramec River Watershed

Stream (WBID)	County	Length of impaired portion from Mouth (miles)	Pollutant (Year Listed)	Impaired Use	Source of Impairment
Antire (2188)	St. Louis	1.9	*E. coli* (2012)	WBC-B	Urban runoff/storm sewers
			pH (2012)	AQL	Sources unknown
Fox (1842)	St. Louis	7.2	Aquatic macroinvertebrate bioassessments/ Unknown (2012)	AQL	Source unknown
enton (3595)	St. Louis	0.5	*E. coli* (2012)	WBC-B	Urban runoff/storm sewers
			Chloride (2016)	AQL	Source Unknown
Fishpot (2186)	St. Louis	3.5	*E. coli* (2008)	WBC-B	Urban runoff/storm sewers
			Chloride (2012)	AQL	Urban runoff/storm sewers
Grand Glaize (2184)	St. Louis	4	*E. coli* (2008)	WBC-B	Urban runoff/storm sewers
			Chloride (2006)	AQL	Urban runoff/storm sewers
			Mercury in Fish Tissue (2002)	HHP	Atmospheric deposition - toxics
Kiefer (3592)	St. Louis	1.2	*E. coli* (2012)	WBC-A	Rural non-point source
			Chloride (2012)	AQL	Road/bridge runoff, non-construction
Mattese (3596)	St. Louis	1.1	*E. coli* (2014)	WBC-B	Urban runoff/storm sewers
			Chloride (2014)	AQL	Urban runoff/storm sewers
Williams (3594)	St. Louis	1	*E. coli* (2012)	WBC-B	Residential area

Table 7. 2016 Section 303(d) Impaired Waters List for the Lower Meramec River Watershed

Stream (WBID)	County	Length of impaired portion from Mouth (miles)	Pollutant (Year Listed)	Impaired Use	Source of Impairment
Bee Tree Lake (7309)	St. Louis	10 acres	Mercury in Fish Tissue (2014)	HHP	Atmospheric deposition-toxics
Meramec River section Valley Park to Confluence (2183)	St. Louis	22.8	*E. coli* (2016)	WBC-B	Source unknown
			Lead in sediment (2008)	AQL	Old Lead belt tailings
Meramec River section Eureka-Valley Park (2185)	Jefferson/St. Louis	15.7	Lead in sediment (2008)	AQL	Old Lead belt tailings

Source: MoDNR, 2016 EPA Approved Section 303(d) Listed Waters, final approval October 2016
Impairment based on stream use designation(s)

Designated Use AQL – Protection of aquatic life
Designated Use HHP – Human health protection

*TMDL Schedule sources of information - 1 – MoDNR Online TMDL under development schedule https://dnr.mo.gov/env/wpp/tmdl/wpc-tmdl-progress.htm and 2 – Missouri Integrated Water Quality Report and Section 303(d) List, 2016 (April 2016)

G. Watershed Data Collection

Information on conditions within the HUC12 watersheds can be found in Section II, Characterize the Watershed, in the 2012 Plan and Appendix A of this Plan Some of the elements from Section II Characterize the Watershed of the 2012 Plan have been updated and revised to include information for the Sugar/Fenton Creeks and Pomme/Mattese Creeks watersheds. The elements which have not been updated are noted. Existing pollutant loads for the HUC12 watersheds and impaired sub-watersheds were calculated using the Simple Method to Calculate Urban Stormwater Loads. Table 8 below presents the types of information assembled.

Table 8. Data Assembled for the 2012 and 2017 Plans

Information	Information
Incorporated Land	Cultural Resources
Demographics	Water Quality Sampling – Volunteer
Wastewater Systems	Water Quality Sampling – Government/Sewer District
On-Site Wastewater Systems as of 1990	Biological Assessment
Hydrologic Soil Group Classification	Threatened or Endangered Species
Geology	Sugar/Fenton Creeks Watershed Description
Conservation Opportunity Areas	Pomme/Mattese Creeks Watershed Description

Chapter III. Kiefer Creek Nine Element Plan for Bacteria

Element A – Identification of the Causes and Sources, or Groups of Similar Sources that will need to be controlled to achieve the Load Reductions and Water Quality Goal.

1. Causes and Sources of Bacteria Impairment in Kiefer Creek

The draft Kiefer Creek watershed Restoration Plan developed by the Missouri Coalition for the Environment in 2014[26] (referred to as MCE draft Kiefer Creek plan) researched literature, analyzed data and conducted field studies to determine the likely causes and sources of the bacteria impairment in Kiefer Creek. The draft Kiefer Creek Plan noted that "the high bacteria levels in Kiefer Creek could come from a variety of sources in the watershed, the most likely being faulty on-site wastewater treatment systems contaminating the groundwater and pet and wildlife waste washed into the creek."[27] Historical data shows Kiefer Creek having a steadily elevated level of *E. coli* bacteria, although not nearly as high as has been recorded by the USGS, MSD and MoDNR in recent years.

In September 1972, East West Gateway published the St. Louis County Water Pollution Control Study - Phase I -Areas Tributary to the Meramec River.[28] In this study, EWG looked specifically at the potential to expand sewer services to tributary areas of the Lower Meramec River, with specific emphasis on Fishpot and Grand Glaize Creek, but also including the Kiefer Creek watershed. (See Map 10) As a regional planning agency, EWG saw that the population would inevitably expand into these areas and the existing wastewater infrastructure, or lack thereof, would be inadequate to handle this influx. This study included testing of three locations in the Kiefer Creek watershed for a variety of parameters. The data indicates high bacteria levels in Kiefer Creek, showing that Kiefer Creek has had a bacteria problem for a long time, although the scale may have fluctuated over time. Recent data shows that Kiefer Creek can have very low levels of bacteria during low water and very high levels during high water.[29]

Table 9. 2016 Section 303(d) Impaired Waters List for the Lower Meramec River Watershed

Stream (WBID)	County	Length of impaired portion from Mouth (miles)	Pollutant (Year Listed)	Impaired Use	Source of Impairment
Kiefer (3592)	St. Louis	1.2	*E. coli* (2012)	WBC-A	Rural non-point source

Source: MoDNR, 2016 EPA Approved Section 303(d) Listed Waters, final approval October 2016
Impairment based on stream use designation(s)

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[26] Missouri Coalition for the Environment. Kiefer Creek Watershed Restoration Plan Draft Development Copy, October 20, 2014. http://www.ewgateway.org/wp-content/uploads/2017/09/KieferCreekDraftPlan-October2014.pdf

[27] Ibid., page 10

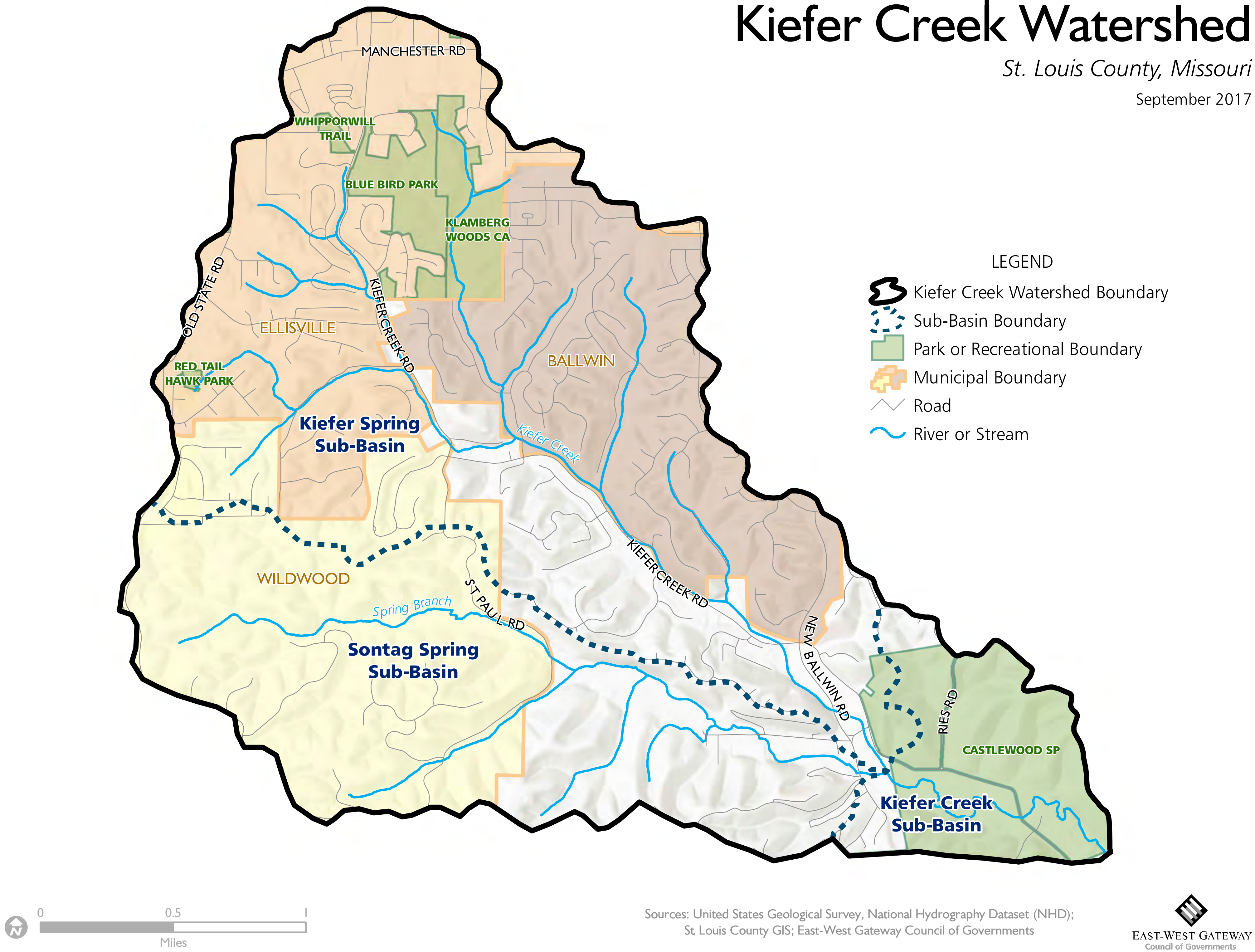
[28] Hard copy available from the reference library at East-West Gateway Council of Governments.

[29] Missouri Department of Natural Resources Keifer Creek *E. coli* Load Duration Curve and Estimates of Needed Load Reductions, March 16, 2017 contained in Appendix B and also refer to pages 18-21 of the MCE draft Kiefer Creek plan for a review of bacteria data collected from MoDNR, USGS and MSD.

Map 10
Kiefer Creek Watershed

St. Louis County, Missouri

September 2017



Sources: United States Geological Survey, National Hydrography Dataset (NHD); St Louis County GIS; East-West Gateway Council of Governments

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1.1 Domestic pets as a source

In the urban watersheds in the St. Louis region, domestic pet waste has been identified as common nonpoint source of bacteria.[30] To gauge the potential for bacteria from pets to cause the impairment of Kiefer Creek, the MCE draft Kiefer Creek plan applied the American Veterinary Medicine Association's 'Pet Ownership Calculator' to the estimate number of pets in the watershed. The calculator returned an estimated pet population of 2,472 dogs and 2,700 cats based on the human population.[31] When this waste isn't properly managed it can contribute significantly to high bacteria levels in our waterways. The MCE draft Kiefer Creek plan assumed the bacterial output from dogs was entirely outdoors with a 50% likelihood of cleanup before a rain event could wash the waste into the stream. Outdoor cats are likely to defecate outdoors 100% of the time, but only about 55% of cats in the US have outdoor access. Dogs have been found to contribute up to 15% of the bacteria in local watersheds that have a higher population density, and subsequently more pets, than the Kiefer Creek Watershed. These highly pet-populated watersheds display lower concentrations of bacteria than Kiefer Creek, and so it is unlikely that waste from domestic pets is the primary bacteria source in Kiefer Creek.[32]

1.2 Wildlife as a source

The MCE draft Kiefer Creek plan ruled out wildlife waste as a major source because the relatively small impact of wildlife waste is apparent in healthy watersheds which typically support a panoply of wildlife without violating water quality criteria. In the Kiefer Creek watershed, there are many pets and horses as well as an array of wildlife, all of which contribute to the bacteria that is present in the watershed. As a watershed changes from natural to developed, and its natural land cover is reduced, its capacity to process the waste from animals diminishes, whether they are native wild animals, or domesticated animals brought in with development. In the MCE draft Kiefer Creek plan's efforts to develop a watershed model, wildlife waste and urban runoff were accounted for in pathogen loading analyses.[33] It has also been found that desiccation of animal and wildlife waste typically results in 90% die off of bacteria.

1.3 Horse farms as a source

The MCE draft Kiefer Creek plan evaluated the potential for bacterial nonpoint sources typical to both urban and rural regions of the Meramec Basin that are represented within the watershed. In the rural Ozarks, common nonpoint bacteria sources include livestock, horses and broken or poorly designed on-site wastewater treatment systems. Many parts of Kiefer Creek are still quite rural in terms of the land use and land cover, allowing for many watershed residents to keep horses at their home. The Kiefer Creek watershed does not contain any livestock operations, however there are many horses in the watershed at two commercial stables and on over a dozen residential parcels (see Map 11).

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[30] Donald H. Wilkison and Jerri V. Davis, U.S. Department of the interior, U.S. Geological Survey, *Occurrence and Sources of Escherichia coli in Metropolitan St. Louis Streams, October 2004 through September 2007,* Scientific Investigations Report 2010-5150 (Reston, VA: U.S. Geological Survey, 2010), 28, Figure 12. https://pubs.usgs.gov/sir/2010/5150/pdf/sir2010-5150.pdf

[31] MCE draft Kiefer Creek Plan, page 23.

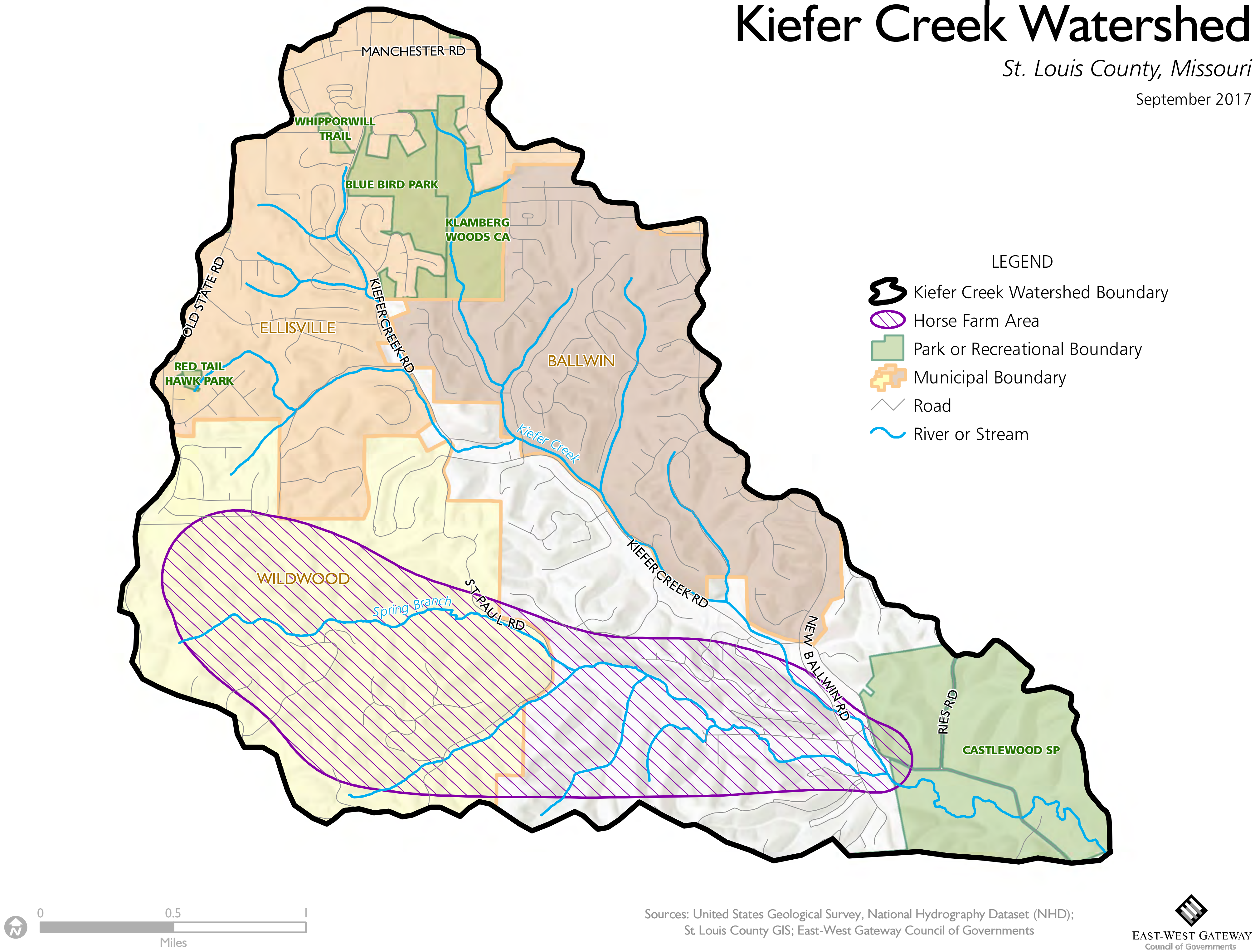
[32] Ibid., page 30

[33] Ibid., page 23

Map 11
Kiefer Creek Watershed

St. Louis County, Missouri

September 2017



Sources: United States Geological Survey, National Hydrography Dataset (NHD); St Louis County GIS; East-West Gateway Council of Governments

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Horse manure is a common nonpoint source of bacteria in watersheds across the United States. The MCE draft Kiefer Creek plan used field observations and aerial imagery to identify all of the pastures and visible horses, and spoke with residents about manure management practices. The imagery review and interviews led to an informed estimate of 116 horses in the watershed mostly housed at the commercial stables with some form of manure management, but many issues were identified relating to exhausted pastures and erosion. Residential owners employed less effective manure management practices, however their horses tended to have access to more area of pasture per horse resulting in healthier pastures.[34] The MCE draft Kiefer Creek plan estimated that each individual horse produces an average of 9 tons of manure and 3.5 tons of urine per year.

Horse waste has been known to cause issues in other Ozark waterways, such as the Jack's Fork, which was listed as impaired in 1998 for recreational use due to bacteria in 1998 and 2002. The TMDL written to address the impairment of the Jack's Fork River included a specific assessment of potential waste loading from horses and proposed management measures to reduce this source of bacteria. Through interviews with horse owners in the watershed, the MCE draft Kiefer Creek plan estimated on average local horses are outside 70% of the time, where manure is not typically cleaned up and about 10% of the manure in the watershed is stored outdoors in uncovered piles. Horses produce a high volume of waste that has a low density of bacteria so the small population of horses in the watershed should not pose a significant threat to water quality, especially with improved storage and composting of horse manure and effective pasture management. Even if the horse manure is uncovered and located close to a tributary channel, it could contribute only a relatively small amount of bacteria compared to other likely sources such as on-site wastewater treatment systems.[35]

1.4 On-site wastewater treatment systems as a source

Failing on-site wastewater treatment systems can produce a very high concentration of bacteria that is highly mobile, especially in a karst area such as the Kiefer Creek watershed. Untreated wastewater from leach fields can also build up in shallow soils to be washed into a nearby stream by rainfall. According to EPA, the estimated failure rate of on-site wastewater treatment systems in Missouri is 30% to 50%, with old age and poor design being major factors responsible for system failure.[36] The primary source of bacteria in Kiefer Creek watershed is highly likely to be on-site wastewater treatment systems because of hydrological a soil conditions and because of the significant number, and poor functioning of, on-site wastewater treatment systems in the watershed.

[34] Ibid. page 24.
[35] Ibid. page 30.
[36] U.S. EPA, Office of Water, Office of Research and Development, On-site Wastewater Treatment Systems Manual (EPA/625/R-00/008, Washington, DC: GPO, 2002), 1-7, Table 1-3.

Kiefer Creek is fed by at least six significant springs throughout the watershed, and major portions of the creek may be categorized as losing streams (the portion of Kiefer Creek upstream of Spring Branch is classified as a losing stream, while downstream of Spring Branch it is classified as a gaining stream). These two conditions mean that the water quality of Kiefer Creek is dependent on the quality of the groundwater in addition to the quality of the runoff and drainage that reaches the stream bed. This makes Kiefer Creek highly susceptible to bacteria leaked from faulty on-site wastewater treatment systems in the area. In addition, groundwater does not follow the topographical boundaries that delineate watersheds, and it is likely that the spring water feeding Kiefer Creek originated from an area much wider than the watershed, carrying with it accumulated contamination. According to hydrologic analysis or the East West Gateway's 1978 St. Louis Water Pollution Control Study on areas that are tributaries to the Lower Meramec River, the groundwater in the Kiefer Creek area flows in a northeast direction.[37] This suggests that some of the water entering Kiefer Creek through the various springs likely contains contamination from other areas.

Specific soil characteristics affect the rate of infiltration of water into the soil, and conversely, the volume and velocity of stormwater runoff. Soils are classified by the Natural Resources Conservation Service, or NRCS, into four hydrologic soil groups, A, B, C, D, based on the physical drainage properties of each soil series, including texture and permeability, as well as certain physiographic properties, such as depth to bedrock and water table. Soils are categorized in terms of their runoff potential, with Group A being well-drained and Group D being poorly drained. Group D soils have the highest runoff potential. They have very low infiltration rates when thoroughly saturated, and in combination with suburban development, will intensify runoff volumes and velocities which will increase streambank erosion and flash flooding. This group contains clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious materials. These poorly drained soils should be avoided for placement of on-site wastewater treatment drainfields. Dual soil groups include certain soils placed in Group D because of a high water table, creating a drainage problem. If these soils can be adequately drained, they can be placed in a different soil hydrologic group. The first letter of the dual group applies to the drained condition.

Table 10, based on information from the 2012 Lower Meramec Watershed Plan, shows that 30.9 percent of the Hamilton Creek watershed (which contains Kiefer Creek) has Group D poorly drained soils not suitable for on-site wastewater treatment systems.[38]

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[37] East-West Gateway Council of Governments, St. Louis, MO Water Quality Management Plan, Area-wide waste treatment management study (208), May, 1978. http://www.ewgateway.org/pdffiles/library/wrc/208Rpt-1978/208Rpt-Part1.pdf

[38] East-West Gateway Council of Governments, Lower Meramec Watershed Plan 2012, page 114. http://www.ewgateway.org/lowermeramec/lowermeramecwatershedplan-final.pdf

Table 10. 2012 Lower Meramec Plan Hamilton Creek Watershed Hydrologic Soil Groups

Hydrologic Soil Group	Acres	Percent Share
A	385.8	1.1
B	12,730.2	36.4
B/D	18.4	0.1
C	9,702.6	27.8
C/D	41.8	0.1
D	10,802.2	30.9
No Data	1,275.0	3.6
Total	34,956.0	100

The MCE draft Kiefer Creek plan estimated the number and age of on-site wastewater treatment systems in the watershed using datasets and assistance from MSD and St. Louis County, which rendered a highly refined on-site wastewater treatment system dataset for the watershed.
The St. Louis County Parcel Database contains a wide range of useful attribute data including a column called 'YEARBLT,' which refers to the year in which a structure was first built according to county records. The MSD pump station in Castlewood State Park came online in 1986, and serves the majority of the parcels within the Kiefer Creek catchment. All non-vacant watershed parcels developed prior to the operational date of the pump station were extracted to a new dataset representing potentially un-sewered parcels based on the infrastructure timeline.

Table 11. On-site Wastewater Treatment System Dataset

Year Built Range	Non-Vacant Parcels	Single Family	Duplex Townhome	Multi-Family	Institutional & Parks	Commercial & Industrial
1900 >	**3**	3	0	0	0	0
1901 - 1910	**2**	2	0	0	0	0
1911 - 1920	**20**	19	1	0	0	0
1921 - 1930	**62**	58	1	1	1	1
1931 - 1940	**12**	8	1	2	1	0
1941 - 1950	**33**	32	0	0	0	1
1951 - 1960	**64**	58	1	0	2	3
1961 - 1970	**62**	55	1	1	1	4
1971 - 1980	**310**	247	0	53	2	8
1981 - 1985	**180**	140	0	33	1	6
Total	**748**	**622**	**5**	**90**	**8**	**23**

Table 12. Kiefer Creek Age of Structure Dataset

Kiefer Spring Branch					Sontag Spring Branch			Kiefer Main Branch		
Year Range	**Count**	**Single Family**	**Dplx/ TwnH**	**Commercial**	**Single Family**	**Dplx/ TwnH**	**Commercial**	**Single Family**	**Dplx/ TwnH**	**Multi-Family**
1850 - 1920	**6**	0	0	0	5	0	0	1	0	0
1921 - 1940	**19**	3	1	0	10	0	1	1	1	2
1941 - 1960	**9**	3	1	1	3	0	0	1	0	0
1961 - 1980	**37**	23	0	0	12	1	1	0	0	0
1981 - 2000	**23**	8	0	0	15	0	0	0	0	0
2001 - 2012	**6**	4	0	0	2	0	0	0	0	0
Total	**100**	41	2	1	47	1	2	3	1	2

With this approach, the MCE draft Kiefer Creek plan identified properties unlikely to be connected to sanitary sewers and are therefore likely using an on-site wastewater treatment system - 159 residences that do not pay for sanitary sewers and another 100 non-vacant residential and commercial properties that were not detected as unbilled, but are outside of the feasible reach of the existing infrastructure (See Map 12 which presents extent of sanitary facilities in the watershed). The MCE draft Kiefer Creek plan then evaluated the functioning of the on-site wastewater treatment systems based on a number of factors related to age of the system and drainfield effectiveness. Each factor was broken down into a ranking representative of the relative significance of each factor attribute, the higher the category and overall ranking, the higher the potential for system failure and bacterial loading.

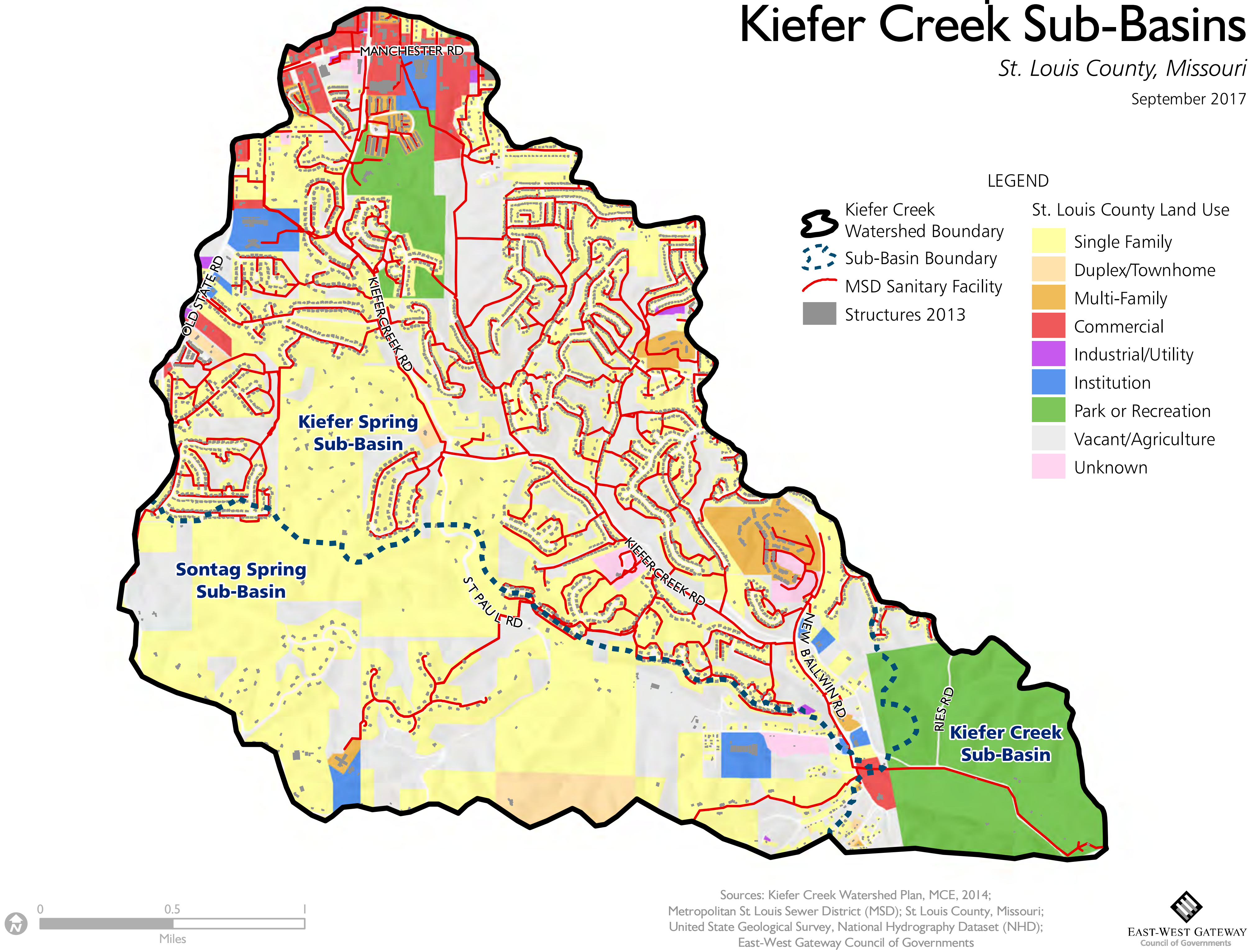
Parcel Area: Without sufficient area for an on-site wastewater treatment system it is unlikely that the system is effectively eliminating the bacteria in the effluent. St. Louis County requires a minimum lot size of 20,000 square feet if the premises are served by a public water main or 30,000 square feet otherwise.[39] The MCE draft Kiefer Creek Plan found there are 80 likely on-site wastewater treatment systems, or about 31 percent of the likely systems in the watershed, on parcels that are less than 20,000 square feet, with 33 which are less than 10,000 square feet.[40] These systems are likely to be failing due to a lack of sufficient area for processing of effluent to effectively eliminate bacteria. All of these systems are located within 1.25 miles of the swimming area in Castlewood State Park and all but one are on parcels developed before 1980 with an overall average estimated system age of 82 years (See Map 12.)

[39] http://www.stlouisco.com/Portals/8/docs/Document%20Library/Public%20Works/code%20enforcement/ordinances/09-UPC-Plumb-Ord.pdf.
[40] MCE draft Kiefer Creek plan, page 27.

Map 12
Kiefer Creek Sub-Basins

St. Louis County, Missouri

September 2017



Sources: Kiefer Creek Watershed Plan, MCE, 2014;
Metropolitan St Louis Sewer District (MSD); St Louis County, Missouri;
United State Geological Survey, National Hydrography Dataset (NHD);
East-West Gateway Council of Governments

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Table 13. Parcel Area- On-site Wastewater Treatment System

Parcel Area (Square Feet)	Rank	Kiefer Spring Branch	Sontag Spring Branch	Kiefer Main Branch	Total
< 10000	**10**	5	17	11	**33**
10000 –20000	**9**	13	23	11	**47**
> 20000	**1**	80	95	4	**179**

On-site wastewater treatment system estimated age: As on-site wastewater treatment systems age, the likelihood of failure increases. Older systems also lack the advantage of modern system design and any system built prior to 1996 were not subject to state design standards. The MCE draft Kiefer Creek plan used parcel data to rank from 1 to 10 on-site wastewater treatment systems based on age.[41]

Table 14. Estimated Age- On-site Wastewater Treatment System

System Age (Years)	Rank	Kiefer Spring Branch	Sontag Spring Branch	Kiefer Main Branch	Total
> 50	**10**	38	68	25	**131**
41 -50	**9**	6	9	0	**15**
31 -40	**7**	34	12	1	**47**
21 -30	**5**	12	26	0	**38**
11 -20	**3**	5	19	0	**24**
1 -10	**1**	3	1	0	**4**

The plan found there are only 28 systems that were likely to be built in accordance with state design standards. At the same time, 146 systems are likely to be more than 40 years old. With excellent design and maintenance, including replacement of broken and rusted components, an on-site wastewater treatment system can function indefinitely. Without information on specific system designs it is difficult to assume a certain rate of failure based on age, for example concrete on-site wastewater treatment tanks can last indefinitely while metal tanks usually fail due to rust in 15 to 20 years. Drip fields tend to have a lifespan of around 20 years, however this can vary depending on the soils, slope and encroachment of plant root systems. Considering these factors it is also very likely that many older systems in the watershed have had failing components replaced at some point, however for this to happen a failure would have to have been detected. In some cases a failing system may not be apparent if the effluent flows directly into the sub-surface flows where it will not be easily detected.

Land Cover: Overall trees are great for the watershed and perform irreplaceable environmental services while providing habitat, however they can also wreak havoc on an on-site wastewater treatment system. Some newer on-site wastewater treatment systems do not require a drip field, however most do, and drip fields work best when the effluent is exposed to the ultra violet rays from sunlight. Tree root systems can also damage the drip field, lateral connection and on-site wastewater treatment tank. The MCE draft Kiefer Creek plan ranked from 1-10 drip field areas with low amounts of un-forested areas because they are more likely to malfunction.[42]

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[41] Ibid.
[42] Ibid. page 28.

Table 15. Land Cover- On-site Wastewater Treatment System

Grass Area	Rank	Kiefer Spring Branch	Sontag Spring Branch	Kiefer Main Branch
10m2>	**10**	0	2	0
11m2 - 25m2	**9**	0	2	2
26m2 - 50m2	**8**	0	6	3
51m2 - 75m2	**7**	1	6	4
76m2 - 125m2	**6**	4	12	5
126m2 - 175m2	**5**	3	5	3
176m2 - 250m2	**4**	5	9	5
251m2 - 500m2	**3**	19	16	3
500m2 - 1000m2	**2**	14	11	1
1001m2<	**1**	52	66	0

Soils: The typical Ozark soils and karst topography in the watershed are not well suited for on-site wastewater treatment systems. That said, the MCE draft Kiefer Creek plan considered the hydrologic soil groups in terms of their potential to process on-site wastewater treatment system effluent or transmit it untreated into the stream flow. When an on-site wastewater treatment system is installed or inspected according to current design guidelines and local ordinance, a percolation test is conducted to calibrate the system design, especially the drip field, to the soil conditions on site.[43]

Table 16. Soils- On-site Wastewater Treatment System

Hydrologic Soil Group	Rank	Kiefer Spring Branch	Sontag Spring Branch	Kiefer Main Branch
D	**10**	6	11	0
C	**7**	57	84	16
B	**3**	35	40	10

Slope: The steeper the slope of an on-site wastewater treatment system drip field the less likely that effluent will be fully treated before it runs off the site and into the nearest stream channel. The average slope of each potential drip field zone was calculated to assign a ranking from 1 to 10.

[43] Ibid.

Table 17. Slope- On-site Wastewater Treatment System

Average Slope (%)	Rank	Kiefer Spring Branch	Sontag Spring Branch	Kiefer Main Branch
9.01 -10	**10**	0	1	0
8.01 -9	**9**	0	0	0
7.01 -8	**8**	0	1	0
6.01 -7	**7**	0	6	0
5.01 -6	**6**	2	17	1
4.01 -5	**5**	25	22	12
3.01 -4	**4**	24	30	10
2.01 -3	**3**	9	24	2
1.01 -2	**2**	9	19	0
0.0 -1	**1**	29	15	1

The MCE draft Kiefer Creek plan added up each attribute ranking for each parcel with an on-site wastewater treatment system to create an overall ranking the system in the watershed with a maximum possible raw score of 50 and a minimum raw score of 5.

Table 18. Overall Ranking- On-site Wastewater Treatment System

Raw Score	Kiefer Spring Branch	Sontag Spring Branch	Kiefer Main Branch	Total
46 to 50	0	1	0	1
41 to 45	0	4	1	5
36 to 40	0	14	11	25
31 to 35	1	16	6	23
26 to 30	19	16	7	42
21 to 25	36	26	1	63
16 to 20	36	42	0	78
11 to 15	4	15	0	19
5 to 10	2	1	0	3

The raw score provides a good overview of the conditions that affect each system in the watershed, however certain conditions are more consequential to the function of a system than others. Parcel area, age and grass area are all critical aspects of on-site wastewater treatment system function, while slope and soil group are less pertinent in this analysis. Estimating the failure rate of on-site wastewater treatment systems is imprecise; only through a professional inspection can a system be conclusively evaluated. However, inspection reports are not necessarily submitted to or collected by any regulatory agency, making it necessary to use estimates such as these to evaluate the potential impacts from failing systems when developing a watershed plan. Using this analysis, the MCE draft Kiefer Creek plan assumed that all systems with an age, parcel area or grass area rank of 9 or 10 are likely to be failing.

The data gathering and analysis done as part of the MCE draft Kiefer Creek plan demonstrates that on-site wastewater treatment systems are the source of the majority of the excess bacteria in Kiefer Creek. These systems also happen to be a very complex and expensive source of bacteria to control.

Element B: An Estimate of the Load Reductions Expected for the Management Measures Described in Element C

1. Estimating Pollutant Loadings

In the 2012 Lower Meramec Watershed Plan, the Simple Method to Calculate Urban Stormwater Loads was used to estimate stormwater pollutant loadings for developed land uses within four watersheds, and it has again been used here within Kiefer Creek sub-watershed. It is a spreadsheet model which requires basic information characterizing a watershed, including the watershed drainage area and impervious cover by land use type, stormwater runoff pollutant concentrations and annual precipitation. With the Simple Method, the various pollutant loads, i.e. total nitrogen (N), total phosphorus (P), Total Suspended Solids (TSS), Biological Oxygen Demand (BOD), and bacteria loads (fecal coliform and *E. coli*) are calculated by land use type and then totaled. The stormwater pollutant concentrations can be estimated from local or regional data or from national data sources. For the purposes of this analysis, default concentration factors from both the Simple Method and the spreadsheet tool for Estimating Pollutant Load (STEPL)[44] were utilized. Model default values represent best professional judgement and give additional weight to studies conducted at a national level. These default values do not incorporate studies on arid climates. Bacteria concentrations came from the Minnesota Pollution Control Agency Estimator tool to calculate TMDL benefits.[45] A description of the Simple Method technique can be found in Appendix D of the 2012 Plan.[46] Table 19 below contains the baseline estimates developed for the four pollutants and bacteria in the Kiefer Creek sub-watershed. The estimates calculated using the Simple Method can be used as a starting point for making decisions on management strategies until additional funds become available to conduct more sophisticated watershed modeling or coupled with additional water quality monitoring efforts.

Table 19. Kiefer Creek Sub-watershed Baseline Annual Loads

Pollutant	Pounds per year	Billion colonies
Phosphorous	1,529.6	
Nitrogen	9,499.5	
Total Suspended Solids	417,528.9	
Biological Oxygen Demand	28,894.1	
Fecal Coliform		82,220.5
E. coli		73,315.0

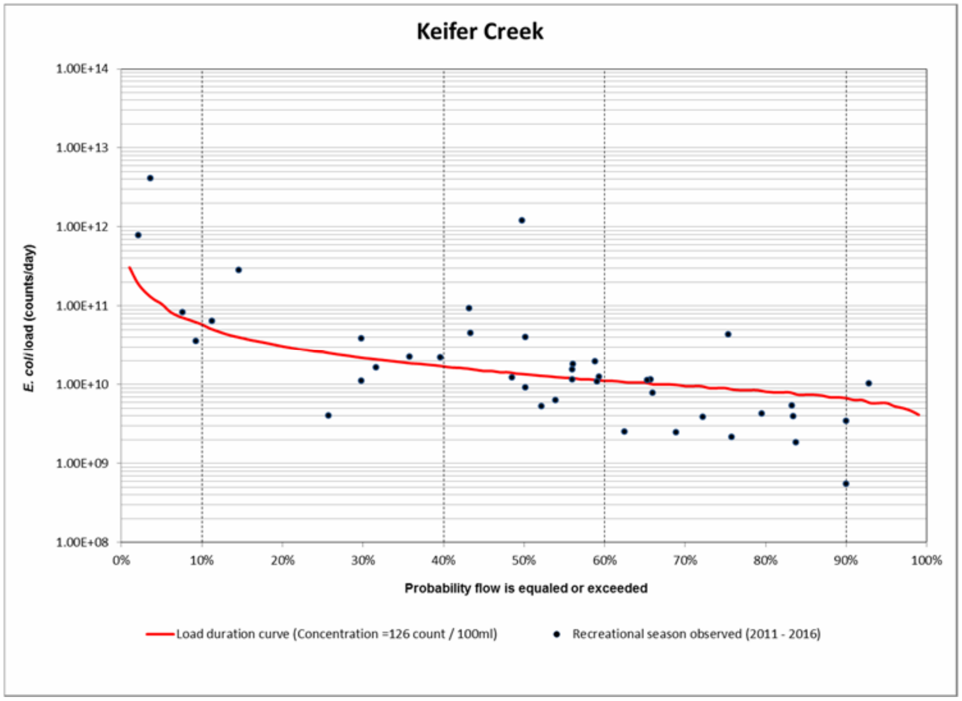
2. Kiefer Creek Load Duration Curves and Pollutant Reduction Estimates

Load duration curves and pollutant reduction estimates for *E. coli* bacteria for impaired streams in the lower Meramec watershed, including Kiefer Creek, have been prepared by MoDNR. These load duration curves and reduction estimates were developed to support this plan, and are for informational purposes only as they are not part of a TMDL. Percent reductions were calculated using the load duration curve and available water quality data collected from the water body. Load

[44] http://it.tetratech-ffx.com/steplweb/default.htm
[45] https://stormwater.pca.state.mn.us/index.php/Guidance_and_examples_for_using_the_MPCA_Estimator
[46] http://www.ewgateway.org/lowermeramec/lowermeramecwatershedplan-final.pdf

duration curves are a visual tool used to characterize water quality concentrations at different flow levels and the relationship between stream flow and loading capacity. The preliminary load reduction curve for Kiefer Creek is presented below in Figure 4. Table 20 presents the reduction estimate for the 50 percent flow range and can be used to aid in the selection and placement of BMPs. This load reduction was selected as these are flows associated with runoff when nonpoint source contributions are likely to occur. Appendix B contains a complete discussion of load duration curves and pollutant reduction estimates for those streams impaired by bacteria (load duration curves prepared by MoDNR).

Figure 4. Kiefer Creek Load Duration Curve



Source: MoDNR

Table 20. Estimate of Bacteria (*E. coli*) Load Reduction Needed to Attain Water Quality Standards

Impaired Stream	Flow (cfs)	Loading Capacity (counts/day)	Existing Loading (counts/day)	Reduction Needed (counts/day)	Percent Reduction Needed
Kiefer Creek	4.39	1.35E+09	2.21E+10	8.58E+09	38.8

cfs – cubic feet per second

Loading Capacity – The greatest amount of pollutant loading that a water body can receive without violating water quality standards.

Existing Loading – Estimated as the geometric mean of all observed *E. coli* loads within a specific flow range

Reduction Needed – Amount of reduction in bacteria loading needed to achieve Loading Capacity

Source: MoDNR

The percent share of bacteria loading from on-site wastewater systems, farm animals, urban areas and wildlife (including pets) was estimated by the MCE as part of the modeling they calculated for the MCE draft Kiefer Creek Plan. EWG used these percentages to allocate the estimated existing *E. coli* loading among these sources (see Table 21).

Table 21. Kiefer Creek Estimated Bacteria Contribution by Activity

Bacteria Source Groups	Percent Share	Existing *E. coli* Loading (counts/day)
On-Site Wastewater Treatment Systems	83.6	1.85E+10
Farm Animals	6.4	1.41E+09
Urban Areas	4	8.84E+08
Wildlife (and Pets)	6	1.33E+09
Total	100	2.21E+10

3. Load reductions from management measures in Element C

3.1 Load reduction estimates from on-site wastewater treatment system management measures

Element A provides information about on-site wastewater treatment systems as a primary source of bacteria in the Kiefer Creek watershed. Of the 259 properties identified in Element A likely to contain an on-site wastewater treatment system, 95 percent are single family residential units. The remaining parcels are multi-family residential (7), commercial (3), institutional (2) and recreational (1). The parcel area (in square feet) of these 259 properties was calculated and is presented in Table 22. It was assumed that on-site wastewater systems on parcels which are 20,000 square feet (0.46 acres) or less could potentially be failing because of the lack of square footage for the operation of an effective drainfield. Assumption for total acreage was that all parcels in: Category A were 10,000 square feet in size; Category B, 20,000 square feet; and Category C, 30,000 square feet.

Table 22. Kiefer Creek Sub-watershed Size of Parcels with On-site Wastewater Systems

Parcel Category	Parcel Area In Square Feet	Sub-watershed	Acreage
A	< 10,000	33	7.6
B	10,000 – 20,000	47	21.6
C	> 20,000	179	123.5
Total		259	152.7

To reduce bacteria levels, management measures target connecting half of the parcels from each category to the MSD collection system where physically feasible, or making repairs to, or replacement of, the on-site wastewater system so that it functions properly (see Element C). For this subset of properties with individual on-site wastewater systems in the Kiefer Creek watershed, baseline and future year pollutant and bacteria loadings were calculated using the Simple Method to determine annual urban stormwater loads[47]. Since 95 percent of the parcels are single family residential, the mean concentrations of the single family residential pollutant concentrations and bacteria event were utilized. The focus of this management practice is to reduce the pollution contribution from on-site wastewater treatment systems. Instead of only

[47] Since the Simple Method uses annual load, and the TMDLs identify daily count, for this plan an approximate correlation of percent load must be assumed for all watersheds. Monitoring will be necessary to obtain actual load reduction counts.

using the residential impervious acreage in the calculation, all of the acreage associated with this subset were used as a failing on-site wastewater treatment system can impact an entire parcel. For future years, it was assumed that half of the acreage in Categories A, B and C would receive improvements and, therefore would no longer contribute to the bacteria impairment in Kiefer Creek. Table 23 presents the baseline and future year loadings from the on-site wastewater system subset.

Table 23. Kiefer Creek On-site Wastewater System Subset

Kiefer Creek Sub-watershed (Hamilton watershed)			
Pollutant	**Baseline Loading Pounds per Year**	**Future Loading with MSD Connection and On-site Waste Water System Improvements Pounds per Year**	**Reduction Pounds per Year**
Phosphorus	139.4	69.5	69.9
Nitrogen	766.8	382.2	384.6
Total Suspended Solids	34,855.3	17,370.6	17,484.7
Bacteria	**Baseline Loading Billion Colonies per Year**	**Future Loading with MSD Connection and On-site Waste Water System Improvements Billion Colonies per Year**	**Reduction Billion Colonies per Year**
Fecal Coliform	12,311.2	6,135.4	6,175.8
E. coli	11,188.1	5,575.7	5,612.4

Simple Method to Calculate Urban Stormwater Loads

Referencing the load duration curve prepared by MoDNR for the 50 percent of time creek flow is equaled or exceeded, management measures are planned for improvements to be made to 130 parcels over the next twenty years[48], either by connecting to the MSD collection system or by replacing or repairing on-site wastewater treatment systems, resulting in a 50 percent reduction in bacteria loading from on-site wastewater systems (see Table 24). It is assumed that this effort would begin in year 3 after the adoption of this plan.

Table 24. Kiefer Creek- Estimated Improvements to Residential Properties with On-site Wastewater Treatment Systems

Time Period	Residential Properties	Estimated Loading Reduction
End of Year 4	10	7.11E+08
End of Year 5	10	7.11E+08
End of Year 10	30	2.13E+09
End of Year 15	40	2.84E+09
End of Year 20	40	2.84E+09
Total	130	9.24E+09

3.2 Load reductions from manure management measures

In addition, outreach and education on manure management techniques for the commercial stables and residential parcels with horses in the sub-watershed are planned. It is assumed that efforts will be focused on those owners of parcels adjacent to Kiefer Creek and its branches. It is

[48] This assumes that half of the systems may be failing, need servicing, or replacement.

estimated that by 2038, there will be a 30 percent reduction in bacteria load associated with farm animals (primarily horses). Table 25 presents the bacteria load reduction estimates.

Table 25. Kiefer Creek- Implementation of Manure Management Education and Outreach

Time Period	Parcel Owners Participating	Estimated Loading Reduction
Year 1 – Year 3	2	4.04E+07
Year 4 - Year 5	4	8.08E+07
Year 6 – Year 10	6	1.21E+08
Year 10 –Year 20	9	1.82E+08
Total	21	4.24E+08

3.3 Load reductions from riparian buffer and stream channel stabilization management measures

Protecting and improving the riparian buffer along Kiefer Creek will result in a passive bio-filter for remaining urban overland runoff and further reduce NPS bacteria loads from wildlife and pet waste. Data on pollutant and bacteria removal efficiencies for naturalized stream buffers come from the Lower DuPage River Watershed Study (see Table 26). The Lower DuPage watershed study recommends using the middle value when a range of pollutant removal efficiencies are provided.

Table 26. Examples of Riparian Buffers Pollutant Removal Efficiencies

Reference Source*	Percent Total Phosphorus	Percent Total Nitrogen	Percent Total Suspended Solids	Percent Fecal Coliform
Lower DuPage River watershed Plan, 2011 – Naturalized Stream Buffer	40 - 65	40 - 50	55- 85	45 - 55
Chesapeake Bay Program – Urban Riparian Forest Buffer	50	25	50	N/A
Eightmile River, 2005 – Forested Buffer	36 – 70	48 – 74	70 – 90	N/A
Eightmile River, 2005 – Vegetated Filter Strips	24 – 85	4 – 70	53 – 97	Not Calculated
Eightmile River, 2005 – Forested and Vegetated Filter Strips	73 - 79	75 - 95	92 - 96	Not Calculated

The Conservation Foundation, Lower DuPage River Watershed Plan, 2011(http://www.dupagerivers.org/LDRWatershedPlan.htm)
Yale School of Forestry and Environmental Studies, Riparian Buffer Zones: Functions and Recommended Widths for the Eightmile River Wild and Scenic Study Committee, 2005 (http://eightmileriver.org/resources/digital_library/appendicies/09c3_Riparian%20Buffer%20Science_YALE.pdf)
Chesapeake Bay Program, Best Management Practices for Sediment Control and Water Clarity Enhancement, 2006 http://www.chesapeakebay.net/content/publications/cbp_13369.pdf)

Table 27. Naturalized Stream Buffer Pollutant/Bacteria Removal Efficiencies

Best Management Practice	Percent Removed
Total Phosphorous	53
Total Nitrogen	45
Total Suspended Solids	70
E. coli	Not Calculated
Fecal Coliform	50

In the Lower DuPage River Watershed Study, the cost to construct a naturalized stream buffer was between $5,000 and $10,000 per acre.

Based on results from the DuPage River Watershefed Plan, it is estimated that bacteria load from the continuation and expansion of buffers in the Kiefer Creek sub-watershed would be reduced by 50 percent. The Nature Conservancy has proposed performing stream channel stabilization and buffer improvement on a 3,565 foot long portion of Kiefer Creek within Castlewood State Park. This bacteria reduction has been assigned to both the Urban Areas and Wildlife groups. Table 28 presents the overall load reduction allocated by source groups for Kiefer Creek.

Table 28. Kiefer Creek Estimate Load Reductions Allocated by Source Group

Kiefer Creek Watershed Groups with Bacteria Contribution	Bacteria Percent Share	Existing *E. coli* Loading (counts/day)	Percent Loading Reduction with Implementation of BMPs and Naturalized Stream Buffer by Group	Estimated Reduction with Implementation of BMPs and Naturalized Stream Buffer by Group	20 Years *E. coli* Loading (counts/day)
On site Wastewater Systems	83.6	1.85E+10	50	9.26E+09	9.24E+09
Farm Animals	6.4	1.41E+09	30	4.28E+08	9.90E+08
Urban Areas	4	8.84E+08	50	4.42E+08	4.42E+08
Wildlife (& Pets)	6	1.33E+09	50	6.67E+08	6.63E+08
Total	100	2.21E+10	48.7	1.08E+10	1.13E+10

MoDNR has estimated the Kiefer Creek loading capacity for the 50 percent of time creek flow is equaled or exceeded at 1.35E+10. At the end of the 20 year period, by improving on-site wastewater treatment systems, connecting to sewer lines, improving horse manure management practices and improving the riparian buffer of Kiefer Creek, it is estimated the *E. coli* loading could be 1.13E+10, a 48.7 percent reduction. This target may exceed the 38 percent reduction required to achieve water quality standards as identified in Table 19.

4. Stormwater BMP Removal Efficiencies

Four stormwater BMPs (e.g. rainscaping) were selected based on their ability to reduce bacteria and other pollutants in the impaired streams:

- Bioretention
    - Swales
    - Native Soil Rain Gardens
- Pervious Pavements

Tables 29 and 30 contain information on pollutant and bacteria removal efficiencies for these BMPs.

Table 29. BMP Pollutant Removal Efficiencies

Best Management Practice	Percent Total Phosphorus	Percent Total Nitrogen	Percent Total Suspended Solids
Bioretention	50	60	80
Pervious Pavement	45	10	90
Vegetated Swale	25	20	65
Rain Garden	65	60	75

Sources for bioretention, pervious pavement (permeable pavement with underdrain), vegetated swale and rain garden removal efficiencies can be found in Table 20 of the 2012 Plan at
http://www.ewgateway.org/lowermeramec/lowermeramecwatershedplan-final.pdf –

Table 30. BMP Bacteria Removal Efficiency

Best Management Practice	Removal Fraction	
	E. coli	Fecal Coliform
Biofiltration*	0.75**	0.75
Permeable pavement	0.70	0.70
Swale	0.00	0.00

Minnesota Pollution Control Agency Estimator for TMDL Annual Reporting -
https://stormwater.pca.state.mn.us/index.php/Guidance_and_examples_for_using_the_MPCA_Estimator
*Biofiltration assumed to be same as bioretention (large properties and individual raingardens).
**A value of 0.50 means that the BMP removes half of the pollutant/bacteria. The values for infiltration BMPs is 0 because it is assumed that all pollutant/bacteria in infiltrated water is removed.

4.1 Bioretention

Bioretention is a depressed landscape feature which stores, filters, and infiltrates stormwater runoff. Bioretention is an effective BMP in areas already developed because it can be tucked into greenspace such as curb and cul-de-sac islands, streetscapes, and even planter boxes, and in parks it can be strategically located to capture stormwater from impervious surfaces.
Basic components important to most St. Louis area bioretention "cells" are native (or deep rooted) vegetation and organic soil that will drain well and provide growing media for plants. An ample supply of mulch to a bioretention cell along with native deep rooted plants will open heavy clay soil to improve drainage over time. Any bioretention feature should include an overflow structure to compensate for stormwater volumes exceeding the capacity of the bioretention cell.

Bioretention can include swales or rain gardens. Swales are shallow, grass or vegetated-covered channels designed to convey and slow down stormwater runoff and facilitate infiltration. A native soil rain garden is a small depression planted with native vegetation. It is designed to temporarily hold and soak in runoff from impervious surfaces (roads, roofs, and parking lots) and yards. A rain garden can be installed for an individual residence or government or commercial structures. For existing construction, the native soil garden offers a low-cost opportunity to capture and hold stormwater. Like stream buffers, the advantage of the native soil rain garden is that it improves efficiency over time, as plant roots continue to improve soil porosity. The proposed voluntary bioretention projects refer to native soil and native or deep rooted plants.

These projects can be sited in, or adjacent to, parking lots, near roads or buildings, or in residential yards and common ground areas, which would otherwise be conventionally landscaped.

4.2 Pervious Pavement

Pervious pavement is designed to allow water to drain through the surface and into the underlying soil or a stone reservoir. Pervious pavement includes porous asphalt and porous concrete as well as materials with void spaces for drainage such as porous pavers or interlocking grid materials. Pervious pavement is effective in parking lots, but not in areas that may experience erosion or flooding that deposits sediment in the pores of the pavement.

5. Load Reductions from Short-term Stormwater BMP Management Measures

5.1 Estimated Load Reductions from Rainscaping in Castlewood State Park

Demonstration rain garden projects are proposed for Castlewood State Park. Approximately 6,800 square feet of rain gardens would be installed at sites adjacent to the State Park office, one trailhead parking lot and the parking lots for the shelter/picnic areas. Table 31 below shows the estimated reduction associated with these raingardens.

Table 31. Castlewood State Park Demonstration Rain Gardens Estimated Reductions

Demonstration Rain Gardens Estimated Reductions			
Pollutant	**Baseline Loading (Pounds per Year)**	**Future Reduction (Pounds per Year)**	**Future Loading with BMPs (Pounds per Year)**
Phosphorus	1.4	0.7	0.7
Nitrogen	7.4	4.4	3.0
Total Suspended Solids	337.8	270.2	67.6
Bacteria	**Baseline Loading (Billion Colonies per Year)**	**Future Reduction (Billion Colonies per Year)**	**Future Loading with BMPs (Billion Colonies per Year)**
Fecal Coliform	119.3	89.5	29.8
E. coli	108.4	81.3	27.1

5.2 Estimated Load Reduction from Rainscaping on Private Property

A rainscaping cost-share program for privately owned lands has been proposed for the Kiefer Creek sub-watershed. The program would be focused on the installation of rainscaping on residential properties. A subdivision was identified as a critical area for rainscaping (see Element C) so the baseline load and estimated reduction of pollutant and bacteria was calculated for the 160 acre single family residential development. This subdivision contains 252 parcels with 34 impervious acres. It was assumed that 200 square foot raingardens would be installed on 60 percent of the parcels (30,200 square feet). Table 32 presents the estimated reductions associated with the raingardens.

Table 32. Kiefer Creek Estimated Pollutant Load Reduction with Rain Gardens in One Subdivision

Example Subdivision Rain Gardens Estimated Reductions			
Pollutant	**Baseline Loading (Pounds per Year)**	**Future Reduction (Pounds per Year)**	**Future Loading with BMPs (Pounds per Year)**
Phosphorus	33.2	13	20.2
Nitrogen	182.8	65.7	117.1
Total Suspended Solids	8,308.7	3,732.1	4,576.6
Bacteria	**Baseline Loading (Billion Colonies per Year)**	**Future Reduction (Billion Colonies per Year)**	**Future Loading with BMPs (Billion Colonies per Year)**
Fecal Coliform	2,934.7	1,315	1,619
E. coli	2,667	1,198	1,469

6. Load Reductions from Long-term Implementation of Stormwater BMPs

Table 33. BMP Package

Land Use	BMP
Commercial	Bioretention (for 90 percent of impervious acreage) Pervious Pavement (for 10 percent of impervious acreage)
Industrial	Bioretention
Institutional	Bioretention
Multi-Family Residential	Vegetated Swales
Single-Family Residential	Rain Gardens
All land uses	Naturalized Stream Buffer
Roads	Vegetated Swales

In years 5-10, the widespread installation of stormwater BMPs in this sub-watershed will be encouraged by the cost share program to reduce the volume of runoff, reduce potential for streambank erosion and reduce pollutant and bacteria loading. Depending on the type of land use, BMPs will be implemented by individual homeowners, homeowner associations, private businesses, local governments or school districts. The BMP selection will require an analysis and evaluation of cost, funding sources, operation and management requirements, environmental evaluation and BMP siting and construction requirements. The full extent of BMP implementation in years 5-10 will be dependent upon the success of the demonstration BMP projects planned in years 1-5.

The full suite of BMPs will enable a reduction in average volume of stormwater runoff to local streams, and these practices will help to reduce general nonpoint pollutant load.
The design goals for the selected BMP demonstration projects are as follows:

1. Implement the selected BMP's in the locations identified in Element C. The BMPs installed on public lands will maximize speed of installation, and expand opportunities for educational and public outreach opportunities.
2. The performance goal of the various BMP installations will be capturing and treating stormwater runoff from 90 percent of the recorded daily rainfall events, which is based on a rainfall amount of 1.14 inches of rain during a typical storm event.
3. Monitor the reduction in peak flow rates in relation to rainfall events, overall volume reduction due to plant uptake and infiltration. Also, document the effectiveness of filtering at least one organic pollutant.

4. Use the BMP demonstration results to build public awareness of the cost-effectiveness of bio-retentive BMPs and their applicability to local building and sanitation codes.

In years 10-20, the BMP package will eventually be implemented on 60 percent of the existing and planned commercial, industrial, institutional, multi-family residential and single-family residential impervious acreage in the sub-watershed. For roads, the assumption will be 20 percent of the impervious surface acreage. Element C outlines the initial projects that have been identified as ways to encourage land managers to meet the goal of having BMPs installed on 5 percent of impervious acreage. This will increase to 10 percent by year 10, 30 percent by year 15 and 60 percent by year 20. Such an aggressive implementation percentage will be dependent upon significant "buy-in" by local governments and developers as well as private land owners. New development and redevelopment is already being addressed by permitting, so the focus of this plan is centered on the voluntary efforts that must also take place. Table 34 presents the estimated BMP load reductions in five-year increments for the Kiefer Creek sub-watershed. Based on the calculated load reductions by land use impacting the impaired streams, if BMPs are implemented across 60 percent of impervious acreage within each sub-watershed, then water quality standards will be met after 20 years. The Simple Method was used to calculate the estimated load reduction.

Table 34. Kiefer Creek Sub-watershed Estimated BMP Load Reduction over Time

Kiefer Creek Sub-watershed	Annual Pollutant Loading (lbs/year)				
Pollutant	**Baseline Loading**	**End of Year 5 5% Impervious Acreage Affected By BMP Suite**	**End of Year 10 15% Impervious Acreage Affected By BMP Suite**	**End of Year 15 35% Impervious Acreage Affected By BMP Suite**	**End of Year 20 60% Impervious Acreage Affected By BMP Suite**
Phosphorus	1,529.6	1,499.5	1,448.5	1,355.6	1,241.8
Nitrogen	9,499.5	9,325.5	9,023.1	8,462.0	7,771.1
Total Suspended Solids	417,528.9	424,944.2	401,394.6	361,530.1	313,410.0
Bacteria	**Baseline Loading**	**Annual Billion Colonies**			
		End of Year 5 5% Impervious Acreage Affected By BMP Suite	**End of Year 10 15% Impervious Acreage Affected By BMP Suite**	**End of Year 15 35% Impervious Acreage Affected By BMP Suite**	**End of Year 20 60% Impervious Acreage Affected By BMP Suite**
Fecal Coliform	82,229.1	78,810.2	72,545.6	60,586.5	45,778.9
E. coli	73,322.4	70,279.7	64,669.2	53,920.5	40,602.0

Element C: Descriptions of the NPS Management Measures that will need to be implemented to Reach Load Reductions and Identification of the Critical Areas in which to implement those Measures

1. Water Quality Goal

Based on pollutant loading modelling and load reduction curves contained in Element B (see Table 20), the water quality goal for Kiefer Creek watershed is to:

Reduce Bacteria loading in Kiefer Creek by 38.8 percent to meet water quality standards by 2038

2. Management Measures and Project Descriptions to Achieve Water Quality Goal

Four non-point source management measures are proposed in key critical areas to address the sources of impairment in Kiefer Creek and result in the attainment of water quality standards

Management Measure 1: Restore the Riparian Corridor of Kiefer Creek to Enhance its Ecological Functions Associated with Reducing Sediment Loads and Filtering Pollutants.

Kiefer Creek flows through Castlewood State Park, which experienced 750,000 visitors in 2015. The creek is an attractive area for families to wade and play in the water during the summer. Although protected as a state park since the 1980s, the creek has experienced excessive streambank erosion and sedimentation that will continue unless actively stabilized and restored. Pet and wildlife waste can be filtered through a healthy riparian buffer. The buffer can reduce the amount of nonpoint source pollution entering waterbodies, enhance stream bank stability, reduce erosion, and provide aquatic and wildlife habitat. A buffer can also help slow runoff velocity from impervious surfaces and trap and filter out sediments and bacteria. The impaired section of Kiefer Creek also coincides with an eroded and degraded riparian buffer and stream channel in Castlewood State Park. A section of Kiefer Creek in Castlewood State Park has been identified as a critical area to stabilize the stream channel in order to improve buffer conditions and the ability to filter pollutants (see Map 13). Stream channel stabilization and riparian buffer restoration at this location will filter out bacteria and slow polluted water containing pet or wildlife waste from entering the stream where people swim and recreate as trees, shrubs and grasses grow and extend roots more deeply into the soil.

Solution 1.1: Stabilize Kiefer Creek streambank to facilitate riparian corridor filtration of pollutants

Project description - Kiefer Creek Stream Channel Stabilization & Buffer Improvement

The Nature Conservancy (TNC) has proposed to stabilize Kiefer Creek streambank and undertake riparian restoration in the lower section of Kiefer Creek in Castlewood State Park.[49]

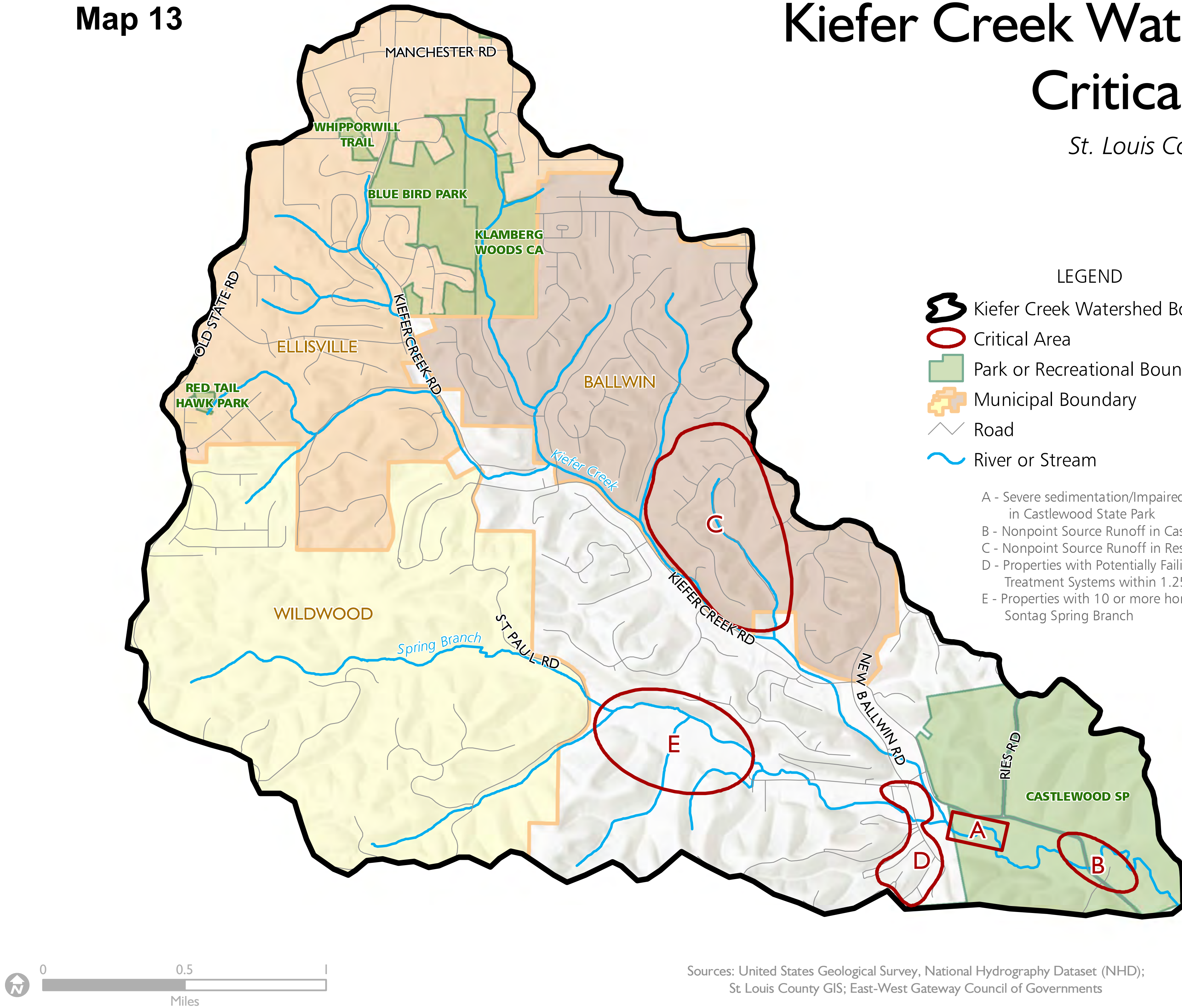
[49] A full project design plan can be found at https://tnc.app.box.com/s/e26gbr8fldzcbb1n01t0wqhctv0q7mcf

Map 13

Kiefer Creek Watershed Critical Areas

St. Louis County, Missouri

September 2017



LEGEND

- Kiefer Creek Watershed Boundary
- Critical Area
- Park or Recreational Boundary
- Municipal Boundary
- Road
- River or Stream

A - Severe sedimentation/Impaired Section of Stream in Castlewood State Park
B - Nonpoint Source Runoff in Castlewood State Park
C - Nonpoint Source Runoff in Residential Area
D - Properties with Potentially Failing On-site Wastewater Treatment Systems within 1.25 miles of Kiefer Creek
E - Properties with 10 or more horses within 400 feet of Sontag Spring Branch

Sources: United States Geological Survey, National Hydrography Dataset (NHD); St Louis County GIS; East-West Gateway Council of Governments

East-West Gateway Council of Governments

This section is classified as impaired and identified as a critical area to improve riparian filtration of bacteria. The restoration objectives are: to reduce sedimentation by stabilizing streambanks using bioengineering; increase in-stream aquatic habitat; and improve the riparian corridor by invasive species management, planting native species, and increasing the riparian width of the stream. The stabilization of the channel will enable restoration of a healthy forested buffer zone along the creek, and the shaded buffer will help reduce bacteria, because stream temperatures will be lower. The buffer will also help to capture and filter pollutants, especially in high water conditions, which is when bacteria counts increase. The channel restoration will also improve aquatic habitat. This natural stream channel design project is a centerpiece for education and community engagement on water quality and stream health both for the Kiefer Creek watershed, and as a demonstration and model for on-the-ground work and education efforts in the entire Lower Meramec River Basin.

Management Measure 2: Expand the use of Rainscaping BMPs throughout the Kiefer Creek Watershed to Treat Stormwater at its Source.

Projects on public and private property that are beyond MS4 permit requirements can serve to reduce stormwater runoff and demonstrate the practices for the many visitors to the parks and residents of subdivisions.

Solution 2.1: Implement Demonstration Rainscaping Projects on Public Property

Project Description: Rainscaping Projects to Capture Stormwater from Parking Lots and Roads in Castlewood State Park

Based on the location of the impaired section of Kiefer Creek, high resolution land cover data, aerial photography and MSD stormwater drainage data identified impervious surfaces that may be contributing sources of polluted runoff from pet and wildlife waste to Kiefer Creek. Through this analysis, critical areas for rainscaping on public property near the impaired section of Kiefer Creek in Castlewood State Park were identified (see Map 13). Approximately 6,800 square feet of rain gardens are to be installed at sites adjacent to the State Park office, one trailhead parking lot and the parking lots for the shelter/picnic areas. Rain garden projects will be implemented by the partnership, and will also include expanding the riparian buffer zone in the center of the park.

Solution 2.2: Implement a Private Lands Rainscaping Cost-Share Program.

Project description: Kiefer Creek Watershed Rainscaping Cost-Share Program

Lower Meramec watershed plan partners will develop a rainscaping cost-share program to support homeowners in the Kiefer Creek watershed. Native soil raingardens can reduce runoff, capture rainwater, and improve water quality Based on the location of the impaired section of Kiefer Creek, high resolution land cover data, aerial photography and MSD stormwater drainage data, impervious surfaces were identified that may be contributing sources of polluted runoff from wildlife and pet waste to Kiefer Creek. Through this analysis, a stormwater outfall from a piped stream that conveys stormwater from a large subdivision was identified as a critical area for rainscaping to achieve significant reduction in contaminated runoff (see Map 13). The subdivision is a160 acre single family residential development. It contains 252 parcels with 34 impervious acres. It was assumed that 200 square foot raingardens would be installed on 60 percent of the parcels for a total of 30,200 square feet. Sign-up for the cost-share program will be conducted via the Clear Choices Clean Water platform for Kiefer Creek. Parcels that have applied for the program and that have been approved for the program can be placed on an interactive map.[50]

Management Measure 3: Mitigate On-site Wastewater Treatment System Discharges

Parcel area, age and grass area are key factors in a failing on-site wastewater treatment system. Those parcels with a ranking of 9 or 10 in Element A are targeted as critical areas to do further on-site wastewater treatment system investigation, remediation or replacement. The MCE draft Kiefer Creek Plan identified 80 likely on-site wastewater treatment systems on parcels that are less than 20,000 square feet, with 33 which are less than 10,000 square feet within 1.25 miles of the swimming area in Castlewood State Park. Those 33 parcels are the critical areas to focus on in a sewer connection feasibility study and educating homeowners about repair or replacement (see Map 13).

Solution 3.1: Upgrade, Repair, Replace or Connect On-site Wastewater Treatment Systems Though Resident Education and Cost-Share Assistance

Project description: Develop and Implement Individual On-site Wastewater treatment system, Connection, Maintenance or Replacement Cost-Share Program

Encouraging homeowners to take action to repair, replace or connect their systems to the public sewer lines can be facilitated by a cost-share program, or if necessary by stronger enforcement of St. Louis County Department of Public Health regulations. An outreach strategy and informational materials on maintenance considerations for on-site wastewater treatment systems will be developed and a database created of owners of parcels which are not currently connected to MSD. To specifically engage homeowners in the cost-share program, *Clear Choices Clear Water* will be used to encourage people to take a pledge related to their septic system. After taking a *Clear Choices, Clean Water* pledge, they receive feedback about how much pollution they have prevented from entering Kiefer Creek. They get to see their location on an interactive map – providing further confirmation that they are doing their part. They also get an easy, low-pressure way to encourage their friends, family, and neighbors to do their part by way of email invitations or Facebook and Twitter feeds.

The goal is to achieve a minimum of 20 properties either connected to sewer or with an improved on-site wastewater treatment system by Year 5 and a total of 130 homes with failing on-site wastewater treatment systems in full compliance by Year 20.[51] The ability to determine which properties could be feasibly connected to public sewer lines will be determined through a sewer connection feasibility study undertaken by EWG in cooperation with MSD through funding under section 604(b) of the Clean Water Act. Property owners interested in connecting to MSD where economically and physically feasible, technical assistance will be made available as well as information on sources of financial assistance. It would be the responsibility of property owner(s) to construct sewer laterals and connect to MSD or construct a collection system and turn it over to MSD.

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[50] See Solution 2.1 in Element E for more information on Clear Choices Clean Water project description.

[51] See Element F for full implementation schedule.

Management Measure 4: Reduce Runoff from Agricultural Property

Critical areas to focus project implementation for manure management practices are the parcels with the largest number of horses identified in the MCE draft Kiefer Creek Plan and are closest to the Sontag Spring Branch of Kiefer Creek, (see Map 13). These parcels are likely to be producing more pounds of manure and have less healthy pastures as identified through interviews in the MCE draft Kiefer Creek plan. Furthermore, these parcels are located in the Sontag Spring Branch sub-watershed which enters the portion of Kiefer Creek that has been classified as impaired. Smaller parcels can be eligible for cost-share assistance. The land upon which the cooperator intends to install an eligible practice through program assistance must be located within a Missouri soil and water conservation district. In order to be eligible for cost-share, the land must have an FSA farm number. A cooperator must either have agricultural activity on three acres or more, or may own land of any size if $1,000 or more of agriculture products are normally produced and sold in a year. Funding for agricultural cost-share programs will be sought for those practices over and above, or not supported by the Natural Resource Conservation Service (NRCS) or State cost-share programs.

Solution 4.1: Encourage Agricultural Best Management Practices (BMPs) to Manage Animal Waste in Kiefer Creek Watershed.

Project description: Work with Local Horse Stables on Manure Management Education
Through a cooperative effort with the St. Louis County SWCD, partners will engage with parcels where horses are stabled about manure management education through implementation of Comprehensive Nutrient Management Plans (CNMP), Nutrient Management Plans (NMPs) and the use of BMPs to reduce animal waste entering the stream. The NMP is a farm-specific document designed to help farmers minimize nutrient runoff into local streams and rivers within a watershed. NMP's keep track of the amount, time, and application of manure on a farm. NMP's can also work to balance farm profits by implementing cost-effective alternatives to fertilizer management. A CNMP provides storage and destination ideas for managing manure produced within a farm. To accommodate specific needs of a NMP or CNMP a horse owner should consult with the Natural Resources Conservation Service (NRCS) or SWCD. In order to utilize the services of the NRCS in composing a NMP or CNMP, a horse owner must first register with the USDA Farm Service Agency as a farm. Keeping, raising and stabling horses is considered an agricultural practice. Many of the horse owners in the Kiefer Creek watershed are probably unaware of the benefits of a NMP or CNMP and the support offered through the NRCS and the SWCD.

BMPs include improved manure storage, composting horse manure, and installing grazing systems. Often times it may be the case that the location of manure piles and the design of storage area have not been considered in terms of reducing runoff to the stream. Ideally a manure pile will be located as far from the nearest stream channel or flow path as is possible on a given lot. In addition it is recommended that the location of the pile be graded to drain inwards and that the pile be covered by a roof or a weighted tarp to prevent any runoff.
When properly treated, horse manure is a valuable commodity for replenishing and fertilizing depleted soil, and it is wasteful and harmful to let it wash into Kiefer Creek. If properly composted, the manure from the horses in the Kiefer Creek watershed could be put to good use rebuilding the watershed soils that were depleted in the course of development and deforestation.

Grazing management is another practice that distributes manure throughout pastures for best uptake by vegetation. The potential for bacteria from manure to enter the stream channel can be further reduced by cleaning up manure in areas with high slopes, riparian buffer zones, and in areas where there isn't a healthy vegetative land cover. Targeted area cleanup could be expedited by placing manure composters in multiple locations.

Clear Choices Clean Water[52] contains a Soil Health Program that can be customized for horse property owners and manure management practices. All horse operations who pledge to develop nutrient management plans or other BMPs identified in CCCW will receive fence signage, tack medallions and other materials as well as information on the impacts their practices are making. An interactive map displays who is pledging to encourage uptake by other horse property owners.

[52] Refer to Element E for full project description of *Clear Choices Clean Water*

Element D: Estimate of the Amounts of Financial Assistance and the Sources and Authorities that will be relied upon for Each Project.

Table 35 lists the estimated costs associated with each project described in Elements C and E, the agencies, organizations and/or groups involved, and the amount of funding sought. Sources for the costs estimates for rainscaping practices can be found in Table 21 in the 2012 Lower Meramec Watershed Plan. Other sources of available funding through grants or loans are found in Table 36.

Table 35. Estimated Project Costs for Kiefer Creek

Project Description	Project Costs	Partner Contribution	Funding Sought
Kiefer Creek streambank stabilization and buffer improvement	Phase 1: 375 feet of stream construction Observation: $22,497.00 Construction Total: $85,391.00 Contingency: $21,347.75 Total:$129,235.75	TNC $150,000 Other match is still TBD	42% or $300,000 in Year 1
	Phase 2: 3190 feet of stream construction Observation: $51,289.00 Construction Total: $420,588.17 Contingency: $$105,147.04 Total: $577,024.21		
	Total: $706,259.96		
Demonstration rainscaping projects in Castlewood State Park	Average cost for raingarden is $10 per square foot for design and installation	MO State Parks – providing equipment Open Space Council – providing labor for installation 40% of total cost or $27,200	60% $9,600 in Years 2-3 $31,200 in Years 4- 6 Total amount sought $40,800
	1,600 sq. ft. of rain gardens in Year 2-3		
	5,200 sq. ft. of rain gardens in Year 4-6		
	Total cost $68,000		
Kiefer Creek Watershed	Average cost of raingarden is $10 per sq. ft. for design and installation	40% contributed by residents cost share and	60% $36,000 in Years 4-6

Project Description	Project Costs	Partner Contribution	Funding Sought
Rainscaping Cost Share Program	6,000 sq. ft. in Years 4 -6 $60,000	MDC cost share towards design and plants[53] $120,800	$145,200 in Years 6-20 Total amount sought $181,200
	24,200 sq. ft. in Years 6- 20 $242,000		
	Total cost of $302,000		
Develop and Implement Individual On-site Wastewater Treatment System Connection, Maintenance or Replacement Cost Share Program	Costs range from $300 for a simple pump-out to $25,000 per property for a new system	40% contributed by Property owner cost share	60% For 33 systems costs range from $5,940 to $495,000 depending on whether repairing, replacing or connecting to sewer line For all 130 systems costs range from $23,400 to $1,950,000
	Costs to connect homes to sewer lines range from $10,000-$30,000 per property. The number of homes to be connected is dependent on recommendations in the study.		
	33 systems have been identified as critical areas nearest Kiefer Creek to address either by repair, replacement or connection to sewer lines. Costs could range from $9,900 to repair 33 systems to $825,000 to replace or connect.		
	Costs range from $39,000 to repair all 130 systems to $3,250,000 to replace or connect all systems.		
Work with Local Horse property owners on Manure Management Education	Average cost of $1500 per farm for comprehensive nutrient management plans[54]	40% provided by: SWCD NRCS Horse property owners cost share $12,600	60% Year 1- 3 $1800 Year 4-5 $1800 Year 6-20 $15,300 Total: $18,900
	4 horse property owners by end of Year 5 for a cost of $6,000		
	17 additional horse property owners by Year 20 for a cost of $25,500		
	Total cost = $31,500		
Expand Operation Clean Stream from main	$10,000 is required for volunteer coordination, event liability insurance, signage and supplies	40% or $4,000 provided by Open Space Council Missouri Stream Team	60% or $6,000

[53] Refer to Table 35 for more information about MDC private land cost-share assistance as well as Appendix D
[54] https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_012131.pdf

Project Description	Project Costs	Partner Contribution	Funding Sought
stem of Meramec River to Kiefer Creek.			
Clear Choices Clean Water Pilot in Kiefer Creek Watershed	Software License: 4 years. $16,300 Municipal Mapping GIS: $500 Private Septic Mapping GIS: $500 Private Septic Pledge Collateral: $1,000 Pet Waste Pledge Collateral: $1,000 Lawn Fertilizer Pledge Collateral: $500 Volunteer Service Pledge Collateral $500 Native Plants and Gardens Pledge Collateral $500 Marketing and Signage: $25,000 MS&T Biological Sciences: $3,000 America's Confluence overhead: $10,000 Total cost for 4 years: $58,000	40% $23,200 provided by America's Confluence	60% or $34,800
Technical Workshop on Channel Stabilization and Buffer Improvement for Local Governments	$7000 for contractor to present at workshop $300 for room rental $375 for refreshments $2,927 for personnel $1,590 for overhead $1800 for advertisement and registration Total Cost: $13,992	45% TNC Personnel Match: $2927 TNC 15% overhead Match: $1590 East West Gateway Council of Governments Match: $1800	55% or $7675
Install Signage along Walking Trail in Kiefer Creek Watershed about Stabilization Project for Park Visitors	Personnel: $2796 Overhead: $1169 Design and production: $5000 Installation: $6500 Total Cost: $15,465	68% TNC Personnel Match: $2796 TNC 15% overhead Match: $1169 Castlewood State Park Match: $6500	32% or $5000
Homeowner education through	$14,500 for SLU to conduct residential surveys and outreach $2320 for the handout design and printing for homeowners and park visitors	40% or $12,218 TNC Personnel Match: $5560 TNC 15% overhead Match: $3983	60% or $18,230 To cover residential surveys, design and

Project Description	Project Costs	Partner Contribution	Funding Sought
interviews with residents in Kiefer Creek	Personnel: $9735 Overhead: $3983 Project Cost with overhead: $30,538	DNR Watershed Coordinator Match: $2675	printing and partial personnel costs
Citizen science volunteer training	$170 for supplies above and beyond what is supplied by Missouri Volunteer Water Quality Monitoring Program $1840 TNC Personnel Overhead: $544 Total Cost: $4169	15% TNC 15% overhead match: $544	85% or $3,625
Long-term water quality monitoring strategy	**Year 1** $116,674 **Year 2** $148,183 **Year 3** $125,066 **Year 4** $88,861 **Year 5** $139,307 Refer to Appendix E for costs for Years 6-20	**MSD match** **Year 1** $19,600; **Year 2** $19,992; **Year 3** $20,392; **Year 4** $20,800; **Year 5** $21,216 **Stream team in-kind** **Year 1** $6,886; **Year 2** $7,024; **Year 3** $16,509; **Year 4** $11,951; **Year 5** $11,981 **USGS Match** **Year 1** $20,200; **Year 2** $32,300; **Year 3** $13,126 **Total match** **Year 1** $46,686; **Year 2** $59,316; **Year 3** $50,026; **Year 4** $32,750; **Year 5** $33,196	Year 1 $69,998 Year 2 $88,867 Year 3 $75,040 Year 4 $56,111 Year 5 $106,111

Table 36. Grants and Funding Opportunities

Grant Program Sponsoring Agency	General Information	Eligibility	Level of Assistance	Website
North American Wetland Conservation Act – U.S. Standard Grants Program U.S. Fish and Wildlife Service	Program that supports public-private partnerships carrying out projects in U.S. Projects must Involve long-term protection, Restoration and/or enhancements of wetlands and associated uplands habitats.		50% matching funds required. Grants start at $100,000	www.fws.gov/birdhabitat/grants
Planning Assistance to States U.S. Army Corps of Engineers	Provides assistance with the development of comprehensive plans for the development and conservation of land and water resources. Cover planning level of detail.	States, local governments and other non-federal entities. Non-profits are not eligible but could partner with state or local governments.	Limit for each state is $500,000 Annually. Cost Share is 50-50. Generally studies range from $25,000-$75,000.	www2.mvn.usace.army.mil/pd/pppmd_assistance_states.asp
Environmental Education Grants U.S. Environmental Protection Agency	EPA's Office of Environmental Education, Office of External Affairs and Environmental Education supports environmental education projects that enhance the public's awareness, knowledge and skills to help people make informed decisions that affect environmental quality. Grants are awarded based on funding appropriated by Congress.	Applicant must represent one of the following types of organization to be eligible: local education agency; state education or environmental agency; college or university; non-profit organization 501(c) (3), noncommercial educational broadcasting entity; or tribal education agency	Annual funding for this program ranges between $2 and $3 million range. Non-federal matching funds of at least 25% are required.	www2.epa.gov/education/environmental-education-ee-grants
Watershed Management Plan Development Grant - U.S. Environmental Protection Agency administered through Missouri Department of Natural Resources	Provides funding for development of watershed-based management plans to restore watersheds impaired by non-point source pollution. Due to funding limitations and a new approach, the general solicitation schedule for watershed Planning has been discontinued.	Eligible organizations include state and local agencies, educational institutions and Non-profits organizations with demonstrated 501 (c) (3) status.		www.dnr.mo.gov/env/wpp/nps

Grant Program Sponsoring Agency	General Information	Eligibility	Level of Assistance	Website
Section 319 Nonpoint Source Grant Program U.S. Environmental Protection Agency administered through Missouri Department of Natural Resources	NPS source grant funds are provided from EPA through Section 319(h) of Clean Water Act. Funds can be used to implementing Best Management Practices and associated activities as detailed in their watershed management plan. Annual announcement on availability of funds. Amount of funding is dependent upon number of applications received.	Eligible organizations include state and local agencies, educational institutions and non-profits organizations with demonstrated 501 (c) (3) status.	Variable award amounts will be based on number of applicants, amount of funding available at time of request. Matching support: 60% federal and 40% non-federal (cash or eligible in-kind contribution)	www.dnr.mo.gov/env/swcp/nps
Targeted Watershed Grants Program U.S. Environmental Protection Agency	Program is designed to encourage successful community-based approaches and management techniques to protect and restore the nation's waterways. It is a competitive program. Program focuses on multi-faceted plans for protecting and restoring water resources that are developed using partnership efforts of diverse stakeholders. Implementation grants support on-the-ground watershed projects and Capacity Building grants are awarded to leading organizations with a national or regional focus that are able to provide training, technical assistance and education to local watershed groups. Check with EPA for next proposal cycle.	Eligible organizations include State and local governments, public and private non-profit institutions/organizations, federally recognized Indian tribal governments, U.S. territories or possessions and interstate agencies. For profit commercial entities and all federal agencies are ineligible.	Applicants are required to demonstrate a minimum non-federal match of at least 25% of total project cost. Funding could range from $400,000 to $900.000.	Http://water.epa.gov/grants_funding/twg/initiative_index.cfm
Private Services Landowner Assistance Program Missouri Department of Conservation	Financial assistance is offered to communities interested in habitat and natural recourse management every year	Nonprofits, city/county units of government and non-government entities are eligible to apply	Assistance is available on July 1 each year. All applicable projects are subject to reimbursement caps per cooperator year. Most projects will be reimbursed at a rate of 50 percent of total costs up to a	For additional information regarding landowner assistance and project eligibility, please contact Josh Ward, Private Land Conservationist at: 636-441-4554 or Josh.Ward@mdc.mo.gov

Grant Program Sponsoring Agency	General Information	Eligibility	Level of Assistance	Website
			maximum limit, some restrictions apply.	
Clean Water Act Section 604(b) federal grant funds administered by the U.S. Environmental Protection Agency through the Department of Natural Resources	The Water Protection Program components under the Clean Water Act Section 604(b) federal grant, are intended to assist with the revision of Water Quality Standards, risk-based groundwater standards, the anti-degradation policy and implementation method, toxicity testing, area-wide wastewater management prioritization, including planning studies and, wastewater feasibility studies. A portion of the 604(b) federal grant is awarded to Missouri communities for water quality planning.	Communities are invited to submit their competitive project proposals through their Regional Planning Commissions and the Missouri Councils of Governments for funding. The water quality management funds could be used for activities such as: watershed management plans, urban stormwater management plans, and stormwater planning. Applicants were especially encouraged to give priority to watershed management planning in urban watersheds or sensitive watershed threatened by development, along with green infrastructure, water or energy improvements related to water quality, or other environmentally innovative planning activities.	Missouri's share of the 604(b) Recovery Act Funding is $1,097,400 million. The Clean Water Act Amendments required states to pass through 40 percent of the 604(b) funds to regional public comprehensive planning organizations.	https://energy.mo.gov/division-of-energy/transform/water-quality-planning-and-management---604(b)
State Revolving Fund (SRF) Loan Program Missouri Department of Natural Resources	The State Revolving Loan Program provides low-interest loans to Missouri communities for projects that improve wastewater and drinking water infrastructure. The Missouri Department of Natural Resources and the Environmental Improvement and Energy Resource Authority work together to administer this program and to protect public health and the environment. The SRF has implemented an agriculture loan program, in cooperation with the Missouri Agriculture and Small Business Development Authority, to fund certain nonpoint source projects, and has recently set aside funding for new initiatives to	Cities, towns, counties, regional sewer/water districts, water authorities and instrumentalities of the state are eligible for wastewater, drinking water and nonpoint source SRF loans. Private and nonprofit facilities are eligible for drinking water and nonpoint source loans. Individuals and citizen groups are also eligible for nonpoint source loans.	Missouri applies to the U.S. Environmental Protection Agency (EPA) annually for capitalization grants to fund its SRF Programs. To increase available funds, the state leverages its EPA capitalization grants in the municipal bond market. These funds are combined with the EPA required state match and then	https://dnr.mo.gov/env/wpp

Grant Program Sponsoring Agency	General Information	Eligibility	Level of Assistance	Website
	fund on-site wastewater treatment projects.		made available to Missouri communities in the form of low interest loans. As the loans are repaid, the money is reused (revolved) by the SRF to provide for future projects. The SRF is a fixed rate, 20-year loan. Interest rates are generally 30 percent of the market rate.	

Element E: Education Component used to Enhance Public Understanding and Encourage Continued Participation

1. Importance of Education

The Kiefer Creek watershed has approximately 3,220 suburban single-family households which constitutes 53 percent of its land-use, thus the small size of this watershed means residential decision-making about property management could have a significant impact on the quality of water within the stream. Educating residents and visitors to the watershed will help to increase public awareness of water quality issues and ways individuals can act to improve and protect water quality in the Kiefer Creek watershed.

2. Management Measures to Enhance Public Understanding and Encourage Continued Participation in Water Quality Projects

Three management measures have been proposed as an education component to enhance public understanding of the projects proposed in Element C and to encourage continued participation in those projects. This section describes the projects associated with each management measure.

Management Measure 1: Engage Public in Positive Action to Improve Stream Buffers

Solution 1.1: Engage Citizens in Volunteer River Clean up and Riparian Buffer Improvements

Project description - Expand Operation Clean Stream from main stem of Meramec River into Kiefer Creek

Open Space Council plans several river trash removal projects under their program called Operation Clean Stream to improve water quality and access to the river, while also motivating more people to become involved in watershed protection. Each year Operation Stream Clean involves over 2,000 volunteers in river and stream clean-ups in the Lower Meramec watershed. In 2016, over 1,632 citizen volunteers cleaned up nearly 500 miles of waterway in the Meramec River watershed. Volunteers donated 4,900 hours and pulled 1,904 tires, 12,518 pounds of metal and 355.35 cubic yards of trash from the river. This effort has become a popular tradition and much of the outreach is done through word of mouth, Facebook and reaching out to existing stream teams. The EPA has recognized the role trash plays in contributing to water quality problems.[55] Open Space Council seeks to expand their clean-up activities to include Kiefer Creek to recruit volunteers in the watershed and provide education about water quality for residents in the watershed. The Open Space Council will start outreach efforts in order to engage Kiefer Creek residents in stream clean-up activities. This process will involve new volunteers signing up for monthly newsletters containing opportunities to get involved and encourage registration. *Clear Choices Clean Water*[56] also contains a volunteer services module to help people take a pledge do volunteer work and can connect pledgers to Operation Stream Clean activities.

[55] https://www.epa.gov/trash-free-waters/clean-water-act-and-trash-free-waters

[56] See Solution 2.1 below

Management Measure 2: Provide Education Resources to Citizens in the Kiefer Creek Watershed to Affect Behavior Change on Private Property

Solution 2.1: Use social media and web-based platforms to affect behavior change in the Kiefer Creek Watershed

Project description - Clear Choices Clean Water Pilot in Kiefer Creek Watershed
Clear Choices Clean Water (CCCW) is a social marketing initiative that increases public awareness about the choices we make and the impacts those choices have on our lakes, streams, and groundwater. The ultimate vision for the initiative is to change people's behavior while implementing a program that easily allows for the evaluation of educational successes and environmental impacts at the same time. Clear Choices, as it was first developed for the Central Indiana region, has several topical, action-oriented campaigns underway (lawn fertilizer, pet waste, native plantings, septic system maintenance, water conservation, and volunteer service, as well as the new 2016 kids pledge and soil health campaign). More pledge modules are in development with new partners, including a Pollinator Protection pledge and a Forest Stewardship pledge. A vast potential exists for topics to be added to the platform such as agricultural BMPs and horse manure management. This flexibility provides for a dynamic outreach program that can grow over time or be changed seasonally or regionally to focus on 'hot topics'. This project proposes America's Confluence to become an affiliate and administer and choose which pledge campaigns to include in the program based on the management measures in this plan.

The focal point of the initiative is a modern, interactive website that includes several additional multimedia and grassroots marketing elements. Visit Indiana's site as an example (Indiana.clearchoicescleanwater.org). Individuals who take the action pledge are immediately "put on the map." The map provides immediate feedback and gratification for the participant that they are doing their part to make a difference. It helps people visualize how their pledge of action, alongside thousands of other pledges, will impact water quality in their watershed. For the program administrators and Affiliates, the map also provides real-time evaluation of the success of the campaign. In addition to map recognition, the feedback participants receive includes an estimate of water quality improvements (e.g. decrease in algae or bacteria in a nearby stream, lake, or river) or an estimate of water saved based upon their "clear choice" behavior pledge. They also have the opportunity to invite others via social media or email to join them in making a difference. Follow-up emails and reminders are sent to participants following their pledge using automated email responders, thus limiting the burden on the program's administrators to maintain communication with participants. According to social marketing research, in order to change behaviors, individuals need to feel like their actions matter and are socially acceptable, encouraged, and positively recognized. They need to be empowered to act. The Clear Choices program does this by providing information, access to materials, and 'how to' instructions. The Clear Choices initiative breaks down knowledge and resource barriers while providing an opportunity for everyone to do something and make their mark on the watershed map. Reaching people with messages about simple behavior changes not only improves water quality by cumulative impact, but begins to incubate a culture of stewardship that transcends the family, business, or classroom. While the program was developed for Indiana, it is applicable to other states and regions and has been successfully launched in other watersheds.

This project proposes Kiefer Creek watershed to have its own site, complete with localized resources and mapping features and administered by America's Confluence. Refer to Appendix C for more detailed information about CCCW and how to license the program.

Solution 2.2: Provide Technical Assistance to Local Governments and Educational Opportunities to the Public

Project description - Technical workshop on channel stabilization and buffer improvement for local governments based on Kiefer Creek experience
As the Kiefer Creek Stream Channel Restoration is completed, TNC and EWG will work with the engineering firm contracted to complete the restoration to provide professional on-site training on science and application of natural stream restoration using bioengineering to protect roads, bridges and other infrastructure. A workshop for at least 25 participants from local governments and consultants who serve local governments in the region, will address best practices and solutions. Current practices throughout the region use traditional hard armoring (e.g., riprap) to reduce streambank erosion; unfortunately, those techniques are commonly expensive, prone to failure, are aesthetically unattractive, and often have minimal ecological benefits to stream habitat and water quality. This site is well located to engage municipal public works officials, engineers, consultants, construction contractors, and state and federal agency staff to learn from stream restoration experts (contracted by TNC for this project) on innovative bioengineering techniques that provide natural habitat while providing stabilization and reduction of erosion and related NPS pollutant loadings to the stream. Such natural stream restoration practices are effective in protecting infrastructure, including sewers, roads and bridges, as well as reducing erosion that damages private property. In addition to the training, products will include a handout on the "why" and the "how" of best practices to share with professionals and stakeholders throughout the region.

Project description - Install signage along walking trail in Kiefer Creek watershed about stabilization project for park visitors
To explain the streambank stabilization project and why it is important for water quality and habitat, TNC and MoDNR State Parks will develop on-site signage for a visitor trail along the restored creek, create video of the construction process, provide website stories on TNC and partner websites, Facebook and public television stories, and prepare information handouts for park visitors, local stakeholders, and residents of the St. Louis metropolitan area.

Project description - Homeowner education through interviews with residents in Kiefer Creek
St. Louis University Center for Sustainability (SLU) will conduct homeowner outreach and residential surveys reaching approximately 3,220 households and interview up to 40 residents. They will examine homeowner motivations and interests regarding the protection of water resources and associated habitats. This effort will inform outreach activities here and in other parts of the Meramec River Basin. To generate interest and participation, homeowners will be informed via mailing about the streambank stabilization project and why it is being done. To engage homeowners in ongoing water quality improvements, SLU will gather information about how they value the stream and related amenities; their understanding of urban stream characteristics; knowledge of water quality improvement efforts via stream bank restoration;

ideas they have for improving water quality on their properties; and desire to become involved in the restoration of Kiefer Creek, including the possible formation of a citizen advisory committee. Homeowner outreach is anticipated to set the stage for receptivity for future efforts to encourage homeowners to replace and maintain on-site wastewater treatment systems to address this primary source of bacterial contamination in Kiefer Creek.

Project description – Citizen Science volunteer training
TNC and MO Stream Team will train and support up to 25 Castlewood State Park Stream Team citizen science volunteers on how to rapidly assess and prioritize streambank erosion for NPS pollution reduction. Citizen scientists will monitor streambank erosion before and after the Kiefer Creek streambank stabilization project. For more information about the efforts described in Solution 2.2, see Appendix L, the TNC Five Star Urban Waters Restoration Project, Education Component.

Element F: Schedule for Implementing the NPS Management Measures

Element G: Description of Interim, Measurable Milestones

Element H: Criteria to Determine Whether Loading Reductions are being achieved over Time and Substantial Progress is being made toward Attaining Water Quality Standards

Table 37 contains the schedule for implementing the NPS management measures identified in Elements C and E; the interim, measurable milestones for determining that the projects listed in Elements C and E are being implemented; and a set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards. By tracking indicators/criteria and milestones, both qualitative and quantitative, adaptive management can take place. The most recent information can be used to make a course correction to a specific project or update the plan. Overtime, as practices and/or cost-share programs are implemented, the proposed USGS water quality monitoring plan (See Element I) will help to determine if progress is being made to meet the estimated load reductions in Column 5 of Table 37 as well as the overall water quality goal for bacteria for Kiefer Creek (see Table 20). The core partners will meet on an ongoing basis (at minimum twice a year) to evaluate the progress of implementation activities and achieving load reductions, and to identify any implementation problems. When any course corrections are to occur, the associated schedule and project focus will be revised to address issues noted.

Table 37. Schedule of Implementation for Kiefer Creek Projects

Timeframe	Project description	Indicator/criteria to determine progress	Measurable Milestone	Estimated load reduction
Years 1-3	Kiefer Creek Streambank Stabilization construction	# of linear feet of streambank constructed and stabilized	375 ft.	*E. coli* 1.51E+08 (counts/day) 0.7 percent reduction Phosphorous 0.14 (pounds/year) 0.4 percent reduction Nitrogen 0.9 (pounds/year 0.5 percent reduction Total Suspended Solids 54 (pounds/year) 0.6 percent reduction
	Design and installation of Rainscaping at Castlewood State park	# of square feet of rainscaping installed	1600 square feet	
	Develop residential application process and recruitment strategy for private property rainscaping cost-share program		Application instructions and form completed	
	Secure funding, develop residential application process for cost-share program, and conduct outreach to confirm interested homeowners who need connection, repair or replacement of on-site wastewater treatment systems	# of confirmed property owners with failing on-site wastewater treatment systems recruited to address system issues	10 property owners	
	Starting in year two, manure management information materials will be distributed. Commitments to implement manure management efforts will begin	# of horse property owners involved in developing a plan	2 horse property owners	
	Beginning in year one, Open Space Council will begin outreach efforts and register volunteers for Operation Stream Clean expansion into Kiefer Creek.	# of volunteers recruited for Kiefer Creek cleanup and riparian restoration event	30 Volunteers	
	Beginning in year two, Clear Choices Clean Water pledge-based NPS watershed social marketing program will begin, a combination of education with commitments/pledges to take action elements	% of pledges made by on-site wastewater treatment system owners % of pledges by pet owners % of pledges by horse property owners	30% of system owners 10% of horse property owners 20% of pet owners	
	Technical Workshop on Kiefer Creek Channel Stabilization and Buffer Improvement for Local Governments	# of participants in workshop and percentage who find it useful	Expected number of participants is up to 25. Of participants, 50-85% finding it useful and requesting additional information	

Timeframe	Project description	Indicator/criteria to determine progress	Measurable Milestone	Estimated load reduction
Years 1-3	Install Signage along Walking Trail in Kiefer Creek Sub-watershed about Stabilization	# of signs installed	3-5 signs	
	Homeowner Education through surveys and Interviews with Residents in Kiefer Creek Sub-watershed	Survey response rate and # of interviews conducted	3,220 surveys distributed. Response rate 35 – 65 percent. Up to 40 one-on-one interviews conducted	
	In Year 1, training of citizen science volunteers would take place and rapid streambank assessment would take place before the streambank stabilization project begins.	# of volunteers trained and # of assessments undertaken	25 citizen science trained 1 Rapid stream assessment completed	
	Water quality monitoring strategy	# of gages installed # of monitoring sites established and frequency of monitoring frequency of monitoring results reports	1 new gage installed 3 primary monitoring sites established At least 36 monitoring results recorded from routine monthly monitoring 1 monitoring report after Year 3	
Years 4-5	Kiefer Creek Streambank Stabilization construction	# of linear feet of streambank constructed and stabilized	3,190 additional ft. Total of 3,565 feet by end of Year 5	*E. coli* 1.72E+09 (counts/day) 7.8 percent reduction Phosphorous 2.86 (pounds/year) 8.3 percent reduction Nitrogen
	Installation of rainscaping projects in Castlewood State Park	# of square feet of rainscaping installed	2,600 ft2	
	In year four, continued outreach, education and recruitment of homeowners to rainscaping cost-share program	# of square feet of rainscaping installed	6,000 ft^2	
	Beginning in year four, owners, interested in connecting to sewer lines, repairing or replacing on-site wastewater treatment systems, can participate in cost-share program	# of homeowners participating in cost-share program that have either connected to a sewer line, repaired or replaced on-site	20 homeowners	

Timeframe	Project description	Indicator/criteria to determine progress	Measurable Milestone	Estimated load reduction
		wastewater treatment system		14.7 (pounds/year) 7.7 percent reduction Total Suspended Solids 842.7 (pounds/year) 9.7 percent reduction
	Continuation of working with horse property owners to develop comprehensive nutrient management plans	# of horse property owners who have developed and are implementing a plan	4 Property Owners Involved	
	Open Space Council will conduct a cleanup and riparian restoration event in Kiefer Creek	# of cleanup and restoration events in Kiefer Creek	2 events	
	In Year 5, citizen science volunteers will do rapid streambank assessment after the streambank stabilization project is completed.	# of assessments completed	1 assessment completed	
	Pledge-based NPS Clear Choices Clean Water watershed social marketing program will continue, a combination of education with commitments/pledges to take action and feedback measurement elements	% of residents who have made pledges	Additional 70% of system owners Additional 40% of horse property owners Additional 40% of pet owners	
Years 6-20	Year six complete rainscaping in Castlewood State Park.	# of square feet of rainscaping installed	2,600 square feet of 6,800 square feet by Year 20	*E. coli* 8.90E+09 (counts/day) 40.3 percent reduction Phosphorous 10.7 (pounds/year) 30.9 percent reduction Nitrogen 54.5 (pounds/year) 28.7 percent reduction Total Suspended Solids 3,105.6 (pounds/year) 35.9 percent reduction
	Rain gardens will continue to be installed in the subdivision	# of square feet of rainscaping installed	24,200 square feet with a Total of 30,200 square feet by Year 20	
	Continue outreach, education and recruitment to on-site wastewater treatment system cost-share program	# of homeowners participating in cost-share program who have connected to sewer line, repaired or replaced on-site wastewater treatment systems	110 homeowners with a total of 130 by Year 20	
Years 6-20	Continuation of working with horse property owners to develop comprehensive nutrient management plans	# of horse property owners who have developed and implemented a plan	15 Property Owners Involved Total of 21 Property Owners (100%) by Year 20	
	Open Space Council will continue to recruit volunteers and conduct clean- up and riparian restoration events in Kiefer Creek	# of volunteers recruited and # of cleanup and restoration events	60 Additional Volunteers and 14 events	

Element I – Monitoring Component to Evaluate the Effectiveness of the Implementation Efforts Over-Time, Measured Against the Criteria Established Under Element H Immediately Above

1. Current Water Quality Monitoring in Kiefer Creek

Water quality monitoring provides an analytical framework to support project implementation and assess effectiveness. It also serves as a tool to inform and educate residents and stakeholders. Continuous water quality monitoring has been undertaken in Kiefer Creek watershed by USGS and MSD through the Kiefer Creek Monitoring Station. Surface water samples are taken from this site and Table 38 lists the items that are analyzed. In addition, a variety of data collected by various entities is available through the MoDNR web site at http://www.dnr.mo.gov/mocwis_public/wqa/waterbodySearch. This data can be screened to determine where additional monitoring is needed and/or to track water quality changes.

Table 38. Items Analyzed for Water Quality Monitoring

USGS Station Number – 0719072	
Location – at Kiefer Creek Road (WBID 3592/0.5)	
Items Analyzed MSD	USGS Parameters
Ammonia-Nitrogen	Discharge
Chemical Oxygen Demand	Gage Height
Chloride	
Dissolved Oxygen	
E. coli	
Fecal Streptococcus Group Bacteria	
Hardness caused by Divalent Cations (Calcium, Magnesium)	
pH	
Sulfate	
Temperature of Water	
Total Suspended Solids	

2. Proposed Project Effectiveness Monitoring

Using this monitoring station, it will be possible to obtain long term analysis of changes over time in the watershed. To monitor the effectiveness of project implementation in the identified critical areas in the Kiefer Creek watershed, USGS has proposed a stream flow and water quality monitoring strategy for which builds off the existing monitoring infrastructure (see Appendix E for full strategy description). This monitoring effort will provide a foundation of routine and event-focused sampling which could be adjusted over time as the projects are implemented and local group(s) become engaged in monitoring.

2.1 Summary of long-term monitoring strategy

This watershed plan indicates enhanced monitoring for fecal bacteria is needed and that monitoring should ensure that samples are collected across the range of hydrologic conditions. Efforts to address *E. coli* standard exceedances in Kiefer Creek will be most successful if restoration efforts can be focused on the primary non-point sources and specific areas or stream reaches contributing substantial *E. coli* loading in the watershed. Interpreting the existing *E. coli* data collected from the three sites is problematic because samples were not collected in a methodical manner and there are inconsistent sampling periods with limited flow data for some samples, and samples from the various sites did not span equivalent ranges of hydrologic conditions. In addition, data are available from only three sites in the watershed and data density is not large (seven or fewer samples per year since 2005).

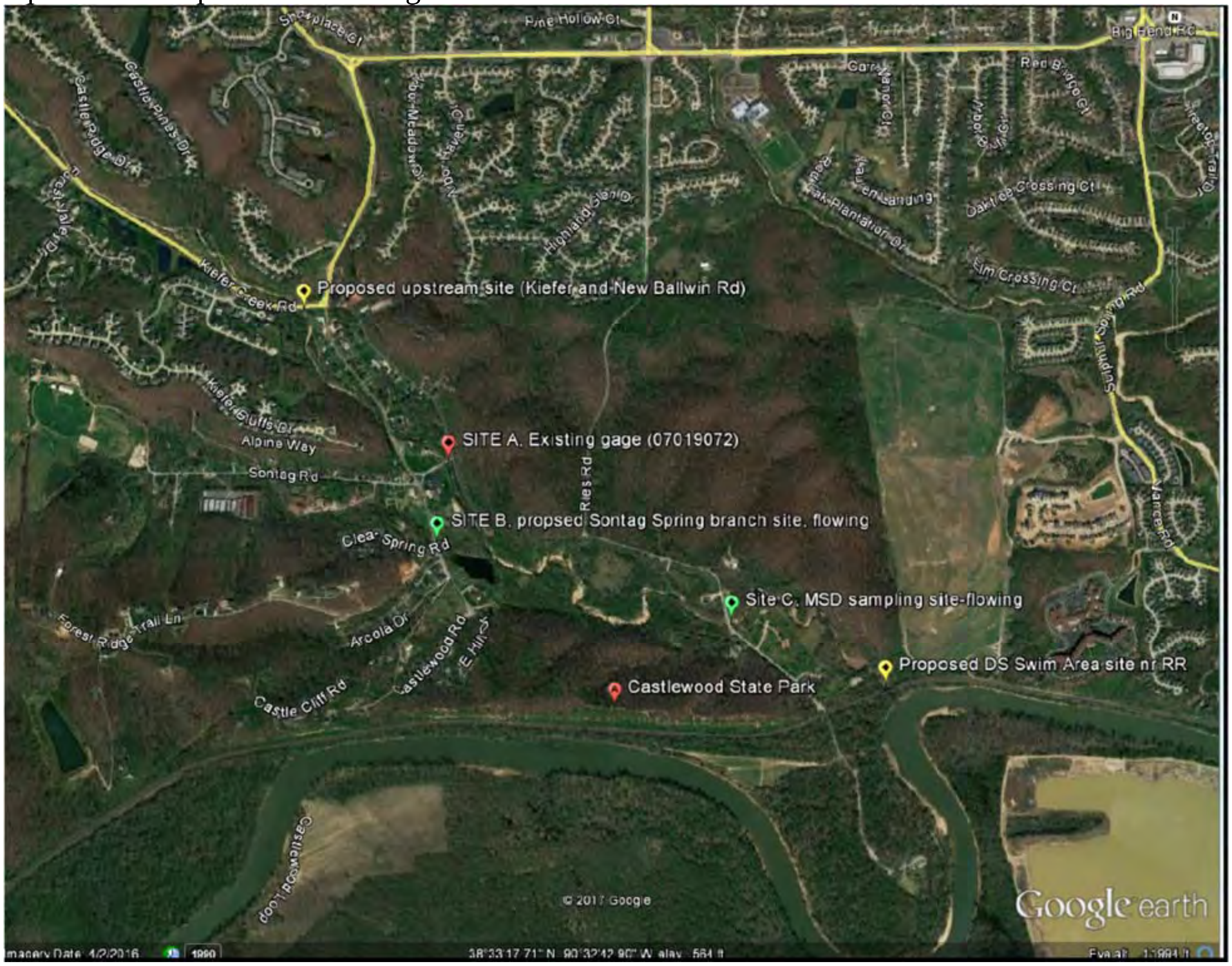
The proposed monitoring plan focuses on a two-year baseline intensive sampling effort that establishes fixed and consistent sampling at six sites combined with distributed sampling across the watershed under various hydrologic conditions via sanitary/seepage surveys. A continuous stage-only gage will be installed on the Sontag Spring branch. Results from this intensive effort will be augmented with microbial source tracking (MST) at selected stream and sediment sites. The results of the baseline intensive effort will be summarized in year three to inform future restoration efforts, provide a baseline from which to assess efficacy of future restoration activities, and optimize longer-term but less-intensive subsequent monitoring.

During the initial baseline intensive effort, routine monthly sampling will be done at four primary sites (A, B, C, and E [Kiefer Creek upstream from the USGS gage at New Ballwin Road]), recreational season sampling at a new site (Site D) near the railroad bridge in Castlewood State Park, and quarterly monitoring of Kiefer Spring (Site F) just upstream from the existing streamgage (see Map 14). Samples will be analyzed for *E. coli* bacteria, suspended sediment, and quarterly for major ions and nutrients. To assist with identification of *E. coli* sources and corroborate the modeled loading presented in the draft watershed plan, distributed sampling will be done as a series of sanitary survey/seepage surveys along the Kiefer Spring branch, the Sontag Spring branch, and the main steam of Kiefer Creek. During the surveys, the stream will essentially be walked (where access can be obtained) and samples collected from multiple locations across the watershed within a one- or two-day period. By noting and sampling all inflows (tributaries, small springs, and seeps) and measuring field parameters (discharge, temp, pH, dissolved oxygen, and specific conductance) and collecting samples at intervals along the main branches and screening for chloride and optical brighteners, the spatial footprint of *E. coli* concentrations can be obtained and perhaps elucidate obvious *E. coli* sources such as septic influences. These studies will be conducted four times during the first two years at various hydrologic conditions (such as summer low flow, spring stable but “wet” condition flow, fall, and winter) to provide additional data on the effect of overall hydrologic conditions on the variability of *E. coli* and chloride concentrations (selected samples will be analyzed for major ions). The routine monitoring and sanitary/seepage surveys will inform microbial source tracking (MST) sampling of selected sites (sediment and water) to assess the predominance of human genetic *E. coli* markers in the samples.

The monitoring plan contains specific work tasks (see Appendix E) that can readily be modified upon discussions with stakeholders and local volunteer groups, and flexibility is paramount to allow for incorporation of local stream teams or other partners to participate in the monitoring effort to the level of their ability and interest. Involvement of local partners will allow increased local ownership in the process, increase awareness, provide for USGS to educate local partners, teachers, and students in water-quality monitoring efforts, and optimize resources. The USGS will provide a backbone of routine and event-based data and sampling efforts can be adjusted over time as best management practices (BMPs) are implemented and local groups are engaged.

Map 14. USGS Option A – Proposed Monitoring Sites

Option A – Proposed Monitoring Sites



Map Key (North to South)

Yellow point – Proposed upstream site (Kiefer Creek and New Ballwin Road

Red point – Site A, existing USGS gage

Green point – Site B, proposed Sontag Spring branch site, flowing

Green point – Site C, MSD sampling site, flowing

Yellow point – Proposed downstream swim area site near railroad

2.2 Streambank Stabilization Monitoring

The Nature Conservancy will monitor success of streambank stabilization from a geomorphological perspective as well as rate of change. TNC will compare bank profiles:

- Before construction (current condition). TNC set up permanent monitoring stations at three streambanks proposed for stabilization as part of the Master Plan (set in April 2016), and also estimated erosion over time, as described in Appendix E (BANCS MODEL).
- Immediately after construction (i.e., as-built)
- At least once yearly after construction for 3-5 years.

Through these measurements the following will be able to be determined:

(1) How much erosion was predicted to occur in the Kiefer Creek project area using the Bank Assessment for the Nonpoint source Consequences of Sediment (BANCS methods), as measured in the Master Plan (Predicted rate in terms of tons/foot/year or cubic yards/foot/year at each streambank)

(2) How much erosion has occurred along the proposed restoration reaches since April 2016, per the existing permanent monitoring stations (Validated rate in terms of tons/foot/year or cubic yards/foot/year at each streambank)

(3) How much erosion has occurred following restoration of the proposed reaches by again setting up new permanent monitoring stations (Validated rate in terms of tons/foot/year or cubic yards/foot/year at each streambank).

Because these are rates, the total amount of erosion per reach over time (in tons and cubic yards) will also be determined. This will provide a good comparison of how much erosion was happening before and after restoration. Results typically show drastic reduction in rates of erosion following restoration, sometimes over 97%. Small adjustments in the bank shape following restoration after Kiefer Creek experiences high flows are to be expected, but those should be very minor versus the current condition.

Chapter IV. Mattese Creek Nine Element Plan for Bacteria

Element A: An Identification of the Causes and Sources or Groups of Similar Sources that will need to be controlled to achieve the Load Reduction and Water Quality Goal.

Mattese Creek (see Map 15) was placed on the Section 303(d) list of impaired waters in 2014 for bacteria and chloride pollution. Urban runoff/storm sewers were listed as the general sources of impairment.

Table 39. 2016 Section 303(d) Impaired Waters List for the Lower Meramec River Watershed

Stream (WBID)	County	Length of impaired portion from Mouth (miles)	Pollutant (Year Listed)	Impaired Use	Source of Impairment
Mattese (3596)	St. Louis	1.1	*E. coli* (2014)	WBC-B	Urban runoff/storm sewers
			Chloride (2014)	AQL	Urban runoff/storm sewers

Information about the sources of *E.coli* in Mattese Creek has primarily come from a water quality study conducted within the boundaries of the Metropolitan Sewer District (MSD) and GIS information used to estimate the quantity and condition of on-site wastewater treatment systems in the watershed.

Streams within the MSD boundaries receive inputs from a variety of sources including, and most predominantly, nonpoint source runoff, combined sewer overflows (CSOs), sanitary sewer overflows (SSOs), and discharges from wastewater treatment plants (WWTPs). To better understand factors that affect stream water quality in the MSD area, the U.S. Geological Survey (USGS), in cooperation with the MSD, initiated a study designed to characterize the occurrence, distribution, and sources of *E. coli* in metropolitan St. Louis streams.[57]

As part of this effort, 14 surface-water sites in metropolitan St. Louis were sampled between October 2004 and September 2007 for *E. coli* and *E. coli* sources. Source sampling was conducted using genotypic, local library-based methods that included *E. coli* host-source identification using rep-PCR and the presence of the anaerobic, enteric human bacteria, B. *thetaiotaomicron*.

[57] Wilkison, Donald H. and Davis, Jerri V. Occurrence and Sources of Escherichia coli in Metropolitan St. Louis Streams, October 2004 through September 2007. Prepared in cooperation with the Metropolitan St. Louis Sewer District, Scientific Investigations Report 2010–5150, U.S. Department of the Interior and U.S. Geological Survey. https://pubs.usgs.gov/sir/2010/5150/pdf/sir2010-5150.pdf.

Map 15

Mattese Creek Watershed

St. Louis County, Missouri

September 2017

Sources: United States Geological Survey, National Hydrography Dataset (NHD); St Louis County GIS; East-West Gateway Council of Governments

EAST-WEST GATEWAY
Council of Governments

Map Samples were collected during base flow and storm events from three sites on the Missouri River, five sites on the Mississippi River, and six sites in smaller basins: Creve Coeur, Coldwater, Maline, and Grand Glaize Creeks and the River des Peres, all of which are tributaries to the larger rivers.[58] The relative contribution of human, dog, goose, and unidentified *E. coli* at these sites was determined. Linear regression models, developed from data collected during a range of hydrologic conditions, were used to estimate annual *E. coli* loads at 10 sites. Water quality data were compared to selected land-cover factors to evaluate the relative role of nonpoint source runoff relative to selected point sources (overflows from combined and sanitary sewers) at study sites.

The study found that on average, approximately one-third of *E. coli* in metropolitan St. Louis streams was identified as originating from humans. Another one-third of the *E. coli* was determined to have originated from unidentified sources; dogs and geese contributed lesser amounts, 10 and 20 percent, of the total instream bacteria indicating that much of the *E. coli* in the study area likely originated from nonpoint source runoff. Sources of *E. coli* were largely independent of hydrologic conditions—an indication that sources remained relatively consistent with time. Unknown sources would include *E. coli* from urban wildlife, feral cats, and birds—excluding geese—but also may have included some percentage of human, dog, or geese samples that did not meet the 80 percent similarity criteria deemed necessary to be considered a match.

Basins with large amounts of impervious surface area potentially have increased runoff, increased stream velocities, and increased channel erosion and therefore, increased levels of streamflow, suspended sediment, and *E. coli*.[59] The study found there was a strong association between the percent of impervious cover and *E. coli* densities in the study area.[60] For reference, the Mattese Creek watershed is estimated to have 27.5% impervious cover. Soil type is also a factor in the amount of runoff entering streams. The majority of the soils found in the Pomme/Mattese Creeks watershed have moderate to high potential for runoff due to slow infiltration rates. Some soils have layers near the surface which limit the downward movement of water or are clayey or are thin soils over bedrock (see Maps 17 in Appendix A and Table 40). In the Pomme/Mattese Creeks watershed the hydrologic characteristics of 50 percent of the soils found there could not be determined because of soil compaction and mixing of types as a result of development. Only three percent of the soils in the Pomme/Mattese Creeks watershed have high to moderate infiltration rates with low to moderate runoff potential.

[58] A map of the study location is found on page 2 of the study.
[59] Paul, M.J., and Meyer, J.L., 2001, Streams in the urban landscape: Annual Review of Ecology and Systematics, v. 32, p. 333–365.
[60] See Figure 19 in the study

Table 40. Pomme/Mattese Creeks Watersheds Hydrologic Soil Groups

Hydrologic Soil Group	Acres	Percent Share
A – low runoff potential, well drained	117.0	0.4
B – moderately low runoff potential	693.9	2.5
B/D – high water table, if soil was drained could be placed in Group B	1,834.7	6.6
C – moderately high runoff potential	3,818.3	13.6
C/D – High water table, if soil was drained could be placed in Group C	2,988.8	10.7
D – high runoff potential, poorly drained	4,931.8	17.6
No Data	13,589.6	48.6
Total	27,974.1	100

Source: USDA, Natural Resource Conservation Service

The study of bacteria occurrences and sources in the MSD service area found that roughly one-third of bacteria loads are from human sources. Human sources of bacteria are usually because of sanitary sewer overflows, combined sewer overflows or failing on-site wastewater treatment systems. In the Mattese Creek watershed, failing on-site wastewater treatment systems are the likely human source of bacteria because no SSOs or CSOs exist in Mattese Creek watershed based on the locations of SSOs and CSOs identified in MSD's Sanitary Sewer Overflow Control Master Plan. [61]

Using GIS data from St. Louis County about the year structures were built on a residential parcel, the estimated timeframe when sewer lines were constructed in the watershed and MSD sewer facility data, the number of on-site wastewater treatment systems in the watershed can be estimated. Parcels older than 1960 and greater than 100 feet from a sewer line were considered as potentially containing an on-site wastewater treatment system. There are a total of 28,667 residential parcels in Mattese Creek watershed. (See Map 16) Of those, 3,910 were built before 1960 and are located greater than 100 feet from MSD sewer lines and could potentially contain an on-site wastewater treatment system[62], see 41.

[61] http://www.stlmsd.com/sites/default/files/FY2017%20-%20FY2020%20Rate%20Proposal%20Exhibits/Exhibit%20MSD%2047B%20-%20MSD%20Sanitary%20Sewer%20Overflow%20Control%20Master%20Plan%20Executive%20Summary.pdf and http://www.stlmsd.com/sites/default/files/education/ConstructedSewerOverflows_04112016.pdf shows locations of SSOs or CSOs and there are none located in Mattese Creek watershed

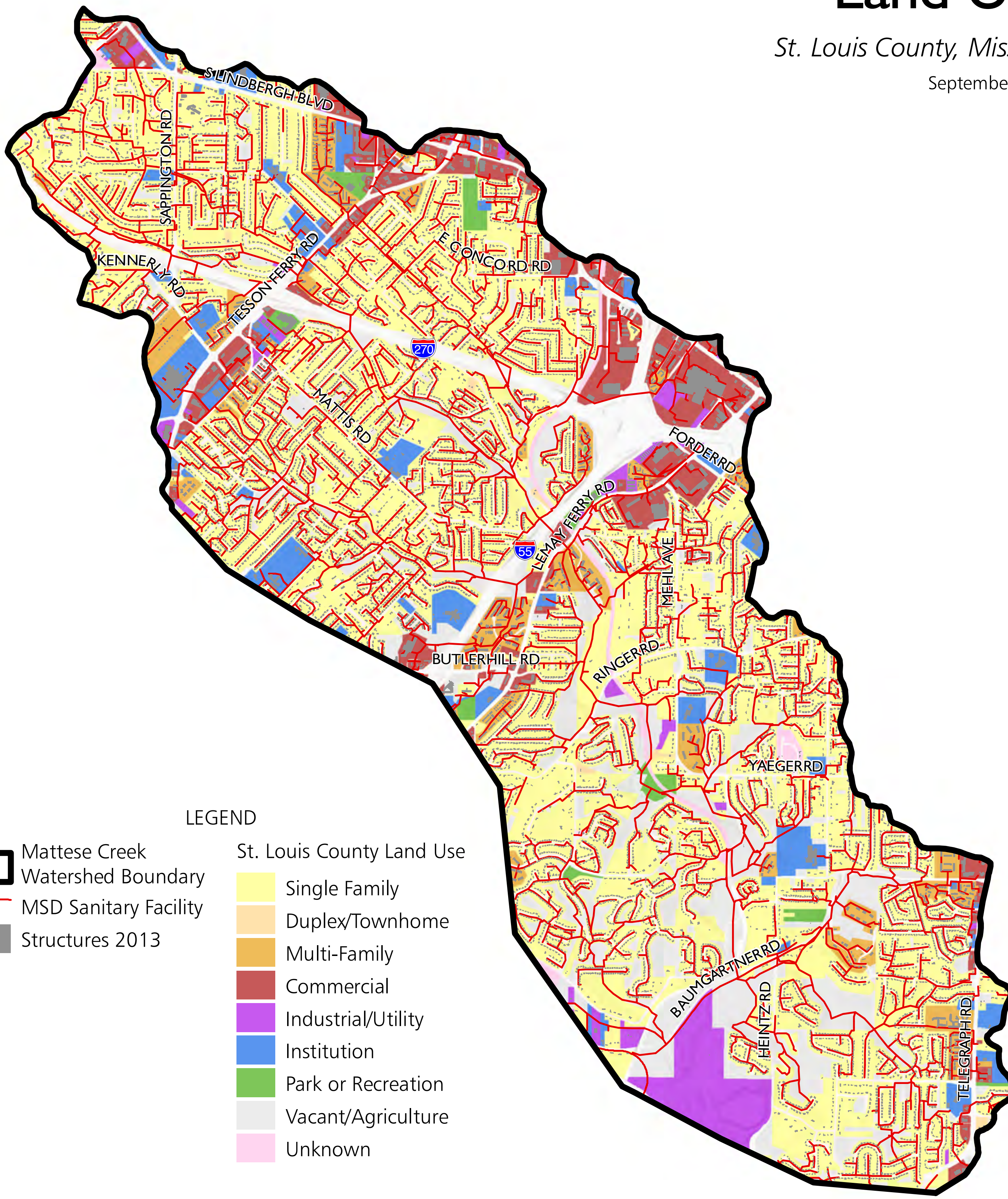
[62] Information on how many of these properties either do or do not receive a sewer bill could help refine this number, but this data is not available for public release.

Map 16

Mattese Creek Watershed Land Use

St. Louis County, Missouri

September 2017



LEGEND

- Mattese Creek Watershed Boundary
- MSD Sanitary Facility
- Structures 2013

St. Louis County Land Use

- Single Family
- Duplex/Townhome
- Multi-Family
- Commercial
- Industrial/Utility
- Institution
- Park or Recreation
- Vacant/Agriculture
- Unknown

0 0.5 1
Miles

Sources: Metropolitan St. Louis Sewer District (MSD); St Louis County, Missouri; United State Geological Survey, National Hydrography Dataset (NHD); East-West Gateway Council of Governments

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Council of Governments

Table 41. Parcel Ages in Relation to Distance from Sewer Lines

Age	# of Residential Parcels	100ft MSD	200ft MSD
pre-1900	27	25	27
1900-1910	48	45	47
1911-1920	36	31	33
1921-1930	77	64	69
1931-1940	222	209	216
1941-1950	365	323	347
1951-1960	3307	3213	3267
Total	4082	3910	4006

Using criteria similar to what Missouri Coalition for the Environment used in their draft Kiefer Creek watershed Restoration Plan for ranking the likelihood of on-site wastewater treatment systems to be failing,[63] a certain percentage of those can be estimated to be failing and a contributing human source of bacteria to Mattese Creek based on their parcel area. The area of the parcel is an important criterion for determining whether an on-site wastewater treatment system is functioning well. Without sufficient area for an on-site wastewater treatment system, it is unlikely that the system is effectively eliminating the bacteria in the effluent. St. Louis County requires a minimum lot size of 20,000 square feet if the premises are served by a public water main or 30,000 square feet otherwise.[64] GIS analysis identified 29 parcels older than 1960 that are 20,000 square feet or less and 2 parcels older than 1960 that are 10,000 square feet or less and could be a contributing human source of bacteria to Mattese Creek. (See Map 17).

[63] Refer to Element A in Chapter III Kiefer Creek of this plan for further information.

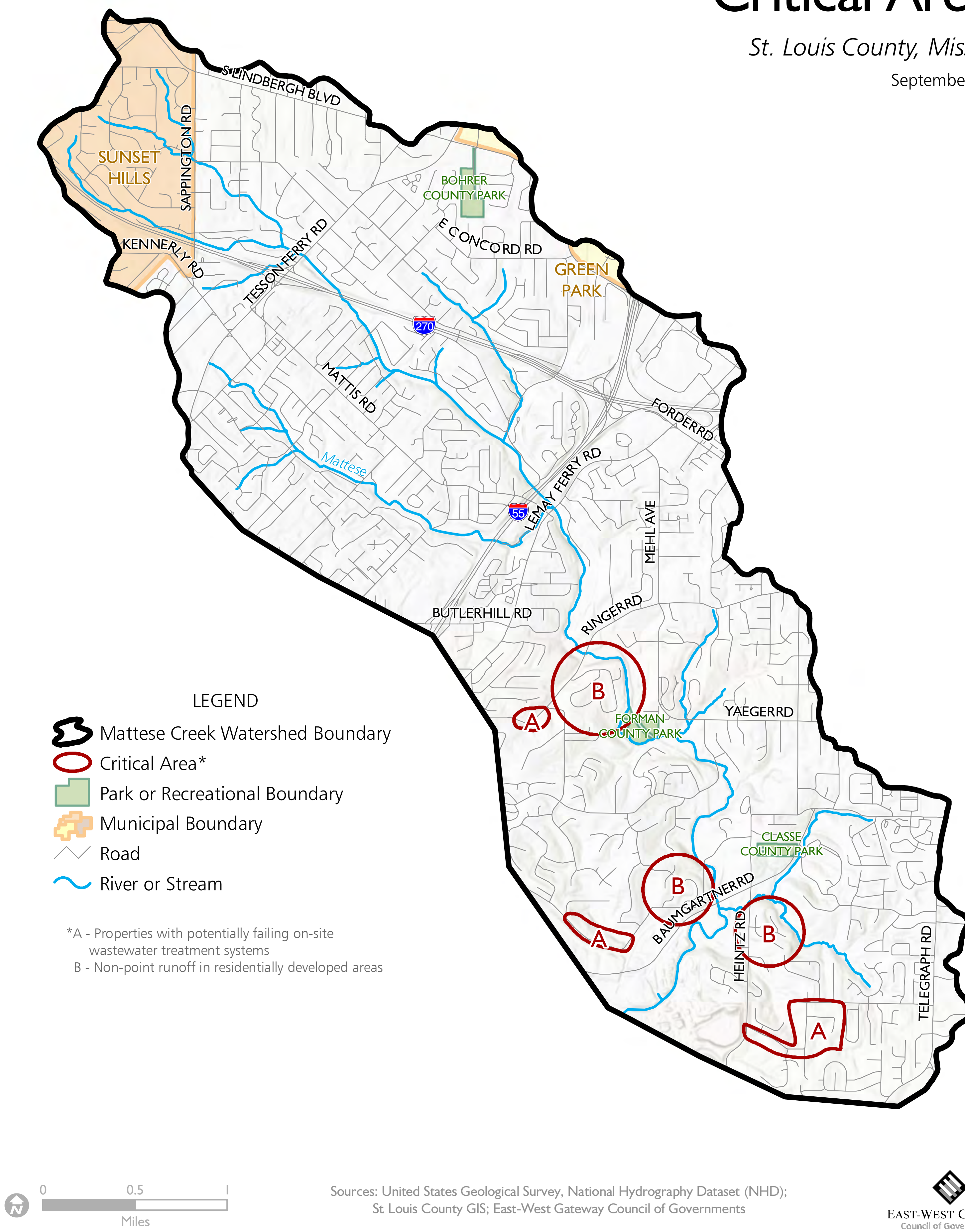
[64] http://www.stlouisco.com/Portals/8/docs/Document%20Library/Public%20Works/code%20enforcement/ordinances/09-UPC-Plumb-Ord.pdf.

Map 17

Mattese Creek Watershed Critical Areas

St. Louis County, Missouri

September 2017



Sources: United States Geological Survey, National Hydrography Dataset (NHD); St Louis County GIS; East-West Gateway Council of Governments

EAST-WEST GATEWAY
Council of Governments

Element B: An Estimate of the Load Reductions Expected for the Management Measures Described in Element C

1. Estimating Pollutant Loadings

In the 2012 Plan, the Simple Method to Calculate Urban Stormwater Loads was used to estimate stormwater pollutant loadings for developed land uses within four watersheds, and it has again been used here within Mattese Creek sub-watershed. It is a spreadsheet model which requires basic information characterizing a watershed, including the watershed drainage area and impervious cover by land use type, stormwater runoff pollutant concentrations and annual precipitation. With the Simple Method, the various pollutant loads, i.e. total nitrogen (N), total phosphorus (P), Total Suspended Solids (TSS), Biological Oxygen Demand (BOD), and bacteria loads (fecal coliform and *E. coli*) are calculated by land use type and then totaled. The stormwater pollutant concentrations can be estimated from local or regional data or from national data sources. For the purposes of this analysis, default concentration factors from both the Simple Method and the spreadsheet tool for Estimating Pollutant Load (STEPL)[65] were utilized. Model default values represent best professional judgement and give additional weight to studies conducted at a national level. These default values do not incorporate studies on arid climates. Bacteria concentrations came from the Minnesota Pollution Control Agency Estimator tool to calculate TMDL benefits.[66] A description of the Simple Method technique can be found in Appendix D of the 2012 Plan.[67] Table 42 below contains the baseline estimates developed for the four pollutants and bacteria in the Mattese Creek sub-watershed. The estimates calculated using the Simple Method can be used as a starting point for making decisions on management strategies until additional funds become available to conduct more sophisticated watershed modeling or coupled with additional water quality monitoring efforts.

Table 42.Mattese Creek Sub-watershed Baseline Annual Loads

Pollutant	Pounds per Year	Billion Colonies
Phosphorous	4,610.1	
Nitrogen	29,428.0	
Total Suspended Solids	1,376,569.6	
Biological Oxygen Demand	92,129.1	
Fecal Coliform		202,702.4
E.coli		178,880.6

[65] http://it.tetratech-ffx.com/steplweb/default.htm
[66] https://stormwater.pca.state.mn.us/index.php/Guidance_and_examples_for_using_the_MPCA_Estimator
[67] http://www.ewgateway.org/lowermeramec/lowermeramecwatershedplan-final.pdf

2. Mattese Creek Load Duration Curves and Pollutant Reduction Estimates

Load duration curves and pollutant reduction estimates for *E. coli* bacteria for impaired streams in the lower Meramec watershed, including Mattese Creek, have been prepared by MoDNR. These load duration curves and reduction estimates were developed to support this plan, and are for informational purposes only as they are not part of a TMDL. Percent reductions were calculated using the load duration curve and available water quality data collected from the water body. Load duration curves are a visual tool used to characterize water quality concentrations at different flow levels and the relationship between stream flow and loading capacity. The preliminary load reduction curve for Mattese Creek is presented below in Figure 1. Table 43 presents the reduction estimate for the 50 percent flow range and can be used to aid in the selection and placement of BMPs. This load reduction was selected as these are flows associated with runoff when nonpoint source contributions are likely to occur. Appendix B contains complete discussion of load duration curves and pollutant reduction estimates for those streams impaired by bacteria (load duration curves prepared by MoDNR).

Figure 5. Mattese Creek Load Duration Curve

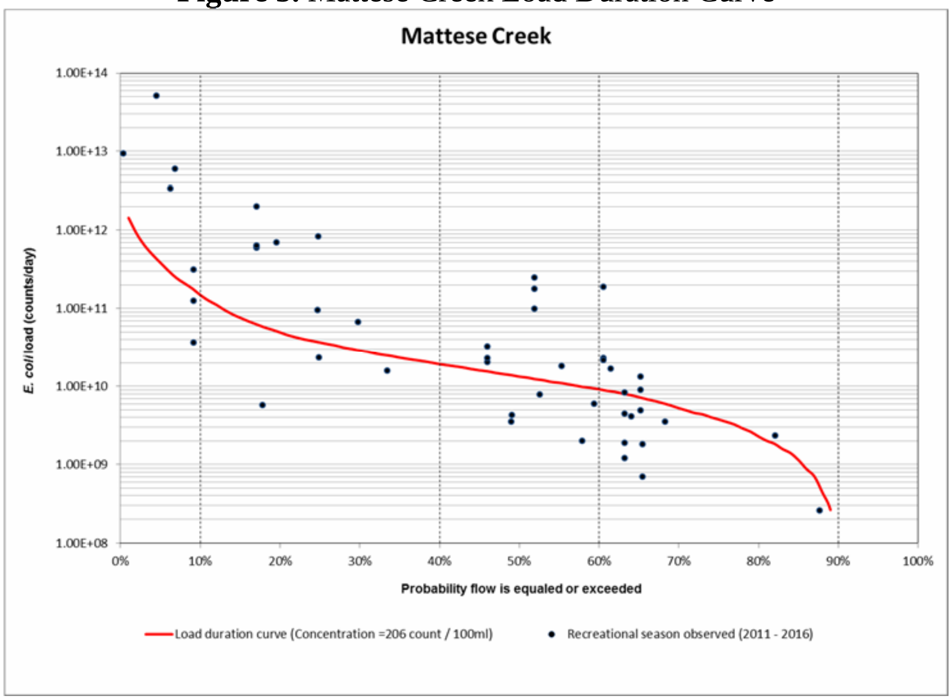


Table 43. Estimate of Bacteria (*E. coli*) Load Reduction Needed to Attain Water Quality Standards

Impaired Stream	Flow (cfs)	Loading Capacity (counts/day)	Existing Loading (counts/day)	Reduction Needed (counts/day)	Percent Reduction Needed
Mattese Creek	2.64	1.33E+10	1.86E+10	5.25E+09	28.3

Cfs – cubic feet per second
Loading Capacity – Allowable capacity of stream (to meet standard)
Existing Loading – Estimated as the geometric mean of all observed *E. coli* loads within a specific flow range
Reduction Needed – Amount of reduction in bacteria loading needed to achieve Loading Capacity
Source: MoDNR

Element A discussed the 2010 USGS study of occurrences and potential sources of *E. coli* in streams in the St. Louis area which estimated the potential sources of in-stream measured *E. coli*. For streams, like Mattese Creek, with similar climate conditions, land use and bacteria sources, it was estimated that over 30 percent of the measured in-stream *E. coli* originated from humans. The percent share of E. coli loading from humans, animals (dogs and geese) and unknown sources was used by EWG to allocate the estimated existing *E. coli* loading among these sources, (See Table 44).

Table 44. Mattese Creek Estimated Bacteria Contribution by Activity

Bacteria Source Groups	Percent Share	Existing *E. coli* Loading (counts/day)
Humans	35	6.51E+09
Dogs	10	1.86E+09
Geese	20	3.72E+09
Unknown Sources	35	6.51E+09
Total	99	1.86E+10

3. Load reductions from Management Measures in Element C

3.1 Load reductions from on-site wastewater treatment system management measures

Element A provides information about on-site wastewater treatment systems as a potential source of bacteria in Mattese Creek watershed. Using St. Louis County parcel data, 29 residential parcels constructed before 1961 which are 20,000 square feet or less in size were identified and two residential parcels which are 10,000 square foot or less were identified. It was assumed that parcels constructed before 1961 would not be connected to the MSD collection system and would have on-site wastewater treatment systems.[68] It was also assumed that these systems on parcels 20,000 square feet (0.46 acres) or less could potentially be failing because of the lack of square footage for the operation of an effective drainfield. It is assumed that the total acreage of these parcels is 13.7 acres (600,000 square feet).

[68] Through email correspondence with a resident in the watershed, there is one confirmed on-site wastewater treatment system and the home was built in 1957. It is also known that Royal Hills subdivision was constructed in 1976 and is connected to MSD sanitary system, so the date 1961 is an estimated average of when sewer lines may have been constructed in the watershed areas.

To reduce bacteria levels, management measures target connecting half of the parcels to the MSD collection system where physically feasible, or making repairs to or replacement of the on-site wastewater system so that it functions properly (see Element C).

For this subset of residential properties with individual on-site wastewater treatment systems in the Mattese Creek watershed, baseline and future year pollutant and bacteria loadings were calculated using the Simple Method to Calculate Annual Urban Stormwater Loads[69]. The focus of this management practice is to reduce the pollution contribution from on-site wastewater treatment systems. Instead of only using the residential impervious acreage in the calculation, all of the acreage associated with this subset were used as a failing on-site wastewater treatment system can impact an entire parcel. For the future years, it was assumed that half of the acreage would receive improvements and, therefore would no longer contribute to the bacteria impairment in Mattese Creek. Table 45 presents the baseline and future year loadings from the on-site wastewater system subset.

Table 45. Mattese Creek On-site Wastewater System Subset

Mattese Creek Sub-watershed (Pomme/Mattese)			
Pollutant	**Baseline Loading Pounds per Year**	**Future Loading with MSD Connection and On-site Waste Water System Improvements Pounds per Year**	**Reduction Pounds per Year**
Phosphorus	12.5	6.5	6.0
Nitrogen	68.8	35.7	33.1
Total Suspended Solids	3127.2	1620.6	1506.6
Bacteria	**Baseline Loading Billion Colonies per Year**	**Future Loading with MSD Connection and On-site Waste Water System Improvements Billion Colonies per Year**	**Reduction Billion Colonies per Year**
Fecal Coliform	1104.5	572.4	532.1
E. coli	1003.8	520.2	483.6

Simple Method to Calculate Urban Stormwater Loads

Referencing the load duration curve, prepared by MoDNR, for the 50 percent of time creek flow is equaled or exceeded, this plan calls for improvements to be made to 17 parcels over the next twenty years,[70] either by connecting to the MSD collection system or by replacing or repairing on-site wastewater systems, resulting in a 50 percent reduction in bacteria loading assigned to on-site wastewater treatment systems, see Table 46.

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[69] Since the Simple Method uses annual load, and the TMDLs identify daily count, for this plan an approximate correlation of percent load must be assumed for all watersheds. Monitoring will be necessary to obtain actual load reduction counts.

[70] This assumes that half of the systems may be failing need servicing or replacement.

Table 46. Mattese Creek- Estimated Improvements to Residential Properties with On-site Wastewater Treatment Systems

Time Period	Residential Properties	Estimated Loading Reduction
End of Year 4		
End of Year 5	2	3.82E+08
End of Year 10	5	9.65E+08
End of Year 15	5	9.65E+08
End of Year 20	5	9.65E+08
Total	17	3.25E+09

Table 47. Mattese Creek Estimate Load Reductions Allocated by Source Group

Mattese Creek Bacteria Sources	Bacteria Percent Share	Existing *E. coli* Loading (counts/day)	Percent Loading Reduction with Implementation of BMPs by Source	Estimated Reduction with Implementation of BMPs by Sources	20 Years *E. coli* Loading (counts/day)
Humans	35	6.51E+09	50	3.25E+09	3.26E+09
Dogs	10	1.86E+09	0	0	1.86E+09
Geese	20	3.72E+09	0	0	3.72E+09
Unknown	35	6.51E+09	0	0	6.51E+09
Total	99	1.86E+10	17.4	3.25E+09	1.52E+10

MoDNR has estimated the Mattese Creek loading capacity for the 50 percent of time creek flow is equaled or exceeded at 1.33E+10. At the end of the 20 year period, by improving on- site wastewater systems, connecting to sewer lines, it is estimated the *E. coli* loading could be reduced by approximately 17 percent (to 1.52E+10).

4. Stormwater BMP Removal Efficiencies

The following stormwater (rainscaping) BMPs were selected based on their ability to reduce bacteria and other pollutants in the impaired streams:

- Bioretention
  - Swales
  - Native Soil Rain Gardens
- Pervious Pavements
- Stream Channel Stabilization and Riparian Buffer Improvement

Tables 48 and 49 contain information on pollutant and bacteria removal efficiencies for these BMPs.

Table 48. BMP Pollutant Removal Efficiencies

Best Management Practice	Percent Total Phosphorus	Percent Total Nitrogen	Percent Total Suspended Solids
Bioretention	50	60	80
Pervious Pavement	45	10	90
Vegetated Swale	25	20	65
Rain Garden	65	60	75
Naturalized Stream Buffer	53	45	70

Sources for bioretention, pervious pavement (permeable pavement with underdrain), vegetated swale and rain garden removal efficiencies can be found in Table 20 of the 2012 Plan at
http://www.ewgateway.org/lowermeramec/lowermeramecwatershedplan-final.pdf –
Riparian Buffer - The Conservation Foundation, Lower DuPage River Watershed Plan, 2011,
www.dupagerives.org/LDRWatershedPlan.htm

Table 49. BMP Bacteria Removal Efficiency

Best Management Practice	Removal Fraction	
	E. coli	**Fecal Coliform**
Biofiltration*	0.75**	0.75
Permeable pavement	0.70	0.70
Swale	0.00	0.00
Naturalized Stream Buffer***	Not Calculated	50

Minnesota Pollution Control Agency Estimator for TMDL Annual Reporting -
https://stormwater.pca.state.mn.us/index.php/Guidance_and_examples_for_using_the_MPCA_Estimator
*Biofiltration assumed to be same as bioretention (large properties and individual raingardens).
**A value of 0.50 means that the BMP removes half of the pollutant/bacteria. The values for infiltration BMPs is 0 because it is assumed that all pollutant/bacteria in infiltrated water is removed.
*** The Conservation Foundation, Lower DuPage River Watershed Plan, 2011

4.1 Bioretention

Bioretention is a depressed landscape feature which stores, filters, and infiltrates stormwater runoff. Bioretention is an effective BMP in areas already developed because it can be tucked into greenspace such as curb and cul-de-sac islands, streetscapes, and even planter boxes, and in parks it can be strategically located to capture stormwater from impervious surfaces.
Basic components important to most St. Louis area bioretention "cells" are native (or deep rooted) vegetation and organic soil that will drain well and provide growing media for plants. An ample supply of mulch to a bioretention cell along with native deep rooted plants will open heavy clay soil to improve drainage over time. Any bioretention feature should include an overflow structure to compensate for stormwater volumes exceeding the capacity of the bioretention cell.

Bioretention can include swales or rain gardens. Swales are shallow, grass or vegetated-covered channels designed to convey and slow down stormwater runoff and facilitate infiltration. A native soil rain garden is a small depression planted with native vegetation. It is designed to temporarily hold and soak in runoff from impervious surfaces (roads, roofs, and parking lots) and yards. A rain garden can be installed for an individual residence or government or commercial structures. For existing construction, the native soil garden offers a low cost opportunity to capture and hold stormwater. Like stream buffers, the advantage of the native soil rain garden is that it improves efficiency over time, as plant roots continue to improve soil porosity.

In new developments or redevelopment projects, the sewer district may require use of a constructed bioretention cell that includes a graded filter of sands and gravels below the soil along with a perforated underdrain pipe beneath the graded filter to ensure the bioretention will drain within 48 hours. For the purposes of the 2017 plan, however, the proposed voluntary bioretention projects refer to native soil and native or deep rooted plants. These projects can be sited in or adjacent to parking lots, near roads or buildings, or in residential yards and common ground areas, which would otherwise be conventionally landscaped.

4.2 Pervious Pavement

Pervious pavement is designed to allow water to drain through the surface and into the underlying soil or a stone reservoir. Pervious pavement includes porous asphalt and porous concrete as well as materials with void spaces for drainage such as porous pavers or interlocking grid materials. Pervious pavement is effective in parking lots, but not in areas that may experience erosion or flooding that deposits sediment in the pores of the pavement.

4.3 Stream Channel Stabilization and Riparian Buffer Improvement

A riparian buffer is an area of native vegetation located adjacent to stream and river channels. A healthy buffer requires a heathy and stable stream channel. The buffer can reduce the amount of non-point source pollution entering waterbodies, enhance stream bank stability, reduce erosion, and provide aquatic and wildlife habitat. A buffer can help to slow runoff velocity from impervious surfaces and trap and filter out sediments, nutrients and other pollutants. The width of the buffer depends on site characteristics and specific function of the buffer. For the purpose of this plan, the goal is that in the sub-watersheds of the tributaries there will be riparian buffers with minimum width of 50 feet from each stream bank. In many cases the stability of the buffer zone will also depend on improving and stabilizing the stream channel. A stabilized stream channel and enhanced buffer should improve efficiencies of pollutant removal and improve habitat over time, as trees, shrubs and grasses grow and extend roots more deeply into the soil. The riparian buffer protection acts as a passive bio-filter for remaining urban/suburban overland runoff and further reduce NPS bacteria loads from wildlife and pet waste. Data on pollutant and bacteria removal efficiencies for naturalized stream buffers come from the Lower DuPage River Watershed Study (see Table 50). The study recommends using the middle value when a range of pollutant removal efficiencies are provided. In those streams identified as impaired due to bacteria levels, like Mattese Creek, the addition of channel stabilization and buffer zone improvement is just the first of many steps which can improve water quality.

Table 50. Examples of Riparian Buffers Pollutant Removal Efficiencies

Reference Source*	Percent Total Phosphorus	Percent Total Nitrogen	Percent Total Suspended Solids	Percent Fecal Coliform
Lower DuPage River Watershed Plan, 2011 – Naturalized Stream Buffer	40 - 65	40 - 50	55- 85	45 - 55
Chesapeake Bay Program – Urban Riparian Forest Buffer	50	25	50	N/A
Eightmile River, 2005 – Forested Buffer	36 – 70	48 – 74	70 – 90	N/A
Eightmile River, 2005 – Vegetated Filter Strips	24 – 85	4 – 70	53 – 97	Not Calculated
Eightmile River, 2005 – Forested and Vegetated Filter Strips	73 - 79	75 - 95	92 - 96	Not Calculated

The Conservation Foundation, Lower DuPage River Watershed Plan, 2011(www.dupagerives.org/LDRWatershedPlan.htm)
Yale School of Forestry and Environmental Studies, Riparian Buffer Zones: Functions and Recommended Widths for the Eightmile River Wild and Scenic Study Committee, 2005 (www.eightmileriver.org/resources/digital_library/appendices/09c3_Riparian%20Buffer%20Science_Yale.pdf)
Chesapeake Bay Program, Best Management Practices for Sediment Control and Water Clarity Enhancement, 2006 (www.chespeakebay.net/content/publications/CBP_13369.pdf)

Table 51. Naturalized Stream Buffer Pollutant/Bacteria Removal Efficiencies

Best Management Practice	Percent Removed
Total Phosphorous	53
Total Nitrogen	45
Total Suspended Solids	70
E. coli	Not Calculated
Fecal Coliform	50

In the Lower DuPage River Watershed Study, the cost to construct a naturalized stream buffer was between $5,000 and $10,000 per acre.

5. Load Reductions from Short-term Stormwater BMP Management Measures

5.1 Estimated Load Reductions from Rainscaping in Royal Hills Subdivision

A rainscaping cost-share program to install raingardens on residential lands has been proposed for Mattese Creek sub-watershed. A critical area for rainscaping (see Element C) was identified in Royal Hills subdivision where the homeowner's association plans to install raingardens on the common grounds in their 57.8 acre single family residential subdivision. The baseline load and estimated reduction of pollutant and bacteria was calculated for the 57.8 acre single family residential subdivision. This subdivision contains 106 residential parcels with 13.7 impervious acres. It was assumed that three raingardens, totaling 12,800 square feet, would be installed on common ground. Stormwater runoff from 60 percent of the parcels would be affected. Table 52 presents the estimated reductions associated with the raingardens.

Table 52. Mattese Creek Estimated Pollutant Load Reduction with Rain Gardens in One Subdivision

Example Subdivision Raingardens Estimated Reductions			
Pollutant	**Baseline Loading (Pounds per Year)**	**Future Reduction (Pounds per Year)**	**Future Loading with BMPs (Pounds per Year)**
Phosphorus	12.5	4.8	7.7
Nitrogen	69	24.7	44.3
Total Suspended Solids	3,136.3	1,403.8	1,732.5
Bacteria	**Baseline Loading (Billion Colonies per Year)**	**Future Reduction (Billion Colonies per Year)**	**Future Loading with BMPs (Billion Colonies per Year)**
Fecal Coliform	1,107.8	495.8	612.0
E. coli	1006.7	450.6	556.1

5.2 Estimated Load Reductions from other Private Property Rainscaping

Two other subdivisions were identified as critical areas for rainscaping, located adjacent to Mattese Creek (see Element C). Baseline load and estimated reduction of pollutant and bacteria was calculated for the 14.49 acre and 34.9 acre single family residential subdivisions. One subdivision contains 55 residential parcels with 5.3 impervious acres. For this subdivision it was assumed that 200 square foot raingardens would be installed on 60 percent of the parcels (6,600 square feet). The other contains 77 single family residential parcels with 9.2 acres of impervious cover. It was assumed that 200 square foot raingardens would be installed on 60 percent of the parcels (9,200 square feet). Stormwater runoff from 60 percent of the parcels would be affected. Table 53 presents the estimated reductions associated with the raingardens.

Table 53. Mattese Creek Estimated Pollutant Load Reduction with Rain Gardens in Two Subdivisions

Example Subdivision Rain Gardens Estimated Reductions			
Pollutant	**Baseline Loading (Pounds per Year)**	**Future Reduction (Pounds per Year)**	**Future Loading with BMPs (Pounds per Year)**
Phosphorus	13.2	5.1	8.1
Nitrogen	72.8	26.3	46.5
Total Suspended Solids	3309.8	1,489.4	1,820.4
Bacteria	**Baseline Loading (Billion Colonies per Year)**	**Future Reduction (Billion Colonies per Year)**	**Future Loading with BMPs (Billion Colonies per Year)**
Fecal Coliform	1,169.0	526.0	643.0
E. coli	1.062.6	478.2	584.4

6. Load Reduction from Long-term Implementation of BMPs

Table 54. BMP Package

Land Use	BMP
Commercial	Bioretention (for 90 percent of impervious acreage) Pervious Pavement (for 10 percent of impervious acreage)
Industrial	Bioretention
Institutional	Bioretention
Multi-Family Residential	Vegetated Swales
Single-Family Residential	Rain Gardens
All land uses	Naturalized Stream Buffer
Roads	Vegetated Swales

In years 5-10, the widespread installation of stormwater BMPs in this sub-watershed will be encouraged by the cost share program to reduce the volume of runoff, reduce potential for streambank erosion and reduce pollutant and bacteria loading. Depending on the type of land use, BMPs will be implemented by individual homeowners, homeowner associations, private businesses, local governments or school districts. BMP selection will require an analysis and evaluation of cost, funding sources, operation and management requirements, environmental evaluation and BMP siting and construction requirements. The full extent of BMP implementation in years 5-10 will be dependent upon the success of the demonstration BMP projects planned in years 1-5.

The full suite of BMPs will enable a reduction in average volume of stormwater runoff to local streams, and these practices will help to reduce general non-point pollutant load.
The design goals for the selected BMP projects are as follows:

1. Implement the selected BMP's in the locations identified in Element C. The BMPs installed on public lands will maximize speed of installation, and expand opportunities for educational and public outreach opportunities.
2. The performance goal of the various BMP installations will be capturing and treating stormwater runoff from 90 percent of the recorded daily rainfall events, which is based on a rainfall amount of 1.14 inches of rain.
3. Monitor the reduction in peak flow rates in relation to rainfall events, overall volume reduction due to plant uptake and infiltration. Also, document the effectiveness of filtering at least one organic pollutant.
4. Use the BMP demonstration results to build public official awareness of the cost-effectiveness of bio-retentive BMPs and their applicability to local building and sanitation codes.

In years 10-20, the BMP package will eventually be implemented on 60 percent of the existing and planned commercial, industrial, institutional, multi-family residential and single-family residential impervious acreage in the sub-watershed. For roads, the assumption would be 20 percent of the impervious surface acreage. Element C outlines the initial projects that have been identified as ways to encourage land managers to meet the goal of having BMPs installed on 5 percent of impervious acreage. This will increase to 10 percent by year 10, 30 percent by year 15 and 60 percent by year 20. Such an aggressive implementation percentage will be dependent upon significant "buy-in" by local governments and developers as well as private land owners. New development and redevelopment is already being addressed by permitting, so the focus of this plan is centered on the voluntary efforts that must also take place. Tables 55 and 56 presents the estimated BMP load reductions in five-year increments for the Mattese Creek sub-watershed. Based on the calculated load reductions by land use impacting the impaired streams, if BMPs are implemented across 60 percent of impervious acreage within each sub-watershed, then water quality standards will be met after 20 years. The Simple Method was used to calculate the estimated load reduction.

Table 55. Estimated Future Year Loads with BMPS

Mattese Creek Sub-watershed (Pomme/Mattese Creeks Watershed)			
Pollutant	**Baseline Loading Pounds per Year**	**Future Loading with BMPs Pounds per Year**	**Percent Change**
Phosphorus	4,610.1	3,867.7	- 16.1
Nitrogen	29,428.0	24,562.4	- 16.5
Total Suspended Solids	1,376,569.6	1,016,221.6	- 26.2
Bacteria	**Baseline Loading Billion Colonies per Year**	**Future Loading with BMPs Billion Colonies per Year**	**Percent Change**
Fecal Coliform	202,702.4	119,105.3	- 41.2
E. coli	178,880.6	104,348.3	- 42.7

Table 56. Estimated Future Year Loadings by Five Year Increments

Mattese Creek Sub-watershed	Annual Pollutant Loading (lbs/year)				
Pollutant	**Baseline Loading**	**End of Year 5 5% Impervious Acreage Affected By BMP Suite**	**End of Year 10 15% Impervious Acreage Affected By BMP Suite**	**End of Year 15 35% Impervious Acreage Affected By BMP Suite**	**End of Year 20 60% Impervious Acreage Affected By BMP Suite**
Phosphorus	4,610.1	4,525.3	4,390.1	4,154.1	3,867.7
Nitrogen	29,428.0	28,912.3	28,046.9	26,479.7	24,562.4
Total Suspended Solids	1,376,569.6	1,328,650.0	1,259,667.8	1,148,477.0	1,016,221.5
Bacteria	**Annual Billion Colonies**				
	Baseline Loading	**End of Year 5 5% Impervious Acreage Affected By BMP Suite**	**End of Year 10 15% Impervious Acreage Affected By BMP Suite**	**End of Year 15 35% Impervious Acreage Affected By BMP Suite**	**End of Year 20 60% Impervious Acreage Affected By BMP Suite**
Fecal Coliform	202,702.4	194,313.3	179,668.7	152,512.0	119,105.3
E. coli	178,880.6	171,498.7	158,504.3	134,184.9	104,348.3

Finally, the riparian buffer along the impaired stream will be protected through partnership with local governments and neighborhood associations. Riparian buffer protection will act as a passive bio-filter for remaining urban runoff that would flow overland into the impaired streams.

Table 57 presents the potential net positive impact from the continuation of and expansion of buffer on Mattese Creek. No information was available on *E. coli* removal efficiency for the naturalized stream buffer.

Table 57. Estimate Loading with BMPs and Naturalized Stream Buffer

Mattese Creek Sub-watershed (Pomme/Mattese Creeks Watershed)			
Pollutant	**Baseline Loading (Pounds per Year)**	**Future Loading with BMPs (Pounds per Year)**	**Future Loading with BMPs and Naturalized Stream Buffer (Pounds per Year)**
Phosphorus	4,610.1	3,867.7	1,817.8
Nitrogen	29,428.0	24,562.4	13,509.3
Total Suspended Solids	1,376,569.6	1,016,221.6	304,866.5
Bacteria	**Baseline Loading (Billion Colonies per Year)**	**Future Loading with BMPs (Billion Colonies per Year)**	**Future Loading with BMPs and Naturalized Stream Buffer (Billion Colonies per Year)**
Fecal Coliform	202,702.4	119,105.3	59,552.7
E. coli	178,880.6	104,348.3	104,348.3

Element C: Descriptions of the NPS Management Measures that will need to be implemented to Reach Load Reductions and Identification of the Critical Areas in which to implement those Measures

1. Water Quality Goal

Based on pollutant loading modelling and load reduction curves (see Table 43) contained in Element B, the water quality goal for Mattese Creek is to:

Reduce Bacteria Loading in Mattese Creek by 28.3 Percent to Achieve Water Quality Standards by 2037

2. Management Measures and Project Descriptions to Achieve Water Quality Goal

Three non-point source management measures are proposed in key critical areas to address the sources of impairment in Mattese Creek and result in the attainment of water quality standards. Mattese Creek is bordered by subdivisions and the opportunity for human exposure is particularly high. Some subdivisions in Mattese Creek have an opportunity to implement BMPs on subdivision land, which can treat and reduce stormwater runoff, reduce erosion and sedimentation, stabilize stream banks and improve the riparian corridor to improve stream health. Voluntary demonstration projects in the first five years of this plan should raise awareness and expand public interest in more complete action to achieve water quality goals in the subsequent years.

Management Measure 1: Restore the riparian corridor of Mattese Creek to enhance its ecological functions associated with reducing sediment loads and filtering pollutants.

Mattese Creek flows through a very suburban part of south St. Louis County with residential subdivisions along either side. The creek has access points for residents to wade and recreate. Due to the presence of a railroad that prohibits natural channel function and the extent of urban development, a number of subdivisions that are located on the banks of the stream are experiencing extreme bank erosion and sedimentation will continue unless actively stabilized and restored.

Pet and wildlife waste can be filtered through a healthy riparian buffer. The buffer can reduce the amount of nonpoint source pollution entering waterbodies, enhance stream bank stability, reduce erosion, and provide aquatic and wildlife habitat. A buffer can also help slow runoff velocity from impervious surfaces and trap and filter out sediments and bacteria. A healthy riparian buffer is dependent on a stabilized stream channel. The many areas of extreme erosion, sedimentation and poor riparian conditions along the creek need to be looked at holistically along with any contributing factors from the railroad in order to identify critical areas and tactics for stabilization and buffer restoration.

Solution 1.1: Undertake watershed master planning and geomorphic analysis in Mattese Creek watershed to understand and mitigate extreme erosion and sedimentation

Project description – Mattese Creek watershed master plan and geomorphic study
Developing a watershed masterplan will involve undertaking a geomorphic study to work towards achieving channel stabilization and enable projects such Solution 2.1 below. This comprehensive plan is also necessary to ensure that any streambank stabilization project does not negatively influence upstream or downstream properties, stream flow, habitat or riparian conditions.

This masterplan will involve a series of stakeholder meetings and project update meetings with EWG, and include an inventory of data collection on a number of items such as geomorphology, hydrology, water quality, species diversity, habitat, and other GIS data, and a capital improvement projects (CIP) list for the watershed. Public involvement is also an important aspect of this project, this will be achieved through the creation of a website that will feature interactive GIS mapping content, general information regarding the masterplan and links to stakeholder websites, as well as newsletters and material distribution, public open houses, and elected official meetings. Further information about the masterplan proposal can be found in Appendix H. The recommended capital improvement projects for stabilization and riparian buffer improvement from the watershed master plan will be proposed in a future update to this plan.

Management Measure 2: Expand use of rainscaping BMPs throughout the Mattese Creek Watershed to Treat Stormwater at its Source
Projects on private common property that are beyond MS4 permit requirements can serve to reduce stormwater runoff and demonstrate the practices for the residents of subdivisions, thereby motivating private actions on private lands. Furthermore, local neighborhood associations have significant common land along the Mattese Creek and getting them involved would improve riparian conditions, and mitigate runoff into the creek from their subdivisions.

Solution 2.1: Implement Rainscaping Projects on Subdivision Common Property.

Project description – Royal Hills common ground rain garden
Royal Hills homeowner association has willing residents and funding to implement a project to help improve the buffer zone of the creek and install rainscaping to filter out pollutants and reduce runoff from its subdivision to the stream. The project will include the following:

1. Create demonstration raingardens on three of its common ground areas to capture stormwater drainage from the subdivision. This would help mitigate overland runoff which currently flows from a pipe to the eroding bank of the stream.
2. Plant trees and shrubs and remove invasive honeysuckle from the riparian corridor. In one location there is virtually no tree cover, and just lawn grass extending some 50 feet to the top of the stream bank.
3. The projects will be evaluated to determine if bacteria in a section of Mattese Creek within the subdivision's boundaries has been reduced, if the raingardens can retain

water and reduce erosion at the bank, if the tree cover can be expanded to help stabilize the bank and to assess whether homeowner awareness of the problem increases and whether homeowners also take action to reduce stormwater runoff from their own properties. [71]

4. Evaluate awareness among subdivision residents, motivation to take other action.

Map 17 contains the location of this project.

Solution 2.2 Implement a Private Lands Rainscaping Cost-Share Program.

Project description: Mattese Creek Watershed Rainscaping Cost-Share Program
Lower Meramec watershed plan partners will develop a rainscaping cost-share program to support homeowners in the Mattese Creek watershed. Native soil raingardens can reduce runoff, capture rainwater, and improve water quality Based on the location of the impaired section of Mattese Creek, high resolution land cover data, aerial photography and MSD stormwater drainage data, two large subdivisions were identified that may be contributing sources of polluted runoff from wildlife and pet waste to Mattese Creek. A Mattese Creek CSI study showed high levels of *E.coli* at a site that drains one of the subdivisions.[72] The other subdivision drains directly into the impaired section of Mattese Creek. Together these two subdivisions have been identified as critical areas (see Map 17) to reduce non-point source runoff. The subdivision is a 160 acre single family residential development. It contains 252 parcels with 34 impervious acres. It was assumed that 200 square foot raingardens would be installed on 60 percent of the parcels for a total of 30,200 square feet. Sign-up for the cost-share program will be conducted via the Clear Choices Clean Water platform for Mattese Creek. Parcels that have applied for the program and that have been approved for the program will be placed on the GIS map.[73]

Management Measure 3: Mitigate On-site Wastewater Treatment System Discharges
Parcel area and age are key factors in a failing on-site wastewater treatment system. Those parcels identified as older than 1960 and less than 20,000 square feet in Element A are targeted as critical areas to do further on-site wastewater treatment system investigation, remediation or replacement (see Map 17).

Solution 3.1 Upgrade, Repair, Replace or Connect On-site Wastewater Treatment Systems Though Resident Education and Cost-Share Assistance

Project description: Develop and Implement Individual On-site Wastewater treatment system, Connection, Maintenance or Replacement Cost-Share Program
Encouraging homeowners to take action to repair, replace or connect their systems to the public sewer lines can be facilitated by a cost-share program, or if necessary by stronger enforcement of St. Louis County Department of Public Health regulations.

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[71] More detained monitoring information for this project is contained in Element I.

[72] Mattese Creek CSI Project Report Saint Louis County, Missouri, November 2013 – October 2014
Prepared by: Missouri Department of Natural Resources Division of Environmental Quality Environmental Services Program Water Quality. Site #6 in the study recorded the highest level of E.coli out of all 7 sampling sites.

[73] See Solution 2.1 in Element E for more information on Clear Choices Clean Water project description

An outreach strategy and informational materials on maintenance considerations for on-site wastewater treatment systems will be developed and a database created of owners of parcels which are not currently connected to MSD. To specifically engage homeowners in the cost-share program, *Clear Choices Clear Water* will be used to encourage people to take a pledge related to their septic system. After taking a *Clear Choices, Clean Water* pledge, they receive feedback about how much pollution they have prevented from entering Kiefer Creek. They get to see their location on an interactive map – providing further confirmation that they are doing their part. They also get an easy, low-pressure way to encourage their friends, family, and neighbors to do their part by way of email invitations or Facebook and Twitter feeds. The goal is to achieve a minimum of repairing or replacing two systems by Year 5 and 17 systems by Year 20.[74]

[74] See Element F for full implementation schedule.

Element D: Estimate of the Amounts of Financial Assistance and the Sources and Authorities that will be relied upon for Each Project.

Table 58 lists the estimated costs associated with each project described in Elements C and E, the agencies, organizations and/or groups involved, and the amount of funding sought. Sources for the costs estimates for rainscaping practices can be found in Table 21 in the 2012 Lower Meramec Watershed Plan. Other sources of available funding through grants or loans are found in Table 59.

Table 58. Estimated Costs of Projects in Mattese Creek

Project Description	Project Costs	Partner Contribution	Funding Sought
Mattese Creek watershed master plan and geomorphic study	$50,000- $80,000 for contracted engineer to conduct study, do outreach with the community and produce master plan[75]	40% from adjacent subdivisions, MSD, St. Louis County and SWCD $20,000 - $32,000	60% or $30,000 - $48,000 in Year 2-3
Royal Hills common ground rain garden	Average cost of raingarden is $10 per square foot for design and installation	40 percent cost share from homeowner association and MDC private land cost share assistance For total cost of $51,200	60 percent $25,200 in Year 1-3 $51,600 in Year 4-5 $76, 800 total
	4,200 square feet installed in Year 1-3 for cost of $42,000		
	8,600 square feet installed in Years 4-5 for cost of $86,000		
	12,800 total square feet for total cost of $128,000		
Mattese Creek watershed Rainscaping Cost-Share Program	Average cost of raingarden is $10 per sq. ft. for design and installation	40% contributed by residents cost share and MDC cost share towards design and plants[77] Total cost of $63,200	60 percent Year 1-3 $15,600 Year 4-5 $24,000 Year 6-20 $55,200 Total cost of $94,800
	Year 1 - 3 13 rain gardens = 2600 sq. ft. for total cost of $26,000		
	year 4- 5 20 rain gardens = 4,000 sq. ft. for total cost of $40,000		
	year 6 20- 46 rain gardens = 9200 sq. ft. for total cost of $92,0007		

[75] Based on estimated costs The Nature Conservancy received to conduct their study of Kiefer Creek for streambank stabilization. Exact cost of their study came it at $44,084.

Project Description	Project Costs	Partner Contribution	Funding Sought
	Total square feet of 15,800 for a total cost of $158,000		
Develop and Implement Individual On-site Wastewater Treatment System Connection, Maintenance or Replacement Cost Share Program	Costs range from $300 for a simple pump-out to $25,000 per property for a new system Costs to connect homes to sewer lines range from $10,000-$30,000 per property. The number of homes to be connected is dependent on recommendations in the study. Years 4-5 2 systems Years 6-20 15 systems Costs range from $5,100 to repair all 17 systems to $425,000 to replace or connect all systems.	40% contributed by Property owner cost share Total costs range from $2,040 -$170,000	60 percent Total costs range from $3060 - $255,000
Expand Operation Clean Stream from the main stem of Meramec River to Mattese Creek	$10,000 is required for volunteer coordination, event liability insurance, signage and supplies	40% or $4,000 provided by Open Space Council Missouri Stream Team	60% or $6,000
Expand Clear Choices Clean Water program from Kiefer Creek to Mattese Creek watershed	Software License: 4 years. $16,300 Municipal Mapping GIS: $500 Private Septic Mapping GIS: $500 Private Septic Pledge Collateral: $1,000 Pet Waste Pledge Collateral: $1,000 Volunteer Service Pledge Collateral $500 Native Plants and Gardens Pledge Collateral $500 Marketing and Signage: $25,000 Total cost for 4 years: $44,500	TBD	60% or $26,700
Mattese Creek long-term water quality monitoring strategy	Option C[76]	USGS MO Stream Team 168	60%

[76] A full breakdown of costs for each option is contained in Appendix I.

Table 59. Grants and Funding Opportunities

Grant Program Sponsoring Agency	General Information	Eligibility	Level of Assistance	Website
North American Wetland Conservation Act – U.S. Standard Grants Program U.S. Fish and Wildlife Service	Program that supports public-private partnerships carrying out projects in U.S. Projects must Involve long-term protection, Restoration and/or enhancements of wetlands and associated uplands habitats.		50% matching funds required. Grants start at $100,000	www.fws.gov/birdhabitat/grants
Planning Assistance to States U.S. Army Corps of Engineers	Provides assistance with the development of comprehensive plans for the development and conservation of land and water resources. Cover planning level of detail.	States, local governments and other non-federal entities. Non-profits are not eligible but could partner with state or local governments.	Limit for each state is $500,000 Annually. Cost Share is 50-50. Generally studies range from $25,000-$75,000.	www2.mvn.usace.army.mil/pd/pppmd_assistance_states.asp
Environmental Education Grants U.S. Environmental Protection Agency	EPA's Office of Environmental Education, Office of External Affairs and Environmental Education supports environmental education projects that enhance the public's awareness, knowledge and skills to help people make informed decisions that affect environmental quality. Grants are awarded based on funding appropriated by Congress.	Applicant must represent one of the following types of organization to be eligible: local education agency; state education or environmental agency; college or university; non-profit organization 501(c) (3), noncommercial educational broadcasting entity; or tribal education agency	Annual funding for this program ranges between $2 and $3 million range. Non-federal matching funds of at least 25% are required.	www2.epa.gov/education/environmental-education-ee-grants
Watershed Management Plan Development Grant - U.S. Environmental Protection Agency administered through Missouri Department of Natural Resources	Provides funding for development of watershed-based management plans to restore watersheds impaired by non-point source pollution. Due to funding limitations and a new approach, the general solicitation schedule for Watershed Planning has been discontinued.	Eligible organizations include state and local agencies, educational institutions and Non-profits organizations with demonstrated 501 (c) (3) status.		www.dnr.mo.gov/env/wpp/nps

Grant Program Sponsoring Agency	General Information	Eligibility	Level of Assistance	Website
Section 319 Nonpoint Source Grant Program U.S. Environmental Protection Agency administered through Missouri Department of Natural Resources	NPS source grant funds are provided from EPA through Section 319(h) of Clean Water Act. Funds can be used to implementing Best Management Practices and associated activities as detailed in their watershed management plan. Annual announcement on availability of funds. Amount of funding is dependent upon number of applications received.	Eligible organizations include state and local agencies, educational institutions and non-profits organizations with demonstrated 501 (c) (3) status.	Variable award amounts will be based on number of applicants, amount of funding available at time of request. Matching support: 60% federal and 40% non-federal (cash or eligible in-kind contribution)	www.dnr.mo.gov/env/swcp/nps
Targeted Watershed Grants Program U.S. Environmental Protection Agency	Program is designed to encourage successful community-based approaches and management techniques to protect and restore the nation's waterways. It is a competitive program. Program focuses on multi-faceted plans for protecting and restoring water resources that are developed using partnership efforts of diverse stakeholders. Implementation grants support on-the-ground watershed projects and Capacity Building grants are awarded to leading organizations with a national or regional focus that are able to provide training, technical assistance and education to local watershed groups. Check with EPA for next proposal cycle.	Eligible organizations include State and local governments, public and private non-profit institutions/organizations, federally recognized Indian tribal governments, U.S. territories or possessions and interstate agencies. For profit commercial entities and all federal agencies are ineligible.	Applicants are required to demonstrate a minimum non-federal match of at least 25% of total project cost. Funding could range from $400,000 to $900.000.	Http://water.epa.gov/grants_funding/twg/initiative_index.cfm
Private Services Landowner Assistance Program Missouri Department of Conservation	Financial assistance is offered to communities interested in habitat and natural recourse management every year	Nonprofits, city/county units of government and non-government entities are eligible to apply	Assistance is available on July 1 each year. All applicable projects are subject to reimbursement caps per cooperator year. Most projects will be reimbursed at a rate of 50 percent of total costs up to a	For additional information regarding landowner assistance and project eligibility, please contact Josh Ward, Private Land Conservationist at: 636-441-4554 or Josh.Ward@mdc.mo.gov

Grant Program Sponsoring Agency	General Information	Eligibility	Level of Assistance	Website
			maximum limit, some restrictions apply.	
Clean Water Act Section 604(b) federal grant funds administered by the U.S. Environmental Protection Agency through the Department of Natural Resources	The Water Protection Program components under the Clean Water Act Section 604(b) federal grant, are intended to assist with the revision of Water Quality Standards, risk-based groundwater standards, the anti-degradation policy and implementation method, toxicity testing, area-wide wastewater management prioritization, including planning studies and, wastewater feasibility studies. A portion of the 604(b) federal grant is awarded to Missouri communities for water quality planning.	Communities are invited to submit their competitive project proposals through their Regional Planning Commissions and the Missouri Councils of Governments for funding. The water quality management funds could be used for activities such as: watershed management plans, urban stormwater management plans, and stormwater planning. Applicants were especially encouraged to give priority to watershed management planning in urban watersheds or sensitive watershed threatened by development, along with green infrastructure, water or energy improvements related to water quality, or other environmentally innovative planning activities.	Missouri's share of the 604(b) Recovery Act Funding is $1,097,400 million. The Clean Water Act Amendments required states to pass through 40 percent of the 604(b) funds to regional public comprehensive planning organizations.	https://energy.mo.gov/division-of-energy/transform/water-quality-planning-and-management---604(b)
State Revolving Fund (SRF) Loan Program Missouri Department of Natural Resources	The State Revolving Loan Program provides low-interest loans to Missouri communities for projects that improve wastewater and drinking water infrastructure. The Missouri Department of Natural Resources and the Environmental Improvement and Energy Resource Authority work together to administer this program and to protect public health and the environment. The SRF has implemented an agriculture loan program, in cooperation with the Missouri Agriculture and Small Business Development Authority, to fund certain nonpoint source projects, and has recently set aside funding for new initiatives to	Cities, towns, counties, regional sewer/water districts, water authorities and instrumentalities of the state are eligible for wastewater, drinking water and nonpoint source SRF loans. Private and nonprofit facilities are eligible for drinking water and nonpoint source loans. Individuals and citizen groups are also eligible for nonpoint source loans.	Missouri applies to the U.S. Environmental Protection Agency (EPA) annually for capitalization grants to fund its SRF Programs. To increase available funds, the state leverages its EPA capitalization grants in the municipal bond market. These funds are combined with the EPA required state match and then	https://dnr.mo.gov/env/wpp

Grant Program Sponsoring Agency	General Information	Eligibility	Level of Assistance	Website
	fund on-site wastewater treatment projects.		made available to Missouri communities in the form of low interest loans. As the loans are repaid, the money is reused (revolved) by the SRF to provide for future projects. The SRF is a fixed rate, 20-year loan. Interest rates are generally 30 percent of the market rate.	

Element E: Education Component used to Enhance Public Understanding and Encourage Continued Participation

1. Importance of Education

Mattese Creek flows through a very suburban part of south St. Louis County with residential subdivisions along either side. Residential decision-making about property management could have a significant impact on the quality of water within the stream. Educating residents in the watershed will help to increase public awareness of water quality issues and ways individuals can act to improve and protect water quality in the Mattese Creek watershed.

2. Management Measures to Enhance Public Understanding and Encourage Continued Participation in Water Quality Projects

Two management measures have been proposed as an education component to enhance public understanding of the projects proposed in Element C and to encourage continued participation in those projects. This section describes the projects associated with each management measure.

Management Measure 1: Engage Public in Positive Action to Improve Stream Buffers

Solution 1.1: Engage Citizens in Volunteer Stream Clean up and Riparian Buffer Improvements

Project description - Expand Operation Clean Stream from the Main Stem of Meramec River to Mattese Creek

Open Space Council plans several river trash removal projects under their program called Operation Clean Stream to improve water quality and access to the river, while also motivating more people to become involved in watershed protection. Each year Operation Stream Clean involves over 2,000 volunteers in river and riparian buffer clean-ups in the Lower Meramec Watershed. In 2016, over 1,632 citizen volunteers cleaned up nearly 500 miles of waterway in the Meramec River watershed. Volunteers donated 4,900 hours and pulled 1,904 tires, 12,518 pounds of metal and 355.35 cubic yards of trash from the river, its tributaries and their banks. This effort has become a popular tradition and much of the outreach is done through word of mouth, Facebook and reaching out to existing stream teams. The EPA has recognized the role trash plays in contributing to water quality problems.[1] Open Space Council seeks to expand their clean-up activities to include Mattese Creek to recruit volunteers in the watershed and provide education about water quality for residents in the watershed. The Open Space Council will start outreach efforts in order to engage Mattese Creek residents in stream clean-up activities. This process will involve new volunteers signing up for monthly newsletters containing opportunities to get involved and encourage registration. *Clear Choices Clean Water*[1] also contains a volunteer services module to help people take a pledge do volunteer work and can connect pledgers to Operation Stream Clean activities.

Management Measure 2: Provide Education Resources to Citizens to Affect Behavior Change on Private Property

Solution 2.1: Use social media and web-based platforms to affect behavior change in the Mattese Creek Watershed

Project description - Clear Choices Clean Water roll-out to Mattese Creek Watershed
Clear Choices Clean Water (CCCW) is a social marketing initiative that increases public awareness about the choices we make and the impacts those choices have on our lakes, streams, and groundwater. The ultimate vision for the initiative is to change people's behavior while implementing a program that easily allows for the evaluation of educational successes and environmental impacts at the same time. Clear Choices, as it was first developed for the Central Indiana region, has several topical, action-oriented campaigns underway (lawn fertilizer, pet waste, native plantings, septic system maintenance, water conservation, and volunteer service, as well as the new 2016 kids pledge and soil health campaign). More pledge modules are in development with new partners, including a Pollinator Protection pledge and a Forest Stewardship pledge. Flexibility to add new focus pledge areas provides for a dynamic outreach program that can grow over time or be changed seasonally or regionally to focus on 'hot topics'. This project proposes America's Confluence to become an affiliate and administer and choose which pledge campaigns to include in the program based on the management measures in this plan.

The focal point of the initiative is a modern, interactive website that includes several additional multimedia and grassroots marketing elements. Visit Indiana's site as an example (Indiana.clearchoicescleanwater.org). Individuals who take the action pledge are immediately "put on the map." The map provides immediate feedback and gratification for the participant that they are doing their part to make a difference. It helps people visualize how their pledge of action, alongside thousands of other pledges, will impact water quality in their watershed. For the program administrators and Affiliates, the map also provides real-time evaluation of the success of the campaign. In addition to map recognition, the feedback participants receive includes an estimate of water quality improvements (e.g. decrease in algae or bacteria in a nearby stream, lake, or river) or an estimate of water saved based upon their "clear choice" behavior pledge. They also have the opportunity to invite others via social media or email to join them in making a difference. Follow-up emails and reminders are sent to participants following their pledge using automated email responders, thus limiting the burden on the program's administrators to maintain communication with participants. According to social marketing research, in order to change behaviors, individuals need to feel like their actions matter and are socially acceptable, encouraged, and positively recognized. They need to be empowered to act. The Clear Choices program does this by providing information, access to materials, and 'how to' instructions. The Clear Choices initiative breaks down knowledge and resource barriers while providing an opportunity for everyone to do something and make their mark on the watershed map. Reaching people with messages about simple behavior changes not only improves water quality by cumulative impact, but begins to incubate a culture of stewardship that transcends the family, business, or classroom. While the program was developed for Indiana, it is applicable to other states and regions and has been successfully launched in other watersheds.

This project proposes Mattese Creek watershed to have its own site, complete with localized resources and mapping features and administered by America's Confluence. Refer to Appendix C for more detailed information about CCCW and how to license the program. CCCW will be piloted in Kiefer Creek watershed before being rolled out to Mattese Creek watershed.

Element F: Schedule for Implementing the NPS Management Measures

Element G: Description of Interim, Measurable Milestones

Element H: Criteria to Determine Whether Loading Reductions are being achieved over Time and Substantial Progress is being made toward Attaining Water Quality Standards

Table 60 contains the schedule for implementing the NPS management measures identified in Elements C and E; the interim, measurable milestones for determining that the projects listed in Elements C and E are being implemented; and a set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards. By tracking indicators/criteria and milestones, both qualitative and quantitative, adaptive management can take place. The most recent information can be used to make a course correction to a specific project or update the plan. Overtime, as practices and/or cost-share programs are implemented, the proposed USGS water quality monitoring plan will help to determine if progress is being made to meet the overall water quality goal for bacteria for Mattese Creek (see Table 43). The core partners will meet on an ongoing basis (at minimum twice a year) to evaluate the progress of implementation activities and achieving load reductions, and to identify any implementation problems. When any course corrections are to occur, the associated schedule and project focus will be revised to address issues noted.

Table 60. Project Timeframe, Indicators, Measurable Milestones and Estimated Load Reductions				
Timeframe	**Project description**	**Indicator/criteria to determine progress**	**Measurable Milestone**	**Estimated load reduction**
Years 1-3	Beginning in year one: Develop and release RFP for watershed master plan and contract with the successful bidder Year two-three: develop and finish Mattese Creek Watershed Plan.	# of bidders for RFP	1 contract secured to develop master plan	*E. coli* 3.82E+099(counts/day) 2 percent Phosphorous 2.4 (pounds/year) 9.3 percent Nitrogen 16.2 (pounds/year) 11.4 percent Total Suspended Solids 713 (pounds/year) 11.1 percent Fecal Coliform 315.5 (billion colonies) 13.8 percent *E. coli* 228.9 (billion colonies) 11.1 percent
	Beginning in year one: installation of one community raingarden on the common grounds of Royal Hills	# of square feet of rainscaping installed	4,200 ft^2	
	Beginning in year one: develop residential application process and recruitment strategy for private property rainscaping cost-share program. In year three: recruitment of homeowners to rainscaping cost-share program and installation of rainscaping	# of square feet of rainscaping installed	2,600 square feet	
	Beginning in year three: secure funding, develop residential application process for cost-share program, and conduct outreach to confirm interested homeowners who need connection, repair or replacement of on-site wastewater treatment systems	# of confirmed property owners with potentially failing on-site wastewater treatment systems recruited to address system issues	2 homeowners	
	Beginning in year one, Open Space Council will begin outreach efforts and register volunteers for Operation Stream Clean expansion into Mattese Creek.	# of volunteers recruited and # of events held	40 Volunteers 2 events	
Years 4-5	Beginning in year five: expand the pledge-based NPS Clear Choices Clean Water watershed social marketing program to Mattese Creek- a combination of education with commitments/pledges to take action.	% of residents who made a pledge to take action on water quality	20% of residents	*E. coli* 3.82E+099(counts/day) 2 percent Phosphorous 4.5 (pounds/year) 17.5 percent Nitrogen 16.2 (pounds/year) 16.4 percent Total Suspended Solids 1313(pounds/year)
	Beginning in year five: owners interested in connecting to sewer lines, repairing or replacing on-site wastewater treatment systems, can participate in cost-share program	# of homeowners participating in cost-share program that have either connected to a sewer line, repaired or replaced on-site wastewater treatment system	2 homeowners	

	Further installation of an additional two community raingardens on the common grounds of Royal Hills	# of square feet of rainscaping installed	8,600 additional square feet 12,800 ft^2 total	20.4 percent Fecal Coliform 463.7 (billion colonies) 20.4 percent *E. coli* 421.5 (billion colonies) 20.4 percent
	In years four-five: continued outreach, education and recruitment of homeowners to rainscaping cost-share program	# of square feet of rainscaping installed	4,000 square feet	
	Open Space Council will continue to recruit volunteers and conduct clean- up and riparian restoration events in Mattese Creek	# of volunteers and clean-up events	10 additional volunteers and 2 events	
Years 6-20	Expansion of Clear Choices Clean Water from Kiefer Creek to Mattese Creek watershed will continue if effective.	% of residents who have made pledges to take action on water quality	30% of residents for a total of 50% of residents making pledges	*E. coli* 2.4E+09 (counts/day) 13.4 percent Phosphorous 3.0 (pounds/year) 22.7 percent Nitrogen 15.3 (pounds/year) 21 percent Total Suspended Solids 867.2 (pounds/year) 26.21 percent Fecal Coliform 306.3 (billion colonies) 26.2 percent *E. co*li 278.4 (billion colonies) 26.2 percent
	Open Space Council will continue to recruit volunteers and conduct clean- up and riparian restoration events in Mattese Creek	# of volunteers recruited and # of cleanup and restoration events	75 additional volunteers 14 events	
	Owners with continued interested in connecting to sewer lines, repairing or replacing on-site wastewater treatment systems, can participate in cost-share program	# of homeowners participating in cost-share program that have either connected to a sewer line, repaired or replaced on-site wastewater treatment system	15 additional homeowners for a total of 17 homeowners	
	In year six: continued outreach, education and recruitment of homeowners to rainscaping cost-share program	# of square feet of rainscaping installed	9,200 square feet 15,800 total square feet	

Element I: Monitoring Component to Evaluate the Effectiveness of the Implementation Efforts over Time

1. Watershed-wide Water Quality Monitoring

USGS has developed several options for water quality monitoring in the watershed to allow for scaling to available resources and level of potential local Stream Team involvement.[77] In general, the plan consists of several seepage studies done during the first part of the effort (year 1), installation and operation of a continuous water-quality monitor (CWQM) on the lower reach of Mattese Creek, routine monthly sampling at the existing USGS stream gage and CWQM, storm event sampling, and microbial source tracking. Allowance is made to incorporate Stream Team efforts (assistance with storm sampling and seepage studies).

The purpose of a seepage study is to understand the surface water-groundwater relationship by determining gain and loss of streamflow and identifying locations of pollutants. During seepage studies, discharge and field properties are measured along with visual observations of the stream and adjacent floodplain, and water quality samples will be collected at various locations along the main steam of Mattese Creek at the mouth of primary tributaries during several seasons (allowance for additional sites is included). A seepage study in the winter/early spring is intended to focus on the distribution of chloride primarily resulting from road salt use. A low-base flow seepage study during the summer will focus on assessing the spatial extent of *E. coli* exceedances from base flow and shallow subsurface sources (such as groundwater seeps, localized septic sources, leaking sanitary sewer etc.). A planned high base flow seepage study in the fall or early winter is focused on assessing *E. coli* sources during wet periods other than wintertime that are not necessarily resulting from recent runoff but could be from saturated septic leach fields, sewer overflows, etc.

In general water samples will be analyzed for *E. coli*, major ions including chloride, and suspended sediment. The suspended sediment concentrations will assist in interpreting *E. coli* density and overall stream quality. Because the chloride standard is based on water hardness and sulfate concentration, a suite of major ions (calcium, magnesium, sodium, chloride, and sulfate) will be analyzed. In addition, bromide is included as ratios of chloride/bromide have been useful in discriminating chloride originating from road salt from other sources such as wastewater. All chemical constituents will be sent to the USGS National Water Quality Laboratory in Denver, Colorado for analyses. Suspended sediment will be analyzed by the USGS Missouri Water Science Center Sediment Laboratory in Rolla, Missouri. The *E. coli* analyses will be performed by USGS Missouri Water Science Center staff with possible assistance from the Stream Team.

Microbial source tracking (MST) studies are performed to assist in the identification of E. coli sources in a water sample. The USGS Microbial Laboratory has an extensive source library of warm-blooded species common across the Nation, including humans, to compare DNA of fecal bacteria indicators against. Results of a MST do not determine the amount of a particular source, but can determine presence or absence of a source, such as human, geese, deer, or other wildlife

[77] See Appendix I to see descriptions of all four monitoring strategy options

species. Understanding the source of E. coli in conjunction with the density of the bacteria can assist in remediation and restoration efforts.

Stormflow event samples will be collected with the assistance of the Stream Team and with the use of passive samplers. The passive samplers will be placed in the stream at a designated river stage above base flow, to collect the rising limb of a stormflow event (also known as the "first flush" when constituents are of an elevated concentration). Passive samplers are ideal in sampling rising conditions on smaller streams that peak quickly, and can assist in accessing a stream when conditions are not suitable for wading or approaching the streambank. The budget assumes that runoff samples will be collected by Stream Team, and the USGS will process the samples and ship to the USGS laboratory.

The proposed study is a three year effort. Routine monthly sampling of the two sites (Site C and CWQM location), CWQM operation, and storm event sampling are planned for three years. Seepage studies should be completed within the first 12 months of the project and microbial source tracking likely would be done during year 2-3. Development of a chloride regression model would be done during year 3.

2. Royal Hills Rainscaping and Riparian Buffer Improvement Monitoring Strategy

A group of 4-8 Stream Team volunteers from Missouri Stream Team 168 has adopted a section of Mattese Creek from Ringer road downstream approximately 3,300 feet to be able to monitor upstream and downstream of the raingarden site.[1] A stream gage used by USGS and MSD is already present at the Ringer Road Bridge. The stream team will conduct watershed mapping, measure stream discharge, along with conducting biological and chemical monitoring to identify stream health. The team will sample at least three sites in the 3,300ft stretch of stream for E.coli and use macroinvertebrates and basic field parameters of dissolved oxygen, pH, and conductivity. If any issues are identified, more selective screenings will be conducted. Monitoring will occur a minimum of twice a year in the spring and fall to coincide with the recreation season. Any major land changes in the area will be noted when tracking any changes in the monitoring results.

Citizen volunteers could also conduct photo-point monitoring to document changes in time in those areas where there has been riparian buffer improvements. In addition, a variety of data collected by various entities is available through the MoDNR web site at http://www.dnr.mo.gov/mocwis_public/wqa/waterbodySearch. This data can be screened to determine where additional monitoring is needed and/or to track water quality changes.

Chapter V. Fishpot Creek Nine Element Plan for Bacteria

Element A – Identification of the Causes and Sources, or Groups of Similar Sources that will need to be controlled to achieve the Load Reductions and Water Quality Goal.

1. Total Maximum Daily Load for Fishpot Creek

The Missouri Department of Natural Resources (MoDNR) established a Total Maximum Daily Load, or TMDL, for Fishpot Creek which was approved on July 13, 2016.[78] The TMDL process quantitatively assesses the impairment factors so that states can establish water quality- based controls to reduce pollution and restore and protect the quality of their water resources. The purpose of a TMDL is to determine the pollutant loading a water body can assimilate without exceeding state water quality standards. Part of the process to establish the TMDL for Fishpot Creek involves undertaking a source inventory and assessment to characterize known, suspected and potential sources of pollutant loading to the impaired water body. Pollutant sources identified within the watershed are categorized and quantified to the extent that information is available. Sources of pollutants may be point (regulated) or nonpoint (unregulated) in nature. Section 3 of the Fishpot Creek TMDL describes the full source inventory and assessment. Map 18 presents general information about the watershed.

2. TMD Implementation Plan

A TMDL implementation plan was also developed by MoDNR[79] and presents those sources identified by the TMDL as being likely contributors to the impaired condition and those sources where implementation activities should be focused in order to meet the goals established by the TMDL with the greatest efficiency. Sources of bacteria are categorized as being either regulated point sources or unregulated nonpoint sources. In the Fishpot Creek watershed, potential sources are those that are most likely to be contributing bacteria during runoff events. Section five, TMDL source assessment summary, of the TMDL implementation has been repeated below.

2.1 Point Sources

Point sources are defined under Section 502(14) of the federal Clean Water Act and are typically regulated through the Missouri State Operating Permit program.[80] They include any discernible, confined and discrete conveyance, such as a pipe, ditch, channel, tunnel or conduit, by which pollutants are transported to a water body. Two significant point source contributors of bacteria were identified in the Fishpot Creek TMDL; sanitary sewer overflows and urban runoff regulated through Metropolitan Separate Storm Sewer System, or MS4, permitting.

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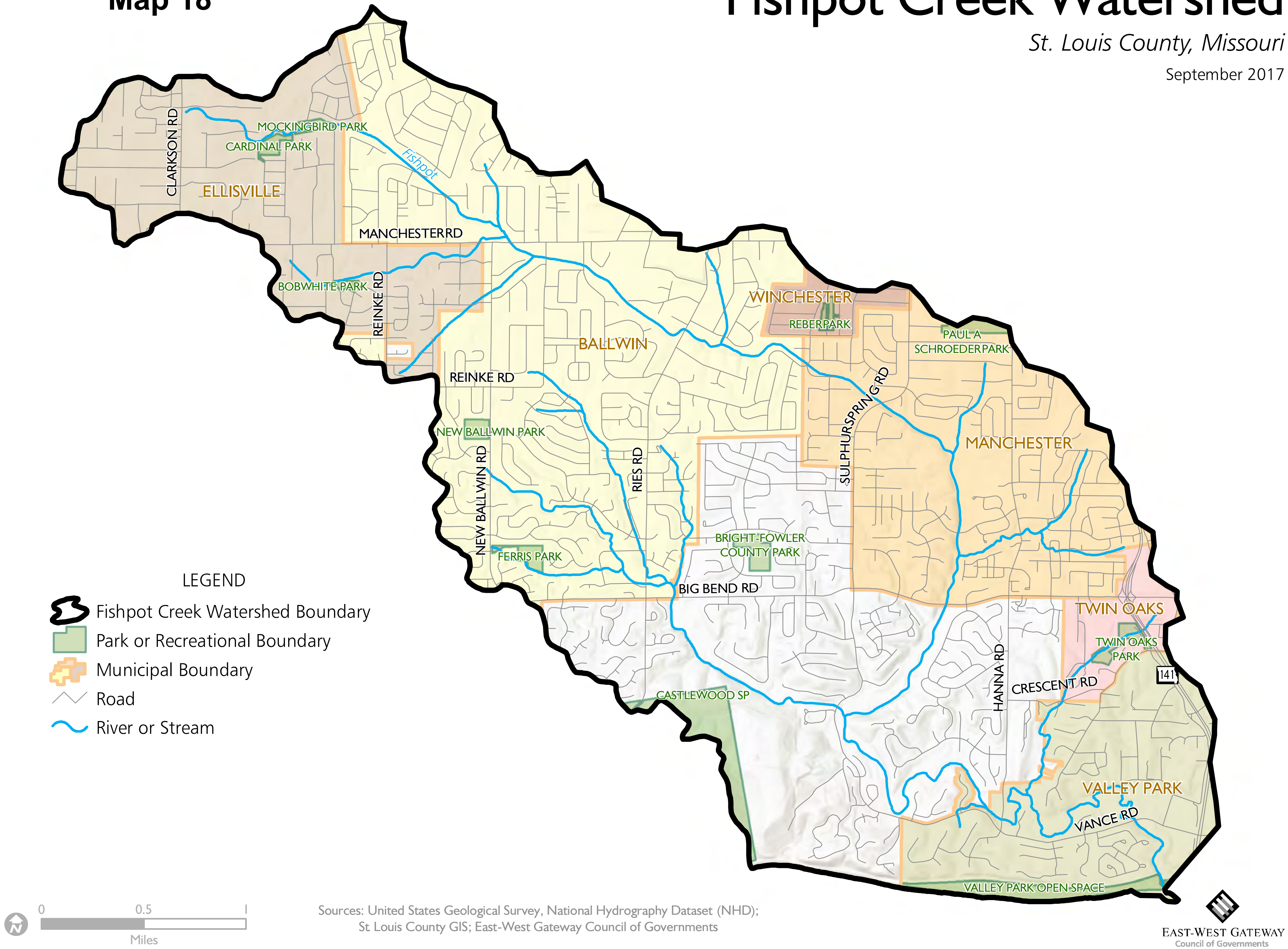
[78] https://dnr.mo.gov/env/wpp/tmdl/docs/tmdl-bacteria-fishpot-cr-final.pdf
[79] https://dnr.mo.gov/env/wpp/tmdl/docs/ip-bacteria-fishpot-cr-final.pdf
[80] The Missouri State Operating system is Missouri's program for administering the federal National Pollutant Discharge Elimination System (NPDES) program. The NPDES program requires all point sources that discharge pollutants to waters of the United States to obtain a permit.

Map 18

Fishpot Creek Watershed

St. Louis County, Missouri

September 2017



Sources: United States Geological Survey, National Hydrography Dataset (NHD);
St Louis County GIS; East-West Gateway Council of Governments

EAST-WEST GATEWAY
Council of Governments

2.1.1 Sanitary Sewer Overflows

Sanitary sewer systems are designed to carry household waste, which includes both grey water and sewage to a wastewater treatment facility. In the Fishpot Creek watershed, this system carries waste to the Grand Glaize wastewater treatment facility located about 1 mile east of the watershed. (See Map 19) Although the treatment facility is located outside the watershed and discharges its wastewater into another stream, the presence of the sewerage system infrastructure within the Fishpot Creek watershed is still a potential source of bacteria due to possible overflows. Sanitary sewer overflows are untreated or partially treated sewage releases from a sanitary sewer system. Overflows can be caused by a variety of reasons including blockages, line breaks, sewer defects, lapses in sewer system operation and maintenance, inadequate sewer design and construction, power failures and vandalism. Sanitary sewer overflows can occur during either dry or wet weather and at any point in the collection system, and include overflows from manholes. Sanitary sewer overflows are unpermitted and are not authorized by the federal Clean Water Act. Occurrences of sanitary sewer overflows can result in periods of elevated bacteria concentrations. In addition to unintended overflows, there is a constructed sanitary sewer overflow outfall located in Ballwin between Barton Lane and Parker Drive that was installed to relieve the sanitary sewer from excess flow caused by inflow and infiltration of stormwater during high rain events[81] (Bruce Litzsinger, Metropolitan St. Louis Sewer District, email communication, Nov. 28, 2011).

2.1.2 MS4 Regulated Urban Runoff

In addition to sanitary sewer inputs, urban runoff has also been found to carry high levels of bacteria and can be expected to exceed water quality criteria for bacteria during and immediately after storm events in most streams throughout the country (EPA 1983). In the case of Fishpot Creek, MS4 permits regulate pollutant contributions from MS4 stormwater discharges for the entire watershed area. For this reason and for purposes of assigning TMDL allocations, urban runoff is considered a regulated point source. Entities regulated by MS4 permits in the Fishpot Creek watershed include the Missouri Department of Transportation and the Metropolitan St. Louis Sewer District and its co-permittees, which in the Fishpot Creek watershed include St. Louis County and the municipalities of Ballwin, Ellisville, Manchester, Valley Park, and Winchester. Although the TMDL considers urban runoff in the Fishpot Creek watershed to be a regulated point source, due to the diffuse nature of urban runoff prior to entering a storm sewer system, implementation efforts should address urban runoff in a manner similar to nonpoint source runoff using BMPs to Gcontrol or reduce stormwater runoff. Reductions in runoff should aid in reducing overall bacteria loading.

2.2 Non-point Sources

Nonpoint source pollution refers to pollution coming from diffuse, non-permitted sources that typically cannot be identified as entering a water body at a single location. They include all other categories of pollution not classified as being from a point source, and are exempt from department permit regulations as per state rules at 10 CSR 20-6.010(1)(B)1. These sources involve stormwater runoff from non-regulated areas and are minor or negligible under low-flow conditions.

[81] See Map 20.

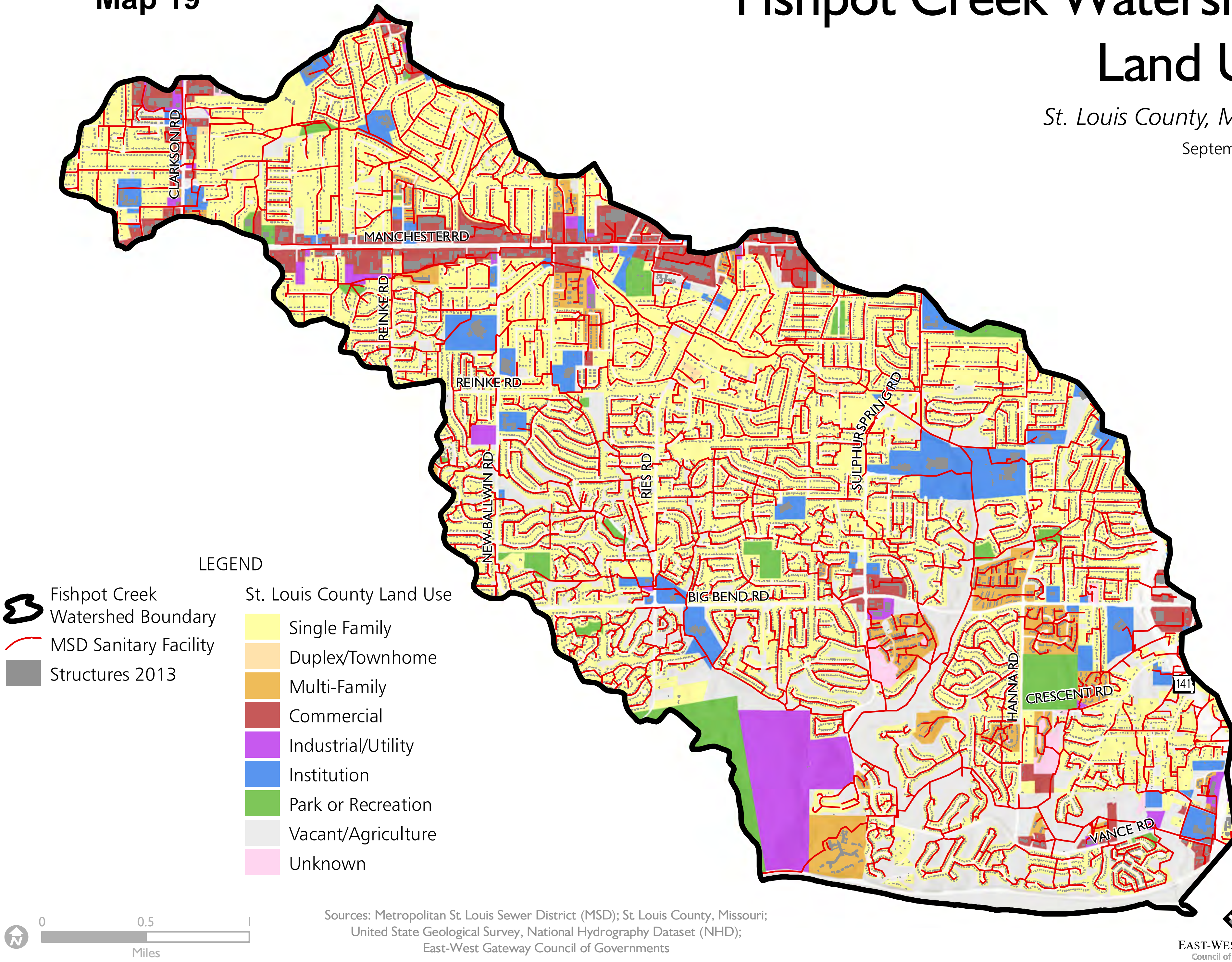
In the Fishpot Creek watershed most stormwater runoff originates from urban areas and is considered a point source for the purposes of the TMDL. Other potential sources of bacteria identified in the TMDL as being nonpoint sources are on-site wastewater treatment systems.

Map 19

Fishpot Creek Watershed Land Use

St. Louis County, Missouri

September 2017



Sources: Metropolitan St. Louis Sewer District (MSD); St. Louis County, Missouri; United State Geological Survey, National Hydrography Dataset (NHD); East-West Gateway Council of Governments

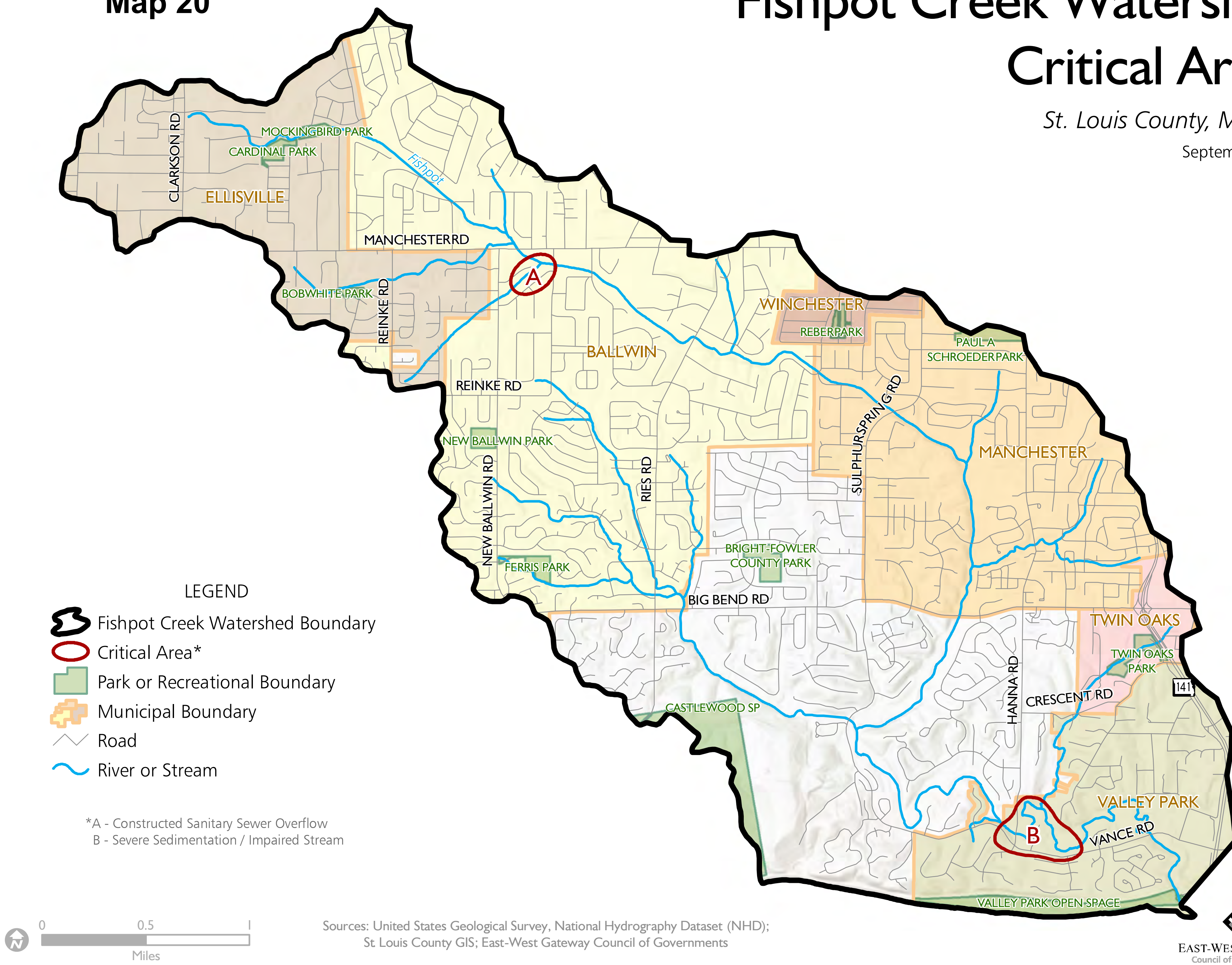
EAST-WEST GATEWAY
Council of Governments

Map 20

Fishpot Creek Watershed Critical Areas

St. Louis County, Missouri

September 2017



Sources: United States Geological Survey, National Hydrography Dataset (NHD);
St Louis County GIS; East-West Gateway Council of Governments

EAST-WEST GATEWAY
Council of Governments

2.2.1 On-site Wastewater Treatment Systems

Failing on-site wastewater treatment systems are known sources of bacteria, which can reach nearby streams through surface runoff and groundwater flows, thereby contributing bacteria loads under either wet or dry weather conditions. They may contribute bacteria loads either directly or as a component of MS4-permitted stormwater. EPA's Spreadsheet Tool for Estimating Pollutant Load, or STEPL, website estimates the failure rate of on-site wastewater treatment systems in St. Louis County as being 39 percent based upon 1990s census data (EPA 2011b). A more recent study conducted by the Electric Power Research Institute suggests that up to 50 percent of on-site wastewater treatment systems in Missouri may be failing (EPA 2011c; EPRI 2000). The exact number of on-site wastewater treatment systems in the Fishpot Creek watershed is unknown; however, such systems built prior to the sewerage systems serviced by the Metropolitan St. Louis Sewer District are known to exist in the older developed areas of St. Louis County (Jack Fischer, St. Louis County Public Works, personal communication, June 6, 2011). Although septic system installations and repairs within St. Louis County require a permit, the county database cannot distinguish between work pertaining to on-site wastewater treatment systems and work pertaining to sanitary sewers because they are classified the same (Jack Fischer, St. Louis County Public Works, personal communication, Jan. 31, 2011).

The Metropolitan St. Louis Sewer District maintains parcel and billing information that can be used to estimate the number of parcels in the watershed without a sewer connection. The majority of parcels in the watershed, approximately 99 percent, do have a sewer connection. Nonsewered or suspected nonsewered parcels in the watershed may include parcels with houses or other structures on them, or may include, parcels comprised entirely of green space. These parcels may potentially have on-site wastewater systems on them. The Metropolitan St. Louis Sewer District confirms that just over 0.6 percent of the parcels in the Fishpot Creek watershed, approximately 90 parcels, are not connected to a sewer. However, it is not known if any on-site systems exist on these parcels. An additional 26 parcels, are suspected of also not having a sewer connection (Kristol Whatley, Metropolitan St. Louis Sewer District, email communication, Aug. 10, 2012).

Much of the Fishpot Creek watershed is serviced by the Metropolitan St. Louis Sewer District's Grand Glaize wastewater treatment plant located about 1 mile east of the watershed. Due to the availability of this sewer system and a St. Louis County ordinance requiring that a sewer connection to a building be made when a sanitary sewer line is within 200 feet of the property, many septic system eliminations have been made. Despite a lack of specific data showing that on-site wastewater treatment systems are a significant problem in the Fishpot Creek watershed, the number of nonsewered or suspected nonsewered parcels in the watershed, combined with the available failure rate data, suggests that on-site wastewater treatment systems are present in the watershed and that these systems are potential contributors of bacteria to Fishpot Creek.

Element B: An Estimate of the Load Reductions Expected for the Management Measures Described in Element C

1. Estimating Pollutant Loadings

In the 2012 Lower Meramec Watershed Plan, the Simple Method to Calculate Urban Stormwater Loads was used to estimate stormwater pollutant loadings for developed land uses within four watersheds, and it has again been used here within Fishpot Creek sub-watershed. It is a spreadsheet model which requires basic information characterizing a watershed, including the watershed drainage area and impervious cover by land use type, stormwater runoff pollutant concentrations and annual precipitation. With the Simple Method, the various pollutant loads, i.e. total nitrogen (N), total phosphorus (P), Total Suspended Solids (TSS), Biological Oxygen Demand (BOD), and bacteria loads (fecal coliform and *E. coli*) are calculated by land use type and then totaled. The stormwater pollutant concentrations can be estimated from local or regional data or from national data sources. For the purposes of this analysis, default concentration factors from both the Simple Method and the spreadsheet tool for Estimating Pollutant Load (STEPL)[82] were utilized. Model default values represent best professional judgement and give additional weight to studies conducted at a national level. These default values do not incorporate studies on arid climates. Bacteria concentrations came from the Minnesota Pollution Control Agency Estimator tool to calculate TMDL benefits.[83] A description of the Simple Method technique can be found in Appendix D of the 2012 Plan.[84] Table 61 below contains the baseline estimates developed for the four pollutants and bacteria in the Fishpot Creek sub-watershed. The estimates calculated using the Simple Method can be used as a starting point for making decisions on management strategies until additional funds become available to conduct more sophisticated watershed modeling or coupled with additional water quality monitoring efforts.

Table 61. Fishpot Creek Sub-watershed Baseline Annual Loads

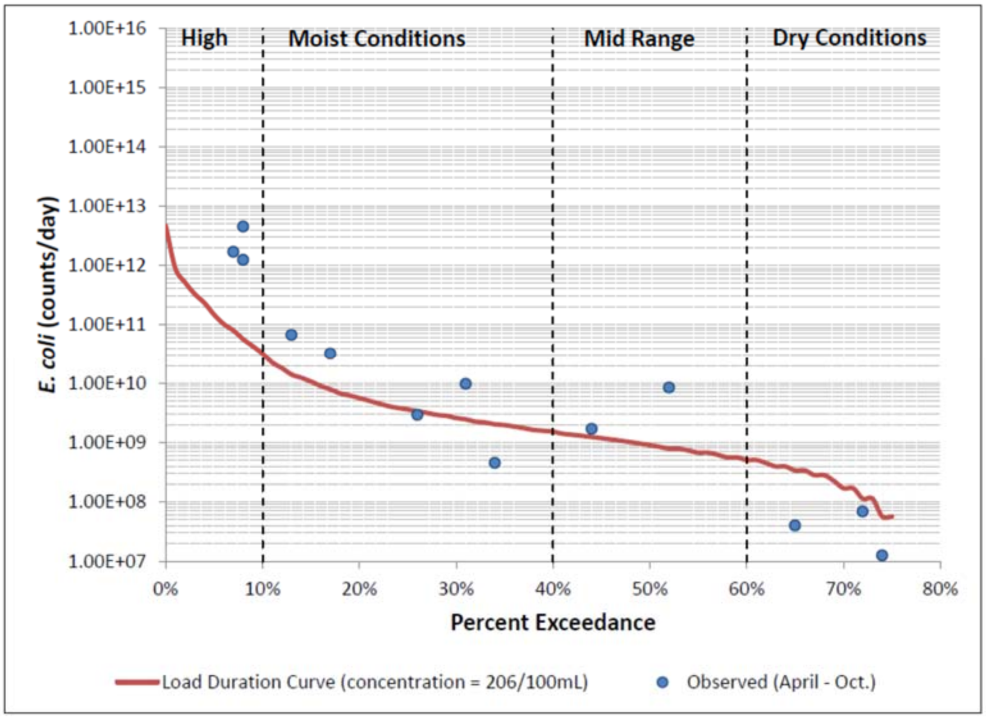
Pollutant	Pounds per year	Billion colonies
Phosphorous	4,280.8	
Nitrogen	26,781.2	
Total Suspended Solids	1,265,913.4	
Biological Oxygen Demand	83,492.5	
Fecal Coliform		170,953.0
E. coli		150,540.5

[82] http://it.tetratech-ffx.com/steplweb/default.htm
[83] https://stormwater.pca.state.mn.us/index.php/Guidance_and_examples_for_using_the_MPCA_Estimator
[84] http://www.ewgateway.org/lowermeramec/lowermeramecwatershedplan-final.pdf

2. Fishpot Creek Load Duration Curves and Pollutant Reduction Estimates

In February 2015, MoDNR released a revised the Fishpot Creek Bacteria TMDL implementation plan.[85] It is a companion document to the Bacteria TMDL for Fishpot Creek approved by EPA in July 2016. The plan contains information on BMPs, potential implementation participants, and calculation of pollutant (bacteria) reduction estimates. The purpose of this plan is to guide the implementation of actions which will assist in the restoration of the stream to unimpaired. The following table presents the reduction estimates for the 50 percent flow range and can be used to aid in the selection and placement of best management practices (BMPs). The 2016 TMDL also contained a load reduction curve for Fishpot Creek, (see Figure 6). A load duration curve is a visual tool used to characterize water quality concentrations at different flow levels and the relationship between stream flow and loading capacity. Percent reductions were calculated using the load duration curve and available water quality data. Table 62 presents the reduction estimate for the 50 percent flow range and can be used to aid in the selection and placement of BMPs. This load reduction was selected as these are flows associated with runoff when nonpoint source contributions are likely to occur.

Figure 6. Fishpot Creek Load Duration Curve



Source: Missouri Department of Natural Resources

[85] https://dnr.mo.gov/env/wpp/tmdl/docs/2186-fishpot-ecoli-tmdl-final.pdf .

Table 62. Estimate of Bacteria (*E. coli*) Load Reduction Needed to Attain Water Quality Standards When 50 Percent of Time Fishpot Creek's Flow is Equaled or Exceeded

Impaired Stream	Flow (cfs)	Existing Load (counts/day)	TMDL (counts/day)	Load Reduction (counts/day)	Percent Reduction Needed
Fishpot Creek	0.18	1.49E+09	9.03E+08	5.84E+08	39.0

Cfs – cubic feet per second
Existing Load – Capacity of stream
Load Reduction – Amount of reduction in bacteria loading needed to achieve Existing Load
Source: Bacteria Total Maximum Daily Load Implementation Plan for Fishpot Creek, MoDNR, 2015

Element A discussed a 2010 USGS study of occurrences and potential sources of *E. coli* in streams in the St. Louis area estimated the potential sources of in-stream measured *E. coli*.[86] For streams like Fishpot Creek with similar climate conditions, land use and bacteria sources, it was estimated that over 30 percent of the measured in-stream *E. coli* originated from humans. The percent share of *E. coli* loading from humans, animals (dogs and geese) and unknown sources was used by EWG to allocate the estimated existing *E. coli* loading among these sources (see Table 63).

Table 63. Fishpot Creek Estimated Bacteria Contribution by Activity

Bacteria Source Groups	Percent Share	Existing *E. coli* Loading (counts/day)
Humans	35	5.22E+08
Dogs	10	1.49E+08
Geese	20	2.98E+08
Unknown	35	5.22E+08
Total	100	1.49E+09

3. Load Reductions from Management Measures in Element C

3.1 Load reductions from riparian buffer and stream channel stabilization management measures

A riparian buffer is an area of native vegetation located adjacent to stream and river channels. A healthy buffer requires a heathy and stable stream channel. The buffer can reduce the amount of non-point source pollution entering waterbodies, enhance stream bank stability, reduce erosion, and provide aquatic and wildlife habitat. A buffer can help to slow runoff velocity from impervious surfaces and trap and filter out sediments, nutrients and other pollutants. The width of the buffer depends on site characteristics and specific function of the buffer. For the purpose of this plan, the goal is that there will be riparian buffers with minimum width of 50 feet from each stream bank. In many cases the stability of the buffer zone will also depend on improving and stabilizing the stream channel. A stabilized stream channel and enhanced buffer should improve efficiencies of pollutant removal and improve habitat over time, as trees, shrubs and

[86] https://pubs.usgs.gov/sir/2010/5150/pdf/sir2010-5150.pdf , Occurrence and Sources of Escherichia coli in Metropolitan St. Louis Streams, October 2004 through September 2007, USGS Scientific Investigative Report 2010-5150

grasses grow and extend roots more deeply into the soil. The riparian buffer protection acts as a passive bio-filter for remaining urban/suburban overland runoff and further reduce NPS bacteria loads from wildlife and pet waste. Data on pollutant and bacteria removal efficiencies for naturalized stream buffers come from the Lower DuPage River Watershed Study, see Table 64. The Lower DuPage study recommended using the middle value when a range of pollutant removal efficiencies are provided. In those streams identified as impaired due to bacteria levels, like Fishpot Creek, the addition of channel stabilization and buffer zone improvement is just the first of many steps which can improve water quality.

Table 64. Examples of Riparian Buffers Pollutant Removal Efficiencies

Reference Source*	Percent Total Phosphorus	Percent Total Nitrogen	Percent Total Suspended Solids	Percent Fecal Coliform
Lower DuPage River Watershed Plan, 2011 – Naturalized Stream Buffer	40 - 65	40 - 50	55- 85	45 - 55
Chesapeake Bay Program – Urban Riparian Forest Buffer	50	25	50	N/A
Eightmile River, 2005 – Forested Buffer	36 – 70	48 – 74	70 – 90	N/A
Eightmile River, 2005 – Vegetated Filter Strips	24 – 85	4 – 70	53 – 97	Not Calculated
Eightmile River, 2005 – Forested and Vegetated Filter Strips	73 - 79	75 - 95	92 - 96	Not Calculated

The Conservation Foundation, Lower DuPage River Watershed Plan, 2011(www.dupagerives.org/LDRWatershedPlan.htm)
Yale School of Forestry and Environmental Studies, Riparian Buffer Zones: Functions and Recommended Widths for the Eightmile River Wild and Scenic Study Committee, 2005 (www.eightmileriver.org/resources/digital_library/appendices/09c3_Riparian%20Buffer%20Science_Yale.pdf)
Chesapeake Bay Program, Best Management Practices for Sediment Control and Water Clarity Enhancement, 2006 (www.chespeakebay.net/content/publications/CBP_13369.pdf)

Table 65. Naturalized Stream Buffer Pollutant/Bacteria Removal Efficiencies

Best Management Practice	Percent Removed
Total Phosphorous	53
Total Nitrogen	45
Total Suspended Solids	70
E. coli	Not Calculated
Fecal Coliform	50

Based on results from the DuPage River Watershed Plan, it is estimated that bacteria load from the continuation and expansion of buffers in the Fishpot Creek sub-watershed would be reduced by 50 percent. The city of Valley Park has proposed to conduct a feasibility study and then perform stream channel stabilization and buffer improvement on a portion of Fishpot Creek (approximately 1,000 feet or 2.3 acres) within Vance Trails Park. This bacteria reduction has been assigned to both the dog and geese groups. Table 66 presents the overall load reduction allocated by source groups for Fishpot Creek.

Table 66. Fishpot Creek Estimate Load Reductions Allocated by Source Group

Fishpot Creek Bacteria Source Groups	Bacteria Percent Share	Existing *E. coli* Loading (counts/day)	Percent Loading Reduction with Implementation of BMPs and Naturalized Stream Buffer by Group	Estimated Reduction with Implementation of BMPs and Naturalized Stream Buffer by Group	20 Years *E. coli* Loading (counts/day)
Humans	35	5.22E+08	0	0	5.22E+08
Dogs	10	1.49E+08	50	7.45E+07	7.45E+07
Geese	20	2.98E+08	50	1.49E+08	1.49E+08
Unknown	35	5.22E+08	0	0	5.22E+08
Total	100	1.49E+09	15	2.24E+08	1.27E+09

MoDNR has estimated the Fishpot Creek loading capacity for the 50 percent of time creek flow is equaled or exceeded at 1.49E+09. At the end of the 20 year period, by improving on-site wastewater treatment systems, connecting to sewer lines and improving the riparian buffer of Fishpot Creek, it is estimated the *E. coli* loading could be 1.27E+09, a 15 percent reduction.

Element C: Descriptions of the NPS Management Measures that will need to be implemented to Reach Load Reductions and Identification of the Critical Areas in which to implement those Measures

1. Water Quality Goal

Based on pollutant loading modelling and load reduction curves contained in Element B (Table 62), the water quality goal for Fishpot Creek is to:

Reduce Bacteria Loading in Fishpot Creek by 39 Percent to Achieve Water Quality Standards by 2037

Based on Elements A and B, we know that the most likely human sources of bacteria in Fishpot Creek are from a constructed sanitary sewer overflow (CSO) outfall in the watershed and on-site wastewater treatment systems. The consent decree established as part of the *United States of America and the State of Missouri, and Missouri Coalition for the Environment Foundation v. Metropolitan St. Louis Sewer District, No. 4:07-CV-1120* requires MSD to eliminate the CSO which is scheduled by MSD to happen in 2014-2018.[87] The consent decree also requires MSD to implement a supplemental environmental project to decommission some septic tanks and repair or replace laterals to low-income residents within the Metropolitan St. Louis Sewer District's service area. This project could aid in further reducing the number of septic tanks within the watershed. Because these projects will address the human sources of bacteria in the watershed and are required to take place, management measures in this plan focus on addressing pet and wildlife waste contained in urban runoff entering Fishpot Creek in places affected by severe erosion and sedimentation.

Management Measurement 1: Restore the Riparian Corridor of Fishpot Creek to Enhance its Ecological Functions Associated with Reducing Sediment Loads and Filtering Pollutants.

Based on a 2003 Fishpot Creek geomorphic study[88] and the Fishpot TMDL, the City of Valley Park has identified a natural stream restoration design to restore the ecological impacts caused by erosion and sedimentation. This section of Fishpot Creek has been identified as a critical area for project implementation because it coincides with the impaired section of Fishpot Creek on the 303(d) list, flows through a public park where people recreate in the stream and that serves as habitat for geese, has an interested partner to do restoration and also involves working with a condominium complex in reducing pet waste. Map 20 contains the location of the proposed project site.

Solution 1.1: Stabilize Stream Banks and improve riparian buffer conditions

Project description - Fishpot Creek Natural Channel Stabilization Feasibility Study

The City of Valley Park has some significant problems along Fishpot Creek at two specific locations and is interested in making some modifications to the channel to minimize some of the

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[87] http://www.stlmsd.com/sites/default/files/FY2017%20-%20FY2020%20Rate%20Proposal%20Exhibits/Exhibit%20MSD%2047B%20-%20MSD%20Sanitary%20Sewer%20Overflow%20Control%20Master%20Plan%20Executive%20Summary.pdf

[88] http://dev.ewgateway.org/wp-content/uploads/2017/08/Fishpot-Creek-Watershed-A-Demonstration-of-Geomorphic-Based-Stream-Channel-Management.pdf

erosive effects during high flow conditions. The two major areas of concern are the erosion of the bank adjacent to the Summertree Condominiums and the bank spillover/erosion from a meander neck or a channel cutoff developing in Vance Trails Park. The impacts of erosive effects have increased over recent years, seemingly due to increased development upstream of the City of Valley Park and/or possibly from stream impacts such as rock deposition. The erosion of the bank adjacent to Summertree Condos has been increasing by getting closer to the actual residential structures. The City would like to prevent further erosion along the bank that may eventually cause the failure/loss of the structure.

A previous solution of rock blanket placed on the bank by the Metropolitan St. Louis Sewer District (MSD) has failed and the City would like to install a natural stream restoration design to restore the ecological impacts caused by the erosion. This natural stream restoration design is intended to prevent future erosion and sedimentation with a particular focus on improving the ability of the riparian corridor to filter pollutants from urban runoff.

The bank spillover/erosion from the meander neck has started to form a channel cutoff along Fishpot Creek through Vance Trails Park and has caused the trail through the park to be in jeopardy. The channel cutoff appears to be developing through the park and if allowed to naturally develop, will eliminate a portion of the trail through the park. The City is reviewing possibly installing a cutoff channel that is of a natural stream design that will prevent future erosion. The channel elevation difference (approx. 4') from the upstream to downstream channel will require stepped solutions to minimize velocities that may lead to bigger erosion problems. The City will also need to install a bridge system to extend over the newly designed channel to provide a continuous trail system within the park. A preliminary engineering study for this solution would include:

- Topographic survey of 2 sites (Summertree Condo's area and Vance Trails Park Site)
- Geomorphology Report for possible Vance Trails Park Channel and verification of Summertree Site. (A previous geomorphology report was completed for Fishpot Creek)
- Slope stability analysis (engineering characteristics beyond geomorphology report)
- Preliminary Hydraulic Analysis
- Engineered Preliminary Cost Estimates with Economic Analysis of possible solutions

This project will include developing a request for qualifications and selection of an engineering firm which will develop alternative design scenarios, cost estimates, and following selection of a preferred design, develop a preliminary engineering design (30 percent engineering design).

Project description: Fishpot Creek Natural Channel Stabilization
This project is to implement the recommendations from the feasibility study to restore the riparian corridor to help filter pollutants from pet and wildlife waste contained in urban runoff. Subject to the study's recommendations, approximately 1,000 feet of streambank are to be stabilized and riparian buffer conditions improved with native plantings.

Element D: Estimate of the Amounts of Financial Assistance and the Sources and Authorities that will be relied Upon for Each Project.

Table 67 lists the estimated costs associated with each project described in Elements C and E, the agencies, organizations and/or groups involved, and the amount of funding sought. Other sources of available funding through grants or loans are found in Table 68.

Table 67. Estimated Project Costs for Fishpot Creek

Project description	Project costs	Partner contribution	Funding sought
Fishpot Creek Natural Channel Stabilization Feasibility Study	The costs for this portion of the project is estimated to be $100,000[89]	City of Valley Park 40% or $40,000	60% or $60,000
Fishpot Creek Natural Channel Stabilization	Costs range from $250,000 - $1 million – to be determined by Feasibility Study but approximately 1,000 feet to be stabilized plus riparian buffer improvements[90]	City of Valley Park TBD	TBD
Expand Operation Clean Stream from the main stem of Meramec River to Fishpot Creek	$10,000 is required for volunteer coordination, event liability insurance, signage and supplies	40% or $4,000 provided by Open Space Council Missouri Stream Team	60% or $6,000
Expand Clear Choices Clean Water from Kiefer Creek to Fishpot Creek watershed	Software License: 2 years. $10,300 Municipal Mapping GIS: $500 Private Septic Mapping GIS: $500 Private Septic Pledge Collateral: $1,000 Pet Waste Pledge Collateral: $1,000 Lawn Fertilizer Pledge Collateral: $500 Volunteer Service Pledge Collateral $500 Native Plants and Gardens Pledge Collateral $500 Marketing and Signage: $25,000 Total cost for 2 years: $39,000	40% or $15,600 TBD	60% or $23,400

[89] This is based on a previous geomorphic study conducted in Fishpot Creek - http://emriver.com/about-us/fishpot-creek/
[90] The Lower DuPage Watershed study estimated riparian buffer improvements alone are between $5,000-$10,000 per acre

Table 68. Grants and Funding Opportunities

Grant Program Sponsoring Agency	General Information	Eligibility	Level of Assistance	Website
North American Wetland Conservation Act – U.S. Standard Grants Program U.S. Fish and Wildlife Service	Program that supports public-private partnerships carrying out projects in U.S. Projects must Involve long-term protection, Restoration and/or enhancements of wetlands and associated uplands habitats.		50% matching funds required. Grants start at $100,000	www.fws.gov/birdhabitat/grants
Planning Assistance to States U.S. Army Corps of Engineers	Provides assistance with the development of comprehensive plans for the development and conservation of land and water resources. Cover planning level of detail.	States, local governments and other non-federal entities. Non-profits are not eligible but could partner with state or local governments.	Limit for each state is $500,000 Annually. Cost Share is 50-50. Generally studies range from $25,000-$75,000.	www2.mvn.usace.army.mil/pd/pppmd_assistance_states.asp
Environmental Education Grants U.S. Environmental Protection Agency	EPA's Office of Environmental Education, Office of External Affairs and Environmental Education supports environmental education projects that enhance the public's awareness, knowledge and skills to help people make informed decisions that affect environmental quality. Grants are awarded based on funding appropriated by Congress.	Applicant must represent one of the following types of organization to be eligible: local education agency; state education or environmental agency; college or university; non-profit organization 501(c) (3), noncommercial educational broadcasting entity; or tribal education agency	Annual funding for this program ranges between $2 and $3 million range. Non-federal matching funds of at least 25% are required.	www2.epa.gov/education/environmental-education-ee-grants
Watershed Management Plan Development Grant - U.S. Environmental Protection Agency administered through Missouri Department of Natural Resources	Provides funding for development of watershed-based management plans to restore watersheds impaired by non-point source pollution. Due to funding limitations and a new approach, the general solicitation schedule for Watershed Planning has been discontinued.	Eligible organizations include state and local agencies, educational institutions and Non-profits organizations with demonstrated 501 (c) (3) status.		www.dnr.mo.gov/env/wpp/nps
Section 319 Nonpoint Source Grant Program	NPS source grant funds are provided from EPA through Section 319(h) of Clean Water Act. Funds can be used to implementing Best Management	Eligible organizations include state and local agencies, educational institutions and non-profits	Variable award amounts will be based on number of applicants, amount	www.dnr.mo.gov/env/swcp/nps

Grant Program Sponsoring Agency	General Information	Eligibility	Level of Assistance	Website
U.S. Environmental Protection Agency administered through Missouri Department of Natural Resources	Practices and associated activities as detailed in their watershed management plan. Annual announcement on availability of funds. Amount of funding is dependent upon number of applications received.	organizations with demonstrated 501 (c) (3) status.	of funding available at time of request. Matching support: 60% federal and 40% non-federal (cash or eligible in-kind contribution)	
Targeted Watershed Grants Program U.S. Environmental Protection Agency	Program is designed to encourage successful community-based approaches and management techniques to protect and restore the nation's waterways. It is a competitive program. Program focuses on multi-faceted plans for protecting and restoring water resources that are developed using partnership efforts of diverse stakeholders. Implementation grants support on-the-ground watershed projects and Capacity Building grants are awarded to leading organizations with a national or regional focus that are able to provide training, technical assistance and education to local watershed groups. Check with EPA for next proposal cycle.	Eligible organizations include State and local governments, public and private non-profit institutions/organizations, federally recognized Indian tribal governments, U.S. territories or possessions and interstate agencies. For profit commercial entities and all federal agencies are ineligible.	Applicants are required to demonstrate a minimum non-federal match of at least 25% of total project cost. Funding could range from $400,000 to $900.000.	Http://water.epa.gov/grants_funding/twg/initiative_index.cfm
Private Services Landowner Assistance Program Missouri Department of Conservation	Financial assistance is offered to communities interested in habitat and natural recourse management every year	Nonprofits, city/county units of government and non-government entities are eligible to apply	Assistance is available on July 1 each year. All applicable projects are subject to reimbursement caps per cooperator year. Most projects will be reimbursed at a rate of 50 percent of total costs up to a	For additional information regarding landowner assistance and project eligibility, please contact Josh Ward, Private Land Conservationist at: 636-441-4554 or Josh.Ward@mdc.mo.gov

Grant Program Sponsoring Agency	General Information	Eligibility	Level of Assistance	Website
			maximum limit, some restrictions apply.	
Clean Water Act Section 604(b) federal grant funds administered by the U.S. Environmental Protection Agency through the Department of Natural Resources	The Water Protection Program components under the Clean Water Act Section 604(b) federal grant, are intended to assist with the revision of Water Quality Standards, risk-based groundwater standards, the anti-degradation policy and implementation method, toxicity testing, area-wide wastewater management prioritization, including planning studies and, wastewater feasibility studies. A portion of the 604(b) federal grant is awarded to Missouri communities for water quality planning.	Communities are invited to submit their competitive project proposals through their Regional Planning Commissions and the Missouri Councils of Governments for funding. The water quality management funds could be used for activities such as: watershed management plans, urban stormwater management plans, and stormwater planning. Applicants were especially encouraged to give priority to watershed management planning in urban watersheds or sensitive watershed threatened by development, along with green infrastructure, water or energy improvements related to water quality, or other environmentally innovative planning activities.	Missouri's share of the 604(b) Recovery Act Funding is $1,097,400 million. The Clean Water Act Amendments required states to pass through 40 percent of the 604(b) funds to regional public comprehensive planning organizations.	https://energy.mo.gov/division-of-energy/transform/water-quality-planning-and-management---604(b)
State Revolving Fund (SRF) Loan Program Missouri Department of Natural Resources	The State Revolving Loan Program provides low-interest loans to Missouri communities for projects that improve wastewater and drinking water infrastructure. The Missouri Department of Natural Resources and the Environmental Improvement and Energy Resource Authority work together to administer this program and to protect public health and the environment. The SRF has implemented an agriculture loan program, in cooperation with the Missouri Agriculture and Small Business Development Authority, to	Cities, towns, counties, regional sewer/water districts, water authorities and instrumentalities of the state are eligible for wastewater, drinking water and nonpoint source SRF loans. Private and nonprofit facilities are eligible for drinking water and nonpoint source loans. Individuals and citizen groups are also eligible for nonpoint source loans.	Missouri applies to the U.S. Environmental Protection Agency (EPA) annually for capitalization grants to fund its SRF Programs. To increase available funds, the state leverages its EPA capitalization grants in the municipal bond market. These	https://dnr.mo.gov/env/wpp

Grant Program Sponsoring Agency	General Information	Eligibility	Level of Assistance	Website
	fund certain nonpoint source projects, and has recently set aside funding for new initiatives to fund on-site wastewater treatment projects.		funds are combined with the EPA required state match and then made available to Missouri communities in the form of low interest loans. As the loans are repaid, the money is reused (revolved) by the SRF to provide for future projects. The SRF is a fixed rate, 20-year loan. Interest rates are generally 30 percent of the market rate.	

Element E: Education Component used to Enhance Public Understanding and Encourage Continued Participation

1. Importance of Education

Fishpot Creek is largely an urban environment, with areas categorized as urban or impervious accounting for over 70 percent of the watershed. Therefore, residential decision-making about property management could have a significant impact on the quality of water within the stream. Educating residents of the watershed will help to increase public awareness of the importance of a quality riparian corridor along Fishpot Creek, water quality issues and ways individuals can act to improve and protect water quality in the Fishpot Creek watershed.

2. Management Measures to Enhance Public Understanding and Encourage Continued Participation in Water Quality Projects

Two management measures have been proposed as an education component to increase public engagement. This section describes the projects associated with each management measure.

Management Measure 1: Engage Public in Positive Action to Improve Stream Buffers

Solution 1.1: Engage citizens in volunteer stream clean up and riparian buffer improvements

Project description - Expand Operation Clean Stream from the main stem of Meramec River to Fishpot Creek

Open Space Council plans several river trash removal projects under their program called Operation Clean Stream to improve water quality and access to the river, while also motivating more people to become involved in riparian corridor improvements. Each year Operation Stream Clean involves over 2,000 volunteers in river and riparian buffer clean-ups in the Lower Meramec Watershed. In 2016, over 1,632 citizen volunteers cleaned up nearly 500 miles of waterway in the Meramec River watershed. Volunteers donated 4,900 hours and pulled 1,904 tires, 12,518 pounds of metal and 355.35 cubic yards of trash from the river, tributaries and their banks. This effort has become a popular tradition and much of the outreach is done through word of mouth, Facebook and reaching out to existing stream teams. The EPA has recognized the role trash plays in contributing to water quality problems.[1] Open Space Council seeks to expand their clean-up activities to include Fishpot Creek to recruit volunteers in the watershed and provide education about water quality for residents in the watershed. The Open Space Council will start outreach efforts in order to engage Fishpot Creek residents in stream clean-up activities. This process will involve new volunteers signing up for monthly newsletters containing opportunities to get involved and encourage registration. *Clear Choices Clean Water*[1] also contains a volunteer services module to help people take a pledge do volunteer work and can connect pledgers to Operation Stream Clean activities

Management Measure 2: Provide Educational Resources to Citizens to Affect Behavior Change on Private Property.

Solution 2.1: Use software and internet- based interactive learning methods to affect behavior change

Project description – Roll-out of Clear Choices Clean Water program to Fishpot Creek watershed

Clear Choices Clean Water (CCCW) is a social marketing initiative that increases public awareness about the choices we make and the impacts those choices have on our lakes, streams, and groundwater. The ultimate vision for the initiative is to change people's behavior while implementing a program that easily allows for the evaluation of educational successes and environmental impacts at the same time. Clear Choices, as it was first developed for the Central Indiana region, has several topical, action-oriented campaigns underway (lawn fertilizer, pet waste, native plantings, septic system maintenance, water conservation, and volunteer service, as well as the new 2016 kids pledge and soil health campaign). More pledge modules are in development with new partners, including a Pollinator Protection pledge and a Forest Stewardship pledge. Flexibility to add new focus pledge areas provides for a dynamic outreach program that can grow over time or be changed seasonally or regionally to focus on 'hot topics'. This project proposes America's Confluence to become an affiliate and administer and choose which pledge campaigns to include in the program based on the management measures in this plan.

The focal point of the initiative is a modern, interactive website that includes several additional multimedia and grassroots marketing elements. Visit Indiana's site as an example (Indiana.clearchoicescleanwater.org). Individuals who take the action pledge are immediately "put on the map." The map provides immediate feedback and gratification for the participant that they are doing their part to make a difference. It helps people visualize how their pledge of action, alongside thousands of other pledges, will impact water quality in their watershed. For the program administrators and Affiliates, the map also provides real-time evaluation of the success of the campaign. In addition to map recognition, the feedback participants receive includes an estimate of water quality improvements (e.g. decrease in algae or bacteria in a nearby stream, lake, or river) or an estimate of water saved based upon their "clear choice" behavior pledge. They also have the opportunity to invite others via social media or email to join them in making a difference. Follow-up emails and reminders are sent to participants following their pledge using automated email responders, thus limiting the burden on the program's administrators to maintain communication with participants. According to social marketing research, in order to change behaviors, individuals need to feel like their actions matter and are socially acceptable, encouraged, and positively recognized. They need to be empowered to act. The Clear Choices program does this by providing information, access to materials, and 'how to' instructions. The Clear Choices initiative breaks down knowledge and resource barriers while providing an opportunity for everyone to do something and make their mark on the watershed map. Reaching people with messages about simple behavior changes not only improves water quality by cumulative impact, but begins to incubate a culture of stewardship that transcends the family, business, or classroom. While the program was developed for Indiana, it is applicable to other states and regions and has been successfully launched in other watersheds.

This project proposes Mattese Creek watershed to have its own site, complete with localized resources and mapping features and administered by America's Confluence. Refer to Appendix C for more detailed information about CCCW and how to license the program. CCCW is proposed to be piloted in Kiefer Creek watershed before being rolled out to Fishpot Creek watershed.

Element F: Schedule for Implementing the NPS Management Measures

Element G: Description of Interim, Measurable Milestones

Element H: Criteria to Determine Whether Loading Reductions are being achieved over Time and Substantial Progress is being made toward Attaining Water Quality Standards

Table 69 contains the schedule for implementing the NPS management measures identified in Elements C and E; the interim, measurable milestones for determining that the projects listed in Elements C and E are being implemented; and a set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards. By tracking indicators/criteria and milestones, both qualitative and quantitative, adaptive management can take place. The most recent information can be used to make a course correction to a specific project or update the plan. Overtime, as practices and/or cost-share programs are implemented, monitoring (as described in Element I) will help to determine if progress is being made to meet the estimated load reductions in Column 5 of Table 69 as well as the overall water quality goal for bacteria for Fishpot Creek (see Table 62). The core partners will meet on an ongoing basis (at minimum twice a year) to evaluate the progress of implementation activities and achieving load reductions, and to identify any implementation problems. When any course corrections are to occur, the associated schedule and project focus will be revised to address issues noted.

Table 69. Project Timeframe, Indicators, Measurable Milestones and Estimated Load Reductions

Timeframe	Project description	Indicator/criteria to determine progress	Measurable Milestone	Estimated load reduction
Years 1-3	Fishpot Creek Feasibility Study in Valley Park	# of sites surveyed for study	2 sites	
	Beginning in year one, Open Space Council will begin outreach efforts and register volunteers for Operation Stream Clean expansion into Fishpot Creek.	# of volunteers recruited and # of Fishpot Creek cleanup and riparian restoration events	30 Volunteers and 2 events held	
Years 4-5	Beginning in year 5: stream channel stabilization and buffer improvements in Valley Park	# linear feet of stream bank stabilized w/ associated buffer improvements	250 ft.	*E.coli* 5.59E+07 or 3.7 %
	Beginning in year five: expand the pledge-based NPS Clear Choices Clean Water watershed social marketing program will to Fishpot Creek- a combination of education with commitments/pledges to take action.	% of residents who made pledges made to take action on water quality	10% of residents	
	Open Space Council will continue to recruit volunteers and conduct clean- up and riparian restoration events in Fishpot Creek	# of volunteers recruited and # of cleanup and restoration events	50 Volunteers and 2 additional events held	
Years 6-20	Continuation of Fishpot Creek stream channel stabilization and riparian buffer improvements	# of linear feet of streambank stabilized and buffer improved	750 additional feet for total of 1,000 feet	*E.coli* 1.68E+08 or 11.3%
	Expansion of Clear Choices Clean Water from Kiefer Creek to Fishpot Creek watershed will continue if effective.	% of residents who made pledges to take action on water quality	Additional 40% of residents for a total of 50% of residents	
	Open Space Council will continue to recruit volunteers and conduct clean- up and riparian restoration events in Fishpot Creek	# of volunteers recruited and # of cleanup and restoration events	75 Volunteers and 14 additional events held	

Element I – Monitoring Component to Evaluate the Effectiveness of the Implementation Efforts Over-Time, Measured Against the Criteria Established Under Element H Immediately Above

1. Current Water Quality Monitoring in Fishpot Creek

Water quality monitoring provides an analytical framework to support project implementation and assess effectiveness. It also serves as a tool to inform and educate residents and stakeholders. Continuous water quality monitoring has been undertaken in Fishpot Creek watershed by USGS and MSD through the Fishpot Creek Monitoring Station. Surface water samples are taken from this site and Table 70 lists the items that are analyzed.

Table 70. Items Analyzed for Water Quality Monitoring

USGS Station Number – 0701920	
Location – at Vance Road	
Items Analyzed MSD	USGS Parameters
Ammonia-Nitrogen	Discharge
Chemical Oxygen Demand	Gage Height
Chloride	
Dissolved Oxygen	
E. coli	
Fecal Streptococcus Group Bacteria	
Hardness caused by Divalent Cations (Calcium, Magnesium)	
pH	
Sulfate	
Temperature of Water	
Total Suspended Solids	

2. Future Monitoring

MoDNR will continue to assess Fishpot Creek for compliance with state water quality standards. MSD collects water quality data for this stream. MoDNR will schedule and perform post-TMDL monitoring approximately three years after the TMDL is approved (approximately 2019) or in a reasonable timeframe after permit compliance schedules and new effluent standards are completed or following the implementation of significant actions. In order to evaluate the effectiveness of TMDL implementation, MoDNR will examine water quality data collected and analyzed by other local, state or federal agencies, including MSD. Other potential options for quality-assured data to use in evaluation of the implementation of the TMDL include universities, private companies, volunteer groups and municipalities. MoDNR input will be needed to identify monitoring activities and sampling and analytical methodologies.

Citizen volunteers could conduct photo-point monitoring to document changes in time in those areas where there has been riparian buffer improvements. In addition, a variety of data collected by various entities is available through the MoDNR web site at http://www.dnr.mo.gov/mocwis_public/wqa/waterbodySearch. This data can be screened to determine where additional monitoring is needed and/or to track water quality changes.

Chapter VI. Lower Meramec River

1. Introduction

A full nine element watershed plan is not provided for the main stem of the lower Meramec River because water quality in the River is also affected by tributaries, riparian conditions and discharges upstream in the Meramec River watershed that are outside the boundaries of this plan. Therefore, Chapter VI focuses on activities that land managers along the riparian corridor within the boundaries of this plan can undertake to improve water quality in the main stem.

2. Water quality in the lower Meramec River

The Meramec River is one of the most biologically diverse, free-flowing, and healthy rivers in any urban area in the United States. It remains generally healthy with a good diversity of species in the lower reaches, even though many of the tributaries in the urban area are severely degraded and not supporting healthy diversity of aquatic life. In 2016, the Meramec River (WBID 2183, from Valley Park to the confluence) was listed as impaired for whole body contact recreation because of excess bacteria (see Map 2). This portion of the river and the portion from Eureka to Valley Park (WBID 2185, 15.7 miles) were also identified as impaired as result of mercury (atmospheric deposition) and lead (in sediment). Because the lower Meramec offers recreational boating and swimming opportunities within a 30 minute drive of nearly half of the region's citizens, addressing the problem is a high priority for the region.

2.1 Sources of Impairments

E. coli may occur as a result of inadequate on-site wastewater treatment systems, the overflow of domestic sewage, or nonpoint sources of human and animal waste. There are several domestic sanitary wastewater treatment facilities that are permitted to discharge effluent to the Meramec River.[91] These point source discharges are unlikely to contribute to the bacteria impairment, though, because they are in compliance with their effluent limits which adhere to water quality standards. On-site wastewater treatment systems in tributary watersheds and urban runoff to the tributaries and Meramec River itself are likely to be contributing high levels of bacteria in the lower Meramec River. The lower Meramec River is also affected by sedimentation from severely eroding river banks caused by degrading riparian buffer conditions and flooding events. Polluted runoff in the watershed can enter the lower Meramec River where riparian conditions are inadequate to absorb and filter the runoff. The lower Meramec River also sees large amounts of trash and debris either dumped or carried into it through flooding.

Mercury occurs in the environment through natural processes and human activity, and because it can vaporize, mercury can enter the atmosphere and is deposited in waterways through precipitation and runoff. Mercury can accumulate in fish muscle tissue (filets) of commercial and recreational bottom-feeding fish. Starting where the Big River enters the Meramec River and eastward, sediment has become contaminated with lead as a result of erosion of lead mine tailing piles to the south in St. Francois County. The contamination of stream sediment has resulted in the contamination of fish and other aquatic life. Ongoing work to address lead contamination is

[91] See Appendix A for a list of NPDES permits and Map 9 in same Appendix for their locations

underway through other efforts and therefore addressing the lead impairment is not a focus of this Chapter.[92]

3. Goal for lower Meramec River

Any actions to reduce stormwater runoff, remediate on-site wastewater treatment systems and improve riparian conditions in the tributary watersheds will help to improve water quality in the main stem lower Meramec River. Without considering water quality conditions for the entire Meramec watershed, it is nearly impossible to determine what the pollutant loads and load reduction should be just for the lower Meramec River. Additional data collection efforts and coordination will be necessary. Because of this, demonstration projects are proposed in the lower reach to contribute to the overall lower Meramec River education and outreach efforts. The Nine Element watershed plans for Kiefer Creek, Mattese Creek and Fishpot Creek tributaries will help those watersheds achieve water quality standards and reduce their bacteria contribution to the lower Meramec River.

Improving severe bank erosion and reducing sedimentation through maintaining or re-establishing a healthy riparian corridor along the lower Meramec River is another key way to reduce the bacteria loading. There are a number of public lands with high numbers of visitors along the lower Meramec River. County and municipal park land and properties owned by Great Rivers Greenway located on or adjacent to the lower Meramec River are ideal locations for demonstration projects such as riparian buffer restoration and stream bank stabilization. Cumulatively, projects along these lands can start to add up to a more robust and healthy riparian corridor along the entire length of the lower Meramec River over time. Potential pollutant load reduction from these small-scale demonstration projects would not be sufficient to achieve water quality standards.[93] However, visitors to these properties can gain understanding about nonpoint source pollution, the range of BMPs that can be implemented and their water quality benefits and what individuals can do. The demonstration projects and education and outreach efforts also can provide a framework for local, state and federal partners to work together to address water quality challenges in the lower Meramec watershed.

Therefore, the goal for the lower Meramec River is to:

Demonstrate the effectiveness and feasibility of re-establishing a healthy riparian corridor and implementing stormwater BMPs to reduce bacteria loading in the lower Meramec River.

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[92] The Natural Resource Damage Assessment and Restoration (NRDA) process of MoDNR in the Southeast Missouri Lead Mining District is ongoing (see http://dnr.mo.gov/env/hwp/sfund/nrda-se.htm). This area included the Big River watershed, a tributary of the Meramec River. Activities are occurring under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). This district is one of the largest lead-producing regions of the world. Funding for this effort has come from legal settlements with mining firms operations in the area for natural resources that were harmed by releases of lead and zinc from current and historic mining and smelting at sites here. MoDNR and U.S. Fish and Wildlife Service, and in some instances U.S. Forest Service, have developed a regional natural resources restoration plan. The USACE has active ecosystem restoration feasibility study underway and investigating the downstream movement of sediment (containing lead), fish passage issues and stream bed and bank instabilities (see http://www.mvs.usace.army.mil/Portals/54/docs/pm/2017%20Project%20Fact%20Sheets/GI/Project%20Fact%20Sheet-St.%20Louis%20Riverfront.pdf?ver=2017-03-14-101350-277). The focus of EPA is on the remediation of lead contamination in the impacted watersheds. Its Remedial Investigation/Feasibility Study is still underway.

[93] Therefore, no load reduction estimates have been calculated from the projects listed in section 4 below.

The Nature Conservancy has started a process to update their 2014 Meramec River Basin Conservation Action Plan (CAP). This process includes using the Soil and Water Assessment Tool (SWAT) to model and simulate the quality and quantity of surface and ground water and predict the environmental impact of land use, land management practices and climate change. SWAT is widely used in assessing soil erosion prevention and control, non-point source pollution control and regional management in watersheds.[94] When the modeling is complete, a more specific load reduction goal for sediment will be available and incorporated as an update to this plan.

4. Management measures to address the sources of impairment and achieve the goal

Three nonpoint source management measures are proposed to improve erosion and sedimentation and to enhance public understanding of these issues and encourage continued participation in efforts to improve riparian conditions and implement BMPs.

Management Measure 1- Restore the Riparian Corridor of the Meramec River to Enhance its Ecological Functions Associated with Reducing Sediment Loads and Filtering Pollutants

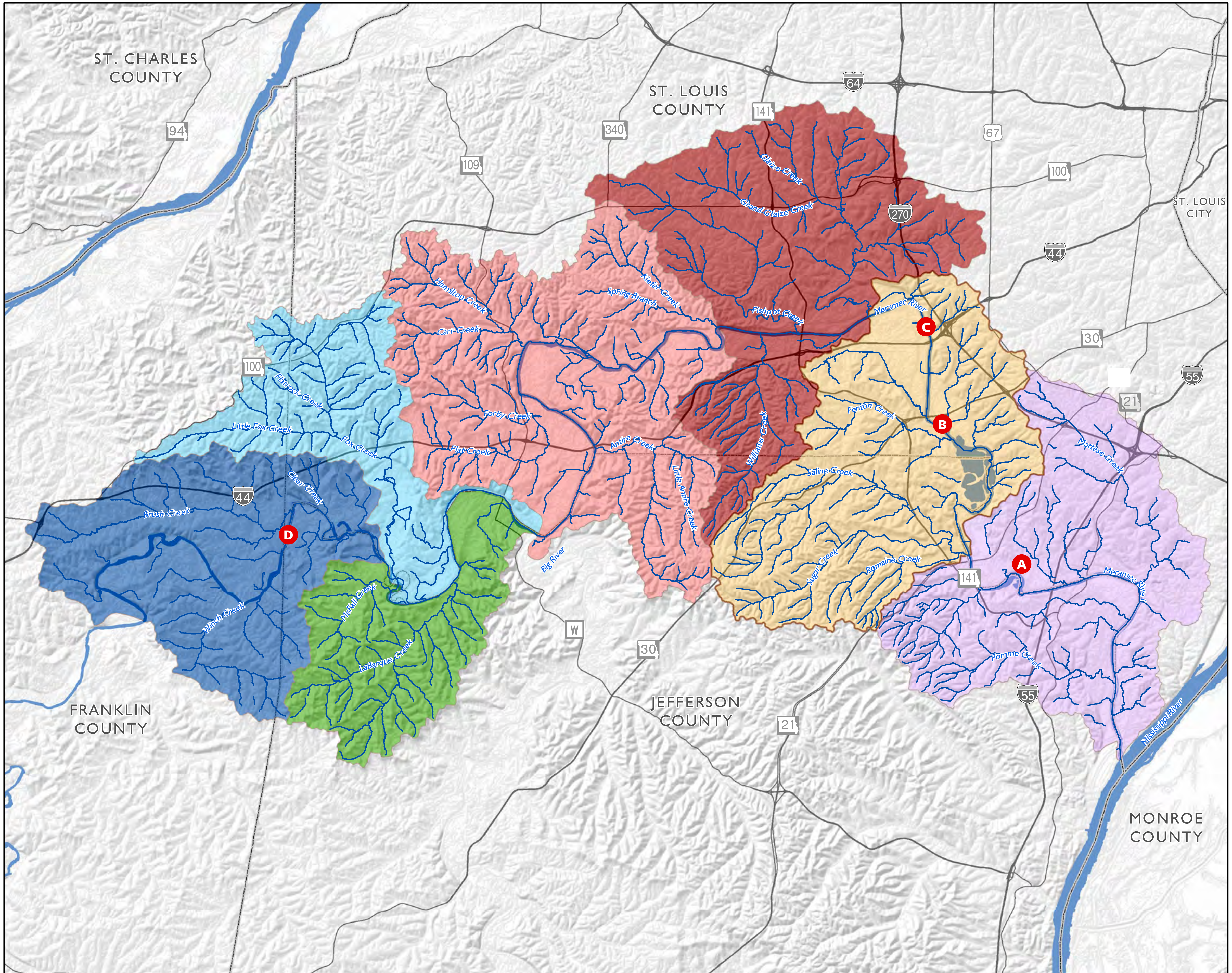
Solution 1.1 Use public land to protect and enhance the riparian corridor while providing public educational opportunities

Project description – Parkland riparian restoration activities
Great Rivers Greenway (GRG), St. Louis County Parks Department, city of Sunset Hills, city of Kirkwood and city of Pacific are all government agencies that own land in the lower Meramec watershed for a combined 6,644 acres. This large amount of public greenspace provides opportunity to implement sound management practices to improve and protect the overall health of the watershed. Furthermore, St. Louis County Parks and GRG own public land contiguous to each other from river miles 7 – 10. The combined acreage for these contiguous properties is just over 638 acres and includes over 20,400 feet of river frontage. This provides a unique opportunity to develop collaborative land management objectives that include riparian corridor restoration projects that have unified goals to manage the entire landscape rather than piecemeal strategies for each site. Efficiencies will be gained by combining efforts to hire a consultant and/or contractor, utilizing in-house equipment and labor, and engaging volunteers in restoration activities.

[94] http://swat.tamu.edu/

Map 21
Proposed Projects

Meramec River



Basemap Elements

- Proposed Projects*
- County Boundary
- Major Road
- Interstate Highway

Selected Watersheds

- Brush Creek
- Fox Creek
- Grand Glaize Creek
- Hamilton Creek
- LaBarque Creek
- Pomme Mattese
- Sugar Creek

*See text for project information

0 1 2
Miles

Sources: County GIS Departments,
East-West Gateway Council of Governments
and other Core Partners
September 2017

EAST-WEST GATEWAY
Council of Governments

The following management practices are proposed on properties owned by St. Louis County Parks, Great Rivers Greenway, the City of Sunset Hills, the city of Kirkwood and the city of Pacific to restore and enhance the riparian corridor on the main stem of the Meramec River (See Map 21 for locations of these properties). The goal of implementing these practices is to reduce sedimentation, improve water quality, and increase biodiversity as they pertain to public lands in the lower watershed.

- Conduct trash pickup and flood debris removal activities
- Identify locations along the Meramec River that have unstable banks and evidence of slope failure.
- Stabilize banks of Meramec River where bare soil is exposed and/or where erosion is actively occurring with native vegetation such as willow staking in places.
- Remove hard structures or riprap materials that have previously been used to armor banks and stabilize the channel along the main stem of the Meramec River located on public land (where feasible).
- Remove invasive plant species and revegetate those areas with native plants, especially bottom land forest species to achieve a minimum buffer width of 100 feet.
- As previously flooded properties are purchased for flood prevention, use the opportunity to improve stream buffers, stabilize the channel and improve water quality through conversion of flooded properties to natural areas and parkland

Partner involvement in these efforts will be crucial to increase project capacity, supplement existing resources and ensure long-term success. The Open Space Council (OSC) works to conserve and sustain land, water and other natural resources throughout the region. The Missouri Stream Team Program is a working partnership of citizens who are involved in the stewardship and conservation of the state's streams and rivers. Through the years, citizen volunteers have been active in clean-up efforts and collection of water quality data (based on training.[95] Both organizations have resources to help coordinate hands on volunteer projects such as trash and flood debris clean-up, streambank stabilization, invasive species removal and native tree planting. The City of Sunset Hills will provide equipment and staff time to assist with restoration activities and volunteer events. Forest ReLeaf of Missouri is a local non-profit that offers 3-gallon container trees at no cost to community groups who implement planting projects on public land. In addition, tree seedlings can be obtained through the Missouri Department of Conservation's George White Nursery for $0.32 each in lots of 100. Approximately 60 volunteers working two days can plant 300 large (5 gallon container) saplings. OSC can organize up to four sites per year.

Management Measure 2- Use stormwater BMPs to reduce runoff to the lower Meramec River and increase public awareness of their benefits

BMPs will be implemented on properties owned by St. Louis County Parks and GRG to inform and educate visitors about water quality issues and ways to get involved. Installation of the BMPs will involve volunteers to attract support for more widespread adoption of BMPs elsewhere.

[95] For more information go to, http://www.mostreamteam.org/mapwelcome.asp

Solution 2.1. Implement demonstration rainscaping projects on public property

Project description –Raingarden installations
St. Louis County Parks will work in cooperation with GRG and OSC to identify sites that produce large amounts of runoff, such as parking lots, and create rain gardens to collect and absorb the runoff. Sites at Suson Park and Lower Meramec Park (Site A on Map 21) will be looked at first because they are near the Mattese Creek watershed so this will have a special educational impact on the residents who frequent those parks.

Management Measure 3- Engage public in positive action to improve river conditions
Providing opportunities for the public to volunteer in activities to improve conditions in the lower Meramec River is crucial to enhancing public awareness and actions to improve water quality. Often times participating in a river clean-up event helps to 'hook' people into becoming more engaged in protection of their local waterways.

Solution 3.1 Engage Citizens in Volunteer River Clean up

Project description – Support Operation Clean Stream programming and events
In 2017, OSC reached a 50 year anniversary milestone with their Meramec River volunteer trash removal program, Operation Clean Stream. By organizing the Operation Clean Stream on the Meramec River, and involving more than 2,000 volunteers annually in river bank and park clean up, the OSC and other partners have expanded volunteer activities to include native planting, riparian corridor restoration and invasive species removal. A large percentage of volunteers become engaged in other projects once they first have an experience in working outdoors in river clean-up or riverbank planting activities.

The Operation Clean Stream event requires an additional $20,000 per year over three years to grow the activity to include more volunteers. Funding will pay for boats that can pick up trash collected at sites on the river that are inaccessible by road. It will also pay for volunteer coordination, reconnaissance of prime clean-up sites, as well as event liability insurance, signage, renting trash dumpsters, and other rental equipment, including boats, tractors and ATVs.

Table 71. Summary of Main Stem Lower Meramec River Projects

Project Description	Estimated Costs	Timeframe	Partner Contribution	Funding Sought
Parkland riparian restoration activities	Costs for the riparian corridor restoration activities may range from $5,000 to conduct a volunteer trash cleanup event to $100,000 to remove hard structures and rip rap materials and replace with appropriate native vegetation. An estimated $5,000 per site is needed to acquire trees and native plants. Averaged together, costs are estimated at $15,000 per site. Estimated total annual costs are $75,000 across five sites $375,000 over a five year period.	Years 1-5	Matching funds include local government staff time, volunteer time, volunteer management, MDC cost share for native plants	Year 1-3 $225,000 Years 4-5 $150,000
Demonstration raingardens	$5,000 per site $10,000 total	Year 1	MDC cost share for native plants Labor and equipment provided by volunteers and park staff	$6,000
Operation Clean Stream support	$20,000 per year $60,000 total	Years 1-3	Private sponsorship, volunteer time and OSC staff time	$60,000 Years 1-3

5. Monitoring

Water quality monitoring provides an analytical framework to support project implementation and assess effectiveness. It also serves as a tool to inform and educate residents and stakeholders. Continuous water quality monitoring has been undertaken in Meramec River by USGS, MSD and USACE at five locations from Pacific to Arnold. MoDNR will continue to assess the Meramec River for compliance with state water quality standards. MoDNR will examine water quality data collected and analyzed by other local, state or federal agencies, including MSD. Other potential options for quality-assured data to use for evaluation purposes include universities, private companies, volunteer groups and municipalities. MoDNR input will be needed to identify monitoring activities and sampling and analytical methodologies.

Citizen volunteers could conduct photo-point monitoring to document changes in time in those areas where there has been riparian buffer improvements. In addition, a variety of data collected by various entities is available through the MoDNR web site at http://www.dnr.mo.gov/mocwis_public/wqa/waterbodySearch. This data can be screened to determine where additional monitoring is needed and/or to track water quality changes.

Projects along the main stem of the lower Meramec River are to be implemented by core partners responsible for developing this plan. The core partners plan to meet regularly to provide updates on the progress of their projects. Tracking implementation will take place through reports provided by the partners at these meetings.