Chapter 3: Element a. - Identifying Impairments

The Deer Creek Watershed is a major sub-watershed of the River des Peres Watershed. Deer Creek and its tributary, Black Creek, are now identified as impaired for chloride on the 303(d) list. Two Mile Creek is identified as impaired to E. coli on that list, and TMDLs for *E. coli* on Deer and Black Creeks were approved by the U.S. Environmental Protection Agency (EPA) in 2019.

3.1 Previous Watershed Assessment Studies and Reports

Numerous studies have been conducted in the Deer Creek watershed, dating back as far as 1963. Following is a known list of studies implemented to date:

A Study of Water Quality in Deer Creek, Metropolitan St. Louis Sewer District, St. Louis County Aug 1963. This study was completed by the Missouri Water Pollution Control Board following the construction of a trunk sewer from the City of Kirkwood to its confluence with River Des Peres. Four sites were chosen along Deer Creek and tests were conducted on the physical, chemical, biological, and bacteriological characteristics of the creek over a three-day period.

Study of the Ecology of Deer Creek, St. Louis County, 1973 by Walter Zachritz, Jr., zoology student at University of Washington. This study is a survey of watershed flora, fauna, weather, and creek conditions at selected sites in the watershed.

RIver Des Peres Interim Flood Protection Plan, Feb 1974. This study was prepared by St. Louis City, St. Louis County, MSD and the Corps of Engineers, St. Louis District.

Metropolitan St. Louis Sewer District: Deer Creek Drainage Survey, Phase I Stormwater Management Program, Jan 1981. (Consultant: Havens and Emerson, Inc.). This study was an inventory of drainage areas and results of US EPA's Stormwater Model (SWMM) simulating a 25 year, 6 hour storm event.

Metropolitan St. Louis Sewer District: Executive Summary Phase I Stormwater Management Program, Feb 1981. Studies performed on 14 different watersheds throughout MSD's district using computer models for hydrologic and hydraulic evaluations.

HEC-1 Study, U.S. Army Corp Of Engineers & HEC-2 Flood Insurance Study by Booker for U.S. Army Corps of Engineers on behalf of FEMA.

River Des Peres, Missouri, Feasibility Report, Environmental Assessment and Finding of No Significant Impact, Corps of Engineers, St. Louis District, Feb 1988. This report addressed the entire River Des Peres watershed and discussed the feasibility of channel modifications and alternatives to solving flooding problems. Most channel modifications in Deer Creek were very costly and did not provide a benefit to cost ratio sufficient to justify constructing improvements.

Metropolitan St. Louis Sewer District: District-wide Analysis of Stormwater Problems, March 1989. This report compiled a list of stormwater-related problems throughout MSD's service area. Three thousand problems were field inventoried and prioritized with respect to potential for property damage and/or loss of life.

An Ecological Survey of the Litzsinger Road Ecology Center, 1992 by Dr. Clifford Ochs, http://www.litzsinger.org/research/ochs.pdf. This report includes lists of the plants and animals observed at the site during the survey, with descriptions of the time of year and habitat in which various organisms are most likely to be found. In addition, there are descriptions of the soils, geology, hydrology, and ecological communities of the LREC, with suggestions for possible management options.

Flood Insurance Study of St. Louis County and incorporated Areas, Federal Emergency Management Agency, Aug 1995. This study provides hydrologic and hydraulic data for Deer Creek including peak discharge estimates and flood elevations for the 10-, 100- and 500-year flood events. The study also includes a map showing the regulatory floodway.

Metropolitan St. Louis Sewer District: Deer Creek Watershed Study for Stormwater System Master Improvement Plan, May 1998. Submitted by CH2MHILL in association with Kowelman Engineering, Inc. Stormwater Management Model (SWMM) simulates watershed discharge, stream flow depths and velocities for both existing and future development using a 2-, 15- and 100-year rainfall event.

Intuition and Logic: Stream Reconnaissance City of Frontenac, Missouri, June 2000. Geomorphic analysis of the Deer Creek and Twomile Creek watersheds in the City of Frontenac.

Federal Emergency Management Agency, Flood Insurance Study, Incorporated and Unincorporated Areas of St. Louis County, Missouri, Revised Aug 2000. Study to develop flood risk data for areas of the county to establish actuarial flood insurance rates and assist the county in its efforts to promote sound floodplain management.

Metropolitan St. Louis Sewer District: Saint Louis County Phase II Stormwater Management Plan, Fall 2002. Plan contains information on the Phase II government jurisdictions, demographics, watershed configurations, current stormwater control activities, stream water quality, and coordinating and permitting strategies for stormwater management.

HNTB Study: Proposed Trail for Great Rivers Greenway, 2005. Study using the Corps of Engineers HEC model to analyze the effects of a proposed trail between Brentwood Park and Deer Creek Park on lower Deer Creek.

Intuition and Logic Stream Study of Deer Creek for Litzsinger Road Ecology Center, 2005. A geomorphology study of approximately 2,500 feet of Deer Creek. The study reach flows south from the northern property line of the Litzsinger Ecology Center to the Litzsinger Road Bridge.
http://www.litzsinger.org/research/streamstudy.pdf

EDM Evaluation Using XPSWMM of the Impact of Stormwater BMP's, 2007. EDM associate Len Madalon, P.E. analyzes the consequences of development and evaluates the impact of Best Management Practices on the City of Frontenac's watersheds using XPSWMM modeling techniques.

River des Peres Watershed Characterization, 2008. Washington University students, Nathan L. Frogge and Arthur J. Singletary, analyze the geology, soils, topography, flood zones, climate, land cover, land use and population density of the River des Peres Watershed.

Occurrence and Sources of Escherichia coli in Metropolitan St. Louis Streams, October 2004 through September 2007 By Donald H. Wilkison and Jerri V. Davis, https://pubs.usgs.gov/sir/2010/5150/pdf/sir2010-5150.pdf.

Deer Creek Alliance Stakeholder Concerns, 2010, Appendix 3-A[1]. The Deer Creek Watershed Alliance collected a survey and created a detailed listing of stakeholder concerns in 2010 and added additional concerns that were received in 2022. A detailed listing of these concerns can be found here.

Washington University Water Quality Report, 2010, Appendix 3-B[2]**.** This water quality report by Robert Criss, Ph.D., and Elizabeth Hassenmueller, Ph.D., from the Washington University Stable Isotope Lab (WUSIL), concludes that EPA established criteria were exceeded for low DO, acute and chronic chloride pollution, and *E.coli* contamination levels.

An Analysis of Samples Collected by Stream Team 2760, 2011 by Danelle Haake, Appendix 3-C[3].

Streamflow measurements collected along the Deer Creek main stem and tributaries on March 26, 2014, in St. Louis County, Missouri: Rydlund, P.H., 2022, U.S. Geological Survey data release, https://doi.org/10.5066/P998NHKU This effort occurred during a date and time void of rainfall or snowmelt runoff to properly evaluate a base-flow condition. Measuring locations were chosen based on inflow junctions (for example open channel tributaries or pipe outflows) such that main stem streamflow could be evaluated above and below the inflow. A total of 31 main stem and 25 inflow streamflow measurements were made over 9 miles along the main stem reach of Deer Creek starting at Magna Carta Drive. This data release includes a table of the streamflow measurements in comma separated values (.csv) format and a map of the main stem and inflow junction measurement locations and graphical representation of the main stem streamflow correlated to distance downstream from Magna Carta Drive.

Comparison of Contributions to Chloride in Urban Stormwater from Winter Brine and Rock Salt Application, 2019 Danelle M. Haake***** and Jason H. Knouft, https://pubs.acs.org/doi/abs/10.1021/acs.est.9b02864

Impacts of urbanization on chloride and stream invertebrates: A 10-year citizen science field study of road salt in stormwater runoff, 2022 Danelle M. Haake, Stephen Krchma, Claire W. Meyners, and Robert Virag, https://setac.onlinelibrary.wiley.com/doi/10.1002/ieam.4594

Deer Creek Water Quality Monitoring Report 2021-22 by Randy Sarver, Appendix 3D[4].

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[1] Appendix 3-A Deer Creek Stakeholder Concerns
[2] Appendix 3-B Washington University Water Quality Report 2010
[3] Appendix 3-C Analysis of Stream Team Water Quality Data
[4] Appendix 3-D Deer Creek Water Quality Monitoring Report 2021-22

3.2 Water Quality Standards

Under the federal Clean Water Act, every state must adopt water quality standards to protect, maintain, and improve the quality of the nation's surface waters. Water quality standards consist of three major components: designated uses, water quality criteria, and an antidegradation policy.[5]

3.21 Designated Uses[6]

Water Quality Standards must be maintained in accordance with the federal Clean Water Act. The following designated uses have been assigned to Black Creek, Deer Creek, and Twomile Creek:

- Livestock and wildlife protection
- Irrigation
- Protection and propagation of fish, shellfish and wildlife – warm water habitat
- Human health protection
- Secondary contact recreation
- Whole body contact recreation category A – Deer Creek (WBID 3826)
- Whole body contact recreation category B – Black Creek (WBID 3825), Deer Creek (WBID 4078), and Twomile Creek (WBID 4079)

The uses impaired by bacteria are the protection of whole body contact recreation category A and B. Whole body contact recreation includes activities in which there is direct human contact with surface water that results in complete body submergence, thereby allowing accidental ingestion of the water as well as direct contact to sensitive body organs, such as the eyes, ears and nose. Category A waters include water bodies that have been established as public swimming areas and waters with documented existing whole body contact recreational uses by the public. Category B applies to waters designated for whole body contact recreation, but are not contained within category A. The warm water habitat use is also impaired by chloride.

3.22 Water Quality Criteria[7]

Water quality criteria are limits on certain chemicals or conditions in a water body to protect particular designated uses. Water quality criteria can be expressed as specific numeric criteria or as general narrative statements.

In Missouri's Water Quality Standards specific numeric criteria are given for the protection of whole body contact recreational uses. For category A waters, *E. coli* counts, measured as a geometric mean, shall not exceed 126 counts/100mL of water during the recreational season. For category B waters, the geometric mean *E. coli* count shall not exceed 206 counts/100 mL of water during the recreational season. The state's recreational season is defined in this section of the rule as being from April 1 to October 31.

The numeric criteria identified for aquatic life protection for chloride is 230 mg/L for a "chronic" condition and 860 mg/L for an "acute" condition.

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[5] Appendix 2-A Bacteria TMDL pg. 8
[6] Appendix 2-A Bacteria TMDL pg. 8
[7] Appendix 2-A Bacteria TMDL pg. 8

3.23 Antidegradation Policy[8]

Missouri's Water Quality Standards include the EPA "three-tiered" approach to antidegradation https://dnr.mo.gov/water/business-industry-other-entities/permits-certifications-engineering-fees/wells-drilling/antidegradation.

Tier 1 – Protects existing uses and a level of water quality necessary to maintain and protect those uses. Tier 1 provides the absolute floor of water quality for all waters of the United States. Existing instream water uses are those uses that were attained on or after Nov. 28, 1975, the date of EPA's first Water Quality Standards Regulation.

Tier 2 – Protects and maintains the existing level of water quality where it is better than applicable water quality criteria. Before water quality in Tier 2 waters can be lowered, there must be an antidegradation review consisting of: (1) a finding that it is necessary to accommodate important economic and social development in the area where the waters are located; (2) full satisfaction of all intergovernmental coordination and public participation provisions; and (3) assurance that the highest statutory and regulatory requirements for point sources and best management practices for nonpoint sources are achieved. Furthermore, water quality may not be lowered to less than the level necessary to fully protect the "fishable/swimmable" uses and other existing uses.

Tier 3 – Protects the quality of outstanding national and state resource waters, such as waters of national and state parks, wildlife refuges and waters of exceptional recreational or ecological significance. There may be no new or increased discharges to these waters and no new or increased discharges to tributaries of these waters that would result in lower water quality.

Waters in which a pollutant is at, near or exceeds the water quality criteria are considered in Tier 1 status for that pollutant. Therefore, the antidegradation goals for Black Creek and Deer Creek are to restore water quality to levels that meet water quality standards.

3.3 Water Quality Analysis

For purposes of this summary, pollutant parameters discussed include *E. coli* bacteria, chloride, nitrates, phosphorus, dissolved oxygen, turbidity (TSS or total suspended solids), as well as highway runoff of heavy metals and aromatic hydrocarbons. Water quality data for Deer Creek can be found by using the MoDNR Water Quality Data Search at https://apps5.mo.gov/mocwis_public/wqa/sampleCollectedSearch.do?action=search&waterbodyId=4078.00&waterbodyName=Deer%20Creek.

[8] Appendix 2-A Bacteria TMDL pg. 9

3.31 Bacteria Pollution[9]

Missouri's Water Quality Standards use *E. coli*, bacteria found in the intestines of humans and warm-blooded animals, as indicators of potential fecal contamination and risk of pathogen-induced illness to humans. The Missouri Department of Natural Resources judges a stream to be impaired if the water quality criteria are exceeded in any of the last three years for which there is a minimum of five samples collected during the recreational season. This approach is detailed in the MoDNR's Listing Methodology Document, which is available online at https://dnr.mo.gov/document/methodology-development-2016-section-303d-list-missouri.

Recreational season *E. coli* bacteria data collected from Deer Creek and Black Creek from 2010 – 2016 was used for the impairment listing and is summarized below in Tables 3-1a & 3-1b. Individual bacteria measurements collected during this period are presented in Appendix 2-A. It should be noted that many of the high *E. coli* values measured in these streams, particularly annual maximum values, result from sanitary sewer overflow events as described in Section 5.1.1 of this report.

Table 3-1a. Recreational season *E. coli* data for Deer Creek (2010 – 2016)

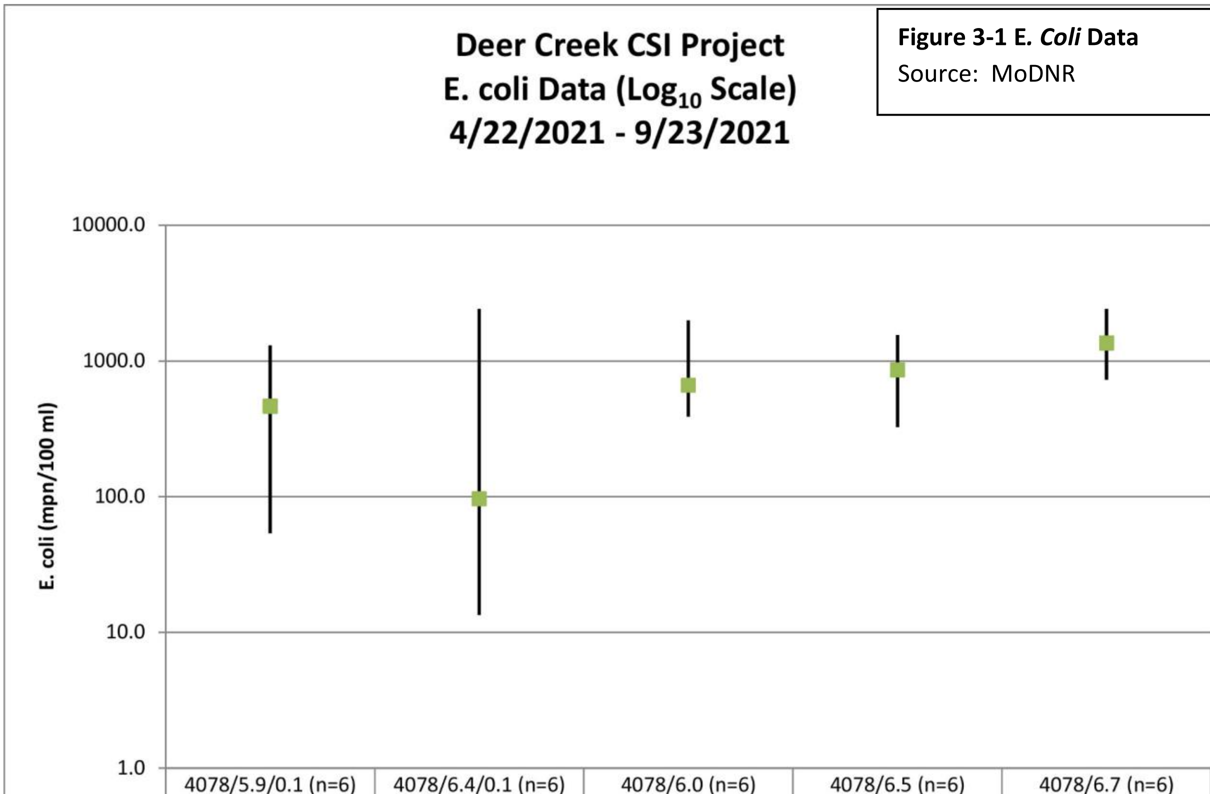
Water Body ID #	***Year***	***Number of Samples***	***Geometric Mean (count/100mL)***	***Minimum (count/100mL)***	***Maximum (count/100mL)***
Deer Creek 3826	2010	7	518	50	3,650
	2011	6	309	41	860
	2012	3	Insufficient data	230	24,000
	2013	9	1,516	150	>24,196
	2014	15	7,013	150	>24,196
	2015	15	1,799	240	17,000
	2016	15	1,849	300	17,000

Table 3-1b. Recreational season *E. coli* data for Black Creek (2010 – 2016)

Water Body ID #	***Year***	***Number of Samples***	***Geometric Mean (count/100mL)***	***Minimum (count/100mL)***	***Maximum (count/100mL)***
Black Creek 3825	2010	7	718	173	2,910
	2011	6	645	145	2,380
	2012	3	Insufficient data	430	20,000
	2013	9	4,569	160	>24,196
	2014	16	5,524	310	>24,196
	2015	15	11,361	1,000	>24,196
	2016	15	2,183	320	24,196

[9] Appendix 2-A Bacteria TMDL pg. 9

Recreational season *E. coli* bacteria data collected from Deer Creek (WBID 4078) and two of its tributaries from April to September 2021 show high levels of *E. coli* with geomeans exceeding the level of 206 cfu/100mL for Category B Use for State of Missouri standards for Whole Body Contact at four out of five monitoring sites. See Figure 3-1 for results included in the Appendix 3-D 2021–22 Deer Creek Water Quality Monitoring Report with site location details.



	4078/5.9/0.1 (n=6)	4078/6.4/0.1 (n=6)	4078/6.0 (n=6)	4078/6.5 (n=6)	4078/6.7 (n=6)
Maximum	1299.7	2419.6	1986.3	1553.1	2419.6
Minimum	53.8	13.4	387.3	325.5	727.0
Geomean	464.3	96.6	663.0	857.4	1358.3

Figure 3-1 E. *Coli* Data
Source: MoDNR [10]

3.32 Chloride Pollution[11]

Tables 3-2 and 3-3 establish that high chloride events in Deer Creek are common over lengthy reaches. The problems are most severe in the lower part of the watershed, at and below the "Rock Hill" site, including the Black Creek tributary. In these areas, the mean chloride concentration typically exceeds the level of 230 mg/L for a "chronic" condition, and many individual samples are well above the established value of 860 mg/L established for an "acute" condition. It is well understood that high chloride levels coincide with winter road salt applications, particularly with the first snowmelt events after such applications, as these quickly dissolve and mobilize the salt, then rapidly transport it over impervious road surfaces and through stormwater culverts

[10] Appendix 3-D Deer Creek Water Quality Monitoring Report 2021-22
[11] Appendix 3-B Washington University Water Quality Report pgs. 2-3

into area streams (e.g., Shock *et al.*, 2003). However, the upper reaches of Deer Creek, the tributary at Chaminade, and Twomile Creek have lower chloride concentrations; these subwatersheds also have a lower population density. Visit https://www.deercreekalliance.org/water_quality to view a map of these water quality monitoring locations in the Deer Creek watershed.

Table 3-2: Chloride & Dissolved Oxygen Pollutant Data for Deer Creek & Several Tributaries

Site Name	Site #	D.O. min mean max (# of samples)	% of all samples <5 mg/l	Chloride min mean max (# of samples)	% samples >230 mg/l	Sampling Period	Data Source
Deer Creek @ Ladue	07010075	3 8.1 18.6 (23)	13	94 256 430 (6)	50	May 2001 to Aug 2004	USGS
Black Creek near Brentwood	07010082	7 9.2 15.2 (6)	0	180 455 730 (2)	50	Dec 2003 to Aug 2004	USGS
Deer Creek @Maplewood	07010086	2.4 7.1 12.2 (23)	17	160 407 800 (6)	50	May 2001 to Aug 2004	USGS
Deer Creek @ Drury Ave.	N/A	4 9.3 13.9 (36)	3	16 301 3400 (36)	28	Feb 2006 to May 2009	MSD
Deer Creek @ Breckenridge Industrial Ct.	N/A	3.5 8.2 13.3 (37)	5	20 239 2710 (37)	16	Feb 2006 to June 2009	MSD
Deer Creek @ Big Bend Ave.	N/A	5.3 7.5 11.0 (11)	0	34 151 640 (11)	18	May 2006 to July 2009	MSD
Deer Creek @ Malcom Terrace Park	N/A	6 10.3 20 (16)	0	30 203 592 (16)	13	Feb 2008 to Sept 2009	LREC*
Tributary @ Chaminade	N/A	1 9.6 23 (17)	6	130 162 409 (16)	25	Feb 2008 to Sept 2009	LREC
Deer Creek @ Log Cabin Ln.	N/A	7 12.6 28 (16)	0	30 174 1375 (17)	12	Feb 2008 to Sept 2009	LREC
Deer Creek @ LREC	07010055	4 8.8 26 (17)	6	42 123 600 (17)	6	Feb 2008 to Sept 2009	LREC

Deer Creek @ Rock Hill	07010075	3 10.1 21 (16)	6	43 173 1048 (15)	20	Feb 2008 to Sept 2009	LREC
Sebago Creek @ Old Warson Rd.	07010070	3 10.6 21 (18)	6	35 175 504 (18)	17	Feb 2008 to Sept 2009	LREC
Twomile Creek @ Overbrook	07010061	3 8.7 18 (17)	12	31 42 65 (17)	0	Feb 2008 to Sept 2009	LREC
Twomile Creek @ Ladue	07010061	5.3 8.4 11.0 (8)	0	29 36 49 (7)	0	Sept 2008 to Dec 2008	WUSIL
Sebago Creek near Rock Hill	07010070	1.5 9.6 15.0 (8)	25	8 140 313 (6)	17	Sept 2008 to Dec 2008	WUSIL
Black Creek near Brentwood	07010082	5.5 8.2 11.9 (8)	0	36 133 195 (6)	0	Sept 2008 to Dec 2008	WUSIL
Deer Creek @ Litzinger Rd. @ Ladue	07010055	5.1 9.1 12.4 (8)	0	67 79 104 (6)	0	Sept 2008 to Dec 2008	WUSIL
Deer Creek @ Ladue	07010075	2.5 9.2 13.5 (7)	14	24 68 104 (5)	0	Sept 2008 to Dec 2008	WUSIL
Deer Creek @ Maplewood	07010086	3.7 7.8 11.4 (9)	22	43 107 166 (6)	0	Sept 2008 to Dec 2008	WUSIL

Table 3-3: Chloride Data for Deer Creek at Big Bend Ave. (2016-2018)

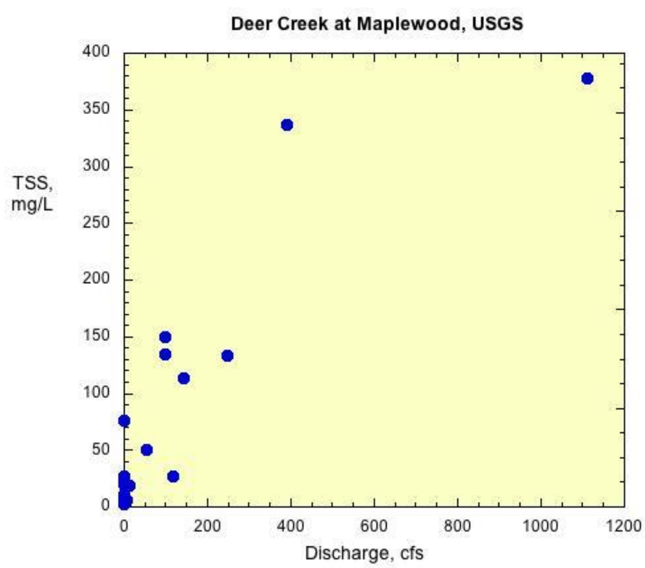
Site Name	Site #	Acute Exceedances	Chronic Exceedances	Chloride min mean max (# of samples)	Sampling Period	Data Source
Deer Creek @ Big Bend Ave.	3826/0.7	1	7	68 288 1540 (26)	Jan 2016 to Dec 2016	MSD
Deer Creek @ Big Bend Ave.	3826/0.7	0	5	36 153 337 (26)	Jan 2017 to Dec 2017	MSD
Deer Creek @ Big Bend Ave.	3826/0.7	0	4	15 155 325 (22)	Jan 2018 to Oct 2018	MSD

3.33 Biological Oxygen Demand (B.O.D.)

Organic matter that accumulates on impervious surfaces is washed off during run off events. Microorganisms utilize oxygen when decomposing this organic matter, which places an oxygen demand on the receiving water body. Biological oxygen demand (BOD) levels in urban runoff can exceed 10 to 20 mg/l during storm "pulses" which can lead to oxygen deprived conditions in shallow, slow moving or poorly flushed receiving waters (Shueler, 1987). A National Urban Runoff Program (NURP) study found that oxygen-demanding substances can be present in urban runoff at concentrations similar to secondary wastewater treatment discharges. (United States Environmental Protection Agency, 1993).

The data in Table 3-2 establish anomalously low D.O. values in several reaches, and a particularly low mean value (7.1 mg/L) for D.O. for Deer Creek at Maplewood, where 17% of all samples analyzed by USGS have less oxygen than the mandated minimum of 5 mg/L. This condition is chronic at this site during the warm period of late April through August when the mean D.O. is only 4.8 mg/L. Thus, this site alone establishes that low D.O. conditions exist in the Deer Creek watershed.[12]

3.34 Total Suspended Solids, Erosion and Sedimentation



The chart on the right is a scatter plot of USGS data on total suspended solids at the Maplewood monitoring station on Deer Creek. This monitoring station is located at the furthest downstream point in the Deer Creek Watershed before Deer Creek enters the River Des Peres. The chart shows a relationship between suspended solids and volume of discharge into the stream at this site. Overall, greater discharge volume is associated with higher TSS levels.

The rapid rise and fall of Deer Creek during and after rain events causes erosion directly to the streambed and stream banks. As a result of these alterations, many parts of the stream bank along Deer Creek are highly eroded and the stream has become incised and wider in places. According to a 2007 study conducted by Len Madalon, P.E. for the City of Frontenac (a municipality in the Deer Creek Watershed), a 5% increase in impervious surface area in Frontenac can lead to the loss of 14 valuable acres of Frontenac land due to erosion and creek widening from increased storm water runoff. In the study, a homeowner survey identified 474 creek-related problems; of these, 187 yard erosion problems were cited (Madalon, 2007). The study further confirms that the first 2.5 inches of stormwater influences the channel-forming flow of the stream.

Erosion from creek widening leads to increased total suspended solids (TSS) in the water.

[12] Appendix 3-B Washington University Water Quality Report pg. 2

3.35 Nitrogen and Phosphorous

In Missouri, Stakeholders began meeting in 2009 for briefings on how criteria development for streams will proceed. These meetings were suspended so a technical workgroup could take the time necessary to make recommendations for criteria that will be scientifically defendable and sufficiently protective of the state's streams and rivers. Missouri does not currently have numeric nutrient criteria for streams. The EPA recommended nutrient criteria for guidance by Ecoregions for rivers and streams can be found at https://www.epa.gov/nutrient-policy-data/ecoregional-nutrient-criteria-rivers-and-streams.

3.36 Emerging Pollutant-plastics

Plastics are persistent, pervasive environmental pollutants with a range of diverse sources. Since the relatively recent discovery of the abundance of microplastic in marine habitats, there has been a rapid development in the literature outlining its distribution and effects. Observations have been reported from lakes to rivers to oceans, and have been recorded in the tissues of species from microscopic invertebrates to whales. Although the impact on biota varies greatly between species, tests have revealed changes in nutritional state, histology, enzyme function, and life span. Annual production of microplastics and their macro plastic parent material presents a huge challenge to management authorities. [13]

Plastic pollution is considered one of today's main environmental problems in oceans, rivers and streams and have potential risks to human health and the environment (Barnes et al., 2009, Wright and Kelly, 2017). The occurrence of plastic debris in rivers has received increased attention (McCormick et al., 2014, Klein et al., 2015, Lechner et al., 2014, Yonkos et al., 2014, Kooi et al., 2016). Recent estimates indicate that rivers transport between 1.15 and 2.41 million tonnes of plastic waste to seas (Lebreton et al., 2017). This estimate is expected to increase in the coming decades (Jambeck et al., 2015). Most studies of marine litter in urban run-off focus on macroplastics rather than on microplastic debris (Ryan et al., 2009).

Microplastics are known to originate from different sources, which can be divided in two broad categories: primary and secondary sources (Bergmann et al., 2015). Primary sources are microplastics that are manufactured in microscopic size for domestic and industrial applications, like plastic pellets used as raw material in the plastic industry and/or abrasive microbeads in cosmetics, detergents, other hygiene and personal care products (Arthur et al., 2009, Cole et al., 2011, Fendall and Sewell, 2009). Secondary microplastics originate from larger plastic materials and are formed from the breakdown of macroplastics through photodegradation and mechanical abrasion of marine debris into small plastic particles (Gewert et al., 2015).

Scarcity of quantitative data is one of the biggest constraints encountered in environmental research of microplastic pollution. There are studies available on accumulation of plastic debris in the environment (Barnes et al., 2009), sources of (micro)plastics (Arthur et al., 2009, Cole et al., 2011, Fendall and Sewell, 2009),

[13] Waste (Second Edition), A Handbook for Management 2019, Pg 405
https://www.sciencedirect.com/science/article/pii/B9780128150603000219

and consequences of plastic pollution in the marine environment (Kühn et al., 2015). Quantitative assessments of per capita microplastic consumption from different sources are available (Essel et al., 2015, Sundt et al., 2014), as well as information on the microplastics content in incoming wastewater at sewage treatment plants (Brandsma et al., 2013, Magnusson and Norén, 2014, Mintenig et al., 2017, Kalčíková et al., 2017, Talvitie and Heinonen, 2014), and river retentions (Besseling et al., 2017). However, on the continental or global scale, the explicit quantitative analyses of the export of microplastics from land to the sea has not been addressed. Quantities that are released into rivers from sewage treatment plants and subsequently enter the sea on these spatial scales are largely unknown, yet crucial for assessing short- and long-term impacts caused by plastics (GESAMP, 2016).[14]

3.4 Identifying Nonpoint Source Stressors

The following section identifies nonpoint source stressors contributing to poor water quality in the watershed. For the purposes of this watershed plan, non-point source water quality threats in the Deer Creek watershed are considered to be stormwater runoff from impervious surfaces, channel straightening and loss of riparian corridor, downspout disconnections, yard and open space maintenance patterns, animal waste, septic systems, road salt, stream bed and bank erosion, increased precipitation, and increases in stormwater runoff volume.

3.41 Stormwater Runoff

Major water quality threats in the Deer Creek watershed derive from stormwater runoff over impervious surfaces. Impervious surfaces drain rainwater from overland into storm drains that carry it directly to the streams. The runoff carries with it the accumulation of yard waste, debris and trash, sediments, animal waste, heavy metals, aromatic hydrocarbons, and in the winter, road salts. In addition, an increase in impervious surface cover in the watershed, such as roads, driveways, parking lots, and rooftops, increases runoff often directed by storm drainage systems. This altered hydrology forces the stream to transport much larger amounts of water and sediment through its channel. Although this was not always the case, the tributary streams within the Deer Creek watershed now experience a rapid rise after even a small rain event and tend to be flashy.

In general, urban runoff carries high levels of bacteria and other pollutants that may result in exceedances of water quality criteria during and immediately after storm events in most streams throughout the country (EPA 1983). Runoff contaminated by *E. coli* and other pollutants can come from heavily paved areas and from open areas where soil erosion is common (Burton and Pitt 2002). For these reasons, urban runoff is a potential contributor of bacteria to Deer Creek and Black Creek.[15]

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[14] Export of microplastics from land to sea. https://www.sciencedirect.com/science/article/pii/S0043135417308400

[15] Appendix 2-A Bacteria TMDL, pg. 15

Bacterial loading to streams from urban runoff can be caused by sanitary sewer overflows as discussed in Section 3.52 of this document, but also commonly results from residential and green space runoff carrying domestic and wild animal waste. Birds, dogs, cats, and rodents have been documented as common sources of *E. coli* in urban stormwater (Burton and Pitt 2002). The USGS study specific to the sources of *E. coli* in metropolitan St. Louis streams discussed in Section 3.52 of this document estimated that in addition to one third of the bacteria originating from human sources, 10 percent of the sampled *E. coli* was attributed to dogs and 20 percent to geese (USGS 2010). [16]

Runoff originating from highway corridors is another component of urban stormwater. The Federal Highway Administration published research showing that runoff from highway corridors may also contain bacteria. Sources of *E. coli* within highway areas identified in the study include bird droppings, soil, and vehicles carrying livestock and stockyard wastes, which may periodically "seed" a roadway with pathogens. The study further notes that the magnitude and contributions from highway systems are site-specific and can be affected by numerous factors, such as traffic, design, maintenance, land use, climate and accidental spills (FHWA 1984). For these reasons, the significance of any highway contributions of bacteria in the Deer Creek watershed cannot be quantified at this time. Due to the intermittent and potentially sporadic nature of highway bacterial contributions described in the federal study, and due to the urban nature of the watershed, which makes contributions from the transport of livestock and stockyard wastes less likely, highway systems are not expected to be a significant contributor to the bacteria impairments in the Deer Creek watershed. Highway systems, however, do remain a potentially significant source of heavy metals, inorganic salts, aromatic hydrocarbons and suspended solids (FHWA 1998).[17]

3.42 Channel Straightening and Loss of Riparian Corridor

The hydrology of Deer Creek has been further altered by channel straightening. A geomorphic study by Intuition & Logic, Inc for the Litzsinger Road Ecology Center found that prior to 1953, much of the Deer Creek Watershed from the center (at mile 5) north to highway 40/64 was undeveloped forest. Over the next thirty years, suburban development converted the forest to large residential lots and the channel was straightened to eliminate nearly 1,000 linear feet of stream. Hardening of the stream banks and straightening of the channel also contributes negatively to the health of Deer Creek by increasing the velocity of water and disconnecting the stream channel from its floodplain. Similar changes have occurred in smaller tributary streams, all of which serve to increase velocity and decrease time of concentration, which further contributes to stream erosion and sedimentation issues.

Remarkably, Deer Creek still maintains its more natural flow in certain areas where it has room to move. For example, in the area of the Litzsinger Road Ecology Center (LREC) that is managed by Missouri Botanical Garden, six meanders, or bends, represent the natural way in which water tends to flow by following the path of least resistance. These meanders also serve an important function in the dynamics of the stream by helping to create in-stream habitats, such as riffles, runs, and pools. This natural flow with meanders and bends is possible because the natural riparian buffer is greater than 100 feet throughout the LREC and its 2,500 linear

[16]Appendix 2-A Bacteria TMDL, pg. 15
[17]Appendix 2-A Bacteria TMDL, pg. 15

feet of stream channel. Restoration of the riparian buffer throughout the watershed would greatly contribute to improved water quality in the Deer Creek Watershed.

3.43 Soil Compaction from Construction Practices

Machinery operating on soils can compact soil, significantly reducing soil permeability and infiltration rates. Compacted soils result in high run off rates, which in turn result in an increase in suspended solids in creeks. In an urban north central Florida study, Gregory et. al. (2006) found that the infiltration rate of compacted soils can be similar to that of impervious surface:

> "Although there was wide variability in infiltration rates across both compacted and non-compacted sites, construction activity or compaction treatments reduced infiltration rates 70 to 99 percent. Maximum compaction as measured with a cone penetrometer occurred in the 20 to 30 cm (7.9 to 11.8 in) depth range. When studying the effect of different levels of compaction due to light and heavy construction equipment, it was not as important how heavy the equipment was but whether compaction occurred at all. Infiltration rates on compacted soils were generally much lower than the design storm infiltration rate of 254 mm hr^{-1} (10.0 inches hr^{-1}) for the 100-yr, 24-hr storm used in the region. This implies that construction activity in this region increases the potential for runoff …not only due to the increase in impervious area associated with development but also because the compacted pervious area effectively approaches the infiltration behavior of an impervious surface."

3.44 Downspout Disconnections

Because of the history in the way homes were constructed in St. Louis County in the 1950's and beyond, there are a significant number of homes in the Deer Creek Watershed with rooftop drains connected to sanitary sewers. Although CSO's and SSO's are point source problems, as homeowners disconnect their roof downspouts from sanitary sewers, the resolution of point source problems in the watershed may serve to generate additional non-point source pollution issues. Unless strategies for detaining the additional stormwater from roof tops are developed and implemented, the increase in overland flow stress created by these disconnections will lead to further stream erosion and sedimentation, as well as the washing of yard waste, nutrients, and other pollutants into streams.

3.45 Yard & Open Space Maintenance Patterns

Multiple yard and open space maintenance patterns can lead to poor water quality, including problems associated with lawn monoculture, fertilizers, pesticides, tree loss and invasive species, as well as practices that lead to increased yard waste, organic debris and trash entering area streams.

Lawn Monoculture

Native plants of the St. Louis region have root structures up to 15 feet deep, which serve to capture and infiltrate stormwater. (See Figure 3-2). By contrast, turf grass (far left on Figure 3-2) has a root structure only a few inches deep. As a result, turf grass, although considered "pervious", is actually a partially impervious surface. According to a study conducted by the Center for Watershed Protection, seventy percent of "pervious" (lawns) surfaces contributed to 60 percent of the runoff in compacted ground studies (Schueler, T.

2000. Comparative Pollutant Removal Capability of Stormwater Treatment Practices: The Practice of Watershed Protection. Center for Watershed Protection, Ellicott City, MD. Pages 371-376).

INVASIVE SPECIES

Many parts of the stream banks, backyards, and other natural areas throughout the watershed have been overtaken by invasive plant species, notably Amur or bush honeysuckle, *Lonicera maackii*, which displaces other plants. Bush honeysuckle also has a shallow root structure that reduces infiltration into the soil, further contributing to stormwater runoff and stream flashiness. Therefore, where bush honeysuckle is growing along streambanks, the influence of its shallow root structure contributes both directly and indirectly to streambank erosion.

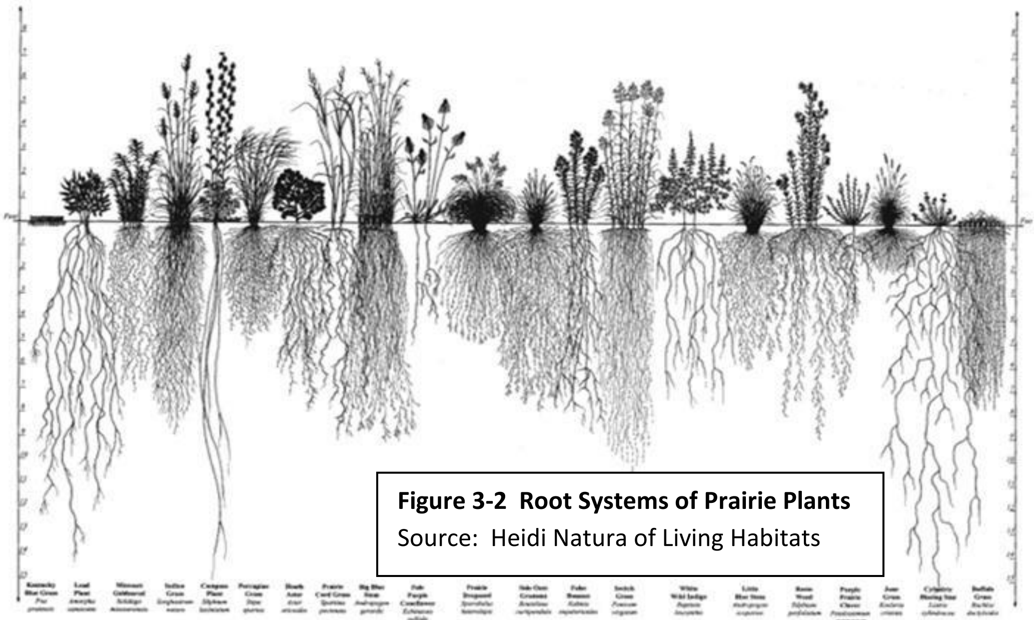


Figure 3-2 Root Systems of Prairie Plants
Source: Heidi Natura of Living Habitats

FERTILIZERS & PESTICIDES

Fertilizers containing nitrogen and phosphorus can become picked up by stormwater runoff and transported to area streams. Nitrogen and phosphorus contribute to stream eutrophication and promote the growth of algae in the water. While the effects of eutrophication such as the formation of algal blooms are readily visible, the process of eutrophication is complex and difficult to measure. In most waterbodies, phosphorus is the limiting nutrient meaning that the quantity of this nutrient that is available limits or controls the speed at which algae and aquatic plants grow. Further, as the algae bloom dies and decays, the decomposing microorganisms utilize oxygen in the water column, thus contributing to lowered dissolved oxygen levels in the water body.

In August of 2010, New York State passed a law prohibiting the application of phosphorus fertilizer on lawn or non-agricultural turf, except when: (1) a soil test demonstrates that additional phosphorus is needed for lawn or non-agricultural turf growth, or (2) new lawn or non-agricultural turf is being established. http://open.nysenate.gov/legislation/api/1.0/html-print/bill/S3780B

Of 30 commonly used lawn pesticides, 17 have been detected in groundwater and 23 have the potential to leach (into the groundwater). Runoff has resulted in a widespread presence of pesticides in streams and groundwater. A chemical found in weed and feed and other lawn products called 2,4-D is the herbicide most

frequently detected in streams and shallow ground water from urban lawns. Of the 50 chemicals on EPA's list of unregulated drinking water contaminants, several are lawn chemicals including herbicides diazinon, diuron, naphthalene, and various triazines, such as atrazine. Runoff from synthetic chemical fertilizers pollutes streams and causes algae blooms, which depletes oxygen and damages aquatic life.
http://www.beyondpesticides.org/lawn/factsheets/facts&figures.htm

Tree Loss

Multiple factors can lead to tree loss in an urban area, which in turn can negatively impact water quality. According to the Center for Urban Forest Research, trees act as mini-reservoirs, controlling runoff at the source. Trees reduce runoff by:

- Intercepting and holding rain on leaves, branches and bark
- Increasing infiltration and storage of rainwater through the tree's root system
- Reducing soil erosion by slowing rainfall before it strikes the soil.

In a study of rainfall interception by Santa Monica's municipal urban forest, rainfall interception ranged from 15.3% (0.8 m3/tree) for a small *Jacaranda mimosifolia* (3.5 cm diameter at breast height) to 66.5% (20.8 m3/tree) for a mature *Tristania conferta* (38.1 cm) (Xiao, 2003). Therefore, a loss of trees in the urban environment increases surface pollutant wash off and pollutant loading to streams. In the Deer Creek watershed, there is a need to conduct tree inventories in order to document tree species, size and location, as well as their impact on water quality.

The City of Rock Hill collaborated with Missouri Botanical Garden's Deer Creek Watershed Alliance to conduct its first comprehensive tree survey of all City of Rock Hill public property in 2017. Key findings of this inventory include the following:

The structural value (an appraised value based on the size, condition, species, and location of each tree) of the inventoried tree population is approximately $2.28 million.

Rock Hill's tree population provides approximately $7,260 in the following annual benefits:

Air Quality: 818 pounds of pollutants removed valued at $3,940 per year.

Carbon Dioxide: 10 tons valued at $1,360 per year.

Stormwater: 29,274 cubic feet valued at $1,960 per year.

https://www.deercreekalliance.org/rock_hill_tree_inventory

The National Tree Benefit Calculator allows anyone to make a simple estimation of the benefits individual trees provide http://www.treebenefits.com/calculator/

Yard Waste, Organic Debris and Trash

During an April 2009 creek clean up, 10 out of 13 comments provided were related to concerns about yard waste and organic debris. Many area citizens do not realize that putting their yard waste and leaf litter nearby or in the creek is not a good ecological practice. Dumping yard waste along a stream bank or in a stream introduces excess organic matter that results in excess nutrients which increase algae growth and decrease oxygen for fish and other aquatic life. This can also kill the underlying vegetation that holds the soil in place along the stream bank leaving the bare soils susceptible to erosion. Surrounding trees fall into the stream as the bank erodes which can obstruct the flow of water and other debris coming down the stream. https://www.stpetersmo.net/Water/StormWaterAndYou-Fall011MH.pdf

Watershed municipalities have identified parcels in the floodplain and floodway that need to have organic debris and trash removed in order to prevent it from entering the stream during high flow periods.

3.46 Animal Waste

Stormwater can become contaminated when it comes into contact with animal waste left in yards and then carry pollutants, such as bacteria, into the storm drain system. The storm sewers drain the water directly to area streams without any treatment. Dogs are major contributors of animal waste in the environment; however, all pets can contribute to the problem. Studies have indicated that up to one third of people who walk their dogs do not pick up after their dog. Additionally, the average horse (1,000 pounds) will produce about 50 pounds of manure a day and 8 to 10
tons per year. Manure should be handled and stored in a way that it becomes an asset and a resource instead of a nuisance and pollutant.

According to the 2017 Census of Agriculture by the U. S. Department of Agriculture, St. Louis County had 101 cattle and cows, and according to the 2012 Census of Agriculture, there were 692 horses and ponies inventoried. According to the American Veterinary Medical Association (AVMA) 2017-2018 U.S. Pet Ownership & Demographics Sourcebook and based on the estimated population of 96,504 in the watershed in 2020, the dog population is estimated to be 22,805 and the cat population is estimated to be 16,970.

Pollutants associated with animal waste include:

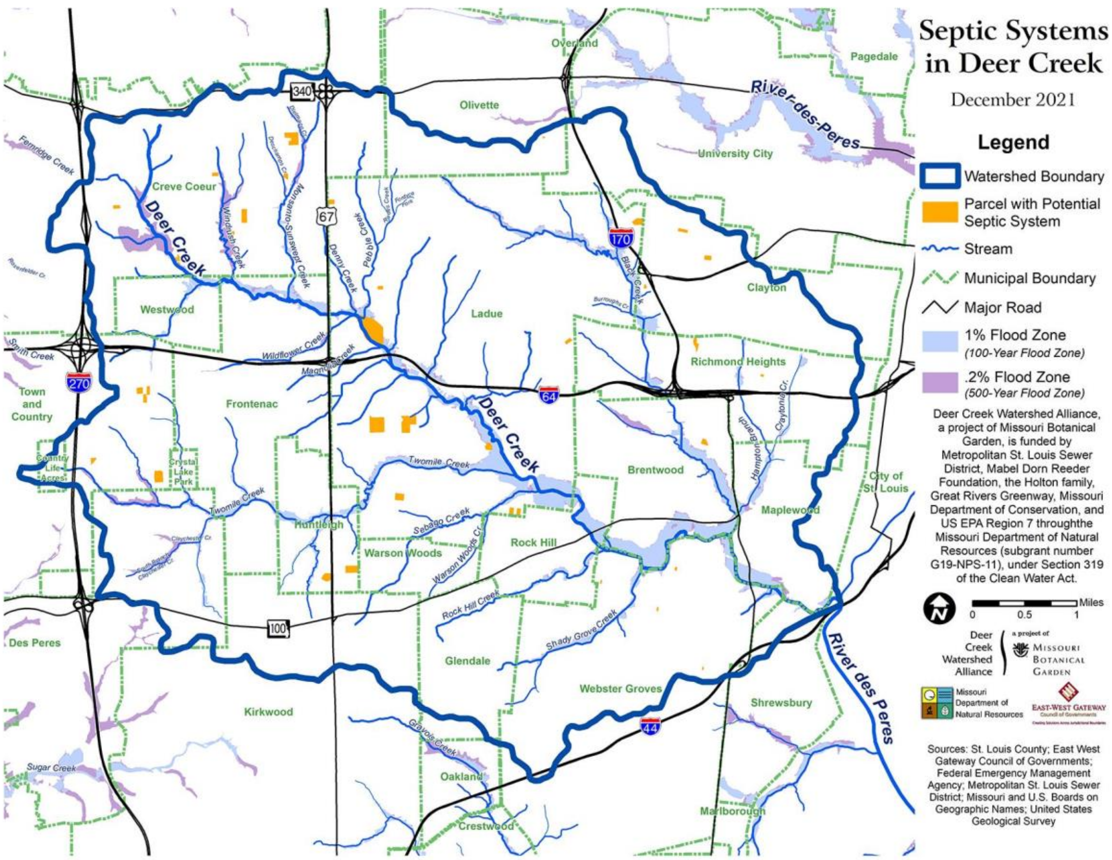
> **Bacteria**—One gram of dog feces contains 23 million fecal coliform bacteria.
> **Nutrients**—Ammonia and nitrogen in the waste promotes unhealthy algae growth.
> **Oxygen demand**—Decomposition of waste and algae may use up the oxygen in the water that fish need.

https://cfpub.epa.gov/npstbx/files/cwc_petwastefactsheet.pdf

3.47 Septic Systems

Forty-two parcels with potential septic systems have been preliminarily identified in the Deer Creek Watershed. See Map 3-1 below. Septic system parcel landowners in riparian corridors, within 500 feet of a stream, will be targeted during years 1 through 6 for septic system inspection, maintenance, and replacement as part of the Rainscaping Cost-Share Program.

Failing septic systems that are in poor condition or have reached capacity are in need of being serviced and pumped to keep sewage from leaking into nearby waterways which can lead to an increase in pollutants associated with this waste. Learn more about septic systems and surface water here https://www.epa.gov/septic/septic-systems-and-surface-water.



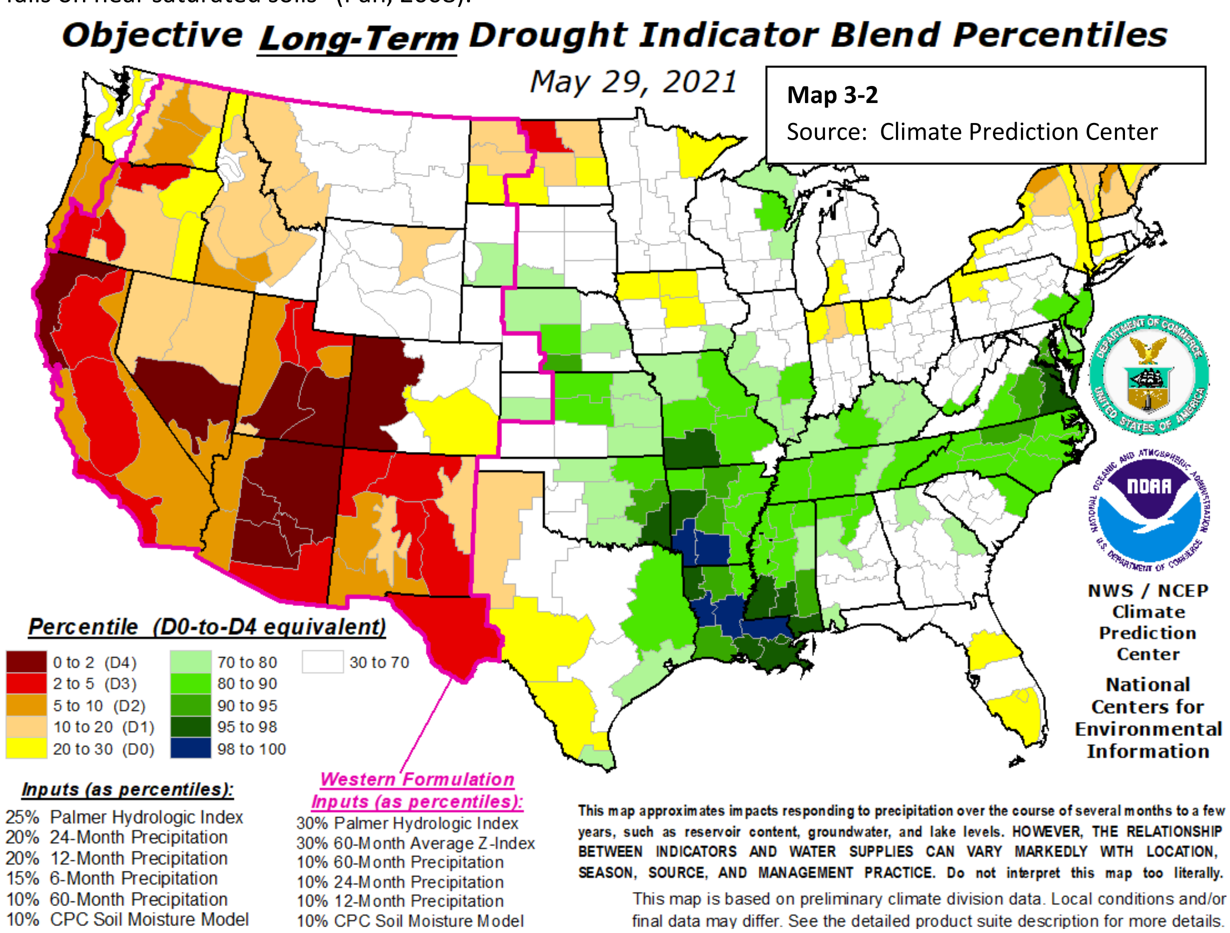
Map 3-1. Potential Septic Systems in the Deer Creek Watershed
Source: East West Gateway Council of Govts

3.48 Road Salt

As reported by Robert Criss in his water quality report on Deer Creek, "high chloride events in Deer Creek are common over lengthy reaches. The problems are most severe in the lower part of the watershed at and below the "Rock Hill" site, including the Black Creek tributary. It is well understood that high chloride levels coincide with winter road salt applications and particularly with the first snowmelt events after such applications, as these quickly dissolve and mobilize the salt, then rapidly transport it over impervious road surfaces and through stormwater culverts into area streams (e.g., Shock *et al.*, 2003). However, the upper reaches of Deer Creek, the tributary at Chaminade, and Twomile Creek have lower chloride concentrations; these subwatersheds also have a lower population density.

3.49 Climate Change

According to several scientific studies, global climate change is also affecting the hydrological pattern of the region. The NWS/NCEP Climate Prediction Center identifies St. Louis as a future high precipitation area. Additionally, the scientific research paper "Climate Change and the Upper Mississippi River Basin" states the following: "Existing studies suggest that the Midwest….will likely see an overall increase in winter and spring precipitation in the coming decades" (Wubbles et.al., 2008). Furthermore, according to "Climate Change, Precipitation, and Stream Flow In The Central United States", presented by Zaitao Pan at a St. Louis University Flood Forum, "Climate models predict that annual precipitation in the Midwest will continue to increase, with extreme precipitation events increasing more rapidly than total rainfall. Flooding on major rivers in the Midwest will worsen because direct runoff will increase even faster than extreme rainfall, as excessive rain falls on near saturated soils" (Pan, 2008).



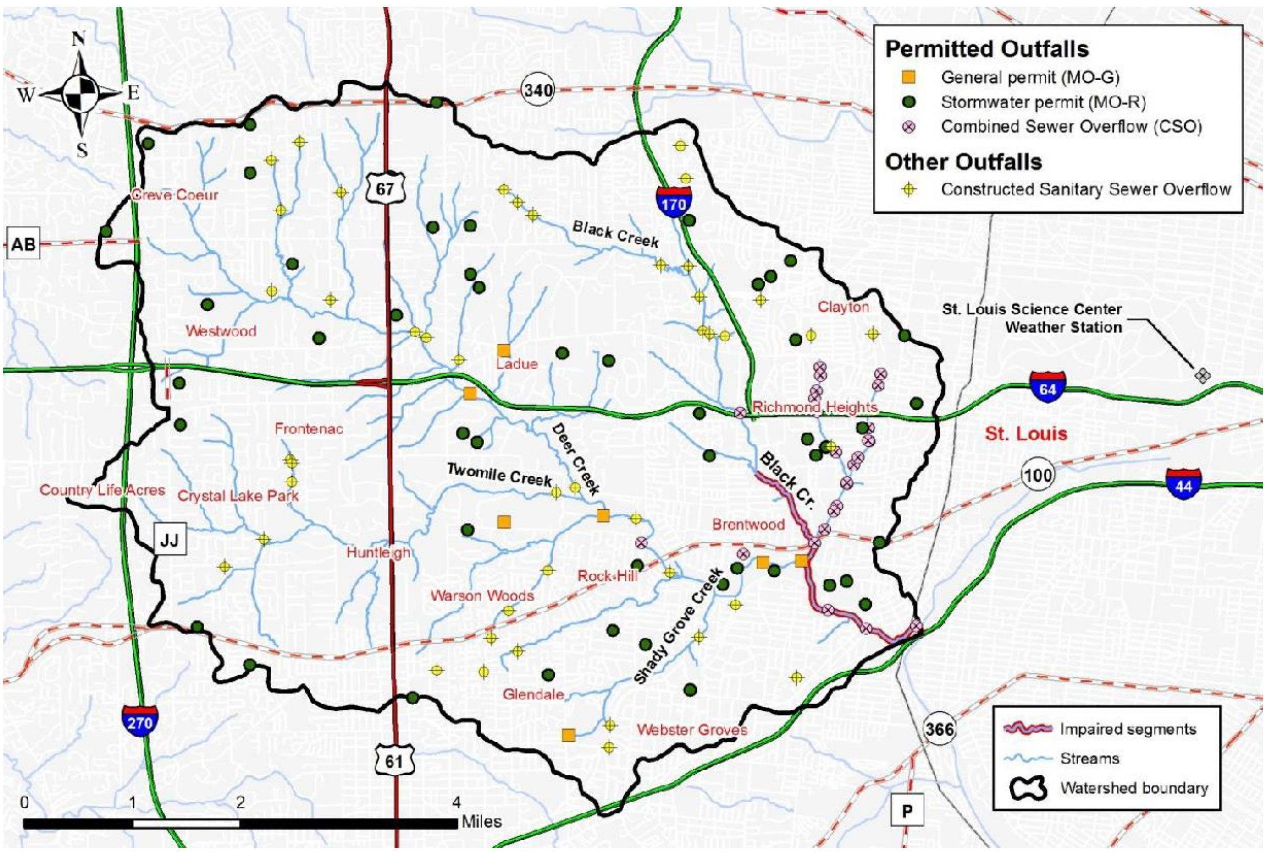
Map 3-2
Source: Climate Prediction Center

https://droughtmonitor.unl.edu/ConditionsOutlooks/CurrentConditions.aspx

3.5 Identifying Point Source Stressors- Permitted Facilities[18]

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. Point sources 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. Under this definition, permitted point sources include permitted municipal and domestic wastewater dischargers, site-specific permitted industrial and non-domestic wastewater dischargers, and general and stormwater permitted entities, which include concentrated animal feeding operations, no-discharge domestic wastewater facilities, and stormwater discharges from municipal separate storm sewer systems. In addition to these permitted sources, illicit straight pipe discharges, which are illegal and therefore unpermitted, are also considered point sources. https://www.epa.gov/cwa-404/clean-water-act-section-502-general-definitions#:~:text=(14)%20The%20term%20%22point,pollutants%20are%20or%20may%20be

As of 2019, the Deer Creek watershed contained 57 permitted facilities, five of which have general wastewater permits and the remaining 52 have stormwater permits. There are no facilities with site-specific permits in the Deer Creek watershed, nor are there any permitted concentrated animal feeding operations, or CAFOs.



Map 3-3. Point source outfalls in the Deer Creek Watershed

[18] Appendix 2-A Bacteria TMDL pgs 10-11

3.51 Municipal and Domestic Wastewater Permits[19]

Domestic wastewater dischargers include both municipal and non-municipal wastewater treatment facilities. Domestic wastewater is primarily household waste, which includes graywater and sewage. Untreated or inadequately treated discharges of domestic wastewater can be significant sources of bacteria to receiving waters (EPA 1986). However, there are no municipal or other domestic wastewater permitted discharges in the Deer Creek watershed.

The Metropolitan St. Louis Sewer District operates and maintains a sanitary sewer system throughout the watershed. The collected domestic wastewater is delivered to the Lemay wastewater treatment facility (permit no. MO-0025151) located outside of the watershed. The sewage collection and transport system infrastructure within the Deer Creek watershed is a potential source of bacteria due to possible breakage or overflows.

3.52 Sanitary Sewer Overflows[20]

Sanitary sewer overflows, or SSOs, are untreated or partially treated sewage released from a sanitary sewer system. Overflows could occur for a variety of reasons including blockages, line breaks, sewer defects, power failures and vandalism. Sanitary sewer overflows can occur during either dry or wet weather and at any point in the collection system, including manholes. Such overflows are unauthorized by the federal Clean Water Act. Occurrences of SSOs can result in elevated bacteria concentrations (EPA 1996).

During the period of January 2012 through December 2015, 48 SSOs were reported to the Missouri Department of Natural Resources. Thirty of these overflows occurred during the recreational season; however, some overflows discharged to dry land or were otherwise contained and did not reach a water body in the Deer Creek watershed.

Through a consent decree, Metropolitan St. Louis Sewer District has committed to remediating all sanitary sewer overflows. See https://msdprojectclear.org/about/our-organization/consent-decree/.

For additional detailed information see also Appendix 2-A Bacteria TMDL, pg. 12.

3.53 Combined Sewer Overflows[21]

In addition to SSOs, combined sewer overflows, or CSOs, are also present within some of the district's service areas. A combined sewer system collects both stormwater runoff and wastewater, including domestic sewage. These systems are designed to transport wastewater to treatment facilities and to discharge directly to a water body if its capacity is exceeded due to stormwater inputs. Combined sewer systems were an early sewer design and are found in approximately 772 cities in the U.S. (EPA 2014c). As with SSOs, CSOs can result in periods of elevated bacteria concentrations in a water body due in large part to the discharge of domestic

[19] Appendix 2-A Bacteria TMDL pg. 11-12
[20] Appendix 2-A Bacteria TMDL pg. 12
[21] Appendix 2-A Bacteria TMDL pgs. 13-14

sewage as well as the runoff component from roofs, parking lots and residential yards and driveways. In the Deer Creek watershed, there are 28 CSO outfalls, 21 of which are also within the drainage area of Black Creek (Map 3-2). Combined sewer overflow discharges are managed through the Metropolitan St. Louis Sewer District's long-term control plan, which includes nine minimum controls as required by EPA's CSO policy dated April 19, 1994 (59 FR 18688) and Missouri's effluent regulations at 10 CSR 20-7.015(10). These nine minimum controls as described in the operating permit for the Lemay wastewater treatment facility are:

- Proper operation and maintenance programs;
- Maximum use of the collection system for storage;
- Review and modification of pretreatment requirements;
- Maximization of flow to the publicly operated treatment works for treatment;
- Dry weather flows from CSOs are prohibited;
- Control of solid and floatable material in CSOs;
- Pollution prevention;
- Public notification; and,
- Monitoring to effectively characterize CSO impacts and the efficacy of CSO controls.

In addition to these nine minimum controls, the district's long-term control plan states that some CSO outfalls will be eliminated by sewer separation and the remaining outfalls will eventually convey all flows to a storage tunnel underneath the River des Peres and will then be pumped to the Lemay wastewater treatment plant (MSD 2012). Controls specified in the long-term control plan are referenced in 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.

A USGS study about the sources of *E. coli* in metropolitan St. Louis area streams estimated that during the study at least one-third of the measured in-stream *E. coli* originated from humans. The study also indicated that there is a correlation between *E. coli* densities and the number of upstream CSOs and sanitary sewer overflows (USGS 2010). For these reasons, both CSOs and SSOs are considered potential contributors of *E. coli* to Black Creek and Deer Creek.

3.54 Site-Specific Industrial and Non-Domestic Wastewater Permits[22]

Site-specific industrial and non-domestic wastewater permits differ from general wastewater permits by having conditions specific to a facility's site and operation. Industrial and non-domestic facilities discharge wastewater resulting from non-sewage generating activities and are typically not expected to cause or contribute to bacteria impairments. There are no industrial or non-domestic wastewater facilities with site-specific permits in the Deer Creek watershed.

[22] Appendix 2-A Bacteria TMDL pgs. 14-15

3.55 Municipal Separate Storm Sewer System (MS4) Permits[23]

There are two municipal separate storm sewer system permits, or MS4 permits, in the Deer Creek watershed. One is a site-specific permit issued to the Missouri Department of Transportation (permit no. MO-0137910) and regulates stormwater discharges from highway right-of-ways and other MoDOT owned properties. This permit is more commonly referred to as a transportation separate storm sewer system permit, or TS4 permit. The second MS4 permit in the watershed is a general small MS4 permit issued to the Metropolitan St. Louis Sewer District and its co-permittees (permit number MO-R040005). Co-permittees in the Deer Creek watershed include St. Louis County and the municipalities of Brentwood, Clayton, Creve Coeur, Des Peres, Frontenac, Glendale, Kirkwood, Ladue, Olivette, Richmond Heights, Rock Hill, Shrewsbury, Town and Country, Warson Woods, and Webster Groves.

3.56 General Wastewater and Non-MS4 Stormwater Permits[24]

General and stormwater permits are issued based on the type of activity occurring and are meant to be flexible enough to allow for ease and speed of issuance while providing the required protection of water quality. General and stormwater permits are issued to activities similar enough to be covered by a single set of requirements and are designated with permit numbers beginning with “MO-G” or “MO-R”, respectively. A summary of the general and stormwater permits in the Deer Creek watershed, as of April 8, 2015, is presented in Table 6. Permits associated with land disturbance activities are temporary and the number of effective permits of this type in the watershed may vary in any given year. Despite this variability, TMDL calculations and targets will not change as a result of any changes in the numbers of these types of permits.

Missouri Department of Natural Resources assumes activities authorized under these general and stormwater permits will be conducted in compliance with all permit conditions, including monitoring and discharge limitations. It is expected that compliance with these permits will be protective of the designated recreation use within the watershed. If at any time the department determines that the water quality of streams in the watershed is not being adequately protected, the department may require the owner or operator of the permitted site to obtain a site-specific operating permit, per 10 CSR 20-6.010(13)(C). See Appendix 2-A, pgs. 16, for a complete list of General (MO-G) and non-MS4 stormwater (MO-R) permits.

Table 3-4 Deer Creek Watershed Alliance Summary

Summary of Watershed Impairments, Pollutants, and Indicators			
Causes/Sources	**Watershed Problems/Concerns**	**Pollutant Loads**	**Other Assessment Indicators**
Increased impervious surface area	Increased creek widening, property loss, bridge damage, gabion wall damage, erosion,	Low dissolved oxygen, High *E. Coli*	Geomorphologic assessment

[23] Appendix 2-A Bacteria TMDL pg. 15
[24] Appendix 2-A Bacteria TMDL pgs. 16-17

Channel straightening and loss of riparian corridor	flash flooding; reduced habitat, species diversity	High TSS, *E. Coli*	Resident reports
High clay soil content, soil compaction from construction	Low soil infiltration, Erosion/sedimentation, stormwater runoff	Low DO High TSS, *E. Coli*	GIS soil analysis chart Onsite soil samples
Increased precipitation from global climate change	Flooding, erosion, sedimentation, creek widening, property loss, sewer overflows	High TSS, *E. Coli*	Climate change prediction models, scientific papers
Commercial/industrial properties clustered in lower floodplain	Economic damage from flooding causing property damage/loss	Industrial pollutants in stream.	GIS Land Use mapping, List of potential industrial point-source polluters
1950's home construction practices	Potential erosion/ sedimentation, basement flooding from increases in overland flow stress	High TSS, *E. Coli* Low DO Habitat Dest.	ID locations of and number of homes with inappropriate downspout connect.
Human waste from CSOs & SSOs and animal waste from pets and wildlife in stream.	Human health hazard	High *E. Coli* count, Low DO	Homeowner surveys
Municipal winter road salting operations, landowner salt use	Human/pet health impact, reduced species diversity	High chloride count	Survey road salt operations
		High specific conductivity	
Lawn monoculture and pervasive invasive species with shallow root structure	Erosion/sedimentation	High TSS, Low DO	Visual plant location assessments
Landowner yard maintenance patterns	Increase in eutrophication; channel obstruction; reduction in scenic beauty	Low DO	Visual assessments
Yard waste, organic debris, trash, lawn fertilizers in stream		High phosphorus	Landowner reports
Tree loss from construction and disease	Erosion, sedimentation, and flooding	Low DO, High TSS	Tree inventory
Presence of karst topography/sinkholes	Potential groundwater pollution	Depends on source	GIS mapping of karst/sinkhole locations
Building in floodplain & floodplain infill	Residential flooding	High TSS, Habitat loss	Citizen reports/MSD database

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