Missouri Department of Natural Resources
Water Protection Program

Bacteria
Total Maximum Daily Load (TMDL)

for

Coldwater Creek
St. Louis County, Missouri

Completed: Dec. 31, 2014
Approved:

Total Maximum Daily Load (TMDL) for Coldwater Creek
Pollutant: *Escherichia coli*


State Map Showing Location of Watershed

Name: Coldwater Creek

Location: St. Louis County near Black Jack

12-digit Hydrologic Unit Code (HUC):
103002000802 - Headwaters Coldwater Creek
103002000803 - Coldwater Creek

Water Body Identification Number (WBID) and Hydrologic Class:[1]
WBID 1706 – Class C

Designated uses:[2]
Livestock and wildlife protection (LWP)
Irrigation (IRR)
Protection of warm water habitat (WWH)
Human health protection (HHP)
Industrial (IND)
Secondary contact recreation (SCR)
Whole body contact recreation category B (WBC-B)

Other designations:
Metropolitan no-discharge stream[3]

Use that is Impaired:
Whole body contact recreation category B (WBC-B)

Length and location of impaired segment:[4]
6.9 miles, from mouth to Section 13, Township 47N, Range 6E.

Universal Transverse Mercator [Zone 15 north] coordinates:
E: 741383, N: 4301808 to E: 735227, N: 4299568

Pollutant on 2014 303(d) List:
Escherichia coli, or E. coli, Bacteria

[1] For hydrologic classes see 10 CSR 20-7.031(1)(F). Class P streams maintain flow during drought conditions. Class C streams may cease flow during dry periods, but maintain permanent pools that support aquatic life. Class E streams have ephemeral surface flow.
[2] For designated uses see 10 CSR 20-7.031(1)(C) and 10 CSR 20-7.031 Table H.
[3] For metropolitan no-discharge stream designations, see 10 CSR 20-7.031, Table F.
[4] The water body segment length is revised in 10 CSR 20-7.031 Table H, effective October 2009. This revision reflects a more accurate measurement of length. The location and the starting and ending points of this segment have not changed. This length differs from what is presented in the U.S. Environmental Protection Agency's Aug. 26, 2014 decision letter approving the listing of Coldwater Creek as impaired by bacteria.

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1. Introduction

The Missouri Department of Natural Resources, in accordance with Section 303(d) of the federal Clean Water Act, is establishing this Coldwater Creek Total Maximum Daily Load, or TMDL. This water quality-limited segment in St. Louis County is included on Missouri's 2014 303(d) List of impaired waters. The listing of Coldwater Creek as impaired by *Escherichia coli* bacteria was approved by the U.S. Environmental Protection Agency on Aug. 26, 2014. The department's 303(d) submittal to EPA cited urban runoff and storm sewers as likely sources of the impairment. This report addresses the Coldwater Creek bacteria impairment by establishing a TMDL for *Escherichia coli*, or *E. coli*. Data analyses conducted to support this listing and TMDL development indicate that *E. coli* bacteria are present at concentrations that result in exceedances of Missouri's water quality criterion for the whole body contact recreation category B designated use.

Section 303(d) of the federal Clean Water Act and Chapter 40 of the Code of Federal Regulations (CFR) Part 130 requires states to develop TMDLs for waters not meeting designated uses. 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. Missouri's Water Quality Standards at 10 CSR 20-7.031 consist of three major components: designated beneficial uses, water quality criteria to protect those uses and an antidegradation policy. The TMDL establishes the pollutant loading capacity necessary to meet the water quality standards established for each water body based on the relationship between pollutant sources and instream water quality conditions. A TMDL consists of a wasteload allocation, a load allocation, and a margin of safety. The wasteload allocation is the fraction of the total pollutant load apportioned to point sources. The load allocation is the fraction of the total pollutant load apportioned to nonpoint sources. The margin of safety is a percentage of the TMDL that accounts for any uncertainty associated with the model assumptions as well as any data inadequacies.

Coldwater Creek was first listed as impaired by bacteria in 2008 due to data showing elevated *E. coli* concentrations. The state's 2014 listing methodology determines a water to be impaired by bacteria if the geometric mean in a given recreational season exceeds the water quality criteria in any of the last three years for which there are available data. This listing methodology also states that at least five samples are needed during the recreational season in order to determine impairment. The state's recreational season is defined as being the seven-month period from April 1 through October 31. Data meeting the 2014 assessment protocol have been collected and do show Coldwater Creek as being impaired by bacteria.

In addition to bacteria, Coldwater Creek is also included on the 2014 303(d) List as impaired by chloride. A separate TMDL will be developed at a future date to address this other pollutant. The department maintains its TMDL development schedule online at dnr.mo.gov/env/wpp/tmdl/wpc-tmdl-progress.htm.

2. Background

Coldwater Creek is an urban stream located in eastern Missouri in northeastern St. Louis County. The lowermost 6.9 miles of stream is identified in the Missouri Use Designation Dataset as water body identification number, or WBID, 1706.[5] The headwaters of Coldwater Creek originate about 5 miles south of Lambert-St. Louis International Airport. The creek has been modified at the airport to flow underground for approximately a mile, after which it resurfaces north of the airport and flows for another 14 miles before entering the Missouri River (Figure 1). The Coldwater Creek watershed drains approximately 44.5 square miles and is located in the Moreau/Loutre Ecological Drainage Unit[6], or EDU, in the Ozark aquatic subregion[7] (MoRAP 2005a).

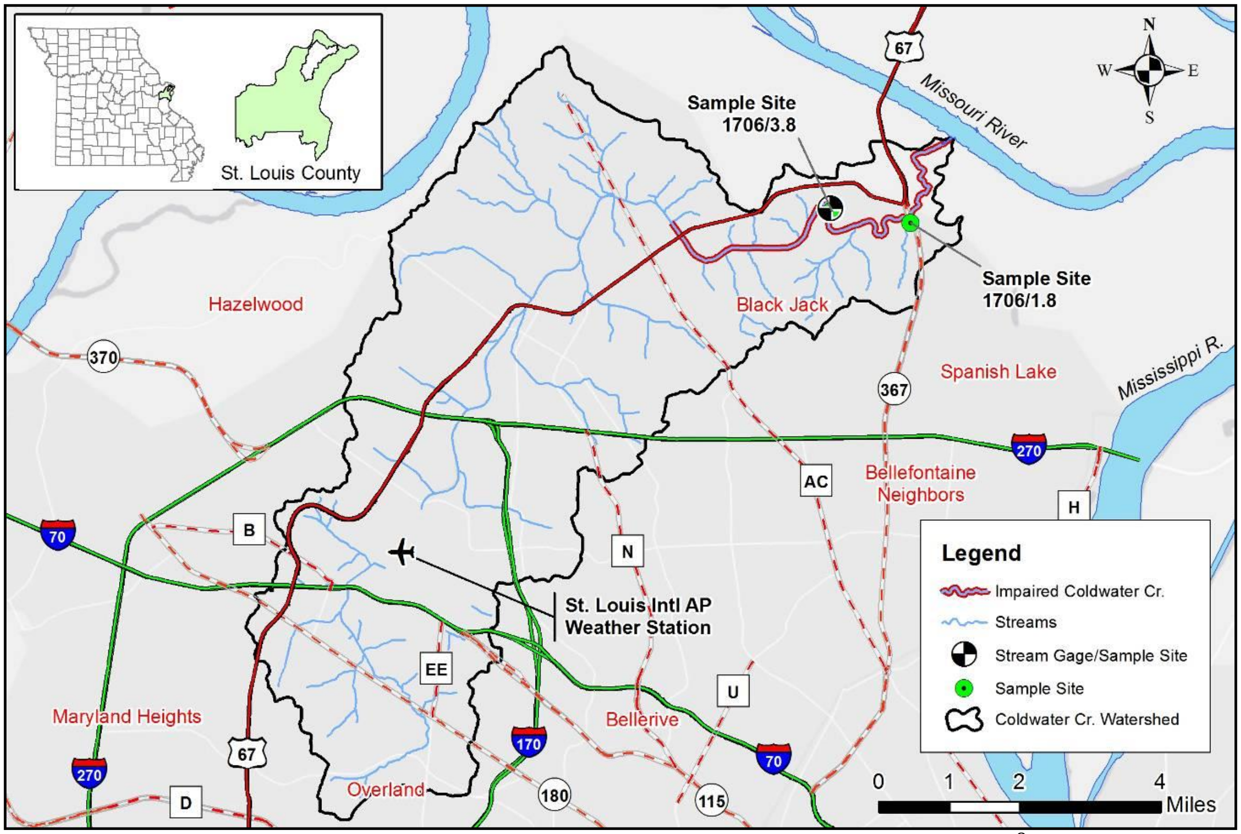

Figure 1. Location of the Coldwater Creek watershed in St. Louis County, Mo.[8]

2.1 Geology, Physiography and Soils

Coldwater Creek is located within the Lower Missouri subbasin, identified by the 8-digit hydrologic unit code, [9] or HUC, 10300200. This subbasin contains portions of the Claypan Prairie, River Hills, Osage/Gasconade Hills, Central Plateau, and Middle Mississippi Alluvial Plain level IV ecoregions.[10] The Coldwater Creek watershed is contained entirely within the River Hills ecoregion.

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[5] The Missouri Use Designation Dataset documents the names and locations of the state's rivers, streams, lakes and reservoirs, which have been assigned designated uses. See 10 CSR 20.7031 (1)(P).

[6] Ecological Drainage Units are groups of watersheds having generally similar biota, geography, and climatic characteristics (USGS 2009).

[7] Missouri's three aquatic subregions are the Central Plains, the Mississippi Alluvial Basin, and the Ozark (MoRAP 2005a).

[8] Sampling sites (downstream to upstream): 1706/1.8 Coldwater Creek at Highway 367 and 1706/3.8 Coldwater Creek at Jamestown Road (also USGS stream gage 06936475 Coldwater Creek near Black Jack, Mo.).

[9] Watersheds are delineated by the U.S. Geological Survey using a nationwide system based on surface hydrologic features. This system divides the country into 2,270 8-digit hydrologic units (USGS and NRCS 2011).

[10] Ecoregions are areas with similar ecosystems and environmental resources. A level I ecoregion is a coarse, broad category, while a level IV is a more defined grouping.

This area is a transition zone between the Central Irregular Plains and the Ozark Highlands. Key characteristic features of the River Hills are loess-covered hills and numerous karst features (Chapman et al. 2002). Karst features in the Coldwater Creek watershed are found primarily in the area near the impaired stream segment and include 15 sinkholes.

The impaired portion of Coldwater Creek, WBID 1706, has a stream length of 6.9 miles. The topographic relief along this segment is generally 65 feet along the stream valley up to 183 feet in the adjoining uplands. The elevation of WBID 1706 ranges from approximately 469 feet above sea level (upstream) to 405 feet (downstream). The elevation of the entire Coldwater Creek watershed ranges from approximately 719 feet (upstream) to 405 feet (downstream) (CARES 2005).

Soils in the Coldwater Creek watershed are varied, but can be grouped based on similar characteristics. Table 1 provides a summary of hydrologic soil groups in the Coldwater Creek watershed. Hydrologic soil groups categorize soils by their runoff potential. A soil's hydrologic soil group relates to the rate at which water enters the soil profile under thoroughly wetted, bare soil surface conditions. Group A represents soils with the highest rate of infiltration and the lowest runoff potential under these conditions and Group D represents the group with the lowest rate of infiltration and highest potential for runoff. The dominant soil group in the Coldwater Creek watershed is Group D, which covers approximately 57 percent of the watershed. In general, soils within this group have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils, 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 material. Soils within the second most represented group, Group C, cover approximately 17 percent of the watershed. Group C includes sandy clay loam soils that have a moderately fine to fine structure. These soils consist chiefly of soils with a layer that impedes downward movement of water. The remaining rated soils in the watershed belong to Group B, which covers approximately 14 percent of the watershed. Group B soils include silt loam and loam that have moderate infiltration rates and are well-drained soils with moderately fine to moderately coarse textures (NRCS 2007). Over 12 percent of the watershed area contains soils that are not rated. Areas not rated are typically areas of open water, quarries or landfills. In the Coldwater Creek watershed, the majority of areas not rated in a hydrologic soil group are classified as being either water or of the soil types Urban land, upland, 0 to 5 percent slopes and Urban land, bottomland, 0 to 3 percent slopes, rarely flooded. These soil types are classified as being 90 to 100 percent urban land and have no specific associated soil data given (NRCS 2010). Figure 2 shows the location and distribution of these hydrologic soil groups throughout the watershed.

Table 1. Hydrologic soil groups in the Coldwater Creek watershed (NRCS 2009)

Hydrologic Soil Group	***Group A***	***Group B***	***Group C***	***Group D***	***Not Rated***
Square Miles	0	6.09	7.63	25.17	5.62
Percentage	0%	13.7%	17.1%	56.5%	12.6%

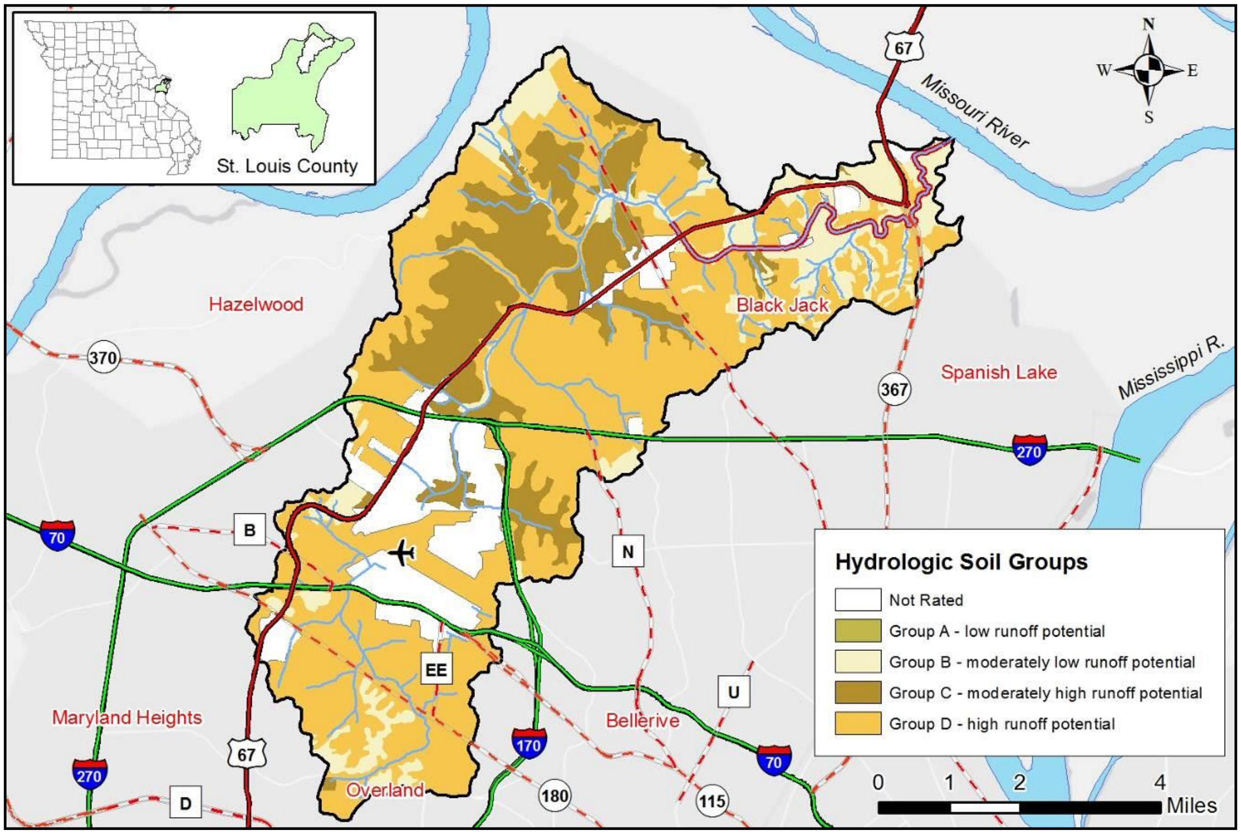

Figure 2. Hydrologic soil groups in the Coldwater Creek watershed (NRCS 2009)

The hydrologic soil groups within the Coldwater Creek watershed are comprised of 27 individual soil types. Four of the five most abundant soil types found in the Coldwater Creek watershed are defined as being primarily urban lands (Table 2). The most abundant is the Urban land-Harvester complex, with 2 to 9 percent slopes. This soil type is defined as 50 percent urban land and 40 percent Harvester soils. This soil type is found along hill slopes and interfluves, is moderately well drained, and is not prone to frequent flooding. The second most abundant soil type is Nevin-Urban land complex, 0 to 2 percent slopes. This soil is defined as 45 percent urban land and 50 percent Nevin soils. This soil type is found along interfluves and is somewhat poorly drained. Urban land, upland, 0 to 5 percent slopes is the third most abundant soil type in the Coldwater Creek watershed. This soil type is defined as being comprised of 90 percent urban land. There is no additional soil information associated with this soil type. The fourth most abundant soil type found in the Coldwater Creek watershed is Urban land-Harvester complex, 9 to 20 percent slopes. This soil type is comprised of 55 percent urban land and 25 percent Harvester soils. This soil type is typically found on hill slopes, is moderately well drained, and is not prone to frequent flooding. Menfro silt loam, 14 to 20 percent slopes, eroded is the fifth most abundant soil type in the watershed. This soil type is defined as 85 percent Menfro and similar soils, is found along hill slopes, is well drained, and is not prone to frequent flooding (NRCS 2010). Together, these five soil types account for 83 percent of watershed area.

Table 2. Abundant soil types in the Coldwater Creek watershed (NRCS 2009)

Soil Type	*Square Miles*	*Percent*
Urban land-Harvester complex, 2 to 9 percent slopes	20.48	46.0 %
Nevin-Urban land complex, 0 to 2 percent slopes	6.98	15.7 %
Urban land, upland, 0 to 5 percent slopes	5.45	12.3 %
Urban land-Harvester complex, 9 to 20 percent slopes	2.74	6.2 %
Menfro silt loam, 14 to 20 percent slopes, eroded	1.31	2.9 %

2.2 Rainfall and Climate

Weather stations provide useful information for developing a general understanding of climatic conditions in the watershed. The St. Louis International Airport weather station is within the Coldwater Creek watershed and can provide recent and available weather and climate data that is representative of the impaired watershed. The St. Louis International Airport weather station is shown in Figure 1 north of Interstate 70 and south of Interstate 270. This station records daily precipitation, maximum and minimum temperatures, snowfall and snow depth data.

Precipitation is an important factor related to stream flow and stormwater runoff events that can influence certain pollutant sources. The average annual precipitation and annual average minimum and maximum temperatures over the 30-year period from 1981 through 2010 are 40.92 inches and 47.8/66.1 degrees Fahrenheit (°F) (NOAA 2011). The 30-year climate data from the St. Louis International Airport weather station is summarized in Figure 3.

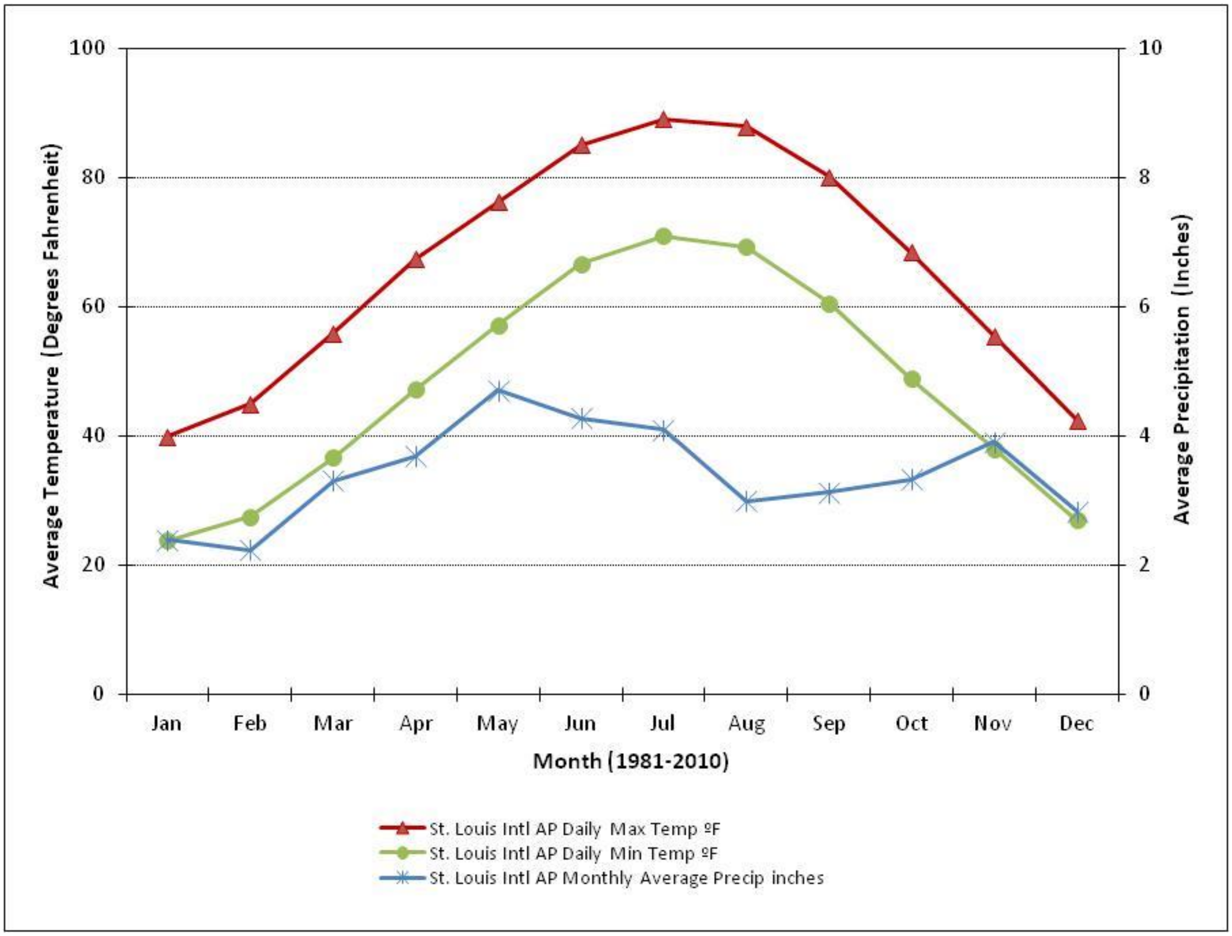

Figure 3. Thirty-year monthly temperature and precipitation averages for the St. Louis International Airport weather station.

2.3 Population

St. Louis County covers an area of 523 square miles and, according to 2010 census data, has a population of 999,021 people (U.S. Census Bureau 2010). The population of the Coldwater Creek watershed is not directly available; however, using U.S. Census Bureau census block data from 2010, the population of the Coldwater Creek watershed was estimated to be approximately 147,467. Approximately 95.5 percent of the watershed, containing over 99 percent of the watershed's population, is categorized by the U.S. Census Bureau as urban area. EPA considers this urban area as an entity requiring stormwater regulations through municipal separate storm sewer system, or MS4, permits (EPA 2002).[11]

This population estimation was completed by using Geographic Information System, or GIS, software and superimposing the watershed boundary over a map of census blocks. Where the centroid of a census block fell within the watershed boundary, the total population of the census block was included in the total. If the centroid of the census block was outside the watershed boundary, then the population was excluded.

[11] An urban area is calculated by the U.S. Census Bureau to determine the boundaries of the country's most developed and densely populated areas (www.census.gov/geo/www/ua/ua_2k.html).

Using 2000 census data and 12-digit hydrologic unit code watershed boundaries, EPA determined that the Coldwater Creek watershed is an Environmental Justice watershed.[12] This determination was based on the area of the 12-digit watershed and the percentages of racial minority and low-income populations (Steve Schaff, EPA, email communication, June 30, 2011). Communities within an Environmental Justice watershed may qualify for financial and strategic assistance for addressing environmental and public health issues (EPA 2011a).

2.4 Land Use

Land use calculations are based on data from 2000 to 2004 at 30-meter resolution obtained from Thematic Mapper imagery (MoRAP 2005b). These calculations are presented in Table 3. Figure 4 graphically presents the available land use data for the Coldwater Creek watershed. The watershed is predominantly an urban environment, with areas categorized as urban or impervious accounting for over 77 percent of the watershed. Areas defined in the land use dataset as low-intensity urban comprise approximately 62 percent of the total area and account for the majority of the watershed's land use. Low-intensity urban is defined as vegetated urban environments with a low density of buildings. In the Coldwater Creek watershed, these areas are primarily residential areas. Areas categorized as high-intensity urban account for 0.69 percent of the watershed area and are defined as vegetated urban environments with a high density of buildings. Areas of the watershed categorized as impervious account for over 15 percent of the watershed area, which is the second most abundant land use type in the watershed. Impervious areas are defined in the land use dataset as being areas with little, if any, vegetation, that are dominated by streets, parking lots, and buildings. The majority of the watershed area that is classified as impervious is concentrated primarily at and around the Lambert-St. Louis International Airport. Although the land use dataset used categorizes specific areas as impervious, impervious areas exist in all urban land use categories due to the presence of roads, parking lots, driveways, and rooftops. The Metropolitan St. Louis Sewer District, which is a public agency responsible for management of wastewater and some stormwater in the watershed, estimates the total imperviousness of the watershed to be approximately 35 percent (Kristol Whatley, Metropolitan St. Louis Sewer District, email communication, Aug. 10, 2012). This amount of imperviousness in the watershed is significant as stream degradation associated with imperviousness has been shown to first occur at about 10 percent imperviousness and to increase in severity as imperviousness increases (Arnold and Gibbons 1996; Schueler 1994).

The third most abundant land use type in the Coldwater Creek watershed is grassland, which accounts for 12 percent of the watershed area. Because of the urban nature of the watershed, areas classified as grassland may include golf courses, cemeteries, parks, school playgrounds and other urban green spaces. Forested areas account for about 6 percent of the watershed and together, the remaining five land use categories found in Table 3 account for just over 3 percent of the watershed.

[12] EPA defines Environmental Justice as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations and policies.

Table 3. Land use in the Coldwater Creek watershed

Land Use Type	***Acres***	***Sq. Miles***	***Percentage***
Impervious	4,347	6.79	15.26 %
High-Intensity Urban	196	0.31	0.69 %
Low-Intensity Urban	17,663	27.60	62.03 %
Row and Close-grown Crops	426	0.67	1.50 %
Grassland	3,637	5.68	12.77 %
Forest & Woodland	1,722	2.69	6.05 %
Herbaceous	20	0.03	0.07 %
Wetland	157	0.25	0.55 %
Open Water	106	0.17	0.37 %
Barren	202	0.32	0.71 %
Total:	28,476	44.51	100.00 %

Source: MoRAP 2005b

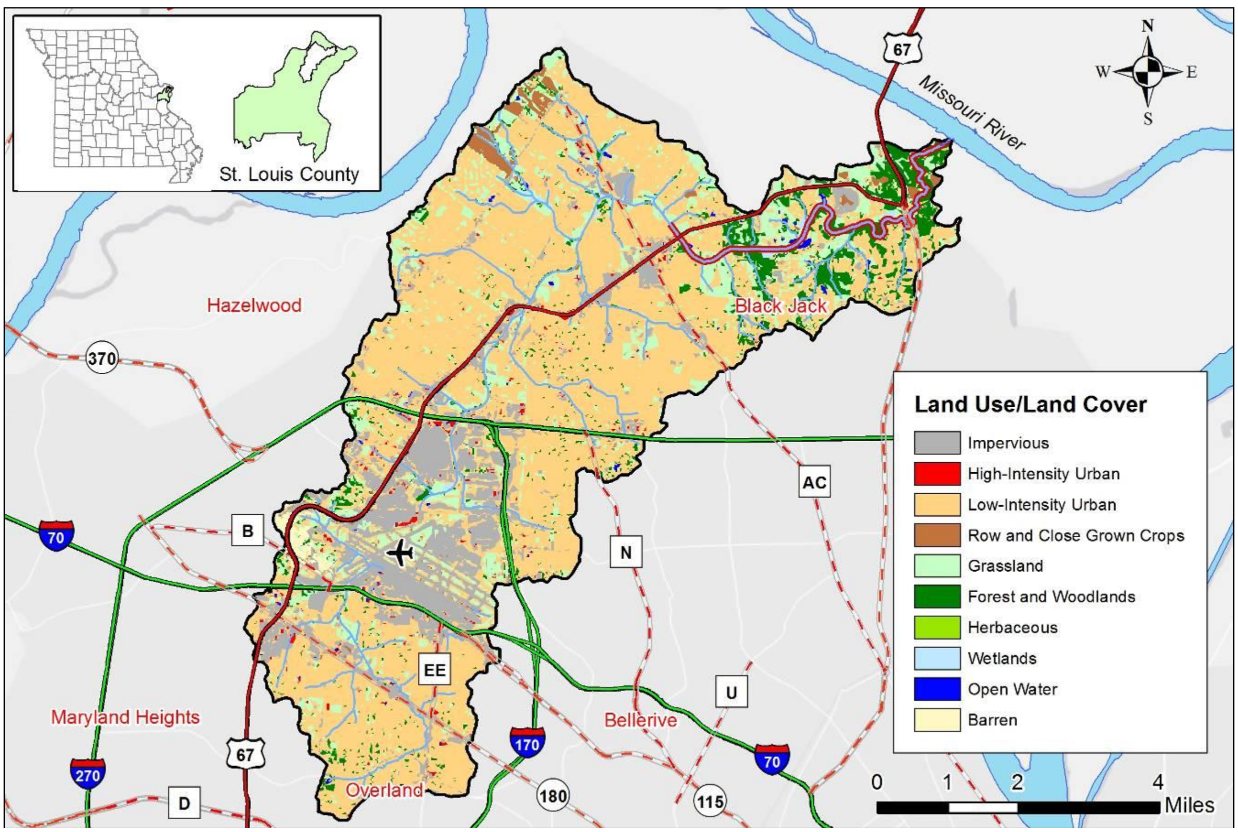

Figure 4. Land use and in the Coldwater Creek watershed (MoRAP 2005b)

2.5 Defining the Problem

A TMDL is needed for Coldwater Creek, because the department has determined that this stream is not meeting the state bacteria water quality criterion for whole body contact recreation category B (See Section 4). Data collected from Coldwater Creek by the U.S. Geological Survey, or USGS, and the Metropolitan St. Louis Sewer District show exceedances of the state's whole body contact recreation category B criterion of 206 *E. coli* counts per 100 milliliters of water (206/100mL). This assessment is based on the geometric mean of samples collected during the state's recreational season (April 1 through October 31). Bacteria data collected from Coldwater Creek within the last five years are expected to be representative of the stream's current condition. Table 4 and Figure 5 summarize bacteria data collected from Coldwater Creek during the 2006 – 2010 recreational seasons. Figure 6 summarizes *E. coli* data by month for this same period. All available *E. coli* data collected from Coldwater Creek, including any collected outside of the recreational season, can be found in Appendix A.

High counts of *E. coli* may be an indication of fecal contamination and an increased risk of pathogen-induced illness to humans. *E. coli* are bacteria found in the intestines of humans and warm-blooded animals and are used as indicators of the risk of waterborne disease from pathogenic bacteria or viruses (EPA 1997). Infections due to pathogen-contaminated waters include gastrointestinal, respiratory, eye, ear, nose, throat, and skin diseases. To address these potential health risks, this TMDL targets instream bacteria levels using *E. coli* as the primary measurement parameter. Selection of *E. coli* as the numeric target enables the use of the highest quality data available and provides consistency with Missouri's water quality standards.

Table 4. Recreational season *E. coli* data for Coldwater Creek (2006 – 2010)*

Year	***Sampling Events***	***Geometric Mean***	***Minimum***	***Maximum***	***WBC Category†***	***Criterion***	***Exceedance‡***
2006	8	353.97	50	3,800	B	206	Yes
2007	12	223.05	20	37,000	B	206	Yes
2008	5	184.89	5	1,500	B	206	No
2009	7	503.46	86	5,172	B	206	Yes
2010	2	121.27	86	171	B	206	--

* The units for all *E. coli* values are counts/100 mL of water. For calculation purposes, *E. coli* measurements recorded as a less than (<) value were halved.
† WBC = whole body contact recreation
‡ Years with fewer than five samples within the recreational season are not assessed against the whole body contact criterion.

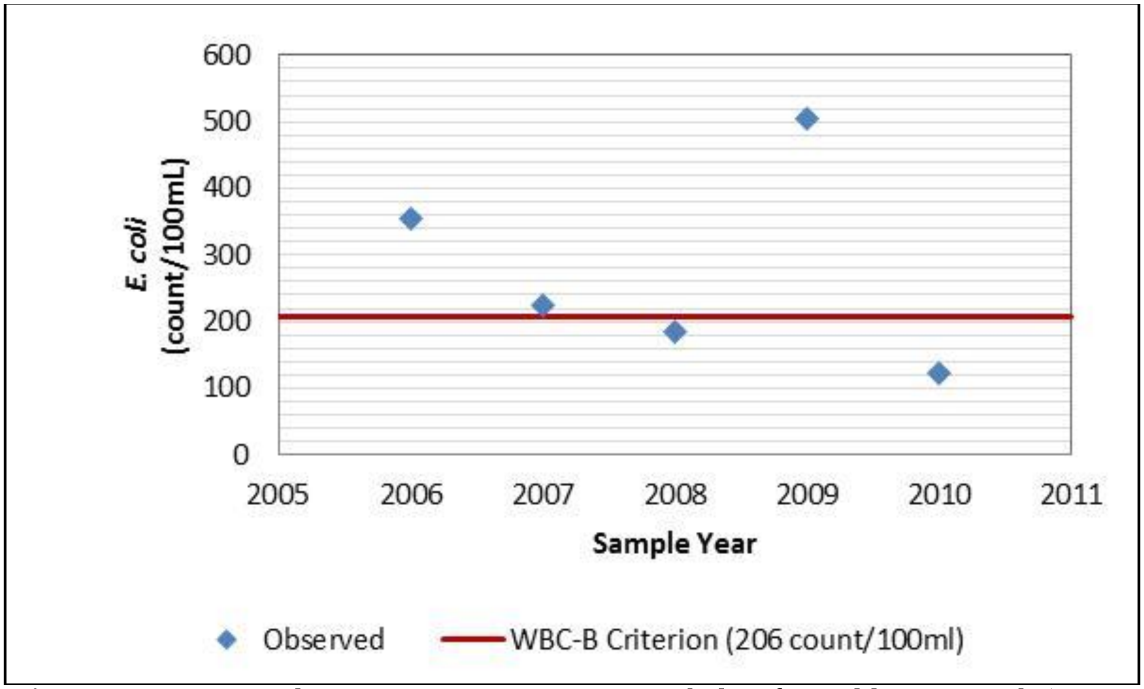

Figure 5. Recreational season geometric mean *E. coli* data for Coldwater Creek (2006 -2010)

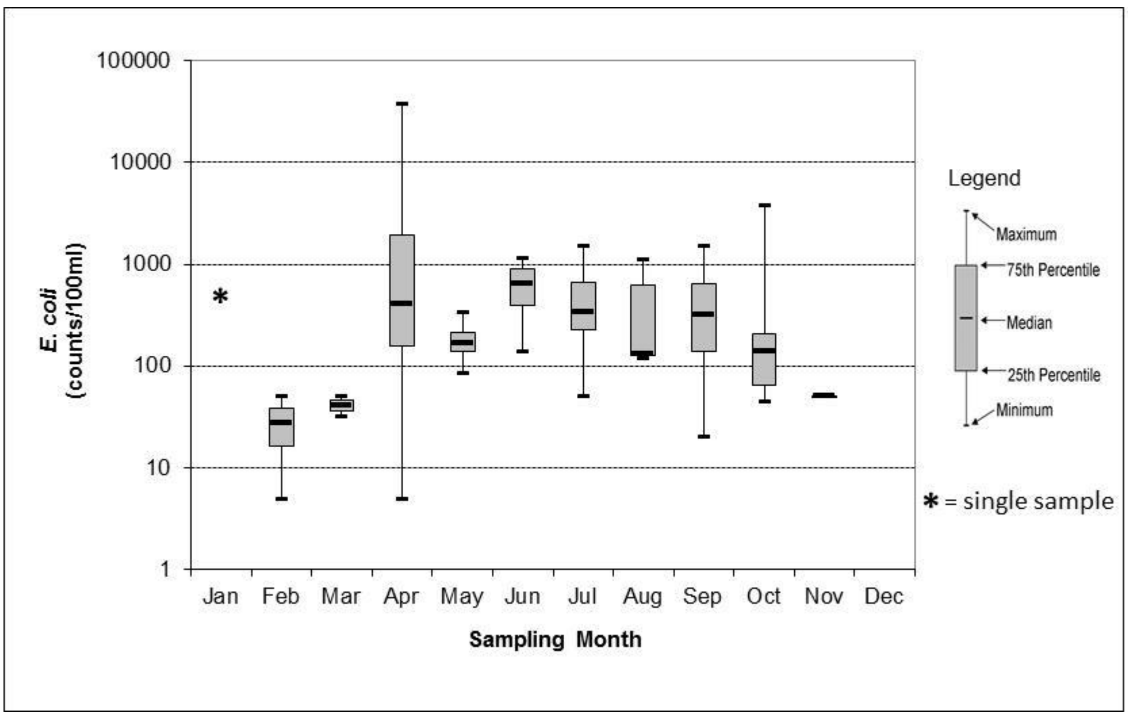

Figure 6. Monthly *E. coli* data for Coldwater Creek (2006 – 2010)

3. Source Inventory and Assessment

Source inventory and assessment characterizes 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.

3.1 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.[13] These 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, point sources include domestic and municipal wastewater treatment facilities, concentrated animal feeding operations, or CAFOs, stormwater discharges from municipal seperate storm sewer systems, illicit straight pipe discharges, and stormwater runoff from construction and industrial sites. Coldwater Creek is designated a Metropolitan No-Discharge Stream in 10 CSR 20-7.031 Table F. According to 10 CSR 20-7.031(7) no water contaminant except uncontaminated cooling water, permitted stormwater discharges in compliance with permit conditions and excess wet-weather bypass discharges not interfering with beneficial uses, shall be discharged to the watersheds of streams listed in Table F..

At the time this document was written, the Coldwater Creek watershed contained 38 permitted entities. Five of these permitted facilities have site-specific permits, of which one is a municipal domestic wastewater discharger (Section 3.1.1). There are also seven facilities with general permits for discharging either non-domestic process water or stormwater. The remaining 26 permited facilities have stormwater permits, including two small MS4 permits. There are no permitted CAFO facilities in this watershed. Figure 7 shows the location of the permitted outfalls within the watershed and the area of the watershed regulated through MS4 permits.

[13] The Missouri State Operating Permit 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.

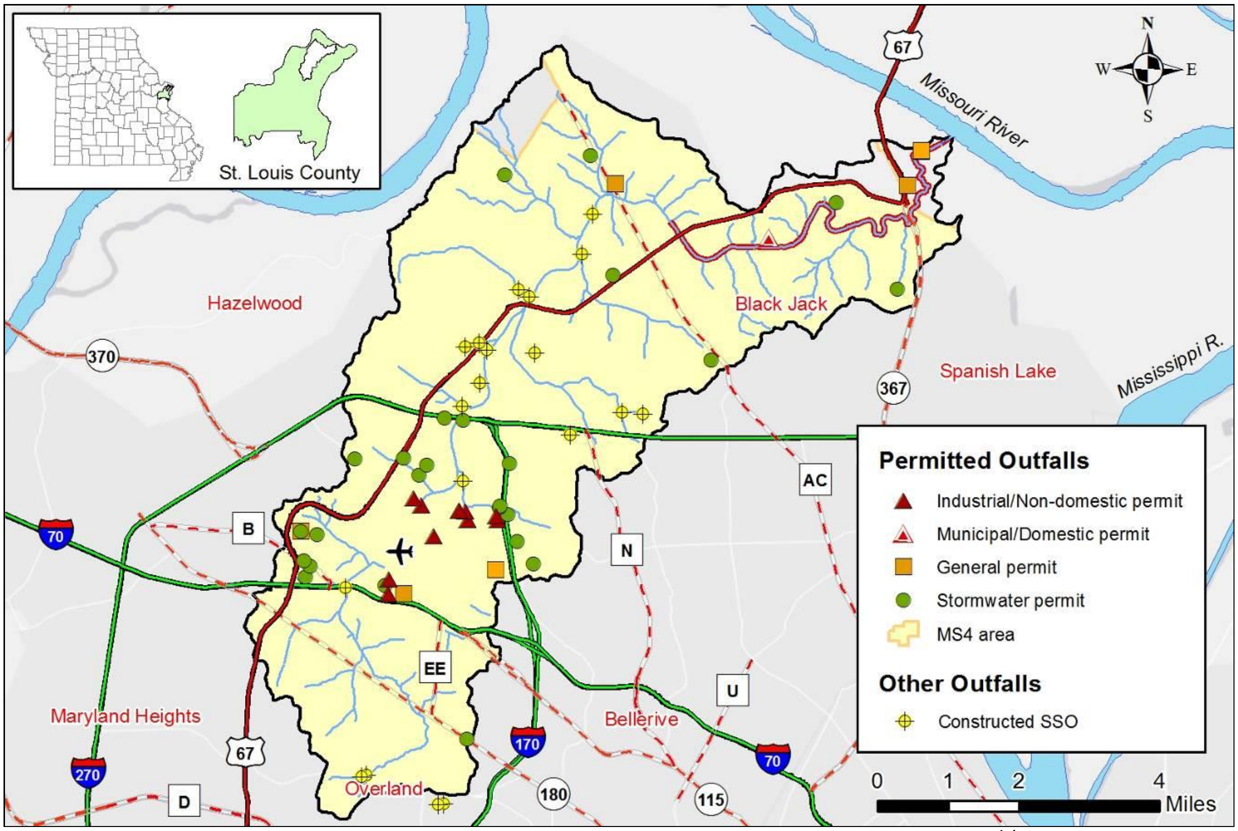

Figure 7. Outfall locations in the Coldwater Creek watershed (Oct. 23, 2012)[14]

3.1.1 Municipal and Domestic Wastewater Permits

Municipal and domestic wastewater treatment facilities are designed to treat household waste, which includes both greywater and sewage and can be sources of bacteria. The Metropolitan St. Louis Sewer District's Coldwater Creek Wastewater Treatment Facility is currently the only facility permitted to discharge municipal domestic wastewater present in the Coldwater Creek watershed (permit no. MO-0025160). However, this facility discharges its domestic wastewater to the Missouri River outside of the Coldwater Creek watershed. This facility's permit was renewed and issued on Jan. 13, 2012 and only allows stormwater discharges in the Coldwater Creek watershed. Prior permits allowed emergency sewage discharges to Coldwater Creek should a failure occur at the facility's main outfall. Emergency discharges were not treated and would therefore be a potential source of bacteria to Coldwater Creek. Despite this allowance, emergency discharges were infrequent. A review of quarterly discharge monitoring report data for this facility indicates that the last occurrence of a discharge from the emergency outfall was recorded for the monitoring period end date of Jan. 31, 2006. The facility's current permit recognizes a change in the department's regulations and no longer authorizes emergency discharges. Under the conditions set forth in the new permit, discharges resulting from emergency diversion will be considered an unauthorized bypass pursuant to 40 CFR 122.41(m) and shall be reported, pursuant to 40 CFR 122.41(m)(3)(i) and (ii). For these reasons, emergency discharges are not considered to cause or contribute to the bacteria impairment of Coldwater Creek.

[14] SSO = sanitary sewer overflow

Despite the infrequency of past emergency discharges and the fact that the primary wastewater outfall is located outside the watershed, the presence of the sewerage system infrastructure within the Coldwater Creek watershed presents 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 could occur for 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, including manholes. Such overflows are unpermitted and are unauthorized by the federal Clean Water Act. Occurrences of sanitary sewer overflows can result in periods of elevated bacteria concentrations (EPA 1996). The department does not have any data regarding occurrences of dry weather sanitary sewer overflows in the Coldwater Creek watershed. However, 20 constructed sanitary sewer overflows, installed to relieve the sanitary sewers from excess flow caused by inflow and infiltration of stormwater during high rain events, are located within the watershed (Bruce Litzsinger, Metropolitan St. Louis Sewer District, email communication, Oct. 24, 2011). A USGS study of the sources of *E. coli* in metropolitan St. Louis streams, including Coldwater Creek, estimated that at least one-third of the measured, in-stream *E. coli* found in St. Louis area streams originates from humans.[15] The study also indicated that there is a correlation between *E. coli* densities and the number of upstream sanitary sewer overflows (USGS 2010). For these reasons, sanitary sewer overflows are considered significant potential contributors of *E. coli* to Coldwater Creek.

In addition to sanitary sewer overflows, combined sewer overflows are also present within some areas serviced by the Metropolitan St. Louis Sewer District. A combined sewer system collects both stormwater runoff and wastewater, including domestic sewage. These systems are designed to not only transport wastewater to treatment facilities, but to also discharge directly to a water body if its capacity is exceeded due to stormwater inputs. Combined sewer systems were an early sewer design and can be found in many older cities. As with sanitary sewer overflows, combined sewer overflows can result in periods of elevated bacteria concentrations in a water body due in large part to the discharge of domestic sewage as well as the runoff component from roofs, parking lots and residential yards and driveways. However, no combined sewer overflows exist within the Coldwater Creek watershed. Therefore, combined sewer overflows do not cause or contribute to the bacteria impairment of Coldwater Creek.

3.1.2 Industrial and Non-Domestic Wastewater Permits

Industrial and non-domestic facilities discharge wastewater resulting from non-sewage generating activities and typically are not expected to cause or contribute to bacteria impairments. There are four industrial or non-domestic wastewater facilities with site-specific permits in the Coldwater Creek watershed (Table 5). According to the fact sheets available for these permits, these facilities are not considered to contribute to the bacteria impairment of Coldwater Creek. Should information become available indicating changes to permit limits or conditions are necessary to assure compliance with Missouri's water quality standards, then these permits may be reopened and modified, or alternatively revoked and reissued.

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[15] This USGS study categorized samples as either human, dog, or geese when 80 percent of the genetic markers were similar. Those with a less than 80 percent match were categorized as unknown. However, those categorized as unknown may include some percentage of human, dog or geese as well as other urban wildlife (USGS 2010).

Table 5. Industrial/non-domestic wastewater site-specific permits in the Coldwater Creek watershed

Permit No.	Facility Name	Design Flow	SIC[16] Description	Permit Expires
MO-0127329	Allied Aviation Fueling Co of St. Louis	0.3 MGD	Petroleum Bulk Stations and Terminals	10/14/2015
MO-0111210	Lambert-St. Louis International Airport	stormwater only	Airports, Flying Fields, and Services	3/31/2016
MO-0004782	The Boeing Company	0.3 MGD and stormwater	Aircraft	3/5/2014
MO-0135950	GKN Aerospace-St. Louis	stormwater only	Aircraft	11/24/2014

MGD = million gallons per day.

3.1.3 General and Stormwater Permits

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. Table 6 summarizes all the general and stormwater permits in the Coldwater Creek watershed.

Table 6. General (MO-G) and stormwater (MO-R) permits in the Coldwater Creek watershed*

Permit No.	Facility Name	Discharge Type	Receiving Stream	Permit Expires
MO-G140040	Signature Flight Support	Stormwater	Trib. to Coldwater Cr.	12/23/2013
MO-G490133	Fort Bellefontaine Quarry CS31	Stormwater	Coldwater Cr.	10/5/2016
MO-G490910	Pace Construction – Fort Belle	Stormwater	Trib. to Coldwater Cr.	10/5/2016
MO-G491175	Millstone Bangert - Natural Bridge Rd	Stormwater	Trib. to Coldwater Cr.	10/5/2016
MO-G760065	The New Wedgewood Bath and Tennis Club	non-domestic	Trib. to Coldwater Cr.	4/9/2014
MO-G940221	Allied Aviation Fueling Co. of St. Louis	Stormwater	Trib. to Coldwater Cr.	11/11/2015
MO-G970015	FT Bellefontaine Compost	Stormwater	Trib. to Coldwater Cr.	11/29/2012
MO-R040005	Metropolitan St. Louis Sewer District and co-permittees' Small MS4	Stormwater	--	6/12/2013
MO-R040063	Missouri Dept. of Transportation Small MS4	Stormwater	--	6/12/2013
MO-RA00161	CVS Pharmacy Store #6745	Stormwater	Trib. to Coldwater Cr.	2/7/2017
MO-RA00263	Lambert St. Louis Airport–East of I-270	Stormwater	Trib. to Coldwater Cr [†]	2/7/2017
MO-RA00262	Lambert St. Louis Airport-West of I-270	Stormwater	Trib. to Coldwater Cr[†]	2/7/2017
MO-RA00298	Millstone Bangert - Natural Bridge Rd	Stormwater	Trib. to Coldwater Cr.	2/7/2017
MO-RA00648	Misty Hollow	Stormwater	Trib. to Coldwater Cr.	2/7/2017
MO-RA00749	Hunter Engineering Co	Stormwater	Trib. to Coldwater Cr.	2/7/2017
MO-RA01020	Florissant Shopping Center Redevelopment	Stormwater	Trib. to Coldwater Cr.	2/7/2017

[16] Standard Industrial Classification (SIC) from the U.S. Department of Labor's Occupational Safety and Health Administration.

Permit No.	***Facility Name***	***Discharge Type***	***Receiving Stream***	***Permit Expires***
MO-RA01393	Dollar General	Stormwater	Trib. to Coldwater Cr.	2/7/2017
MO-RA01456	McDonald's Restaurant – St. John	Stormwater	Trib. to Coldwater Cr.	2/7/2017
MO-RA01809	Hazelwood High School	Stormwater	Trib. to Coldwater Cr.	2/7/2017
MO-RA01977	Aviator Lot 4	Stormwater	Trib. to Coldwater Cr.	2/7/2017
MO-RA02128	Berkeley Manor	Stormwater	Trib. to Coldwater Cr.	2/7/2017
MO-R107791	Victory Baptist Church	Stormwater	Trib. to Coldwater Cr.	2/7/2012
MO-R130014	Bernadette Business Forms	Stormwater	Trib. to Coldwater Cr.	5/27/2008
MO-R130039	Printpack Inc.	Stormwater	Trib. to Coldwater Cr.	5/29/2013
MO-R203051	Hunter Engineering Co	Stormwater	Trib. to Coldwater Cr.	6/14/2014
MO-R203242	The Gateway Company	Stormwater	Coldwater Cr.	6/14/2014
MO-R23A095	LHB Industries	Stormwater	Trib. to Coldwater Cr.	3/11/2015
MO-R23D118	Graham Packaging Company	Stormwater	Trib. to Coldwater Cr.	2/3/2016
MO-R80C254	Fleet Car Carriers	Stormwater	Coldwater Cr.	10/3/2007
MO-R80C325	Prairie Farms Hazelwood	Stormwater	Coldwater Cr.	10/4/2012
MO-R80C395	MO Air National Guard – 131 Bomb Wing	Stormwater	Coldwater Cr.	10/4/2012
MO-R80C484	The Special School District	Stormwater	Trib. to Coldwater Cr.	10/4/2012
MO-R80H119	Republic Services Recycling Of MO North	Stormwater	Trib. to Coldwater Cr.	7/23/2014

* Permitted dischargers in the Coldwater Creek watershed on Oct. 23, 2012
†Receiving stream is misidentified in these permits as Tributary to Missouri River

As noted in Table 6, there are two small MS4 permits regulating portions of the Coldwater Creek watershed. MS4 permits authorize the discharge of urban stormwater runoff. In general, urban runoff has 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). *E. coli* contaminated runoff can come from both heavily paved areas and from open areas where soil erosion is common (Burton and Pitt 2002). For these reasons, urban runoff is a significant potential contributor of bacteria to Coldwater Creek.

Bacterial inputs to streams from urban runoff can be caused by sanitary sewer overflows as discussed in Section 3.1.1 of this document, but also commonly results from residential and green space runoff carrying domestic and wild animal wastes. Birds, dogs, cats, and rodents have been documented as common sources of *E. coli* contamination 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 3.1.1 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 as being from dogs and 20 percent from geese (USGS 2010). Another component of urban runoff is runoff originating from highway corridors. The Federal Highway Administration published research showing that runoff from highway corridors may also contain bacteria. Sources of *E. coli* to highway areas identified in the study include bird droppings, soil, and vehicles carrying livestock and stockyard wastes, which may periodically "seed" a roadway. 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

Coldwater Creek watershed cannot be quantified in this TMDL. However, due to the urban nature of the watershed, contributions from vehicles transporting livestock and stockyard wastes are likely to be less significant than in more rural watersheds. Additionally, bacteria contributions from sanitary sewer overflows, or onsite wastewater treatment systems are not likely to occur from highway corridors. Highway systems, however, do remain a significant source of heavy metals, inorganic salts, aromatic hydrocarbons and suspended solids (FHWA 1998)

In the case of Coldwater Creek, MS4 permits regulate urban stormwater discharges for approximately 95.7 percent of the watershed area. This regulated area corresponds to the MS4 area depicted in Figure 7, which is comprised of the U.S. Census Bureau's defined urban area as well as the Missouri Department of Transportation's right of way. For purposes of this TMDL, urban stormwater runoff from these MS4 regulated areas is considered a point source. Although stormwater discharges are untreated, small MS4 permit holders must develop, implement, and enforce stormwater management plans to reduce the contamination of stormwater runoff and prohibit illicit discharges. These plans must include measurable goals, must be reported on annually, and must meet six minimum control measures. These six minimum control measures are public education and outreach, public participation and involvement, illicit discharge detection and elimination, construction site runoff control, post-construction runoff control, and pollution prevention. Entities within the Coldwater Creek watershed that are regulated under the MS4 permits noted in Table 6 include the Missouri Department of Transportation and the Metropolitan St. Louis Sewer District and its co-permittees, which include St. Louis County and the municipalities of Berkeley, Black Jack, Breckenridge Hills, Bridgeton, Charlack, Ferguson, Florissant, Hazelwood, Overland, St. Ann, St. John, and Woodson Terrace.

Regarding the remaining general and non-MS4 stormwater permits in Table 6, the department assumes activities in the watershed will be conducted in compliance with all permit conditions, including monitoring and discharge limitations. It is expected that compliance with these permits will result in bacterial loadings at or below applicable targets. For these reasons, these facilities are not expected to cause or contribute to the bacterial impairment of Coldwater Creek. If at any time the department determines that the water quality of streams in the watershed is not being adequately protected, then 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).

3.1.4 Illicit Straight Pipe Discharges

Illicit straight pipe discharges of household waste are also potential point sources of bacteria. These sources are illegal and unpermitted discharges straight into streams or land areas and are different from illicitly connected sewers. However, there are no specific data on the number or presence of illicit straight pipe discharges of household waste in the Coldwater Creek watershed. Due to the presence of a sewerage system throughout the watershed, illicit straight pipe discharges are not expected to be significant contributors of *E. coli* to Coldwater Creek. Illicit discharge detection and elimination is one of the six minimum control measures required by an MS4 permit. Such sources are therefore expected to be detected and eliminated in accordance with permitted conditions.

3.2 Nonpoint 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. Typical nonpoint sources of pollution that have the potential to influence water quality include various sources associated with runoff from agricultural lands, unregulated urban stormwater, onsite wastewater treatment systems, and riparian corridor conditions.

3.2.1 Agricultural Runoff

Stormwater runoff from lands used for agricultural purposes is often a source of bacterial loading to water bodies. Activities associated with agricultural land uses that may contribute bacteria to a water body include manure fertilization of croplands or pastures, and livestock grazing. As shown in Figure 4 and noted in Table 3, cropland accounts for less than 2 percent of the entire watershed area. For this reason, although there may be some bacterial inputs from cropland, this loading is not likely to be a significant contributor to Coldwater Creek's impaired condition.

Bacterial inputs to Coldwater Creek from livestock are also likely to be minor. Although nearly 13 percent of the watershed is classified as grassland, due to the urban nature of the watershed these areas include golf courses, cemeteries, parks, or schoolyards where livestock animals are not likely to be grazing. In most instances, county zoning regulations prohibit livestock throughout much of the watershed. However, certain areas, primarily restricted to areas of the watershed that are unincorporated are zoned as non-urban areas where dairy farming and domestic livestock production are allowed. A very small portion of the watershed near the community of Old Jamestown is zoned for karst preservation, which also allows dairy farming and domestic livestock production (St. Louis County 2011a; 2011b). These types of activities may also occur in areas currently not zoned as non-urban areas or karst preservation if they were in existence prior to 1965 when the zoning regulations were established (Gail Choate, St. Louis County Department of Planning, personal communication, July 21, 2011). Despite the fact that these agricultural livestock practices are allowed in some areas, no data exists on the number of livestock that may be present in the watershed. Due to the overall urban nature of the watershed and the very small portion of the watershed that is unincorporated (approximately 4.5 percent), any existing livestock densities are likely to be low.

3.2.2 Urban Runoff (non-MS4 permitted areas)

Stormwater runoff from urban areas not having MS4 permits is considered a nonpoint source. In the Coldwater Creek watershed, urban stormwater runoff falls within the jurisdiction of two MS4 permits. Therefore, for purposes of this TMDL, urban runoff within the Coldwater Creek watershed is considered a potential point source contributor of *E. coli* to Coldwater Creek. For this reason, no nonpoint urban runoff sources have been identified that are likely to be contributing to the bacteria impairment of Coldwater Creek. See Section 3.1.3 of this document for a more detailed discussion of urban runoff contributions and MS4 permitting.

3.2.3 Onsite Wastewater Treatment Systems

When properly designed and maintained, onsite wastewater treatment systems (e.g., home septic systems) should not serve as a source of contamination to surface waters; however, onsite wastewater treatment systems do fail for a variety of reasons. When these systems fail hydraulically (surface breakouts) or hydrogeologically (inadequate soil filtration), there can be adverse effects to surface water quality (Horsley and Witten 1996). Failing onsite wastewater treatment systems are known to be 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. Onsite wastewater treatment systems may contribute bacteria to Coldwater Creek either directly or as a component of MS4-permitted stormwater.

The exact number of onsite wastewater treatment systems in the Coldwater Creek watershed is unknown. However, such systems are known to exist in older areas of the county that were developed prior to the sewerage systems serviced by the Metropolitan St. Louis Sewer District (Jack Fischer, St. Louis County Public Works, personal communication, June 6, 2011). Onsite systems are also likely to exist in areas zoned by the county as non-urban, since these areas are defined as being areas that create "practical difficulties in providing and maintaining…public or private utility services…" (St. Louis County 2011a). Although septic system installations and repairs within St. Louis County require a permit, the county database cannot distinguish between work pertaining to onsite 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 98 percent, do have a sewer connection. Nonsewered or suspected nonsewered parcels in the watershed may include parcels with houses or other structures on them as well as parcels comprised entirely of green space. These parcels may have onsite wastewater systems on them. The Metropolitan St. Louis Sewer District confirms that about 1 percent of the parcels in the Coldwater Creek watershed, approximately 552 parcels, are not connected to a sewer. However, it is not known if an onsite system exists on these parcels. An additional 0.3 percent of the parcels in the watershed, approximately 146 parcels, are suspected of not having a sewer connection. (Kristol Whatley, Metropolitan St. Louis Sewer District, email communication, Aug. 10, 2012).

Much of the watershed is serviced by the Metropolitan St. Louis Sewer District's Coldwater Creek wastewater treatment facility located within 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. For this reason, the number of onsite wastewater treatment systems in the Coldwater Creek watershed is expected to be low. 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 also requires the implementation of a supplemental environmental project to decommission some septic tanks 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, however overall reductions are dependent upon availability of funding for this supplemental project.[17]

EPA's Spreadsheet Tool for Estimating Pollutant Load website estimates the failure rate of onsite wastewater treatment systems in St. Louis County as being 39 percent (EPA 2011b). A more recent study conducted by the Electric Power Research Institute suggests that up to 50 percent of onsite wastewater treatment systems in Missouri may be failing (EPA 2011c; EPRI 2000). Despite the lack

[17] Any references 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 America 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" (John R. Lodderhose, Metropolitan St. Louis Sewer District, email communication, Oct. 24, 2012).

of specific data showing that onsite wastewater treatment systems are a significant problem in the Coldwater Creek watershed, the available failure rate data suggests that onsite wastewater treatment systems in the watershed are potential contributors of bacteria to Coldwater Creek either directly or as a component of MS4 stormwater. However, due to the overall urban nature of the watershed, the number of onsite wastewater systems in the watershed is expected to be low.

3.2.4 Riparian Corridor Conditions

Riparian (streamside) corridor conditions can have a strong influence on instream water quality. Wooded riparian buffers are a vital functional component of stream ecosystems and are instrumental in the detention, removal and assimilation of pollutants from runoff. Therefore, a stream with good riparian cover is better able to moderate the impacts of high pollutant loads than a stream with poor or no riparian cover.

Table 7 presents land use data for the riparian corridor within the Coldwater Creek watershed. This analysis used the land use data calculated in Section 2.4 and defined the riparian corridor as including a 30-meter area on each side of all streams included in the National Hydrography Dataset 1 to 24,000-scale flowline.[18] As can be seen in Table 7, the riparian corridor of Coldwater Creek is predominantly urban. Land classified as low-intensity urban comprises over 53 percent of the riparian corridor. Runoff from low-intensity urban areas, such as residential areas, can contribute bacteria loading to a water body from pet or wild animal wastes. For this reason, the riparian corridor conditions in the watershed are likely to contribute to the bacteria impairment of Coldwater Creek. Vegetated areas categorized as grassland account for about 16 percent of the Coldwater Creek riparian corridor, while area classified as forest and woodland accounts for about 15 percent. In rural areas, grassland areas may provide higher bacterial loading than forest and woodland areas due to the presence of livestock. Due to the highly urbanized environment of the Coldwater Creek watershed, livestock inputs are not likely to be contributing significantly to the bacteria impairment. However, bacterial inputs from these areas may still occur from pets and wildlife.

Table 7. Land use data for the Coldwater Creek watershed riparian buffer, 30-meter

Land Use Category	***Acres***	***Square Miles***	***Percent***
Impervious	144	0.22	8.54 %
High-Intensity Urban	7	0.01	0.40 %
Low-Intensity urban	892	1.39	53.04 %
Row and close-grown crops	29	0.05	1.73 %
Grassland	278	0.44	16.56 %
Forest and woodland	250	0.39	14.89 %
Open water	17	0.03	1.03 %
Barren	1	0.00	0.08 %
Herbaceous	8	0.01	0.46 %
Wetlands	55	0.09	3.27 %
Total:	1,681	2.63	100.00 %

[18] The National Hydrography Dataset is digital surface water data for geographic information systems (GIS) for use in general mapping and in the analysis of surface-water systems. Available URL: http://nhd.usgs.gov

4. Applicable Water Quality Standards and Numeric Target

The purpose of developing a TMDL is to identify the pollutant loading that a water body can assimilate and still achieve water quality standards. Water quality standards are therefore central to the TMDL development process. 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 (U.S. Code Title 33, Chapter 26, Subchapter III). Water quality standards consist of three major components: designated uses, water quality criteria, and an antidegradation policy.

4.1 Designated Uses

Designated uses are the uses for a water body identified in the state water quality standards that must be maintained in accordance with the federal Clean Water Act. The following designated uses have been assigned to Coldwater Creek:

- Livestock and wildlife protection (LWP)
- Irrigation (IRR)
- Protection of warm water habitat (WWH)
- Human health protection (HHP)
- Industrial (IND)
- Secondary contact recreation (SCR)
- Whole body contact recreation category B (WBC-B)

The use impaired by bacteria in this stream is the protection of whole body contact recreation category 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.

4.2 Water Quality Criteria

Water quality criteria are limits on particular 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 at 10 CSR 20-7.031(5)(C) and Table A, specific numeric criteria are given for the protection of the whole body contact recreation use. For category B waters, *E. coli* counts, measured as a geometric mean, 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.

4.3 Antidegradation Policy

Missouri's Water Quality Standards include the EPA "three-tiered" approach to antidegradation, and may be found at 10 CSR 20-7.031(3).

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 Coldwater Creek are to restore the streams' water quality to levels that meet water quality standards.

4.4 Numeric Target for TMDL Development

As noted in Section 4.2 of this document, Missouri's water quality standards include a specific numeric *E. coli* water quality criterion of 206 *E. coli* counts per 100 mL of water, measured as a geometric mean during the recreational season for waters designated with the whole body contact recreation category B use. The concentration value of 206 counts/100 mL will serve as the numeric target for TMDL development. This targeted concentration will be expressed as a daily load that varies by flow using a load duration curve. Achieving this targeted load will also result in achieving the state's whole body contact recreation category B water quality criterion. Because the whole body contact category B criterion is a geometric mean, fluctuations in instantaneous bacteria concentrations are expected, and individual bacteria measurements greater than the TMDL target do not in and of themselves indicate a violation of water quality standards.

5. Modeling Approach

For Coldwater Creek the load duration approach was used. When stream flow gage information is available, a load duration curve is useful in identifying and differentiating between storm-driven and steady-input sources. The load duration approach may be used to provide a visual representation of stream flow conditions under which pollutant criteria exceedances have occurred, to assess critical conditions, and to estimate the level of pollutant load reduction necessary to meet the surface water quality targets in the stream (Cleland 2002; Cleland 2003).

A load duration curve also identifies the maximum allowable daily pollutant load for any given day as a function of the flow occurring that day, which is consistent with the Anacostia Ruling (*Friends of the Earth, Inc., et al v. EPA,* No 05-5010, April 25, 2006) and EPA guidance in response to this ruling (EPA 2006; EPA 2007a). EPA guidance recommends that all TMDLs and associated pollutant allocations be expressed in terms of daily time increments, and suggests that there is flexibility in how these daily increments may be expressed. EPA guidance indicates that where pollutant loads or water body flows are highly dynamic, it may be appropriate to use a load duration curve approach, provided that such an approach "identifies the allowable daily pollutant load for any given day as a function of the flow occurring on that day." In addition, for targets that are expressed as a concentration of a pollutant, it may be appropriate to use a table or graph to express individual daily loads over a range of flows as a product of a water quality criterion multiplied by stream flow and a conversion factor (EPA 2006).

Average daily flow data for Coldwater Creek were directly available from July 11, 1996 to July 7, 2011, from the USGS gaging station USGS 06936475 Coldwater Creek near Black Jack, Mo (Figure 8). Flow data from this gage was adjusted to the impaired watershed based on the ratio of the impaired watershed area to the gage drainage area of 40.4 square miles. A detailed discussion of the methods used to develop the bacteria load duration curves is presented in Appendix B.

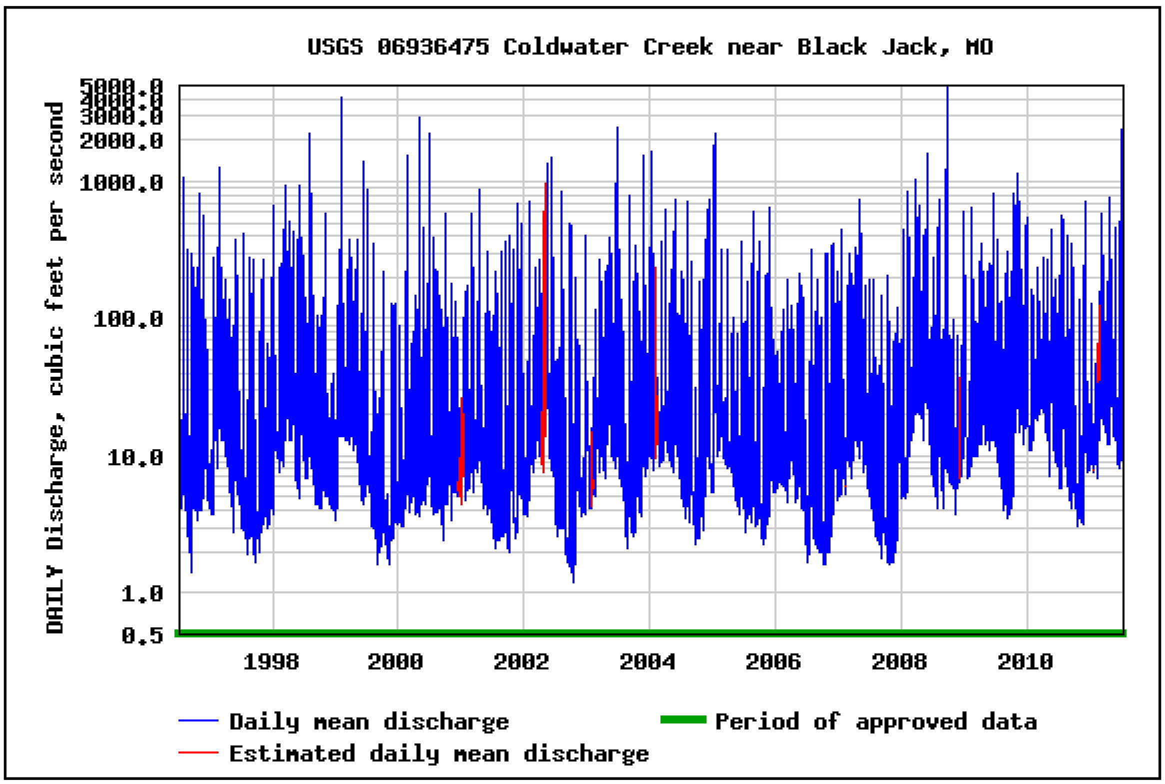

Figure 8. 1996 – 2011 flow data from USGS stream gage 06936475 (USGS 2011)

6. Calculating Loading Capacity

A TMDL calculates the loading capacity of a water body and allocates that load among the various pollutant sources in the watershed. The loading capacity is the maximum pollutant load that a water body can assimilate and still attain water quality standards. It is equal to the sum of the wasteload allocation, load allocation and the margin of safety, and can be expressed as the equation:

$$TMDL = LC = \sum WLA + \sum LA + MOS$$

where LC is the loading capacity, ∑WLA is the sum of the wasteload allocations, ∑LA is the sum of the load allocations, and MOS is the margin of safety.

According to 40 CFR §130.2(i), TMDLs can be expressed in terms of mass per time, toxicity or other appropriate measures. For Coldwater Creek, the bacteria TMDL is expressed as *E. coli* counts per day using a load duration curve. To develop a load duration curve, the TMDL target is multiplied by the flow and a conversion factor to generate the allowable load at different flows. Figure 9 is the bacteria TMDL load duration curve calculated for Coldwater Creek. The y-axis describes bacteria loading as counts per day, which are plotted against the flow duration intervals on the x-axis, which represent the frequency for which a particular flow is met or exceeded. The load duration curve presented in Figure 9 represents the loading capacity as a solid curve over the range of flows. Bacteria measurements collected during the recreational season are plotted as blue points. Flow condition ranges presented in Figure 9 illustrate general base-flow and surface-runoff conditions consistent with EPA guidance on using load duration curves for TMDL development (EPA 2007b). Table 8 presents selected TMDL loading capacities and TMDL allocations for Coldwater Creek representing each flow condition along the load duration curve.

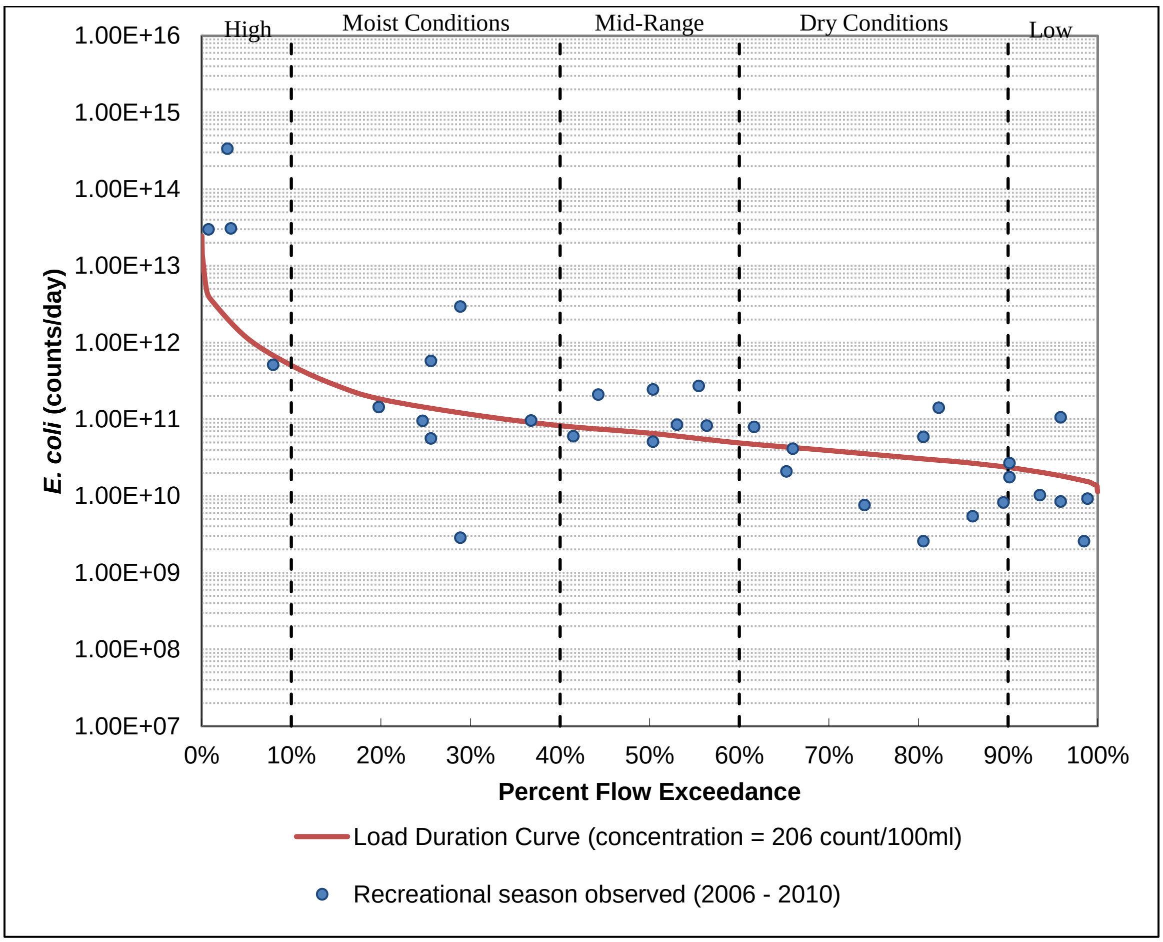

Figure 9. Coldwater Creek load duration curve

Table 8. Selected *E. coli* TMDL values for Coldwater Creek*

Percentile Flow Exceedance	*Flow (cfs)*	*TMDL (counts/day)*	*MS4 WLA (counts/day)*	*LA (counts/day)*
95	3.80	1.91E+10	1.83E+10	8.23E+08
75	6.88	3.47E+10	3.32E+10	1.49E+09
50	13.05	6.58E+10	6.29E+10	2.83E+09
25	27.37	1.38E+11	1.32E+11	5.93E+09
10	99.84	5.03E+11	4.82E+11	2.16E+10

* cfs = cubic feet per second; WLA = wasteload allocation; LA = load allocation;

7. Wasteload Allocation (Point Source Load)

The wasteload allocation is the allowable amount of the pollutant load that can be allocated to existing or future point sources. Typically, point sources are permitted with limits for a given pollutant that are the most stringent of either technology-based effluent limits or water quality-based effluent limits. Technology-based effluent limits are based upon the expected capability of a treatment method to reduce the pollutant to a certain concentration. Water quality-based effluent limits represent the most stringent concentration of a pollutant that a receiving stream can assimilate without violating applicable water quality standards at a specific location. The total wasteload allocations in the Coldwater Creek watershed over a range of flows are presented in Table 8.

As noted in Section 3.1.1 and 3.1.2 of this document, there are no site-specific permitted point sources in the Coldwater Creek watershed that are likely to cause or contribute to the bacteria impairment. For this reason, the industrial and non-domestic dischargers identified in Table 5 are given a wasteload allocation of zero. There is a domestic wastewater facility within the Coldwater Creek watershed, however, this facility discharges its domestic wastewater to the Missouri River. Sanitary sewer overflows may still occur within the watershed and are likely significant contributors of bacteria loading to Coldwater Creek. These discharges are unpermitted and not authorized under the Clean Water Act. For this reason, constructed sanitary sewer overflows in the Coldwater Creek watershed are given a wasteload allocation of zero. Elimination of bacteria loading from these sources will be accomplished through the requirements of the Metropolitan St. Louis Sewer District's consent decree.

Urban stormwater runoff is another potential significant contributor of bacteria loading to Coldwater Creek. In the Coldwater Creek watershed, urban stormwater runoff discharged through the MS4 is regulated through two MS4 permits. Bacterial contributions from MS4 permitted entities are precipitation dependent and vary with flow. Because there are no other permitted facilities found to significantly contribute to bacteria loads to Coldwater Creek, and because there is insufficient data to adequately disaggregate the MS4 wasteload allocation among the permitted entities, all wasteload allocations are aggregated and allocated to the total MS4 area. This MS4 wasteload allocation is based on the proportion of the area of the watershed that is regulated through MS4 permits. This defined MS4 area includes areas categorized by the U.S. Census Bureau as being an urban area and Missouri Department of Transportation right-of-way areas. The MS4 area accounts for approximately 95.7 percent of the entire watershed area.

Table 6 lists other facilities with general or non-MS4 stormwater permits; however, the department assumes activities in the watershed will be conducted in compliance with all permit conditions, including monitoring and discharge limitations. It is expected that compliance with these permits result in bacterial loading at or below applicable targets. For these reasons, these facilities are not considered to cause or contribute to the bacteria impairment of Coldwater Creek and the assigned wasteload allocation for these facilities is zero. 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).

The wasteload allocations listed in this TMDL do not preclude the establishment of future point sources of bacterial loading in the watershed. Any future point sources should be evaluated against the TMDL and the range of flows, which any additional bacterial loading will affect.

8. Load Allocation (Nonpoint Source Load)

The load allocation is the allowable amount of the pollutant load that can be assigned to nonpoint sources and includes all existing and future nonpoint sources, as well as natural background contributions (40 CFR §130.2(g)). Nonpoint sources identified to be potential contributors of bacteria in the Coldwater Creek watershed include onsite wastewater treatment systems and runoff from areas not regulated by MS4 permits, which may include inputs from agricultural sources. Properly functioning onsite wastewater treatment systems should not be contributing to the impaired condition of Coldwater Creek. Onsite wastewater treatment systems are assigned a load allocation of zero. The load allocation associated with areas not having a regulated MS4 is calculated as the remainder of the loading capacity after allocations are made to the wasteload allocation (see Table 8).

9. Margin of Safety

A margin of safety is required in the TMDL calculation to account for uncertainties in scientific and technical understanding of water quality in natural systems. The margin of safety is intended to account for such uncertainties in a conservative manner. Based on EPA guidance, the margin of safety can be achieved through two approaches:

- Explicit - Reserve a portion of the loading capacity as a separate term in the TMDL.
- Implicit - Incorporate the margin of safety as part of the critical conditions for the wasteload allocation and the load allocation calculations by making conservative assumptions in the analysis.

Due to conservative assumptions in the modeling of this TMDL, such as the use of multiple years of flow gage data collected from Coldwater Creek during all seasons, and the reduced uncertainty of the sources of impairment and their remediation through the Metropolitan St. Louis Sewer District's consent decree, the margin of safety for this TMDL is implicit.

10. Seasonal Variation

Missouri's water quality criteria for the protection of whole body contact recreation are applicable during the recreational season defined as being from April 1 to October 31. The TMDL load duration curve in Figure 9 represents stream flow under all conditions and uses flow data collected in all seasons. For this reason, the *E. coli* targets and allocations established in this TMDL will be protective throughout the recreational season. The advantage of a load duration curve approach is that all flow conditions are considered and the constraints associated with using a single-flow critical condition are avoided.

11. Monitoring Plans

The department has not yet scheduled post-TMDL monitoring for Coldwater Creek. Post-TMDL monitoring is usually scheduled and carried out by the department approximately three years after the approval of the TMDL or in a reasonable time period following completion of permit compliance schedules and the application of new effluent limits, or following significant implementation actions, such as removal of constructed sanitary sewer overflows. The department will routinely examine water quality data collected by other local, state and federal entities in order to assess the effectiveness of TMDL implementation. Such entities may include the USGS, EPA, neighboring state agencies, the Missouri Department of Health and Senior Services, the Missouri Department of Conservation, county health departments and the Metropolitan St. Louis Sewer District. In addition, certain quality-assured data collected by universities, municipalities, private companies and volunteer groups may potentially be considered for monitoring water quality following TMDL implementation.

12. Reasonable Assurance

Section 303(d)(1)(C) of the federal Clean Water Act requires that TMDLs be established at a level necessary to implement applicable water quality standards. As part of the TMDL process, consideration must be given to the assurances that point and nonpoint source allocations will be achieved and water quality standards attained. Where TMDLs are developed for waters impaired by point sources only, reasonable assurance is derived from the National Pollutant Discharge Elimination System, or NPDES. The wasteload allocations for MS4s will be implemented through the NPDES MS4 permits with the ultimate goal to employ an iterative process using best management practices (BMPs) to the maximum extent practicable (MEP), assessment, and refocused BMPs to the MEP, leading toward attainment of water quality standards (64 FR 68753)..

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 specific eliminations and reductions of point sources in the Metropolitan St. Louis Sewer District's service area, for which Coldwater Creek is a part. This court-approved decree will provide an additional reasonable assurance of bacteria reductions in Coldwater Creek from point sources over a 23-year period (EPA 2011d).

Where a TMDL is developed for waters impaired by both point and nonpoint sources, point source wasteload allocations must be stringent enough so that in conjunction with the water body's other loadings (i.e., nonpoint sources) water quality standards are met. This generally occurs when the TMDL's combined nonpoint source load allocations and point source wasteload allocations do not exceed the water quality standards-based loading capacity and there is reasonable assurance that the TMDL's allocations can be achieved. Reasonable assurance that nonpoint sources will meet their allocated amount in the TMDL is dependent upon the availability and implementation of nonpoint source pollutant reduction plans, controls or BMPs within the watershed. If BMPs or other nonpoint source pollution controls make more stringent load allocations practicable, then wasteload allocations can be made less stringent. Thus, the TMDL process provides for nonpoint source control tradeoffs (40 CFR 130.2(i)). When a demonstration of nonpoint source reasonable assurance is developed and approved for an impaired water body, additional pollutant allocations for point sources may be allowed provided water quality standards are still attained. When a demonstration of nonpoint source reasonable assurance does not exist, or it is determined that nonpoint source pollutant reduction plans, controls or BMPs are not feasible, durable, or will not result in the required load reductions, allocation of greater pollutant loading to point sources cannot occur.

A variety of grants and loans may be available to assist watershed stakeholders with developing and implementing watershed plans, controls and practices to meet the required wasteload and load allocations in the TMDL and demonstrate additional reasonable assurance.

13. Public Participation

EPA regulations require that TMDLs be subject to public review (40 CFR 130.7). The water quality-limited segment of Coldwater Creek in St. Louis County is included on Missouri's EPA-approved 2012 303(d) List of impaired waters. This TMDL was placed on public notice for a 45-day public comment period from June 29, 2012 to Aug. 13, 2012. Any comments received and the department's responses to those comments will be maintained on file with the department and on the Coldwater Creek TMDL record webpage at dnr.mo.gov/env/wpp/tmdl/1706-coldwater-ck-record.htm. In addition to this public notice and comment period, the department hosted a meeting to provide information to the public regarding the TMDL process and the overall goals of this and other bacteria TMDLs developed for impaired streams in St. Louis County. The public meeting was held on Sept. 12, 2012 from 6 pm to 8 pm at the Daniel Boone Branch of the St. Louis County Library at 300 Clarkson Road in Ellisville. The meeting agenda, the department's presentation, and an attendance sheet are available online on the Coldwater Creek TMDL record webpage.

Due to comments received during the 2012 public comment period and revisions made to the state's water quality standards in 2014, changes to the TMDL were necessary. For this reason, a second public comment period was held for 90 days from May 23, 2014 to Aug. 21, 2014. This public comment period included the Coldwater Creek TMDL as well as TMDLs for Creve Coeur Creek, Fishpot Creek, and Watkins Creek. Due to requests from the Metropolitan St. Louis Sewer District and members of the Partnership for Tomorrow, this comment period was extended an additional 60 days to Oct. 21, 2014.[19]

During the public comment period, the department met with groups who wanted to share their concerns regarding the TMDL. The department met twice during the public comment period with the Metropolitan St. Louis Sewer District, once on July 22, 2014 and again on Oct. 2, 2014. The department also met with MoDOT during the public comment period on June 24, 2014 to discuss their concerns with the TMDL and again on Oct. 9, 2014 to discuss potential bacteria monitoring and implementation of the TMDL. A third meeting, requested in public comments submitted by the Metropolitan St. Louis Sewer District, was held with the district on Dec. 30, 2014.

Groups that received the public notice announcement include the Missouri Clean Water Commission, the Missouri Water Quality Coordinating Committee, the Missouri Department of

[19] Members of the Partnership for Tomorrow include the Associated General Contractors of St. Louis, the Home Builders Association of St. Louis and Eastern Missouri, the Missouri Growth Association, the St. Louis Association of Realtors, the St. Louis County of Construction Consumers, and the St. Louis Regional Chamber.

Conservation, the Missouri Department of Transportation, the St. Louis County Soil and Water Conservation District, the Metropolitan St. Louis Sewer District, the St. Louis County Department of Health, St. Louis County Public Works, the University of Missouri Extension, the Missouri Coalition for the Environment, Stream Team volunteers living in or near the watershed, the Missouri Stream Team Watershed Coalition, any affected permitted entities, the state legislators representing areas within the watershed and any other individual or group who submitted comments during the first public comment period in 2012. For both public comment periods, the department posted the notice, the water body TMDL information sheets and this TMDL document on the department website, making them available to anyone with access to the Internet. Additionally, the department maintains an email distribution list via GovDelivery.com for notifying subscribers regarding significant TMDL updates or activities. Those interested in subscribing to these TMDL updates may do so by submitting their email address at public.govdelivery.com/accounts/MODNR/subscriber/new?topic_id=MODNR_177.

14. Administrative Record and Supporting Documentation

An administrative record on the Coldwater Creek TMDL has been assembled and is being kept on file with the Missouri Department of Natural Resources. It includes any studies, data and calculations on which the TMDL is based. This information is available upon request to the department at dnr.mo.gov/sunshine-form.htm. Any request for information on this TMDL will be processed in accordance with Missouri's Sunshine Law (Chapter 610, RSMO) and the department's administrative policies and procedures governing Sunshine Law requests. For more information on open record/Sunshine requests, please consult the department's website at dnr.mo.gov/sunshinerequests.htm.

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Appendix A

Coldwater Creek *E. coli* data

Sampling Date	*Sampling[20] Organization*	*Site[21] Code*	*UTM Easting*	*UTM Northing*	*Recreational Season?*	*E. coli[22] (#/100mL)*	*Flow[23] (cfs)*
8/1/1996	USGS	1706/3.8	738680	4300116	Yes	4600.0	7.8
9/23/1996	USGS	1706/3.8	738680	4300116	Yes	28000.0	1300.0
12/11/1996	USGS	1706/3.8	738680	4300116	No	61.0	12.0
3/5/1997	USGS	1706/3.8	738680	4300116	No	250.0	16.0
5/25/1997	USGS	1706/3.8	738680	4300116	Yes	25000.0	334.0
6/10/1997	USGS	1706/3.8	738680	4300116	Yes	720.0	3.0
8/26/1997	USGS	1706/3.8	738680	4300116	Yes	1700.0	1.0
9/2/1997	USGS	1706/3.8	738680	4300116	Yes	40000.0	974.0
12/15/1997	USGS	1706/3.8	738680	4300116	No	560.0	3.6
2/24/1998	USGS	1706/3.8	738680	4300116	No	8.0	10.0
4/3/1998	USGS	1706/3.8	738680	4300116	Yes	6000.0	620.0
6/23/1998	USGS	1706/3.8	738680	4300116	Yes	2300.0	15.0
12/1/1998	USGS	1706/3.8	738680	4300116	No	290.0	7.6
2/7/1999	USGS	1706/3.8	738680	4300116	No	11000.0	11600.0
2/10/1999	USGS	1706/3.8	738680	4300116	No	1100.0	28.0
4/15/1999	USGS	1706/3.8	738680	4300116	Yes	6800.0	362.0
6/17/1999	USGS	1706/3.8	738680	4300116	Yes	560.0	8.4
8/2/1999	USGS	1706/3.8	738680	4300116	Yes	44.0	3.2
12/9/1999	USGS	1706/3.8	738680	4300116	No	1100.0	118.0
1/6/2000	USGS	1706/3.8	738680	4300116	No	880.0	4.1
2/29/2000	USGS	1706/3.8	738680	4300116	No	120.0	5.3
4/7/2000	USGS	1706/3.8	738680	4300116	Yes	2100.0	713.0
6/15/2000	USGS	1706/3.8	738680	4300116	Yes	1400.0	5.9
8/1/2000	USGS	1706/3.8	738680	4300116	Yes	730.0	7.2
12/18/2000	USGS	1706/3.8	738680	4300116	No	120.0	7.1
2/9/2001	USGS	1706/3.8	738680	4300116	No	1500.0	678.0
2/27/2001	USGS	1706/3.8	738680	4300116	No	1400.0	18.0
4/3/2001	USGS	1706/3.8	738680	4300116	Yes	3200.0	397.0
8/27/2001	USGS	1706/3.8	738680	4300116	Yes	180.0	3.6
10/10/2001	USGS	1706/3.8	738680	4300116	Yes	11000.0	1640.0
12/10/2001	USGS	1706/3.8	738680	4300116	No	20.0	4.8
2/4/2002	USGS	1706/3.8	738680	4300116	No	27.0	17.0
3/9/2002	USGS	1706/3.8	738680	4300116	No	99.0	189.0
5/28/2002	USGS	1706/3.8	738680	4300116	Yes	200.0	11.0
8/5/2002	USGS	1706/3.8	738680	4300116	Yes	10.0	3.2
10/29/2002	USGS	1706/3.8	738680	4300116	Yes	5400.0	641.0
12/16/2002	USGS	1706/3.8	738680	4300116	No	2.0	3.6
2/3/2003	USGS	1706/3.8	738680	4300116	No	140.0	6.3
3/19/2003	USGS	1706/3.8	738680	4300116	No	5800.0	761.0

[20] MSD = Metropolitan St. Louis Sewer District; USGS = U.S. Geological Survey
[21] See Figure 1 in Section 2 of this document for sample site locations.
[22] For calculation purposes, less-than (<) values were halved. This methodology is consistent with the department's water quality assessment protocols.
[23] cfs = cubic feet per second

Sampling Date	*Sampling[20] Organization*	*Site[21] Code*	*UTM Easting*	*UTM Northing*	*Recreational Season?*	*E. coli[22] (#/100mL)*	*Flow[23] (cfs)*
6/9/2003	USGS	1706/3.8	738680	4300116	Yes	48.0	7.9
8/11/2003	USGS	1706/3.8	738680	4300116	Yes	76.0	2.7
10/9/2003	USGS	1706/3.8	738680	4300116	Yes	20000.0	1510.0
12/3/2003	USGS	1706/3.8	738680	4300116	No	10.0	7.2
2/9/2004	USGS	1706/3.8	738680	4300116	No	21.0	9.6
3/4/2004	USGS	1706/3.8	738680	4300116	No	3800.0	1420.0
5/24/2004	USGS	1706/3.8	738680	4300116	Yes	860.0	12.0
8/4/2004	USGS	1706/3.8	738680	4300116	Yes	1100.0	12.0
10/5/2004	USGS	1706/3.8	738680	4300116	Yes	135.0	3.5
10/12/2004	USGS	1706/3.8	738680	4300116	Yes	1000.0	339.0
11/8/2004	MSD	1706/1.8	740487	4299849	No	<100.0	
12/15/2004	MSD	1706/1.8	740487	4299849	No	<100.0	
1/18/2005	MSD	1706/1.8	740487	4299849	No	100.0	
2/23/2005	MSD	1706/1.8	740487	4299849	No	100.0	
3/22/2005	MSD	1706/1.8	740487	4299849	No	<100.0	
3/22/2005	USGS	1706/3.8	738680	4300116	No	1000.0	1150.0
4/20/2005	USGS	1706/3.8	738680	4300116	Yes	27.0	7.1
4/26/2005	MSD	1706/1.8	740487	4299849	Yes	500.0	
6/20/2005	USGS	1706/3.8	738680	4300116	Yes	500.0	4.2
8/8/2005	USGS	1706/3.8	738680	4300116	Yes	400.0	3.5
9/21/2005	MSD	1706/1.8	740487	4299849	Yes	200.0	9.7
10/3/2005	USGS	1706/3.8	738680	4300116	Yes	640.0	3.5
10/12/2005	MSD	1706/1.8	740487	4299849	Yes	<100.0	2.9
10/31/2005	USGS	1706/3.8	738680	4300116	Yes	9000.0	240.0
11/28/2005	MSD	1706/1.8	740487	4299849	No	1100.0	640.0
12/20/2005	MSD	1706/1.8	740487	4299849	No	<100.0	5.4
2/8/2006	MSD	1706/1.8	740487	4299849	No	<100.0	15.0
3/6/2006	MSD	1706/1.8	740487	4299849	No	<100.0	16.0
4/2/2006	USGS	1706/3.8	738680	4300116	Yes	150.0	217.0
4/4/2006	USGS	1706/3.8	738680	4300116	Yes	590.0	13.0
6/6/2006	USGS	1706/3.8	738680	4300116	Yes	1150	4.5
7/31/2006	MSD	1706/1.8	740487	4299849	Yes	<100.0	5.6
9/21/2006	USGS	1706/3.8	738680	4300116	Yes	1500.0	3.3
10/2/2006	USGS	1706/3.8	738680	4300116	Yes	170.0	2.2
10/16/2006	USGS	1706/3.8	738680	4300116	Yes	3800.0	42.0
10/23/2006	MSD	1706/1.8	740487	4299849	Yes	<100.0	4.0
11/6/2006	MSD	1706/1.8	740487	4299849	No	<100.0	5.5
11/14/2006	MSD	1706/1.8	740487	4299849	No	<100.0	11.0
1/16/2007	USGS	1706/3.8	738680	4300116	No	480.0	29.0
2/5/2007	USGS	1706/3.8	738680	4300116	No	<10.0	3.6
3/19/2007	USGS	1706/3.8	738680	4300116	No	32.0	12.0
4/3/2007	USGS	1706/3.8	738680	4300116	Yes	37000.0	1120.0
4/10/2007	USGS	1706/3.8	738680	4300116	Yes	220.0	12.0
5/21/2007	USGS	1706/3.8	738680	4300116	Yes	340.0	9.2
6/18/2007	USGS	1706/3.8	738680	4300116	Yes	140.0	4.7
7/23/2007	USGS	1706/3.8	738680	4300116	Yes	290.0	3.3

Sampling Date	*Sampling[20] Organization*	*Site[21] Code*	*UTM Easting*	*UTM Northing*	*Recreational Season?*	*E. coli[22] (#/100mL)*	*Flow[23] (cfs)*
8/8/2007	USGS	1706/3.8	738680	4300116	Yes	120.0	2.5
8/28/2007	MSD	1706/1.8	740487	4299849	Yes	130.0	2.9
9/12/2007	MSD	1706/1.8	740487	4299849	Yes	20.0	4.7
9/12/2007	USGS	1706/3.8	738680	4300116	Yes	460.0	4.2
9/25/2007	MSD	1706/1.8	740487	4299849	Yes	190.0	3.4
10/9/2007	MSD	1706/1.8	740487	4299849	Yes	45.0	2.1
10/24/2007	MSD	1706/1.8	740487	4299849	Yes	110.0	7.0
4/9/2008	MSD	1706/1.8	740487	4299849	Yes	160.0	33.0
4/16/2008	MSD	1706/1.8	740487	4299849	Yes	<10.0	21.0
7/30/2008	MSD	1706/1.8	740487	4299849	Yes	1500.0	732.0
9/3/2008	MSD	1706/1.8	740487	4299849	Yes	820.0	11.0
10/10/2008	MSD	1706/1.8	740487	4299849	Yes	220.0	6.9
4/1/2009	MSD	1706/1.8	740487	4299849	Yes	5172.0	21.0
4/21/2009	MSD	1706/1.8	740487	4299849	Yes	880.0	24.0
5/13/2009	MSD	1706/1.8	740487	4299849	Yes	158.0	14.0
7/22/2009	MSD	1706/1.8	740487	4299849	Yes	379.0	7.7
8/11/2009	MSD	1706/1.8	740487	4299849	Yes	1100.0	9.1
9/2/2009	MSD	1706/1.8	740487	4299849	Yes	86.0	3.5
9/23/2009	MSD	1706/1.8	740487	4299849	Yes	318.0	9.8
5/4/2010	MSD	1706/1.8	740487	4299849	Yes	171.0	11.0
5/10/2010	MSD	1706/1.8	740487	4299849	Yes	86.0	24.0

Appendix B

Development of bacteria load duration curves

B. 1 Overview

The load duration curve approach was used to develop a TMDL for the drainage area of Coldwater Creek. The flow duration curve for this stream was developed using area corrected flow from flow gage data from Coldwater Creek. The load duration curve method allows for characterizing water quality concentrations (or water quality data) at different flow regimes and estimating load allocations and wasteload allocations for an impaired segment. The method provides a visual display of the relationship between stream flow and loading capacity.

B. 2 Methodology

Using a load duration curve method requires a long time series of flow data, numeric water quality targets, and bacteria data from the impaired streams. Bacteria data, along with the flow measurements for the same date, are plotted along with the load duration curve to assess when the water quality target is exceeded.

A long record of average daily flow data from a gage or multiple gages that are representative of the impaired reach are used to develop the load duration curve. Therefore, the flow record should be of sufficient length to be able to calculate percentiles of flow (typically 20 years or more). If a flow record for an impaired stream is not available, then a synthetic flow record is needed. For this TMDL, flow gage data from Coldwater Creek was used, USGS 06936475 Coldwater Creek near Black Jack, Mo. This gage had an approved daily flow record from July 11, 1996 to July 7, 2011. Data from this gage were corrected for the drainage area of the impaired segment (Table B.1). From this flow record, a flow duration curve was developed (Figure B.1).

Table B.1. Drainage area of gage and impaired watershed and correction factors

Location:	USGS 06936475	WBID 1706
Drainage Area (sq. miles):	40.4	44.5
Correction Factor:	--	1.10148

The selected TMDL target is multiplied by the flow and a conversion factor to generate the targeted load at different flows. With this load duration curve, the targeted concentration is constant at all flow percentiles. The target concentration used for the load duration curve was the recreation season geometric mean criterion of 206 *E. coli* counts/100 mL of water, which was applied as a daily target.

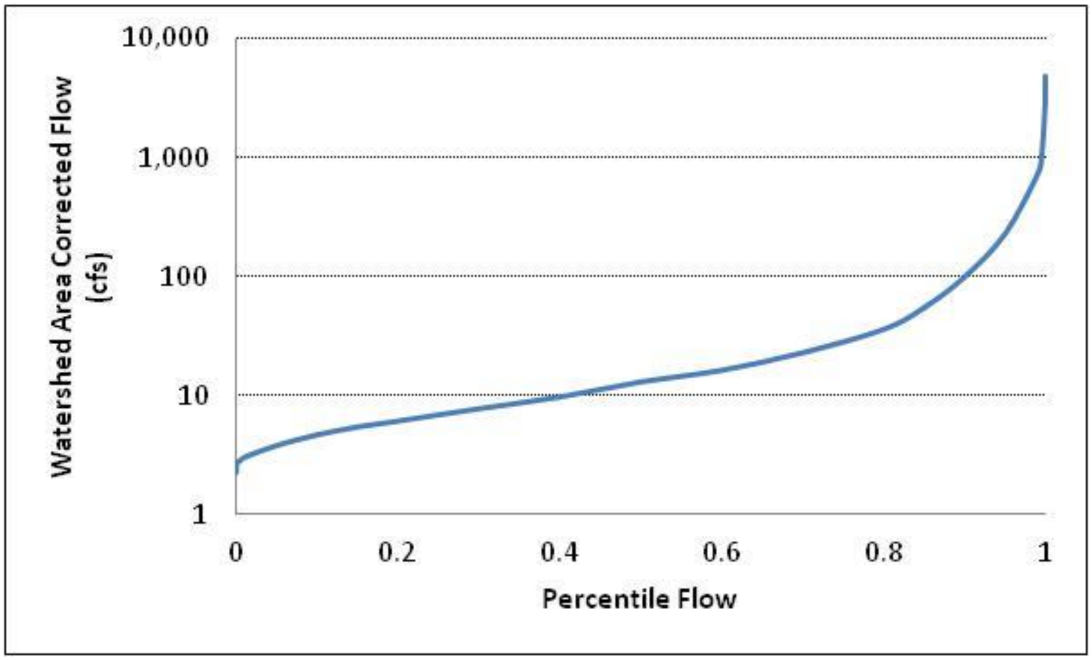

Figure B.1 Flow duration curve for Coldwater Creek