Nine Element Watershed Based Plan

for

Peruque Creek and Lake St. Louis

Warren and St. Charles Counties

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1. Introduction

Missouri's Water Quality Standards at Title 10 of the Code of State Regulations (CSR) Division 20 Chapter 7, Rule 7.031 establishes statewide water quality criteria for the protection of aquatic life. Portions of Peruque Creek are currently impaired for low dissolved oxygen (DO) conditions, low aquatic macroinvertebrate diversity, and habitat indices scoring. Lake St. Louis, which is an impoundment of Peruque Creek, is also impaired for exceedances of Missouri's lake numeric nutrient criteria in the Plains Ecoregion.

Through a watershed approach, establishing total nitrogen (TN), total phosphorus (TP), and total suspended solids (TSS)[1] target load reductions for Peruque Creek and Lake St. Louis will address exceedances of Chlorophyll-a (Chl-a), Nutrient Screening Thresholds, excessive mineral turbidity and sedimentation, and low DO conditions within the impaired water bodies, ultimately restoring water quality for aquatic life in both the stream and the lake. The use of TSS as a surrogate for sediment, is to make use of the best existing available data and is a parameter commonly measured. In reality, it is the inorganic portion of TSS that contributes to in-stream sedimentation and habitat concerns. Inorganic sediment originates from overland runoff, stream bank, and landscape erosion.

Although this plan is specifically intended to address pollutant loading from nonpoint sources, in order to derive pollutant load reduction targets that will achieve water quality standards, all potential loading sources in the watershed are considered. Water quality standards are the basis for establishing targets for load reductions, while water body and watershed models are used to identify required load reductions established in a watershed plan. Implementation of any needed pollutant reductions from point sources will be carried out by the Missouri Department of Natural Resources (department) through the Missouri State Operating Permit Program. Missouri state operating permits ensure discharges from point sources are limited to conditions that meet water quality standards and do not contribute to water quality impairments. Point source loading targets in conjunction with nonpoint source loading targets achieved through implementation of this watershed-based plan will result in attainment of Missouri Water Quality Standards.

The U.S. Environmental Protection Agency (EPA) has established grant guidelines for the development and implementation of watershed-based plans funded by Clean Water Act Section 319 funds. The following guidelines are known as the "nine minimum elements" required for a successful watershed plan:

A. Identification of the causes or sources of the targeted pollutant in the watershed (Watershed Description, Defining the Problem, Source Inventory and Assessment);
B. Quantification of existing loads and reductions necessary to meet water quality targets and applicable water quality standards (Applicable Water Quality Standards, Source Inventory and Assessment, Establishing Watershed Loading Capacity);
C. Identification of planned nonpoint source management practices to reduce pollutant loading (Established Watershed Loading Capacity, Load Allocations and Reductions, Best Management Practices);
D. Measures to implement technical and financial resources watershed planning and management practice installation (Technical and Financial Assistance);

[1]The total suspended solids analysis accounts for both organic and inorganic solids suspended in solution with a size greater than 2 microns in size, inorganic suspended solids (ISS) are the inorganic portion of TSS.

E. Measures to provide educational and public outreach opportunities during the watershed plan development and implementation (Education and Outreach);
F. A clearly defined implementation schedule with expected initiation and completion dates (Implementation Schedule);
G. Identification of milestones for the implementation of the watershed plan (Milestones);
H. Establish evaluation methods to determine the load reduction effectiveness (Evaluation of Load Reductions);
I. Measures to establish future watershed monitoring to determine best management practice effectiveness and if water quality conditions are improving (Monitoring).

These elements will serve as a foundation for the Peruque Creek and Lake St. Louis watershed plan, with the goal of producing sufficient load reductions within the watershed to restore water quality. Previous watershed management planning initiated in 2005 (CDM, 2005) provided insight for the development of the nine elements established in this plan, any short comings or missing requirements of previous planning efforts are addressed in this document.

Watershed-based plans are expected to be reviewed and revised as necessary every five years. This watershed-based plan incorporates the best data and information available today to inform watershed planning. New data and information that becomes available in the future will be considered and incorporated as appropriate during the review period. This adaptive approach will inform future implementation actions based on the effectiveness of the actions taken to restore water quality. In addition to this watershed-based plan, the department is researching and developing total maximum daily loads (TMDLs) for the impaired waters to meet the requirements of Section 303(d) of the Clean Water Act. Future updates to this watershed-based plan will incorporate and consider any additional pollutant reductions needed to meet the nonpoint source load allocation goals established by an approved TMDL.

2. Watershed Description

Peruque Creek, water body identification numbers (WBIDs) 217 and 218, and Lake St. Louis, WBID 7054 are located in central eastern Missouri, approximately 2 miles south of Wentzville. Located within the Peruque-Piasa sub-basin, the stream and lake are cataloged by the U.S. Geological Survey (USGS) within the 8-digit HUC 07110009. Within the Peruque-Piasa sub-basin, the stream segment and lake are located within the Headwaters Peruque Creek subwatershed, which is cataloged by the USGS as the 12-digit HUC 071100090101. Lake St. Louis is formed by an impoundment of the headwaters of Peruque Creek. Low DO conditions and low aquatic macroinvertebrate diversity have been documented on this 10.9 mile segment of Peruque Creek. The impaired segment runs eastward from just south of Archer Road to just east of Highway Z, with the catchment area for the impaired segment being approximately 38 square miles. Peruque Creek flows east from Warren County to St. Charles County, through the municipalities of Foristell, Wentzillve, and Lake St. Louis.

The surface area of Lake St. Louis is 444 acres and has a contributing watershed area of approximately 57 square miles. The watershed includes the drainage (watershed) areas contributing to both WBID 217 and 218 of Peruque Creek. For these reasons and for purposes of this plan, this document will refer to greater contributing area as the Lake St. Louis watershed. The Lake St. Louis watershed is a mix of primarily agricultural and developed land uses. The lake itself is located within the boundaries of the Lake St. Louis municipality and is managed by a private homeowner's lake association. The Lake St. Louis watershed is displayed in Figure 1 and is, along with Peruque Creek, the area of focus for the nine-element watershed plan.

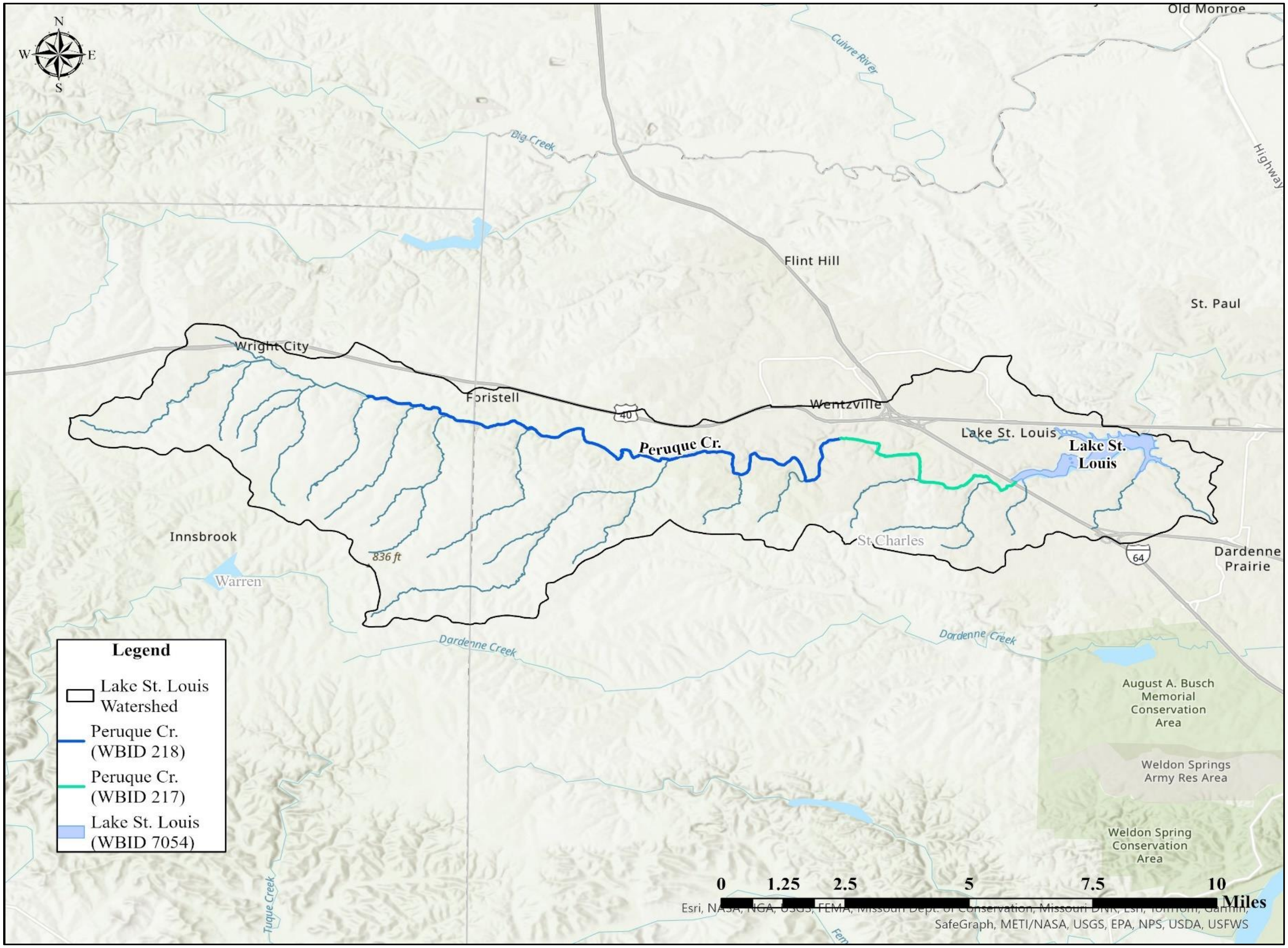


Figure 1. View of the Lake St. Louis watershed

2.1 Geology, Physiography, and Soils

The Lake St. Louis watershed is located within the southern portion of the Central Plain's Cuirve/Salt ecological drainage unit (EDU), which covers portions of central and northeastern Missouri (MoRAP 2005). Ecological drainage units are groups of watersheds that have similar biota, geography, and climate characteristics (USGS 2009). Within the Cuirve/Salt EDU, the watershed is in the River Hills EPA Level IV ecoregion (ecological subsection). Ecoregions are areas with similar ecosystems and environmental resources and are designed to serve as a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components. By recognizing spatial differences in ecosystems, ecoregions stratify the environment by its probable response to disturbance (Bryce et al. 1999). Ecoregions are further defined in Missouri's Water Quality Standards at 10 CSR 20-7.031(1)(H). Topography in the River Hills area within the Interior River Valley and Hills ecoregion varies from flat to moderately hilly. This region is located along the Missouri and Mississippi Rivers, which represents the transition zone (ecotone) between the northern loess and till covered plains and southern dissected forested slopes of the Ozark Highlands. Ridges and valleys can have thick mantles of soil, while slopes can be steep at times with rock outcroppings present (Chapman et al. 2002). Natural Resource Conservation Service (NRCS) Web Soil Survey data indicates approximately 10 percent of soils in the watershed are Armstrong silt-loam texture (NRCS 2022).

Soils are categorized into hydrologic soil groups based on similar runoff potentials. Each hydrologic soil group indicates the rate at which water enters the soil profile under conditions of a bare, thoroughly wetted soil surface (NRCS 2009). This infiltration rate determines the quantity of precipitation that flows over land to water bodies as direct runoff. Group A soils have the highest rate of infiltration and the lowest runoff potential. Group D soils have the lowest rate of infiltration and highest runoff potential. Many wet soils fall into dual soil groups (e.g., Group C/D) due to the presence of a seasonal high-water table that results in saturation to the soil surface. Dual hydrologic soil groups account for this condition by providing both the drained and undrained condition of the soil.[2] It should be noted that soil runoff potential is only one factor that determines the volume of runoff in a watershed. Impervious surfaces, vegetative cover, slope, rainfall intensity, and land use can significantly influence the potential for runoff regardless of the characteristics of the underlying soil. Table 1 provides a summary of the hydrologic soil groups by area in square miles and relative percent. Figure 2 shows the distribution of hydrologic soil groups in the Lake St. Louis watershed. Due to the high percentage of Group D soils, surface runoff is likely and can be a major contributor of sediment to the Peruque Creek and downstream water bodies.

[2] For the purpose of hydrologic soil group, adequately drained means that the seasonal high water table is kept at least 24 inches (60 centimeters) below the surface in a soil where it would be higher in a natural state (NRCS 2009).

Table 1. Hydrologic soil groups in the Lake St. Louis watershed (NRCS 2020)

Hydrologic Soil Groups	Area in the Watershed	
	Square miles	Percent
Group B	2.36	4.93%
Group B/D	1.87	3.91%
Group C	7.06	14.80%
Group C/D	0.95	1.98%
Group D	35.51	74.38%
Total	47.74	100.00%

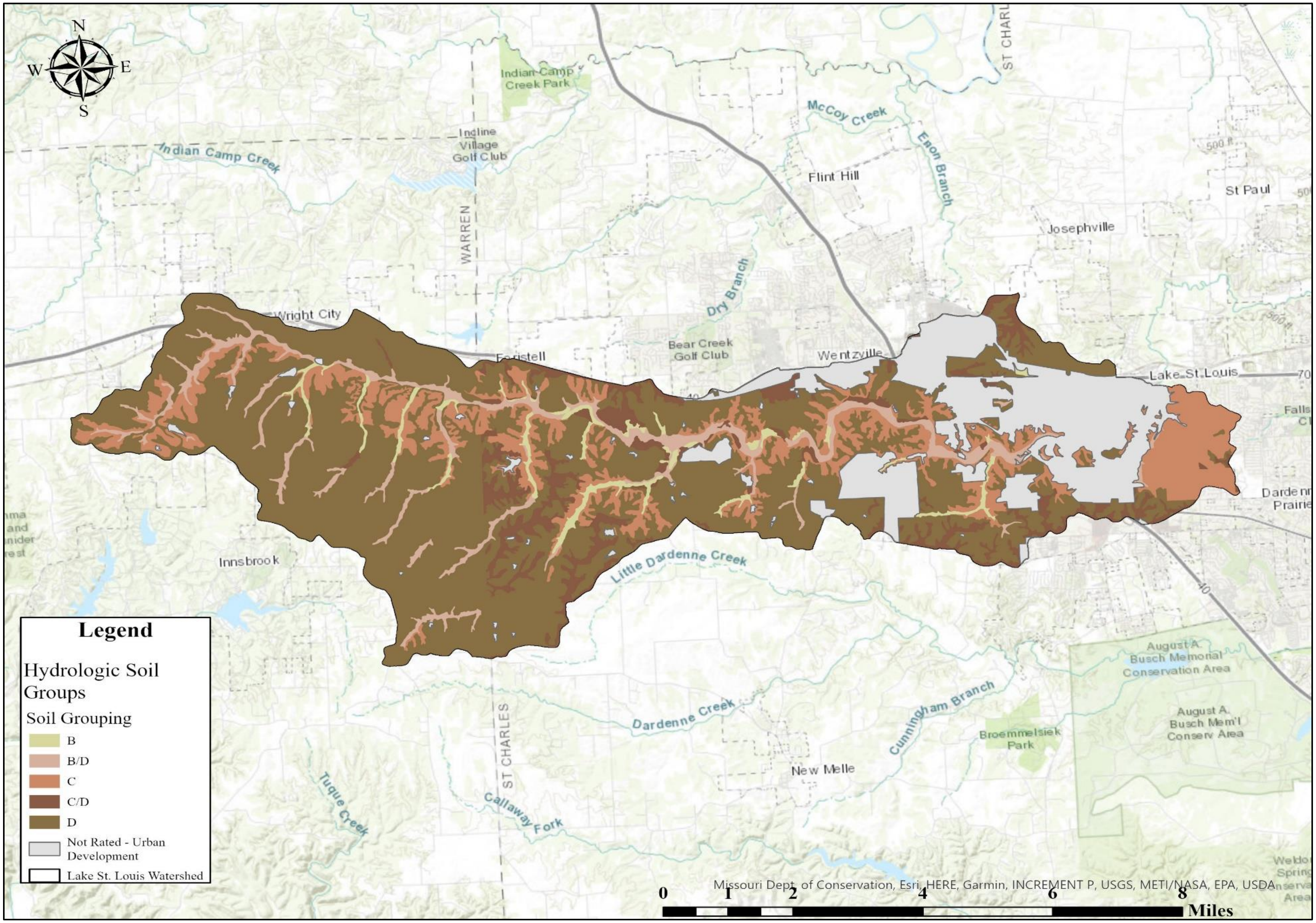


Figure 2. Hydrologic soil groups in the Lake St. Louis watershed

2.2 Climate

The most recent climate data from a weather station nearest to the Lake St. Louis watershed were measured at the National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI) Weldon Springs Weather Station (USC00238805). Climate normals were developed based on temperature and precipitation data collected at that station between 1991 and 2020 (NOAA-NCEI 2020). Table 2 displays the 30-year monthly climate normals from the Weldon Springs Weather Station for precipitation and temperature. Figure 3 is a graphical display of the data.

Table 2. 30-year monthly climate normals at the Weldon Springs weather station

Month	Precipitation Average	Minimum Temperature	Maximum Temperature
	inches	ºF	ºF
January	2.61	21.2	39.3
February	2.43	24.4	44.8
March	3.74	33.3	55.2
April	4.70	43.8	67.0
May	5.09	54.2	75.7
June	4.72	63.3	83.7
July	3.92	67.3	87.5
August	3.58	65.4	86.7
September	3.50	57.0	79.8
October	3.37	45.6	68.3
November	3.69	34.9	55.4
December	3.07	25.9	44.0
	Total	**Average**	**Average**
	44.42	44.7	65.6

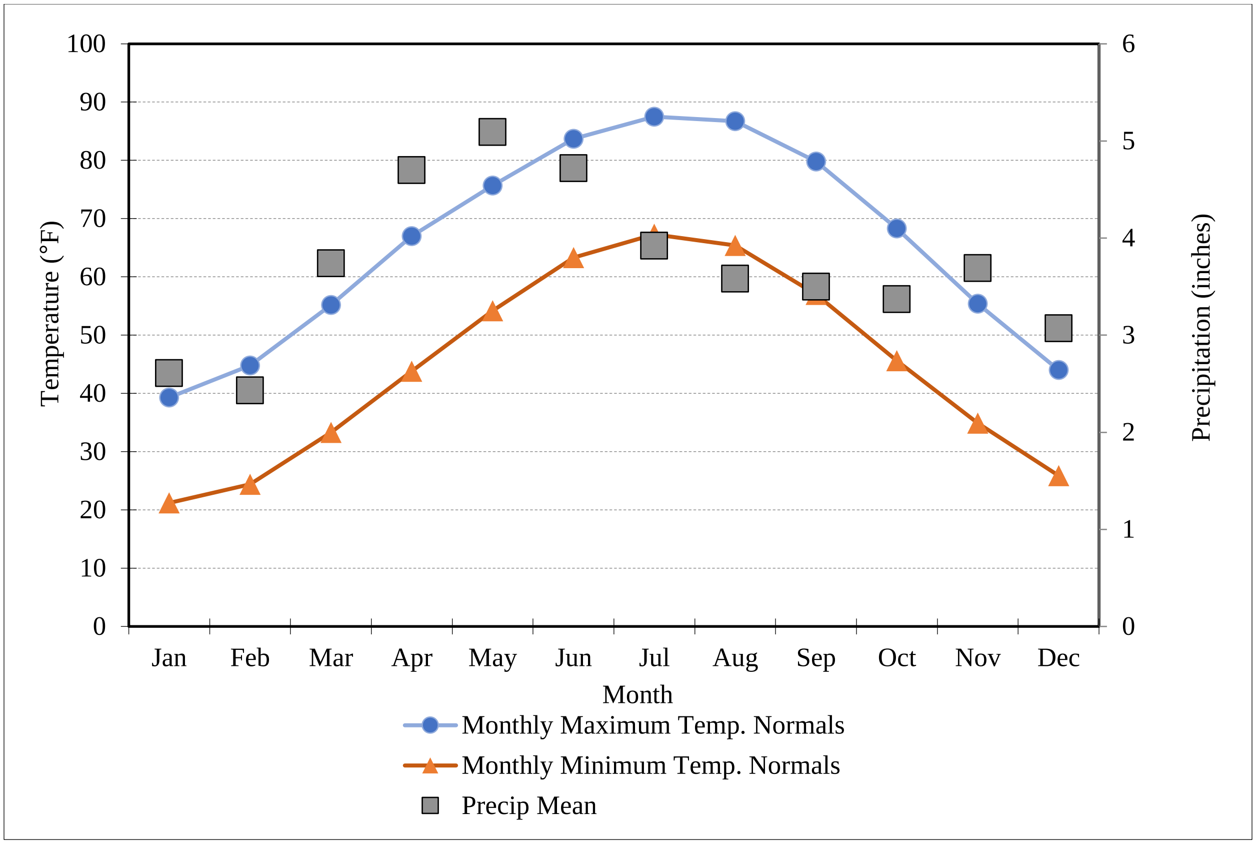


Figure 3. Monthly climate normals – Weldon Springs, MO

Although precipitation amounts have been found to correlate with erosion rates at the local level (Mishra et al. 2019), rainfall intensity is more indicative of soil erosion potential than the quantity of precipitation alone. Rainfall intensity is the amount of rain that falls over time. Compared with moderate rainfall, heavy rainfall and storm rainfall are more likely to cause erosion (Meng et al. 2021). High rainfall intensity occurs when a large amount of rain falls in a short time. Climate warming models predict increases in the intensity of rainfall, especially convective rainfall, which produces short and local heavy rainfall (Martel et al. 2021). Between 2001 and 2020, annual precipitation at the Weldon Springs weather station ranged from a minimum 34.9 inches to a maximum 62.8 inches.

2.3 Population

State and county population estimates are available from the U.S. Census Bureau's 2020 census and can be localized using census block data (U.S. Census Bureau 2020). Population estimates for the Lake St Louis watershed were derived using geographic information system (GIS) software by overlaying the watershed boundary over a map of census blocks. Wherever the centroid of a census block falls within the watershed boundary, the entire population of the census block is included in the total. If the centroid of the census block is outside the boundary, the population of the entire block is excluded.

As shown in Table 3, population in the watershed experienced population growth between 2000 and 2020, with slight decreases occurring for the rural population. The population distribution in the watershed is displayed on Figure 4.

Table 3. Population estimates for the Lake St. Louis watershed

Municipal			Rural			Total		
2000	**2010**	**2020**	**2000**	**2010**	**2020**	**2000**	**2010**	**2020**
17,423	34,993	41,790	4,439	5,530	2,826	21,862	40,523	44,616

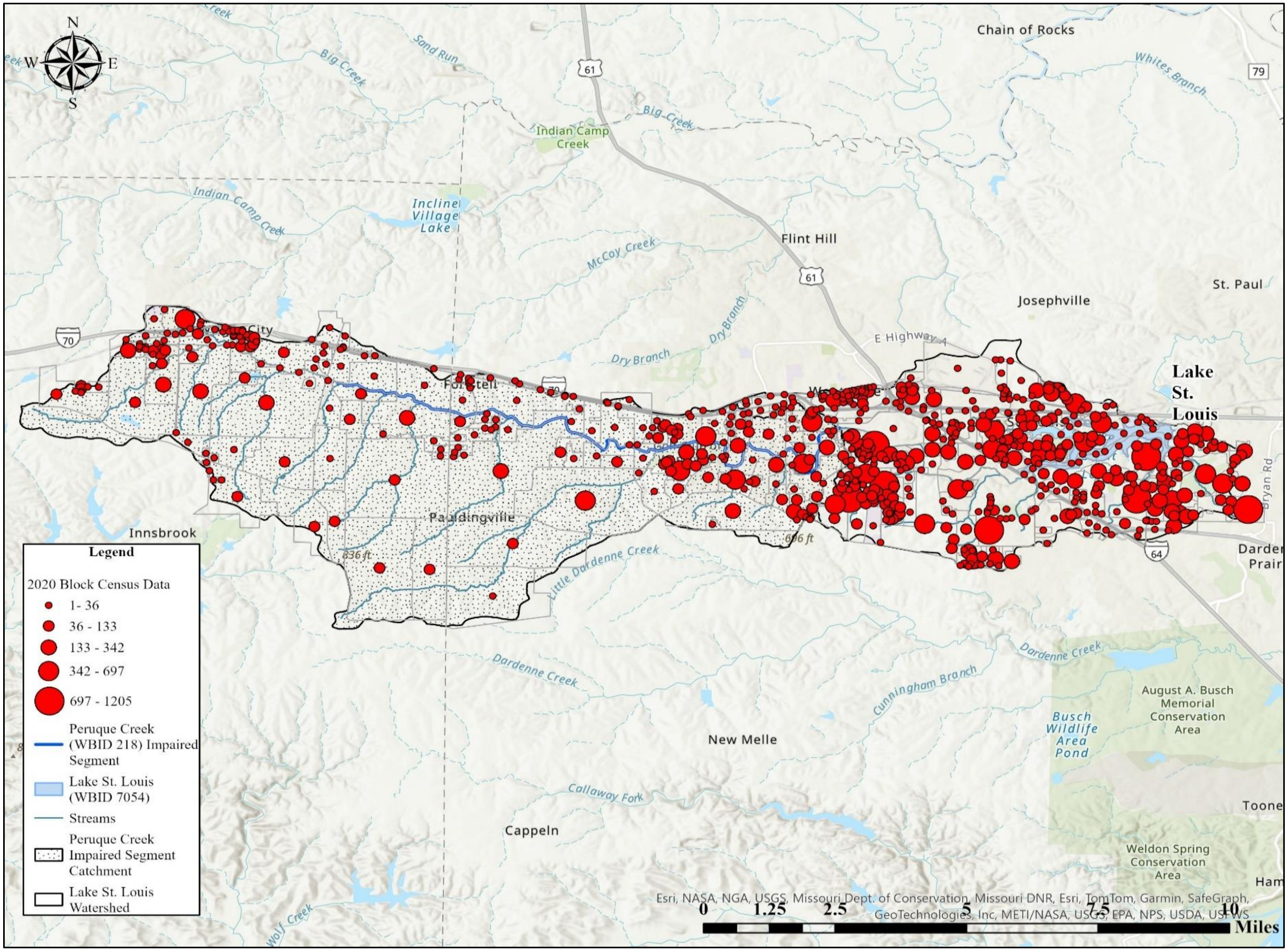


Figure 4. 2020 census block and population in the Lake St. Louis watershed

2.4 Land Cover

A land cover analysis was completed using the 2019 National Land Cover Database (NLCD) published by the Multi-Resolution Land Characteristics Consortium (MRLC 2022). Land cover types present in the Lake St. Louis watershed are summarized in Table 4 and displayed on Figure 5. Areas used for agricultural purposes, such as pasture and cropland, together account for more than 37 percent of the watershed. Additionally, in total, developed areas where impervious surfaces are common account for 30 percent of the watershed. The amount of imperviousness associated with development in the watershed is substantial as stream degradation associated with imperviousness has been shown to first occur at about 10 percent imperviousness and will increase in severity as imperviousness increases (Arnold and Gibbons 1996; Schueler 1994). Runoff from both developed and agricultural areas is a common and potential source of nonpoint source pollution.

Table 4. Land cover in the Lake St. Louis watershed

Land Cover Type	**Area Square miles**	**Percent**
Developed, High Intensity	1.53	2.70
Developed, Medium Intensity	5.57	9.80
Developed, Low Intensity	6.18	10.90
Developed, Open Space	4.17	7.40
Cultivated Crops	10.47	18.50
Barren Land	0.08	0.10
Hay/Pasture	10.81	19.20
Forest	16.09	28.40
Wetlands	0.33	0.60
Shrub and Herbaceous	0.14	0.20
Open Water	1.23	2.20
Total	56.60	100.00

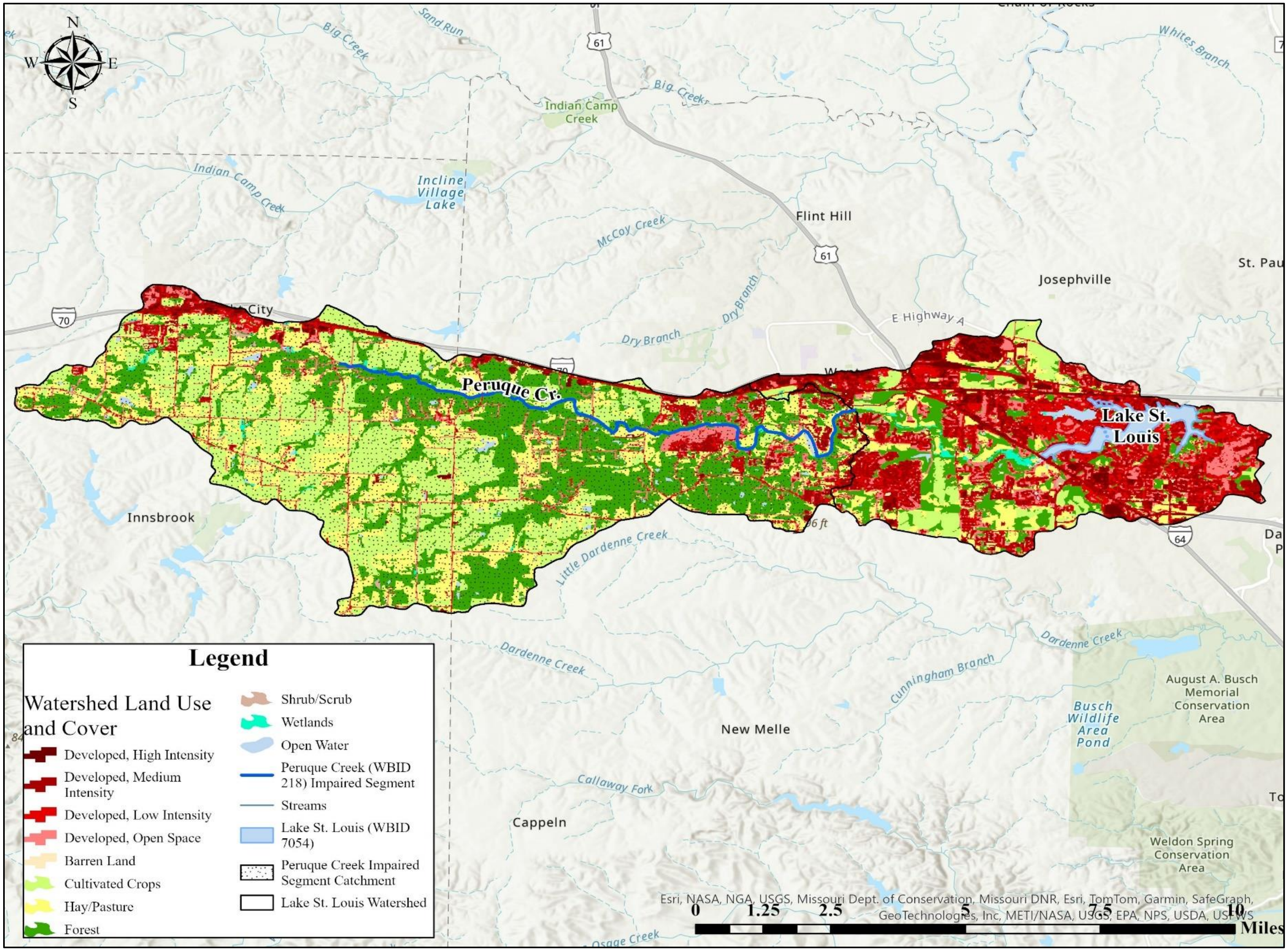


Figure 5. Land cover and land use in the Lake St. Louis watershed

3. Applicable Water Quality Standards

For water quality restoration, it is critical to identify the maximum pollutant load that a water body can assimilate and still attain and maintain 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 (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. In accordance with federal regulations at 40 CFR 131.10, Missouri's Water Quality Standards for each individual water body also provide for the attainment and maintenance of water quality in any downstream waters.

3.1 Designated Uses

Missouri's Water Quality Standards at 10 CSR 20-7.031(1)(F) defines designated uses that are assigned to individual water bodies in accordance with 10 CSR 20-7.031(2) and are listed in 10 CSR 20-7.031, Table G (Lakes) and Table H (Streams). Missouri's Water Quality Standards designate the following uses of Peruque Creek (WBIDs 217/218) and Lake St. Louis:

- Warm water habitat (aquatic life)
- Human health protection
- Whole body contact recreation category A (Lake St. Louis WBID 7054)
- Whole body contact recreation category B (Peruque Creek WBIDs 217 and 218)
- Secondary contact recreation
- Irrigation
- Livestock and wildlife protection

Low DO conditions and low macroinvertebrate diversity are causes for the impairment of warm water habitat (aquatic life) designated use in Peruque Creek WBID 218, while the warm water habitat (aquatic life) designated use of Lake St. Louis is impaired due to frequent exceedances of the Chl-a Response Impairment Threshold and periodic exceedances of the TN and TP Nutrient Screening Thresholds.

3.2 Water Quality Criteria

Water quality criteria represent a level of water quality that supports and protects particular designated uses. Water quality criteria can be expressed as specific numeric criteria or as general narrative statements. Missouri 10 CSR 20-7.031(4) and (5) establish General Criteria applicable to all waters of the state at all times and Specific Criteria applicable to waters contained in 10 CSR 20-7.031 Tables G (Lakes) and H (Streams). Available data and field observations note water quality violations of general criteria associated with sediment loading, as well as specific criteria violations associated with stream DO and lake nutrient criteria as described below.

Missouri's Water Quality Standards include statewide numeric nutrient criteria for lakes that are waters of the state and have an area of at least 10 acres during normal pool condition (10 CSR 20-7.031(5)(N)1.C(II)2.). Due to differences in watershed topography, soils, and geology, nutrient criteria for lakes and reservoirs is determined by four major ecoregions based upon dominant watershed ecoregion (10 CSR 20-7.031(5)(N)1.B.). The four ecoregions include the Big River Floodplain where lake numeric nutrient criteria do not apply. The other three ecoregions are: Plains (north), Ozark Border (middle), and Ozark Highlands (south). Criteria for each ecoregion include Nutrient Screening Thresholds for TN, TP, and Chl-a, and a Chl-a Response Impairment Threshold concentration (10 CSR 20-7.031 Tables L and M). All TP, TN, and Chl-a concentrations must be calculated as the geometric mean of a minimum of four representative samples per year for one year for purposes of comparison to lake ecoregion criteria thresholds. All samples must be collected from the lake surface, near the outflow of the lake, and during the period May 1 - September 30 (10 CSR 20-7.031(5)(N)4.). Lakes with water quality that exceed Response Impairment Thresholds are deemed impaired for excess nutrients (10 CSR 20-7.031(5)(N)5.). Lakes are also deemed impaired for excess nutrients if Nutrient Screening Thresholds are exceeded and any of the Response Assessment Endpoints are documented in the same year (10 CSR 20-7.031(5)(N)6.). The Response Assessment Endpoints are:

A. Occurrence of eutrophication-related mortality or morbidity events for fish and other aquatic organisms;
B. Epilimnetic excursions from DO or pH criteria;
C. Cyanobacteria counts in excess of 100,000 cells per milliliter (cells/mL);
D. Observed shifts in aquatic diversity attributed to eutrophication; and
E. Excessive levels of mineral turbidity that consistently limit algal productivity during the period of May 1 - September 30.

Lake St. Louis is subject to the numeric nutrient criteria for the Plains lake ecoregion displayed in Table 5.

Table 5. Plains lake ecoregion criteria

Chl-a Response Impairment Threshold (µg/L)	Nutrient Screening Thresholds (µg/L)		
	TP	TN	Chl-a
30	49	843	18

Impairments in Peruque Creek WBID 218 are associated with violations of Missouri's minimum DO criterion, and low macroinvertebrate diversity. Low DO can result for a variety of reasons, but is often partly associated with excess nutrients. Loss of habitat can contribute to low macroinvertebrate diversity, which can be caused, in part, by excess sedimentation. Excess sediment also can contribute nutrients that bind to the soil. For warm water habitats, Table A1 of 10 CSR 20-7.031 specifies a minimum criterion of 5.0 mg/L of dissolved oxygen. Excessive sediment deposition, either organic or inorganic, that results in bottom deposits that harm aquatic life or otherwise prevent the full maintenance of beneficial uses are violations of the general criteria specified at 10 CSR 20-7.031(4)(A) and (C). As previously stated, excess sediments also contain nutrients that contribute to the impairment of Lake St. Louis.

3.3 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 public health, existing instream water uses, and a level of water quality necessary to maintain and protect existing 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 November 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. Those waters are identified in 10 CSR 20-7.031 Tables D and E. 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 Peruque Creek and Lake St. Louis are to restore water quality to levels that meet water quality standards.

4. **Defining the Problem**

WBID 218 of Peruque Creek is on the 2022 Missouri 303(d) list of impaired waters for "Aquatic Macroinvertebrate Bioassessments" and general criteria violations, which are attributed to nonpoint pollution sources. Past impairment concerns also pointed to "fish bioassessments" as a cause for concern, due to data showing less diversity than fish communities in similar sized streams (MoDNR 2015). The upper Peruque Creek is in a progressively urbanizing watershed. This urbanization can make the stream susceptible to land and hydrologic disturbance that results in in-stream sedimentation, which adversely affects aquatic macroinvertebrate habitat substrate (Li & Wang 2009). Erosion from agricultural areas can also contribute sediment to surface waters. Such excess sedimentation can smother or reduce fish spawning areas that may contribute to lower community diversity. Additionally, sediment loads can contribute additional nutrient loads and exacerbate existing low DO issues by contributing to algae growth.

Lake St. Louis was placed initially on Missouri's 303(d) List of Impaired Waters in 2020 due to exceedances of the Chl-a Response Impairment Threshold coupled with exceedances of the Nutrient Screening Thresholds for TN and TP during the period of May 1 - September 30. Summer geometric mean lake data from 2016-2020 are displayed in Table 6. As shown, lake water samples exceeded the Plains ecoregion TP Screening Threshold of 49 micrograms per liter (µg/L) in all years, while also exhibiting elevated inorganic suspend solids (ISS) concentrations and shallow Secchi depths in most years. Peruque Creek and Lake St. Louis monitoring data are presented in the Lake St. Louis TMDL document, which is currently under development.

Table 6. 2016-2020 Water quality at Lake St. Louis dam

May-September	Geometric Mean (µg/L)*			Secchi Depth (m)*	Mean ISS (mg/L)
	TP	TN	Chl-a		
2017	*82.00*	*864.00*	*22.42*	0.61	*14.81*
2018	*73.00*	731.00	**31.37**	0.81	4.20
2019	*81.00*	*868.00*	**34.95**	0.66	6.06
2020	*78.00*	*874.00*	*27.82*	0.74	5.64
***Bold** values represent Response Impairment Threshold exceedances and *italicized* values represent Nutrient Screening Threshold exceedances.*					

High in-lake nutrient concentrations and excessive Chl-a concentrations indicate excessive nutrient loading is the cause of impairment to the aquatic life designated use in Lake St. Louis. Primary management concerns in the Cuirve/Salt EDU include soil erosion, excessive sedimentation, excessive nutrient loads, and elevated water temperatures (MoRAP 2005). Soils associated with the Loess Flats and Till Plains area within the Central Irregular Plains ecoregion are inherently fertile, but use can be limited due to severe erosion when appropriate management practices are not in place (Chapman et al. 2002). Natural Resources Conservation Service (NRCS) data indicate soils in the Lake St. Louis watershed have predominately silt loam (NRCS 2022). Fine soils tend to stay suspended in water during and after runoff and erosion events. These factors can potentially contribute to excessive mineral turbidity and sedimentation in Lake St. Louis.

Generally, nitrogen not taken up by plants moves through watershed soils in nitrate form, potentially reaching storm sewers, ditches, grass waterways, or field tiling, then eventually streams and lakes. Excessive nitrogen loading can lead to increased primary production, resulting in elevated Chl-a concentrations in the receiving water body. Resulting algal blooms from nitrogen loading can lead to elevated oxygen demands, ultimately leading to low DO conditions in the water body, which can adversely impact aquatic life. Freshwater algal blooms themselves can pose health concerns when harmful forms of algae or cyanobacteria are present, such as certain cyanobacteria (blue-green algae) which can create dangerous cyanotoxins (Microcystin, Cylindrospermopsin, Anatoxin-a, Saxitoxin). These toxins can be harmful to humans, livestock, and pets. It is important to note that not all cyanobacteria produce cyanotoxins, typically toxins are found when *Mirocystis* are the predominant cyanobacteria present in a harmful algal bloom.

Excessive sediment loading adversely impacts aquatic life and fisheries, source water for drinking supplies, and recreational uses (USEPA, 1999). The Lake St. Louis watershed suffers from sedimentation contributing to excessive mineral turbidity, and watercolor concerns. Fine sediment particles often transport other pollutants such as nutrients. Reducing sediment erosion and overland runoff can improve aquatic habitat, improve water clarity (reduced turbidity), and reduce overall nutrient loading.

5. Source Inventory and Assessment (Element A)

The following source inventory and assessment identifies and characterizes known, suspected, and potential sources of nutrients (TN and TP) and sediment loading to Peruque Creek WBIDs 217 and 218, and Lake St. Louis WBID 7054. Specific sources are identified and quantified to the extent that information is available. More specific sources may be identified may be identified on a case-by-case basis and addressed with consideration of expected potential pollutant load reductions contributing to the impairment and the overall restoration goals of this plan.

5.1 Point Sources

Point sources are defined by Section 644.016(16) of the Missouri Clean Water Law and are regulated pursuant to the National Pollutant Discharge Elimination System through the Missouri State Operating Permit program.[3]A point source is defined as "any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. Point source does not include agricultural storm water discharges and return flows from irrigated agriculture." Based on this definition, point sources include domestic wastewater treatment facilities, industrial and commercial facilities, concentrated animal feeding operations (CAFOs), municipal separate storm sewer systems (MS4s), and stormwater discharges from industrial areas and construction sites. Illicit straight pipe discharges are also point sources but are illegal. Pollutant loading from point sources is typically most evident during low-flow conditions when stormwater influences are lower or nonexistent. Compliance with specified permit limits and conditions will result in loading that does not violate water quality standards or contribute to water quality impairments. Permit limits are required to be consistent with available wasteload allocations established by an approved TMDL.

Illicit straight pipe discharges of domestic wastewater are potential sources of nutrients and sediment. These types of sewage discharges bypass treatment systems, such as septic tanks or sanitary sewers, and discharge directly to a stream or an adjacent land area (Brown & Pitt 2004). Illicit straight pipe discharges are illegal and are not authorized by the federal Clean Water Act or the Missouri Clean Water Law. At present, there are no data about the presence or number of illicit straight pipe discharges in the Lake St. Louis watershed. For this reason, it is unknown if any straight pipe discharges exist and to what significance they contribute nutrient and sediment loads to surface waters in the watershed. Due to the illegal nature of these discharges, any illicit straight pipe discharges must be eliminated. Communities having a regulated MS4 are required to address illicit straight pipe discharges as a condition of their permit.

5.2 Nonpoint Sources

Nonpoint sources are diffuse sources with no discernible, confined, or discrete conveyance, and include all categories of discharge that do not meet the definition of a point source. Nonpoint

[3] The Missouri State Operating Permit program is Missouri's program for administering the federal National Pollutant Discharge Elimination System (NPDES). Generally, the Clean Water Act requires all point sources that discharge pollutants to waters of the United States to obtain an NPDES permit. Issued and proposed operating permits are available online at dnr.mo.gov/water/business-industry-other-entities/permits-certification-engineering-fees/wastewater.

sources are not regulated by the federal Clean Water Act and are exempt from department permit requirements by state regulation at 10 CSR 20-6.010(1)(B)1. Nonpoint source pollutants are typically transported by stormwater runoff, which is minor or negligible during dry weather conditions. Nonpoint sources in the Lake St. Louis watershed primarily include runoff from agricultural lands and urban areas, and areas of construction associated with urban development. Onsite wastewater treatment (septic) systems are present within the watershed are also potential nonpoint sources of nutrients when not operating correctly. Atmospheric deposition of nitrogen and phosphorus can also contribute to nutrient loading in lakes. Internal loading of phosphorus within Lake St. Louis results from past phosphorus deposition. Streams with little to no riparian buffer are most susceptible to erosion, including stream bank erosion, and are potential contributors of nonpoint source pollution.

While nonpoint source TSS loading is a primary concern in the watershed, efforts to reduce pollution from some point sources are ongoing. As a permitting requirement, industrial, commercial, and construction sites (land disturbance) are required to develop a Storm Water Pollution Prevention Plan (SWPPP) if exposure stormwater runoff is expected to occur. Examples of mitigation requirements found in SWPPPs include minimizing exposure to pollution sources, installation of sediment and erosion controls, providing employee training for stormwater management practices, elimination of unauthorized non-stormwater discharges, and implementation of dust control measures. In addition to site specific mitigation controls, site wide minimum best management practices (BMPs) are also established in the SWPPP which require additional mitigation measures to be implemented. It should be noted new construction activities serve as an opportunity to integrate water quality BMPs into planned site designs to maintain and improve watershed conditions. Implementation of BMPs and stormwater management or stream stabilization projects that are above and beyond, or otherwise outside the scope of permit requirements serve as additional means of pollutant reductions that serve the nonpoint source reductions goals of this watershed-based plan.

5.2.1 Agricultural Lands

Croplands, pasturelands, and low-density animal feeding operations are potential sources of nutrients and sediment in surface waters. Nutrients are transported in runoff from areas where fertilizers or animal manure are applied, and areas where livestock are present. Runoff can result from precipitation or excessive irrigation. Soil and Water Conservation Districts provide funding and guidance for the development of nutrient management plans for unregulated private lands. Areas where nutrient management plans guide fertilizer and manure applications, and where BMPs are used to reduce soil erosion, contribute less nutrients to surface waters than unmanaged areas. Although grazing areas are typically well vegetated, livestock tend to congregate near feeding and watering areas, which can create barren areas that are susceptible to erosion (Sutton 1990). Additionally, livestock that are not excluded from streams will deposit manure, and thus nutrients, directly into the waterway.

Areas of hay and pasture areas, which potentially can be used for livestock grazing, are common in the Lake St. Louis watershed. The exact type and number of livestock present in the Lake St. Louis watershed are unknown. The number of cattle in the watershed can be estimated from county cattle population numbers provided in the U.S. Department of Agriculture's 2017 Census of Agriculture (NASS 2022). Using 2022 agricultural census data for Warren and St. Charles

Counties and the area of pasture in the Lake St. Louis watershed, there may be 1,167 cows in the watershed. There is an estimated average cattle density of 118 cattle per square mile of pasture in Warren County and 97 cattle per square mile in St Charles County respectively.[4] Other types of livestock such as pigs, horses, and sheep may also contribute nutrient loads in the Lake St. Louis watershed.

5.2.2 Urban Development and Watershed Land Use Changes

Land use classifications change over time as development increases in a watershed. Impervious surfaces increase as a result of development, resulting in greater runoff intensities, volumes, and increased sedimentation. Table 7 provides summary data for NLCD land use change in the Lake St. Louis watershed from 2011 to 2019. The greatest changes in land coverage were observed in forest and medium intensity development land uses, with medium intensity development increasing by 384 acres (1.57% increase) and forest decreasing by approximately 569 acres (2.33% decrease). It is also worth noting the decrease in wetland acreage, which decreased by approximately 170 acres between 2011 and 2019 (0.69% decrease). Wetlands can provide sediment and nutrient load reductions among other ecosystem services.

Table 7. 2011 to 2019 Land use change summary data for the Lake St. Louis Watershed

LAND COVER	Acreage Increase/ Decrease	Percentage of Watershed 2011	Percentage of Watershed 2019	Percent increase/decrease
Barren Land	34.94	0.05%	0.15%	0.10%
Developed, High Intensity	413.61	1.57%	2.71%	1.14%
Developed, Low Intensity	-288.73	11.69%	10.89%	-0.80%
Developed, Medium Intensity	1439.35	5.87%	9.84%	*3.97%*
Developed, Open Space	-499.27	8.74%	7.37%	-1.38%
Forest	-1005.42	31.21%	28.44%	*-2.78%*
Cultivated Crops	96.29	18.23%	18.49%	0.27%
Hay/Pasture	36.00	18.17%	18.27%	0.10%
Shrub/Scrub	-98.09	1.36%	1.09%	-0.27%
Wetlands	-157.87	1.02%	0.58%	-0.44%
Open Water	29.19	2.09%	2.17%	0.08%

5.2.3 On-Site Wastewater Treatment Systems

Onsite wastewater treatment systems treat and disperse domestic wastewater on the property where it is generated. When properly designed and maintained, these systems perform well and should not contribute substantial amounts of nutrients to surface waters. However, when these systems fail hydraulically (surface breakouts) or hydrogeologically (inadequate soil filtration) there can be adverse effects to surface water quality (Horsley & Witten 1996). The Missouri Department of Health and Senior Services or local administrative authorities (commonly the local health department) have jurisdiction over onsite wastewater treatment systems with a design or actual flow of 3,000 gallons per day or less. Municipalities or counties may impose

[4] This analysis assumes all areas identified as hay and pasture are being used for cattle grazing and that cattle are evenly distributed among those areas. Additionally, although some animals may be confined in some areas, for purposes of this estimation the entire cattle population was assumed to be grazing on pasture areas.

more stringent or additional requirements for owners of septic systems. The Missouri Department of Health and Senior Services estimates that approximately 25 percent of homes in Missouri utilize onsite wastewater treatment systems, particularly in rural areas where public sewer systems are not available (DHSS 2018). Failing onsite wastewater treatment systems can contribute nutrients to nearby streams under wet or dry weather conditions directly or through surface runoff and groundwater flows.

The exact number of onsite wastewater treatment systems in the Lake St. Louis watershed is unknown. EPA's online input data server for the Pollutant Load Estimation Tool (PLET) provides estimates of septic system numbers by 12-digit HUC watersheds based on 1992 and 1998 data from the National Environmental Service Center (USEPA 2014b).[5] The PLET input server estimates that there may be approximately 1,758 septic systems in the watershed. Over time as urbanization expands and availability of sewer system connections become available, the total number of septic systems is expected to decrease. Septic systems can fail due to age and poor maintenance. A study by the Electric Power Research Institute (EPRI 2000) estimates septic system failure rates are 30-50 percent statewide. Newer septic systems are less likely to fail in the short term, but proper maintenance should be completed for successful long-term operation. In general, the greater the distance an onsite system is located from a surface water, the less likely it is to cause contamination (MU Extension 2023).

5.2.4 Atmospheric Deposition

Sources of atmospheric phosphorus include dust from soils, ash from volcanos, combustion of oil and coal, and emissions from phosphate manufacturing (Tipping et al. 2014). Data on phosphorus deposition from the atmosphere are limited compared to that of nitrogen. Based on 2017 data used for Missouri's Nutrient Loss Reduction Strategy Baselines Report (MoDNR 2023), atmospheric phosphorus may account for 1.4 to 14.2 percent of annual phosphorus loading into Lake St. Louis.

Wet deposition (via precipitation) of atmospheric inorganic nitrogen (ammonium (NH_4^+), nitrite (NO_2^-), and nitrate (NO_3^-) is a significant source of nitrogen. Volatilization of fertilizer and manure may account for over 60 percent of total emissions. Other sources of nitrogen include coal-fired power plants, fertilizer manufacturers, and vehicle emissions. Particulate nitrogen can remain in the air for 7-10 days, enabling it to move a good distance from the area of origin (Le Roy et al. 2021). Data on nitrogen deposition from the atmosphere into Lake St. Louis was obtained from the University of Wisconsin's National Atmospheric Deposition Program for Missouri Site 43 (MO043) (University of Wisconsin 2023). Based on that data, atmospheric nitrogen may account for approximately 30 percent of annual loading into Peruque Creek and Lake St. Louis in any given year.

5.2.5 Internal Loading

Although nitrogen may be a minor factor, excess phosphorus is widely considered the primary contributor to potentially harmful cyanobacteria blooms in lakes (Schindler 1977). Internal

[5] The National Environmental Services Center is located at West Virginia University and maintains a clearinghouse for information related to, among other things, onsite wastewater treatment systems. Available URL: www.nesc.wvu.edu/

loading of phosphorus occurs when phosphorus bound to lake sediment is released into the lake water. The unbinding of phosphorus from sediment occurs when lakes are stratified due to substantially different temperatures in the deep water and at the surface. Missouri lakes typically stratify in the summer. During stratification a thermal barrier (thermocline) forms isolating deep water and preventing oxygen replenishment from the atmosphere. When DO is low, the chemical bonds between phosphorus and metal particles in the sediment, such as iron, aluminum, and manganese, weaken and dissolved phosphorus is released into the lake water. Upon release, the phosphorus is sequestered below the thermocline where there is minimal light available. Once the surface and deep-water temperatures equalize, the lake mixes vertically and the phosphorus is available at the water surface where sufficient light enables growth of algae and cyanobacteria. High algae and cyanobacteria growth are indicated by high Chl-a concentrations (James 2016). Limited available profile data collected from Lake St. Louis during summer months presents the thermocline at approximately 3.5-4.0 meters deep, below which, oxygen concentrations steadily declined from approximately 6 milligrams per liter (mg/L) to <0.10 mg/L over the remaining 1.5-2.0 meters (Jones 2023). Natural mitigation of internal phosphorus loading can be achieved by reducing sediment loading from the watershed. Once sediment loading from the watershed is reduced, over time, phosphorus dissolved out of lake sediment may wash out of the lake. Removal of sediments from the lake through dredging can also help reduce overall phosphorus loads in the lake. However, without the addition of overall sediment loading contributions from the watershed, any benefits obtained through dredging will be temporary.

5.2.6 Riparian Corridor Conditions

Riparian corridor conditions have a strong influence on instream water quality. Wooded riparian buffers are a vital functional component of stream ecosystems and are instrumental in the attenuation of pollutants in runoff. Land cover within 100 feet of streams in the Lake St. Louis watershed is presented in Table 8. Agricultural areas (pastureland) constitute 1.86 percent of the riparian corridors of streams in the watershed. Phosphorus loading is highest from agricultural areas (Allafta et al. 2020). Streambanks and floodplains that lack woody vegetation are the most susceptible to erosion and allow nitrogen, phosphorus, and sediment to enter streams with very minimal interception. Establishing woody or vegetated riparian corridors in areas most susceptible to erosion will reduce the amount of sediment and phosphorus transported to Peruque Creek and Lake St. Louis.

Table 8. Land cover in riparian corridors in the Lake St. Louis watershed

Land Cover Type	Riparian Corridor Land Cover Type Area	
	Acres	Percent
Developed (Roads and Residences)	77.35	54.11%
Barren Land	0.29	0.20%
Hay or Pasture	2.66	1.86%
Forest	20.7	14.48%
Open Water	41.94	29.34%
Total:	142.94	100.00%

6. Establishing Watershed Water Quality Targets

Determining the amount of pollutant a water body can assimilate without exceeding applicable water quality criterion, or the loading capacity, is important for identifying water quality restoration targets. The loading capacity (LC) is derived from the numeric water quality criterion for each pollutant or an appropriate surrogate when no numeric criterion is applicable. Calculation of the LC is a requirement of a TMDL. Although not a TMDL, a similar exercise is completed in this watershed-based plan to provide overall water quality restoration targets. Once TMDLs for the impaired water bodies are formally established and approved by EPA, this plan will be updated to ensure consistency with those documents. It is expected that only minor, if any, updates resulting from the separate TMDL endeavor will be necessary.

As is typically done in a TMDL, once the LC is determined, a portion is assigned to point sources as a wasteload allocation (WLA) and to nonpoint sources as a load allocation (LA). A reserve capacity (RC) is also calculated to account for future growth and loading in the watershed. Once the pollutant allocations are allotted the amount of pollutant reductions can be determined. Generally, point source contributors will be assigned permit limits targeting the pollutant of concern to ensure compliance with water quality standards. Typically, nonpoint source load reductions are dependent on voluntary watershed management actions, which most often are BMP's that target load reductions for the pollutant of concern. The equation for calculating the load capacity is as follows:

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

where LC is the loading capacity, $\sum$WLA is the sum of the wasteload allocations to point sources, $\sum$LA is the sum of the load allocations to nonpoint sources, MOS is the margin of safety, and RC represents a reserve capacity. A margin of safety is included to account for uncertainties in scientific and technical understanding of water quality in natural systems. Practices established in this watershed plan will target the nonpoint source loading contributions within the watershed that are assigned to the load allocation. These reductions will be accomplished through the implementation of BMPs, watershed planning actions, and educational outreach opportunities. Dredging activities may provide temporary load reductions, consistent with the goals of this plan. Established load allocations will be referenced to quantify numeric load reduction targets.

7. Load Allocations and Reductions (Element B)

Initial implementation actions associated with this plan will focus on reductions of sediment. Future updates will be made to this plan to address nutrients following development of water quality targets through the TMDL process. In the meantime, addressing sediment will address biological impairments in Peruque Creek and sedimentation issues in Lake St. Louis contributing to mineral turbidity. Reductions of sediment are also expected to result in some reduction of nutrients associated with the Chl-a impairment of Lake St. Louis, as well as nutrients that may be contributing to low DO conditions in Peruque Creek. To address the issue of excessive sedimentation in Peruque Creek and Lake St. Louis, TSS loading targets were developed using the load duration curve method, which visually displays the loading capacity of a water body at all possible flows based on historical flow data and the defined target concentration for a selected pollutant. A portion of the TSS (sediment) loading capacity is assigned as a wasteload allocation based on the individual design flows of the wastewater treatment facilities present in the watershed. Ten percent of the loading capacity is reserved as an explicit margin of safety to account for any unknown uncertainty in the analysis, as well as to ensure water quality standards are met after all point and nonpoint source load reductions have been achieved. Due to the substantial amount of urban development occurring in the watershed, a portion of the loading capacity is also set aside as a Reserve Capacity to accommodate future growth. The remaining portion of the loading capacity after allocations to point sources and the margin of safety is assigned to the load allocation which represents the target nonpoint source load.

Load duration curves are based on flow duration curves developed using a long-term time series of daily flows and a numeric water quality target. Average daily flow data that are representative of the impaired segment are used to develop the flow duration curve. If sufficient flow records for the impaired stream segment are not available, then flow data collected from a gage in a representative watershed may be used, or a flow duration curve can be derived by synthesizing long-term flow data from several gages within the same EDU or ecoregion. Due to limited availability of quality stream gage discharge data for Peruque Creek, a synthetic flow regime from surrounding USGS gages was developed. Five surrounding USGS gages were identified with adequate discharge data sets to develop a synthetic flow regime. Table 9 provides information for the referenced USGS gages. Data from these gages was compiled and area corrected to reflect flow conditions in the Peruque Creek watershed.

Table 9. USGS Stream monitoring gages referenced for the development of synthetic flow regime for the Peruque Creek watershed

Site Name	USGS Gage Number	Drainage Area (mi^2)	Quarried Data Range
Dardenne Creek at Old Town St. Peters, MO	05514860	102.0	2000-2023
Cuivre River near Troy, MO	05514500	903.0	
Bonhomme Creek near Clarkson Valley, MO	06935770	11.3	
Creve Coeur Creek at Chesterfield, MO	06935850	5.6	
Fee Fee Creek near Bridgeton, MO	06935955	11.7	

Next is the selection of an appropriate target value(s) which is protective of water quality standards and will ultimately restore water quality conditions in the impaired water bodies. Point source dischargers within the Peruque Creek watershed will have TSS permit limits assigned based on the selected water quality target or existing limits based on the facility's treatment technology, whichever is more stringent. Nonpoint sources contributing TSS loading to Peruque Creek are unregulated and have no mandated reduction target. Because of this difference in implementation authority, pollutant reductions for nonpoint sources are achieved using voluntary BMPs.

Interior River and Hills Ecoregion Level 3 TSS data were compiled to develop an ecoregional TSS target concentration to calculate sediment reductions necessary to protect designated uses and restore water quality conditions in Peruque Creek and Lake St. Louis. Interior River and Hills Ecoregion water bodies share the same ecological and climatic conditions as those of Peruque Creek and Lake St. Louis, and these similar conditions support the use of the developed ecoregional TSS target. The TSS target set for Peruque Creek is based on the 25th percentile of all USGS data collected within the Level 3 ecoregion, the resulting target value is 18 mg/L TSS.

Use of the 25th percentile provides a conservative target that best represents reference conditions and therefore conditions in which aquatic life are not expected to be negatively impacted. Table 10 provides site information for the ecoregional TSS data complied to develop the reduction target.

Table 10. Interior River and Hills Level 3 Ecoregion Sites used to develop a TSS reduction target for the Peruque Creek

Stream Site Name	Waterbody ID Number (WBID)	Number of Samples	Collecting Agency
South Fork. Salt River @Santa Fe	141	94	USGS
Cuivre River @Old Monroe	151	240	USGS
Cuivre River near Troy	152	206	USGS
Cowmire Creek near Hwy I-270	1604	40	USGS
Caulk's Creek @Chesterfield	1701	12	USGS
Bonhomme Creek @Hwy CC	1701	42	USGS
Creve Coeur Creek @Hwy 340	1703	65	USGS
Fee Fee Creek @McKelvey Rd.	1704	48	USGS
Coldwater Creek @Jamestown Rd.	1706	62	USGS
Watkins Creek @Fry Lane	1708	43	USGS
Maline Creek @Bellefontaine Rd.	1709	72	USGS
River des Peres @St. Louis	1710	34	USGS
Gravois Creek @Green Park Rd, Mehlville	1713	43	USGS
South Fork. Saline Creek @ Hwy T	1769	66	USGS
Peruque Creek 7.6 mi. DS of O'Fallon North STP	215	256	USGS
Dardenne Creek @ Hwy B	219	265	USGS
Dardenne Creek 1.8 mi. DS of Spencer Cr.	219	12	USGS
Dardenne Creek @ Salt River Rd.	221	19	USGS
Spencer Creek 0.1 mi. US of Mouth	224	12	USGS
Bobs Creek @Hwy 79	32	15	USGS
Des Moines River @ St. Francisville, MO.	36	704	USGS
Fox River near Wayland, MO.	38	111	USGS
Black Creek near Brentwood	3825	7	USGS
Deer Creek @Big Bend Blvd	3826	22	USGS
River des Peres @Heman Park	3972	64	USGS
Deer Creek @ LaDue	4078	23	USGS
Engelholm Creek near Wellston	4110	42	USGS
Cedar Cr. 25 miles below Manacle Cr., nr Ashland	737	37	USGS
Lamine River near Pilot Grove	847	222	USGS
Salt River near New London, MO.	91	501	USGS

With the Peruque Creek flow regime established (synthetic flow) and a target TSS concentration for reductions identified (18 mg/L) a load duration curve was developed to determine under which flow conditions TSS load reductions can be targeted. Figure 6 depicts the load duration curve developed for the Peruque Creek watershed, which includes both WBID 217 and WBID 218. Table 11 summarizes reductions at selected flows and the load reductions that are needed to meet the prescribed targets. The load reductions were calculated based on the mean of observed ecoregional TSS data recorded during each selected flow regime. Points above the curve exceed the loading capacity and points on or below the curve meet the TSS water quality target and water quality standards. The load duration curve approach also helps to identify and differentiate between storm-driven loading and the presence of continuous loading. Storm-driven loading is expected under wet conditions when precipitation and runoff are high. Continuous loading is evident at low flows when point source discharges have greater influence on water quality. In general, most nonpoint source contributions will occur during periods influenced by stormwater runoff. Higher loading values occurring during lower flow conditions can often be attributed to an increase of impervious surfaces in the watershed and resulting greater run-off during light to moderate rainfall events. While there are select exceedances during dry conditions, most exceedances occur during moist to high flow conditions. Based on this analysis, it is suggested to primarily select BMPs that address stormwater and runoff conditions.

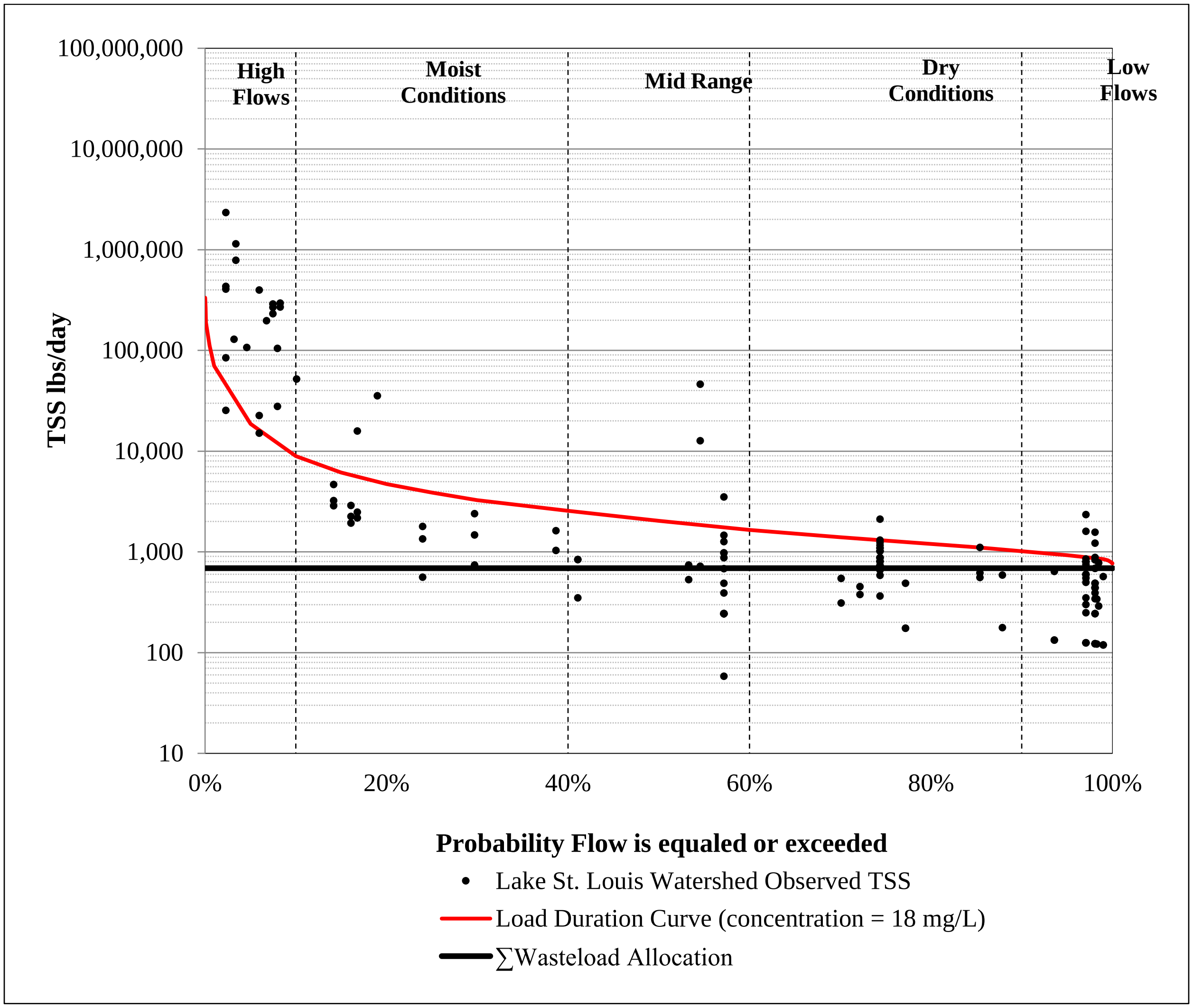


Figure 6. Peruque Creek watershed total suspend solids load duration curve

Table 11. Total suspended solids allocations and reductions across various flow conditions for the Peruque Creek Watershed

Frequency flow is exceeded	Flow Condition	Flow (cfs)	Point Allocations (lbs/day)	Non-point Allocations (lbs/day)	NPS Load (lbs/day)	NPS Reductions (lbs/day)	NPS Reduction (%)
0.95	Low flow	9.58	689.15	148.39	536.19	387.80	72.32%
0.75	Dry conditions	13.35	689.15	477.25	1,116.88	639.62	57.27%
0.5	Mid Range	20.93	689.15	1,139.72	3,981.96	2,842.23	71.38%
0.25	Moist Conditions	39.96	689.15	2,803.37	60,336.13	57,532.76	95.35%
0.05	High Flow	191.51	689.15	16,049.03	1,187,058.10	1,171,009.08	98.65%

8. Best Management Practices (Element C)

Measures to reduce sediment loading are critical to improving water quality conditions in Peruque Creek and Lake St. Louis. Conservation practices such as stream bank stabilization and buffer strip management, which are commonly referred to as BMPs, can reduce sediment loads to adjacent waterbodies and improve downstream water quality conditions. While these practices are effective at reducing sediment loading, the placement of practices at critical locations within the watershed which have the greatest load reduction potential is priority. Identifying these critical locations increases the return on investment of BMP implementation cost and provides the greatest opportunity to improve water quality (Naisargi & Mitteslet 2017).

Source assessment analysis completed in Section 5 identified areas of development and agricultural land cover types as being likely significant contributors of pollutants of concern resulting in impairment of Peruque Creek and Lake St. Louis. Following a watershed approach to address the pollutants of concern, all areas of these land coverage types are critical areas where BMP implementation can aid in pollutant reduction for water quality restoration. For more specific prioritization, an analysis of land cover and hydrologic soil type can be used to identify priority critical areas within a defined buffer area of a stream or lake. For Peruque Creek and Lake St. Louis, a one-hundred-foot (100 ft) buffer zone was established around all classified waters within the watershed. Land use and hydrologic soil types were delineated within the one-hundred-foot buffer area, then land cover (pasture, row crop, urban, barren lands) and hydrologic soil types (Group C/D) with the greatest run-off potential were identified. These conditions establish potential critical buffer areas which could use mitigation to address excessive sediment loading. Ground truthing or stream surveys should be conducted to confirm streambank and buffer area conditions prior to initiating implementation planning. Figure 5 provides land cover location for identifying developed and agricultural land cover types for BMP implementation to achieve the goals of this watershed-based plan. Figure 8 provides prioritized critical areas meeting the defined qualifications described above in the Lake St. Louis watershed. Additional prioritized critical areas are any cropland or pasture areas in the watershed (Figure 5) overlying Group D soils (Figure 2) where significant runoff and potentially significant nutrient and sediment loading may occur. Implementation efforts should focus on prioritized critical areas, however when lacking participation or opportunity, efforts completed in general agricultural or developed land cover areas will support the overall load reduction goals of this plan.

Land disturbance and construction activities occurring in the watershed may serve as potential critical areas of focus as well. Land disturbance activities include clearing, grubbing, excavating, grading, filling and other activities that result in the destruction of the root zone and/or land disturbance activity that is reasonably certain to cause pollution to waters of the state. Land disturbance permits are required for construction disturbance activities of one or more acres or construction activities that disturb less than one acre when part of a larger common plan of development or sale that will disturb a cumulative total of one or more acres over the life of the project. However, those areas that are not permitted are considered potential nonpoint sources. Permit conditions establish BMP requirements to address water quality impacts and may require the development of SWPPP. When permit conditions met and maintained these sites should not contribute significant TSS loading. Additionally, these sites can have long term pollution controls integrated into the new construction activities and planning. Unpermitted land disturbance and construction activities greater than one acre may be considered unlawful and should be reported to the appropriate authorities or managing agencies. Figure 7 displays active land disturbance permits in the Lake St. Louis watershed as of November 2024.

These locations can serve as initial sites to investigate for potential mitigation and BMP implementation, with efforts to improve conditions in all stream and lake buffer areas within the watershed the ultimate goal. Figure 8 depicts critical buffer areas, which are delineated by isolating hay/pasture and row crop land uses which are underlaid by Group C/D or D hydrologic soils. Approximately 70 acres were identified within the one-hundred-foot buffer which meet these qualifications. These areas have soils with the greatest rate of runoff and will be eligible for state and federal cost share and other financial assistance used to support agricultural BMP implementation. Appendix A provides additional figures depicting critical buffer areas at more refined scales to enable identification of critical area locations.

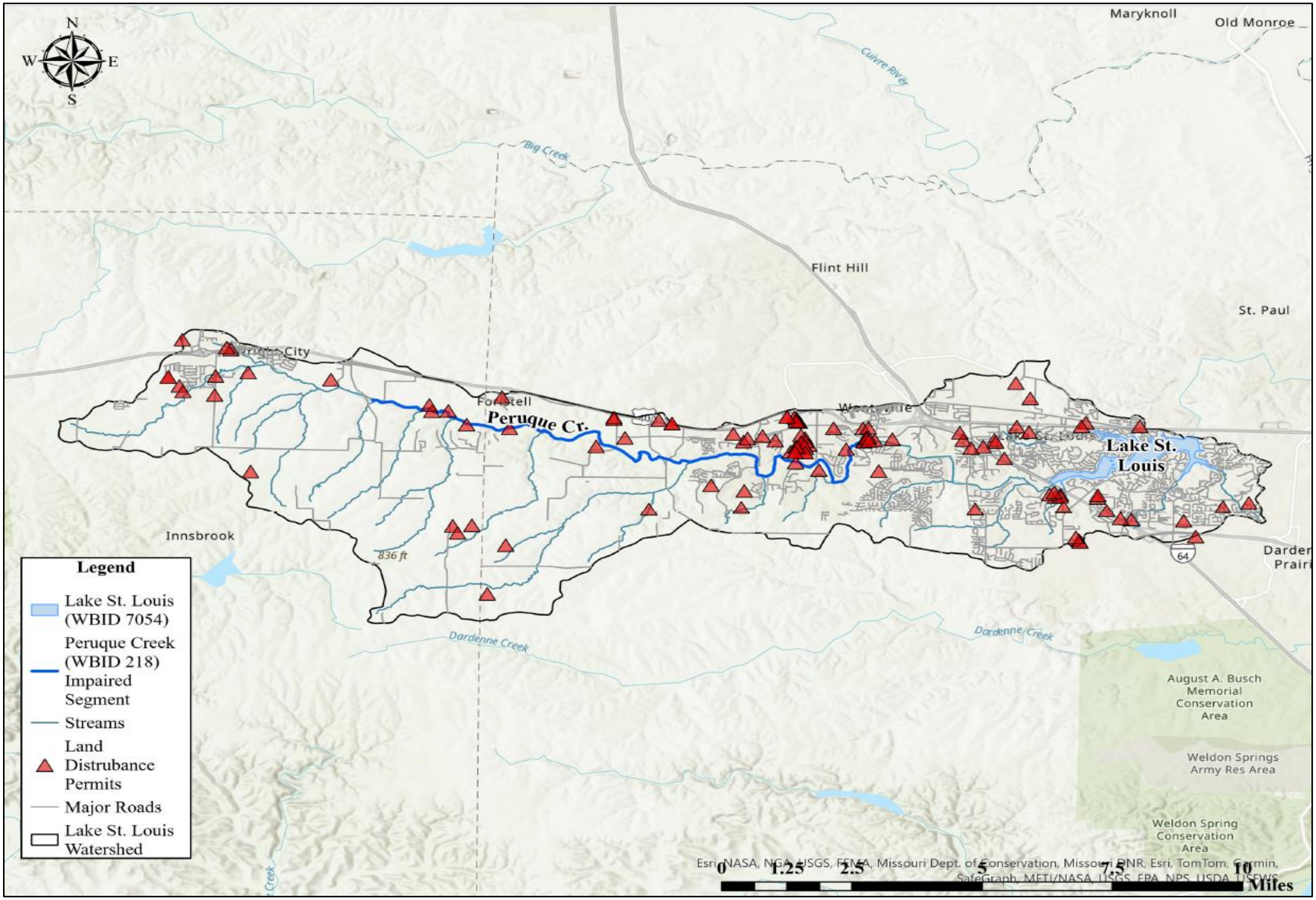


Figure 7. Land disturbance permits located across the Lake St. Louis Watershed

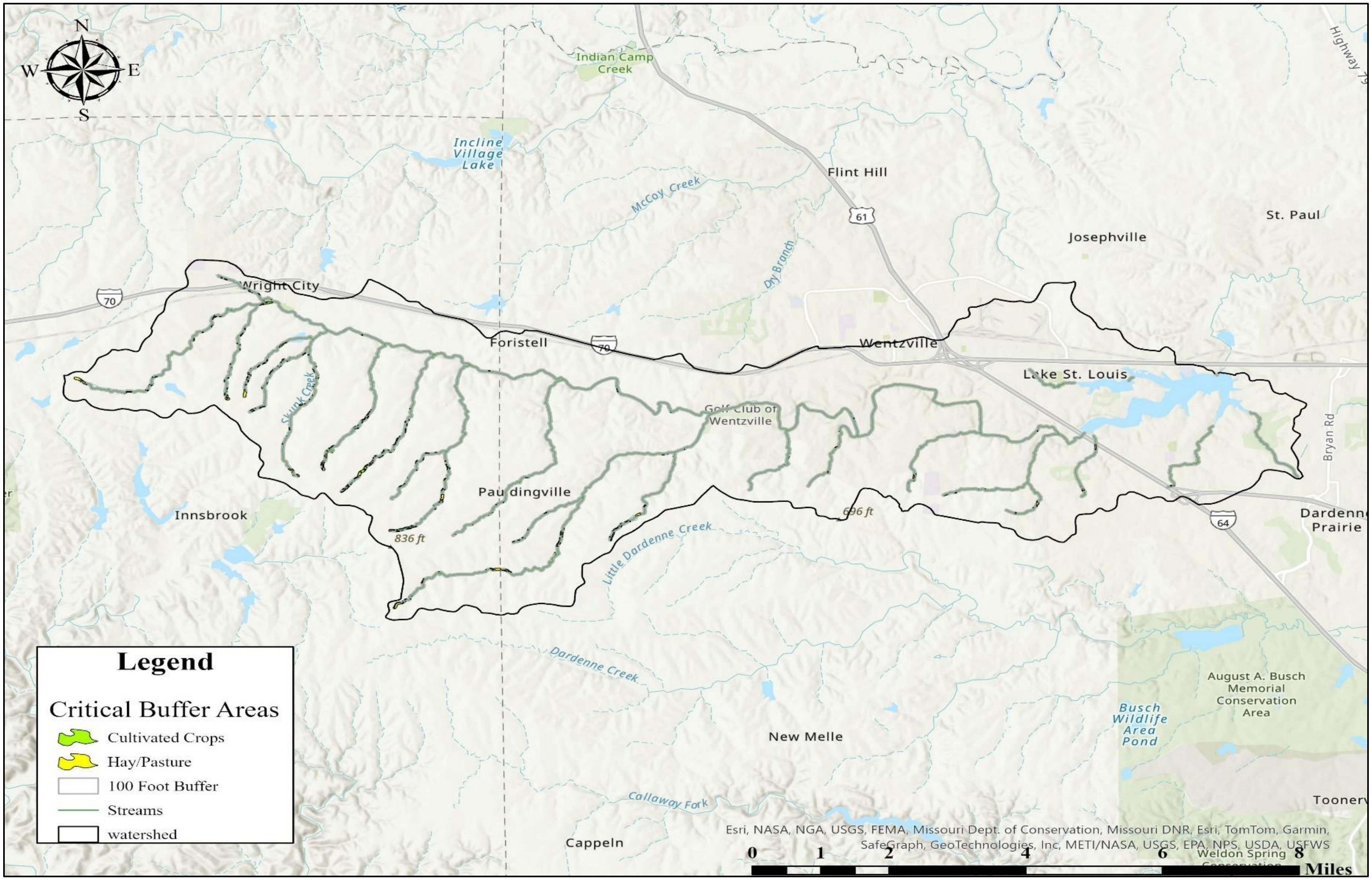


Figure 8. Critical buffer areas identified within a one-hundred-foot buffer around classified waterbodies in the Lake St. Louis Watershed

While practices within the stream buffer zone are important for stream restoration, just as important are management practices placed higher in the watershed uplands. How these lands are managed directly impacts the amount of sediment loading occurring in the watershed. There are several in-channel, streambank, and upland BMPs which can be implemented under appropriate conditions to address excessive sediment loading. Generally, these practices can be grouped by where they are implemented, commonly referred to as agricultural, urban, and streambank or channel BMPs. Following are suggested examples of BMPs that can be implemented in the Lake St. Louis watershed to reduce excessive sediment loading across the referenced practice groups.

Agricultural practices such as cropland and livestock management take place in the Lake St. Louis watershed. As previously discussed, hay/pasture and cropland comprise approximately thirty-eight percent of the watersheds identified land use. Addressing immediate sediment loading concerns with practices such as cultivation off-sets and livestock exclusion can have direct sediment and nutrient load reductions. Prescribing a voluntary no-cultivation (planting) buffer area around stream channels or waterways within the watershed greatly reduce soil disturbance and the resulting erosion from run-off events. Allowing livestock selective access to streams or providing alternative water sources can significantly reduce animal induced erosion areas often found around feeding and watering locations. Any high traffic areas associated with waterway or channel crossing can be subject to greater erosion potential and often serve as areas in need of mitigation and erosion controls. Proper maintenance of pasturelands and row-crop fields can contribute to load reductions when lands are not in working rotation. Soil erosion from row crop fields can be reduced by implementing a variety of practices such as conservation tillage, cover cropping, pasture and crop rotations, and proper nutrient management. Generally, these practices support sustainable agriculture and can often increase the productivity of managed lands.

Impervious surfaces, hydrologic alterations, and construction efforts associated with urban land uses can potentially increase sediment to streams. Precipitation events occurring in urban areas can lead to significant hydrologic short-circuiting (increased waters volumes and velocities) due to land use alterations, resulting in greater erosion and sediment loading to watershed streams. Intensifying storm events make controlling water volume and energy extremely important for sediment loading reductions. Stormwater, retention, detention, and dry basins are structural BMPs which are designed to control storm water volumes and velocities, allowing sediment to be trapped in the basins and reducing the kinetic energy of water flows. Landscape designs such as bio-swales, vegetated filter strips, rain gardens, grass waterways and wetlands also serve as kinetic energy controls. These practices often provide additional ecosystem services beyond sediment control, like nutrient reductions and wildlife habitat (Keeler et al., 2012). Informing urban watershed residents how practices protect and improve water quality conditions can have a dramatic impact on the success of BMP implementation. Community involvement can range from stormwater drain signage posting, to the development of homeowner and business stormwater controls. Urban landscape areas can provide many opportunities for sediment load reductions. Efforts should prioritize areas with greatest load reduction potential first, with work on greater holistic watershed management practices following.

Overland flow produced during run-off events eventually flows to channels and streams, carrying with it a variety of constituents, including sediment and nutrients. Once these waters enter a stream, the accompanying sediment is transported downstream and deposited when stream flow velocities decrease. It is important to note erosional and depositional zones are natural stream geomorphic processes and are part of a healthy stream's hydrology. However, when these processes go to the extreme the results can be environmentally detrimental. Controls to manage stream channel migration and creating streambank stabilization can mitigate excessive erosional processes and reduce the resulting excessive deposition and water turbidity. In-channel controls, such as low-rise dams, wing dikes, and weirs, can be placed at critical locations to manage instream flow conditions, resulting in controlled sediment deposition and stream bank protections. Areas directly adjacent to the channel or floodplain are often ephemeral in nature and do not always contain flowing or standing water. These areas serve as sediment and energy sinks for the primary channel. Efforts to restore, enhance, and maintain these areas will allow for the channel to naturally release high flow water's energy and can assist with flood mitigation (Nehrke et al., 2004). Reduction of overall imperviousness can also aid in reducing erosion by allowing stormwater to infiltrate the ground rather than gain velocity that can disrupt stream channel stability.

There are a variety of BMPs which can be implemented in agricultural, urban, and stream channel settings to address excessive sediment loss within a watershed. Table 12 provides a list of BMP categories recently evaluated by the United States Army Corps of Engineers (ACOE) and the EPA for performance and efficiency (ACOE & EPA, 2020). Several of the BMPs listed can be implemented in the Lake St. Louis watershed to reduce nonpoint source sediment loading from a variety of sources.

Table 12. Common categories of structural Best Management Practices implemented to address nonpoint source loading concerns[6]

BMP Category	Identifier Code	Description
Detention Basin	DB	Dry extended detention grass-lined and concrete lined basins which empty after storm events.
Retention Basin	RP	Surface wet pond, generally maintains a permanent pool, can include additional underground storage capacity.
Wetland Basin	WB	Similar to the retention basin, maintaining permanent pool, also maintains at least 50% coverage of emergent wetland vegetation.
Wetland Channel	WC	Saturated channel with wetland vegetation and slow water residency time.
Grass Swale	BS	Shallow, vegetated channel, termed bioswale or vegetated swale commonly.
Grass Strip	BI	Designated vegetated areas designed to intercept lateral sheet flows from adjacent impervious surface areas, also termed buffer strips or vegetated buffers.

[6] This BMP table was developed directly from the ACOE and EPA International Stormwater BMP Database 2020 Summary Statistics report; https://bmpdatabase.org/performance-summary-reports.

Bioretention Basin	BR	Shallow, vegetated basins with a various plantings and filtration media, with underdrainage often included.
Media Filter System	MF	Filter bed typically filled with sand, gravel, or granular media.
High Rate Biofiltration	HRBF	System designed for high flow rate filtration, typically used to support treatment plants.
High-Rate Media Filtration	HRMF	System designed for high flow rate filtration, media consist of inert and sportive materials and configurations (e.g. membrane filters, up flow filters, vertical bed filters, cartridge filters).
Hydraulic Separation Devices	HDS	Engineered system which uses gravitational settling using baffles, screens, and swirl concentrators.
Oil/Grit Separators and Baffle Boxes	OGS	Engineered systems such as oil/water separators and baffle chambers which remove coarse solids and floatables.
Permeable Friction Course Overlays	PF	Course overlay designed to increase surface friction of impervious surfaces which slows and reduces sheet flow velocities.
Porous Pavements and Surfaces	PP	Engineered surface systems which allow for precipitation infiltration, examples include porous asphalt and concrete, brick and pavers, other permeable surfaces designed to replace pavement.

Using the Lake St. Louis watershed land use and cover distribution, in conjunction with the critical area analysis, locations within the watershed were identified for BMP implementation. Next, estimates of the number BMPs necessary to achieve targeted sediment reductions within the Lake St. Louis watershed were developed. Knowing the load reduction necessary to achieve water quality targets and the load reductions achieved by BMP implementation, an estimated BMP installation count can be calculated. The watershed was divided into seven sub-basins based on topography and watershed hydrology. Pollutant load estimates and BMP load reductions were modeled using the Pollutant Load Estimation Tool (PLET) (Tetra Tech & USEPA, 2024). Table 13 presents combined annual BMP acres implemented per sub-basin for each targeted land use (urban, row crop, pastureland), combined BMP efficiency values per sub-basin, and sub-basin loading summaries. Tables 14 through 16 present individual BMP efficiencies and suggested implementation rates which are based on treating twenty-five percent each of the sub-basin's targeted land uses. The implementation rate values were then disturbed over a twenty-five-year period, allowing for five percent BMP implementation in each sub-basin every five years, totaling twenty-five percent sub-basin treatment at twenty-five years of implementation. At this rate, an expected TSS load reduction of 5,813 pounds (lbs) is expected every five years based on the proposed BMPs until the entire needed reduction of 29,065 lbs is achieved at year 25.

Table 13. Sub-basin Combined BMP and Loading Summary

Combined BMP Acreages, Combined BMP Efficiency Values, and Loading Summary							
	Total Acres Treated per Sub-basin Annually			Combined Sediment BMP Efficiency Values	Estimated Sub-basin Loading (tons/day)	Estimated Sub-basin Load Reductions (tons/day)	Estimated Sub-basin Sediment Loading (tons/day)
Sub-basin	Urban	Cropland	Pastureland				
101	150	400	251	0.41	3.67	3.36	0.31
102	150	560	253	0.43	4.22	3.34	0.88
103	150	270	254	0.41	2.33	1.80	0.53
104	200	220	305	0.42	2.47	1.82	0.65
105	500	100	605	0.43	1.73	1.43	0.30
106	1,160	100	1,266	0.44	3.04	2.74	0.30
107	405	90	512	0.42	1.68	1.44	0.25
	Total Acres			**Estimated Watershed Wide Annual Averages**			
	2,715	*1,740*	*3,446*	*0.42*	*2.74*	*2.28*	*0.46*

Table 14. Suggested Urban BMPs and Implementation Rates*

BMP Category		Grass Swales	Vegetated Filter Strips	Dry Detention Basins	Settling Basins	Infiltration Basin	Porous Pavement	Extended Wet Detention	Street Cleaning Operations
Sediment BMP Efficiency Values**		0.65	0.73	0.58	0.82	0.75	0.90	0.86	0.16
		Suggested BMP Practices (acres treated)							
Sub-basin Number and suggested BMP Implementation Years 0-5	**101**	60	60	60	20	20	70	–	–
	102	30	30	20	20	20	30	–	–
	103	20	20	20	20	20	50	–	–
	104	30	30	30	30	30	50	–	–
	105	75	75	75	75	50	75	75	–
	106	150	150	200	150	100	150	200	60
	107	60	60	60	60	55	50	60	–
Sub-basin Number and suggested BMP Implementation Years 5-10	**101**	60	60	60	20	20	70	–	–
	102	30	30	20	20	20	30	–	–
	103	20	20	20	20	20	50	–	–
	104	30	30	30	30	30	50	–	–
	105	75	75	75	75	50	75	75	–
	106	150	150	200	150	100	150	200	60
	107	60	60	60	60	55	50	60	–
Sub-basin Number and suggested BMP Implementation Years 10-15	**101**	60	60	60	20	20	70	–	–
	102	30	30	20	20	20	30	–	–
	103	20	20	20	20	20	50	–	–
	104	30	30	30	30	30	50	–	–
	105	75	75	75	75	50	75	75	–
	106	150	150	200	150	100	150	200	60
	107	60	60	60	60	55	50	60	–
Sub-basin Number and suggested BMP Implementation Years 15-20	**101**	60	60	60	20	20	70	–	–
	102	30	30	20	20	20	30	–	–
	103	20	20	20	20	20	50	–	–
	104	30	30	30	30	30	50	–	–
	105	75	75	75	75	50	75	75	–
	106	150	150	200	150	100	150	200	60
	107	60	60	60	60	55	50	60	–
	101	60	60	60	20	20	70	–	–
	102	30	30	20	20	20	30	–	–

Sub-basin Number and suggested BMP Implementation Years 20-25	103	20	20	20	20	20	50	–	–
	104	30	30	30	30	30	50	–	–
	105	75	75	75	75	50	75	75	–
	106	150	150	200	150	100	150	200	60
	107	60	60	60	60	55	50	60	–
Totals		*2,125*	*2,125*	*2,325*	*1,875*	*1,475*	*2,375*	*1,675*	*300*

*The suggested BMPs presented in this table may be supplemented or substituted with other BMPs targeting the pollutants of concern addressed by this plan. **An efficiency value is a percentage of a pollutant that is removed when the BMP is applied.

Table 15. Suggested Cropland BMPs and Implementation Rates*

BMP Category		Cover Crops	Conservation Tillage	Grass Field Buffers	Forest Field Buffers	Land Retirement	Contour Farming
Sediment BMP Efficiency Values**		0.20	0.46	0.53	0.60	0.95	0.41
		Suggested Cropland BMP Practices (acres)					
Sub-basin Number and suggested BMP Implementation Years 0-5	101	150	150	50	30	20	–
	102	100	160	100	20	20	160
	103	70	70	30	10	10	80
	104	40	60	30	10	5	75
	105	20	40	5	5	5	25
	106	20	40	10	5	5	20
	107	10	20	20	10	5	25
Sub-basin Number and suggested BMP Implementation Years 5-10	101	150	150	50	30	20	–
	102	100	160	100	20	20	160
	103	70	70	30	10	10	80
	104	40	60	30	10	5	75
	105	20	40	5	5	5	25
	106	20	40	10	5	5	20
	107	10	20	20	10	5	25
Sub-basin Number and suggested BMP Implementation Years 10-15	101	150	150	50	30	20	–
	102	100	160	100	20	20	160
	103	70	70	30	10	10	80
	104	40	60	30	10	5	75
	105	20	40	5	5	5	25
	106	20	40	10	5	5	20
	107	10	20	20	10	5	25
	101	150	150	50	30	20	–

Sub-basin Number and suggested BMP Implementation Years 15-20	**102**	100	160	100	20	20	160
	103	70	70	30	10	10	80
	104	40	60	30	10	5	75
	105	20	40	5	5	5	25
	106	20	40	10	5	5	20
	107	10	20	20	10	5	25
Sub-basin Number and suggested BMP Implementation Years 20-25	**101**	150	150	50	30	20	—
	102	100	160	100	20	20	160
	103	70	70	30	10	10	80
	104	40	60	30	10	5	75
	105	20	40	5	5	5	25
	106	20	40	10	5	5	20
	107	10	20	20	10	5	25
Totals		*2,050*	*2,700*	*1,225*	*450*	*350*	*1,925*

*The suggested BMPs presented in this table may be supplemented or substituted with other BMPs targeting the pollutants of concern addressed by this plan. **An efficiency value is a percentage of a pollutant that is removed when the BMP is applied.

Table 16. Suggested Pastureland BMPs and Implementation Rates*

BMP Category		Grass Field Buffer	Forest Field Buffer	Critical Planting Area	Heavy Use Protection	Stream Bank Stabilization w/Fencing	Prescribed Grazing	Livestock Fencing
Sediment BMP Efficiency Values**		0.65	0.53	0.42	0.33	0.75	0.33	0.64
Subbasin		**Suggested Pastureland BMP Practices (acres)**						
Sub-basin Number and suggested BMP Implementation Years 0-5	**101**	30	25	25	10	10	200	100
	102	40	20	10	10	10	200	50
	103	30	10	10	10	10	60	30
	104	40	20	20	20	20	140	80
	105	30	10	10	10	10	100	20
	106	20	10	10	10	10	40	10
	107	20	10	15	15	10	50	20
Sub-basin Number and suggested BMP Implementation Years 5-10	**101**	30	25	25	10	10	200	100
	102	40	20	10	10	10	200	50
	103	30	10	10	10	10	60	30
	104	40	20	20	20	20	140	80
	105	30	10	10	10	10	100	20

	106	20	10	10	10	10	40	10
	107	20	10	15	15	10	50	20
Sub-basin Number and suggested BMP Implementation Years 10-15	**101**	30	25	25	10	10	200	100
	102	40	20	10	10	10	200	50
	103	30	10	10	10	10	60	30
	104	40	20	20	20	20	140	80
	105	30	10	10	10	10	100	20
	106	20	10	10	10	10	40	10
	107	20	10	15	15	10	50	20
Sub-basin Number and suggested BMP Implementation Years 15-20	**101**	30	25	25	10	10	200	100
	102	40	20	10	10	10	200	50
	103	30	10	10	10	10	60	30
	104	40	20	20	20	20	140	80
	105	30	10	10	10	10	100	20
	106	20	10	10	10	10	40	10
	107	20	10	15	15	10	50	20
Sub-basin Number and suggested BMP Implementation Years 20-25	**101**	30	25	25	10	10	200	100
	102	40	20	10	10	10	200	50
	103	30	10	10	10	10	60	30
	104	40	20	20	20	20	140	80
	105	30	10	10	10	10	100	20
	106	20	10	10	10	10	40	10
	107	20	10	15	15	10	50	20
Totals (acres)		*1,050*	*525*	*500*	*425*	*400*	*3,950*	*1,550*

*The suggested BMPs presented in this table may be supplemented or substituted with other BMPs targeting the pollutants of concern addressed by this plan. **An efficiency value is a percentage of a pollutant that is removed when the BMP is applied.

9. Technical and Financial Assistance (Element D)

Technical resources and financial assistance can be sourced from a variety of local, state, and federal agencies, non-for-profit agencies, or local interest groups (non-governmental organization). Private businesses, companies, and organizations located within the watershed may also have interest in providing technical and financial support to improve local water quality conditions. Federal grant application guidance and support will be provided by Missouri Department of Natural Resources' (MoDNR) 319 Nonpoint Source Unit, applications will then be submitted annually to acquire the necessary funding to implement BMPs under the Lake St. Louis nine-element watershed plan schedule. Additional in-kind funding will be necessary to meet the application requirements of federal 319 grant funding, examples of in-kind funding include monetary matches, material donations, and volunteer hours. Table 17 provides examples of agencies which can provide technical and financial assistance for implementation in the watershed. To inquire about eligibility and availability of Section 319 funding, please contact modnr.npsprogram@dnr.mo.gov.

Table 17. Agency Roles and Funding Options

Agency and Roles	Funding Options
US Department of Agriculture, Natural Resources Conservation Service https://www.nrcs.usda.gov/wps/portal/nrcs/site/mo/home/	
Financial assistance and incentives to implement voluntary BMPs	Environmental Quality Incentives Program (EQIP) Regional Conservation Partnership Program (RCPP) Conservation Stewardship Program (CSP) Agricultural Conservation Easement Program (ACEP)
US Department of Agriculture's Farm Service Agency (FSA) https://www.fsa.usda.gov/	
Administers a program called the Continuous Sign-up Conservation Reserve Program (CCRP) that provides farmers with rental payments on land set-aside for conservation buffers for a period of 10 to15 years. Cost-share payments are also made available to help farmers with the financial burden of establishing the buffers.	Continuous Sign-up Conservation Reserve Program (CCRP)
Missouri Department of Natural Resources https://dnr.mo.gov/	
Water Protection Program https://dnr.mo.gov/water/hows-water Implements federal Clean Water Act regulations including: enforcing National Pollutant Discharge Elimination System (NPDES) regulations through point source facility operating permits, establishing Water Quality Standards, identifying impaired water bodies, and developing TMDLs.	Free volunteer water quality monitoring training and tools

Agency and Roles	Funding Options
Financial Assistance Center dnr.mo.gov/water/business-industry-other-entities/financial-opportunities/financial-assistance-center Provides technical guidance for publicly owned treatment works and administers low-interest long-term loans to assist with technology and capacity upgrades. The Clean Water State Revolving Fund provides subsidized loans to municipalities, counties, public sewer districts, and political subdivisions for wastewater infrastructure projects. Loans may be paired with grant funds for qualifying communities. Eligible projects include new construction or improvement of existing facilities. Information on the department's grant policy is available online at dnr.mo.gov/water/business-industry-other-entities/financial-opportunities.	Clean Water State Revolving Fund
Soil and Water Conservation Program dnr.mo.gov/env/swcp/ The Soil and Water Conservation Program (SWCP) provides financial incentives to landowners to implement practices that help prevent soil erosion and protect water quality. The program offers cost-share practices through its county conservation districts. Landowners may receive up to 75 percent reimbursement of the estimated cost of a practice through the program. The primary funding for cost-share practices from the Soil and Water Conservation Program comes from the one-tenth-of-one percent Parks, Soils, and Water Sales Tax.	SWCP cost-share
Section 319 Nonpoint Source Program dnr.mo.gov/water/what-were-doing/nonpoint-source-pollution-section-319 ▪ Provides assistance with the development of watershed-based plans and administers Section 319 subgrants for plan development and implementation.	Section 319 subgrants
Missouri Department of Conservation mdc.mo.gov/community-conservation/community-conservation-funding-opportunities/.	

Agency and Roles	Funding Options
Offers a number of grant and cost-share options including Community Conservation Grant and Land Conservation Partnership Grant. Provides outreach, education, and technical guidance for stream and watershed management issues. Maintains Missouri Conservation lands.	Community Conservation Grant and Land Conservation Partnership Grant Free volunteer water quality monitoring training and tools
Missouri Agricultural and Small Business Development Authority agriculture.mo.gov/abd/financial/awloanprg.php	
Offers an Animal Waste Treatment System Loan Program in cooperation with the Clean Water State Revolving Fund. Animal Waste Treatment Loans Program may finance eligible animal waste treatment systems for independent livestock and poultry producers with operations of less than 1,000 animal units. Eligible costs include storage structures, land, dedicated equipment, flush systems, composters, and more.	Clean Water State Revolving Fund
University of Missouri Extension https://extension2.missouri.edu/	
Provides guidance for farm management including crop resilience, pond health, and livestock care.	Free information and assistance
County Soil and Water Conservation Districts https://mosoilandwater.land/	
Provides guidance and assistance with the development of nutrient management plans and procurement of funding from the state cost-share program.	Free information and assistance with grant applications
Online Databases of Additional Funding Sources	
▪ Wichita State University, Environmental Finance Center (EFC) Missouri Healthy Watershed Funding Search Tool https://www.wichita.edu/academics/fairmount_college_of_liberal_arts_and_sciences/hugowall/efc/news/meramec-funding-sources-landing-page.php ▪ Catalog of Federal Funding https://www.epa.gov/waterdata/catalog-federal-funding ▪ EPA Nonpoint Source Funding Opportunities http://water.epa.gov/polwaste/nps/funding.cfm ▪ Environmental Justice Grants https://www.epa.gov/environmentaljustice/environmental-justice-grants-and-resources ▪ Grants.gov http://www.grants.gov	

10. Education and Outreach (Element E)

Outreach efforts should be designed to encourage public participation in implementing the goals of this watershed-based plan. Education efforts serve to inform the public of the watershed-based plan, its purpose, goals, and expected outcomes. Efforts should be made to identify and engage landowners and appropriate stakeholders who are willing to support the implementation goals of this watershed-based plans. Building strong working relationships with landowners and stakeholders will allow for ease of implementation (i.e. land access and easement development) and support the overall success of achieving the goals specified in this watershed-based plan. To support this effort, the department has participated in public meetings with interested groups and individuals wanting to reduce pollutant loading in the Lake St. Louis watershed. The department additionally provided public notification of the development of this plan and made the plan publicly available for review and comment for a 45-day period in conjunction with draft TMDL development.

Another important aspect of education and outreach efforts is determining the effectiveness of the programs developed. Program metrics and goals which track progress should be established which are easily tracked. Examples of potential metrics and goals include, but are not limited to, the number of program participants, number of planned events, event attendance, survey response counts, number of training events, the number of participants trained, amount of literature distributed, and the number of electronic newsletters emailed. It is important to identify how (spreadsheet or database), who (volunteers, contractor, agency personnel), and when (on-line registration, mail delivery, on-site registration) education and outreach data metrics are collected. Similarly, establishing the frequency of metric collection and public reporting should be a defined goal. Finally, it should be determined how the results and information will be shared with the target audiences (websites, electronic notification, newsletters, local and regional publications).

Examples of 2024 initial outreach and education activities completed during the development of this watershed-based plan include watershed and lake tours, volunteer water quality sampling, and both agency and watershed group led outreach events or public meetings. Future events will be scheduled throughout the implementation schedule and be integrated into future watershed planning activities. The department intends to provide local outreach and educational opportunities during the public notice and comment period associated with the development of the Lake St. Louis TMDL. Additionally, the department has a statewide watershed coordinator to help facilitate outreach opportunities in these watersheds.

11. Implementation Schedule (Element F)

Suggested implementation scheduling is established in Tables 14 through 16. Currently, the schedule is based on five-year implementation cycles over a twenty-five-year period. Permitting extra time for unexpected events (e.g., weather, funding, contracts) and developing contingency plans will allow for deadlines to be met and will hopefully lead to successful outcomes within the prescribed timeframes. Often a particular BMP will be determined to be more effective at sediment reductions for a particular stream, land use, or watershed. This watershed-based plan will be reviewed and updated, as necessary, every five years. As a result, implementation may adapt or change to use alternative BMPs or schedules.

12. Milestones (Element G)

Often integrated into to an implementation schedule, milestones or goals are used to determine the effectiveness of the watershed plan implementation. Beyond the numeric load reductions, metrics tracked, or deadlines established often include, but are not limited to, on the ground construction actions and BMP installation (linear feet, acres, count), public engagement events, and social or media networking actions. Load reduction milestones are established as percent reductions over a twenty-five-year period, with planned analysis to be conducted every five years to determine progress towards the prescribed load reduction milestones and goals. This analysis is used to determine if the implementation schedule needs to be updated to accommodate changes to the watershed plan to improve overall load reductions in the watershed. There are a variety of physical, chemical, and biological water quality parameters for which baselines can be established and changes tracked, determining the appropriate parameters to track will be watershed and contaminant of concern specific.

13. Evaluation of Load Reductions (Element H)

Quantitively (and qualitatively when applicable) determining the amount of sediment reduction occurring from BMP installations across the watershed will determine if water quality conditions are improving or if water quality standards are being attained. In addition, load reduction evaluations will support future planning actions and assist with identifying the most effective BMPs to install in the Lake St. Louis watershed. The ecoregional 18 mg/L TSS target serves as the numeric water quality target from which load reductions are based. Taking the TSS target value and watershed flow data, a load duration curve for the Lake St. Louis watershed was developed to determine load reductions across varying flow conditions for the stream. Primary load reductions will occur from nonpoint source allocations during high flow events (stormwater flows), while any point source reductions necessary will be addressed via appropriate discharge permit limits. Taking these factors into consideration, evaluation efforts should focus on the locations where the greatest reductions are expected to occur. Therefore, evaluating the effectiveness of BMPs within the watershed will be used to determine their individual effectiveness at load reductions and quantitively identify TSS load reductions.

14. Monitoring (Element I)

Water quality monitoring may be conducted by public entities, private companies, and research institutions for a variety of reasons, and may include both regulatory and non-regulatory interest. On a biennial basis, the department will evaluate all readily available and quality assured data in accordance with Missouri's Listing Methodology.[7]Ultimate determinations of continued impairment or water quality attainment, will be completed by the department on even-numbered consistent with Clean Water Act requirements for Section 303(d) and 305(b) reporting.

In regard to the implementation goals of this plan, monitoring is most appropriate and applicable after BMP implementation to identify progress towards meeting the established pollutant reduction goals establish in Sections 7 and 8, as well as to estimate BMP effectiveness. Data collected from such monitoring may also be used to adjust BMP selection, location, and number

[7] Available online at https://dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/impaired-waters

as appropriate to ensure progress towards the ultimate restoration goal of this plan are maintained. General milestone goals for implementing monitoring associated with BMP implementation, are at the 5-year increments presented in Tables 14-16. However, recognizing those implementation goals likely represent a best-case scenario, an additional milestone of 10 percent BMP implementation within each 5-year period would also be appropriate for initiating monitoring activities associated with determining reduction achievement and overall BMP effectiveness on water quality. In the case of the 10-year implementation goal, actual water quality monitoring should start in the year following BMP implementation. However, QAPP development and overall monitor planning can begin concurrently with BMP implementation.

It should also be noted that the estimated TSS load reduction targets to restore water quality in Peruque Creek and Lake St. Louis are based on loading derived from load duration curves using a synthetic flow. A synthetic flow was used due to a lack of specific long-term flow data from Peruque Creek. For this reason, continuous flow data collection, or paired flow and parameter monitoring, as well any equipment needs to support such monitoring, can aid the implementation goals of this plan by providing site-specific data for which to calculate actual load reductions achieved during known flow conditions. This information can then provide adjustment to BMP activities (i.e., number, types, and locations) to known reduction needs to ensure progress towards attainment of water quality goals are being achieved. For initiation of the implementation goals of this plan, such continuous flow monitoring can begin concurrently with BMP implementation as the data can be used to derive relationships of flow condition and pollutant concentration using future water quality monitoring to aid in overall determination of BMP effectiveness and progress towards achievement of overall pollutant reduction goals.

The department may periodically supplement such monitoring with its own dependent upon available resources, need, weather conditions, and other statewide priority monitoring. In general, the department will not conduct monitoring until an appropriate time after which implementation actions have occurred. However, the department will continue to evaluate all other readily available and quality assured data.

The development of a Quality Assurance Project Plan (QAPP) is often applied and typically required in planning sampling, and analysis type of projects (USEPA, 2002). QAPPs define the goals of the monitoring efforts, helping the project produce successful returns. QAPPs often include details such as the identification of sampling parameters (TSS, DO, nutrients, flow, biological assessment, etc.), sampling locations (upstream, downstream, outfall, weir) sampling type (grab, auto-sampler, depth integrated), sampling event type (baseline, routine, storm event), collecting entity or agency, sampling frequency and duration (seasonality, storm events, discreet sampling, continuous sampling), laboratory quality assurance and quality control documentation, and contracted technical and laboratory support qualifications. Creating a concise and complete QAPP will ensure quality data results that will confidently reflect the performance of implemented BMPs. Often QAPPs are considered ‘living documents” and can be updated if necessary to address changes to the watershed plan and implementation process. Monitoring data will reflect the effectiveness of the watershed plan and ultimately demonstrate sediment loading reductions occurring across the Lake St. Louis watershed. Therefore, QAPP development is critical to the overall success of the watershed plan and should be initiated, and reviewed by the department prior to any data collection efforts. Additional USEPA QAPP development guidance can be found at: https://www.epa.gov/sites/default/files/2015-06/documents/g5-final.pdf

Watershed groups or interested public may participate in the Missouri Stream Team and Volunteer Water Quality Monitoring programs, to collect general water quality indicator data, such as macroinvertebrate sampling, cobble embeddedness, and transparency that may provide general indication of water quality improvement or decline. Such information may be used to inform when and where more robust monitoring may be beneficial, and can generally provide an indicator of BMP effectiveness. More information about these voluntary programs is available at https://mostreamteam.org/.

15. References

Arnold, C.L. and C.J. Gibbons. 1996. Impervious surface coverage: the emergence of a key environmental indicator. Journal of the American Planning Association 62.2

Brown, E., Caraco, D., & Pitt, R. 2004. Illicit Discharge Detection and Elimination a Guidance Manual for Program Development and Technical Assessments. EPA X-82907801-0.

CDM, 2005. Peruque Creek Watershed Management Action Plan. prepared for the City of Lake St. Louis, May 2005.

Clean Lake Alliance. 2023. 2023 State of the Lakes annual report.

Keeler, B., Polasky, S., Brauman, K., and Dalzell, B., 2012. Linking Water Quality and Well-being for Improved Assessment and Valuation of Ecosystem Services. *Proceedings of the National Academy of Sciences (PNAS)* 2012, 109 (45) 18619-18624

Li, Y. and C. Wang. 2009. Impacts of Urbanization on Surface Runoff of the Dardenne Creek Watershed. St. Charles County, Missouri. *Physical Geography* 30(6): 556- 573.

Martel, J-L, F. Brissette, P. Lucas-Picher, M. Troin, and R. Arsenault. Climate Change and Rainfall Intensity–Duration–Frequency Curves: Overview of Science and Guidelines for Adaptation. *Journal of Hydrologic Engineering* Volume 26, Issue 10 https://doi.org/10.1061/(ASCE)HE.1943-5584.0002122

Meng, X., Zhu, Y., Yin, M. *et al.* The impact of land use and rainfall patterns on the soil loss of the hillslope. *Sci Rep* 11, 16341 (2021). https://doi.org/10.1038/s41598-021-95819-5

Missouri Department of Natural Resources (MoDNR). 2015. Total Maximum Daily Load Information Sheet, Peruque Creek. Missouri Department of Natural Resources, Water Protection Program, P.O. Box 176, Jefferson City, Missouri 65102. http://dnr.mo.gov/env/wpp/tmdl/info/docs/0217-0218-peruque-ck-info.pdf 3pp

Missouri Department of Natural Resources (MoDNR). 2016. Biological Assessment and Stressor Study Report Peruque Creek St. Charles and Warren Counties, Missouri July 2014 – March 2015

Missouri Department of Natural Resources (MoDNR). 2022. Methodology for the Development of the 2022 Section of 303(d) List in Missouri. January 7, 2021. Methodology for the Development of the 2022 Section 303(d) List in Missouri | Missouri Department of Natural Resources (mo.gov)

Mishra, A., C. Placzek, and R. Jones. 2019. Coupled influence of precipitation and vegetation on millennial-scale erosion rates derived from ^{10}Be. PLoS One. 2019; 14(1): e0211325. Published online 2019 Jan 25. doi: 10.1371/journal.pone.0211325

MU Extension (University of Missouri Extension). 2023. Household Wastewater: Septic Systems and Other Treatment Methods (Fact Sheet). Available URL: https://extension.missouri.edu/publications/eqm104f#:~:text=How%20close%20is%20too%20close,bed%20or%20drinking%20water%20well. [Accessed 01 April 2025]

Naisargi and Mitteslet, 2017. Quantifying Effectiveness of Streambank Stabilization Practices on Cedar River, Nebraska. *Water* 2017, *9*(12), 930; https://doi.org/10.3390/w9120930

NASS (National Agricultural Statistics Service) USDA. 2022 NASS Online Agricultural Statistics Data. [Online WWW] Available URL: https://www.nass.usda.gov/Publications/AgCensus/2022/Full_Report/Volume_1,_Chapter_2 County Level/Missouri/ [Accessed 18 July 2024].

Nehrke, S. and Larry Roesner, 2004. Effects of Design Practice for Flood Control and Best Management Practices on the Flow-Frequency Curve. *Journal of Water Resources Planning and Management.* 2004, Archive Vol. 130, No. 2

Schindler, D. W. 1977. Evolution of Phosphorus Limitation in Lakes. *Science*, *195*(4275), 260–262. http://www.jstor.org/stable/1743244

Schueler, Tom. 1994. The importance of Imperviousness. Watershed Protection Techniques. 1.3

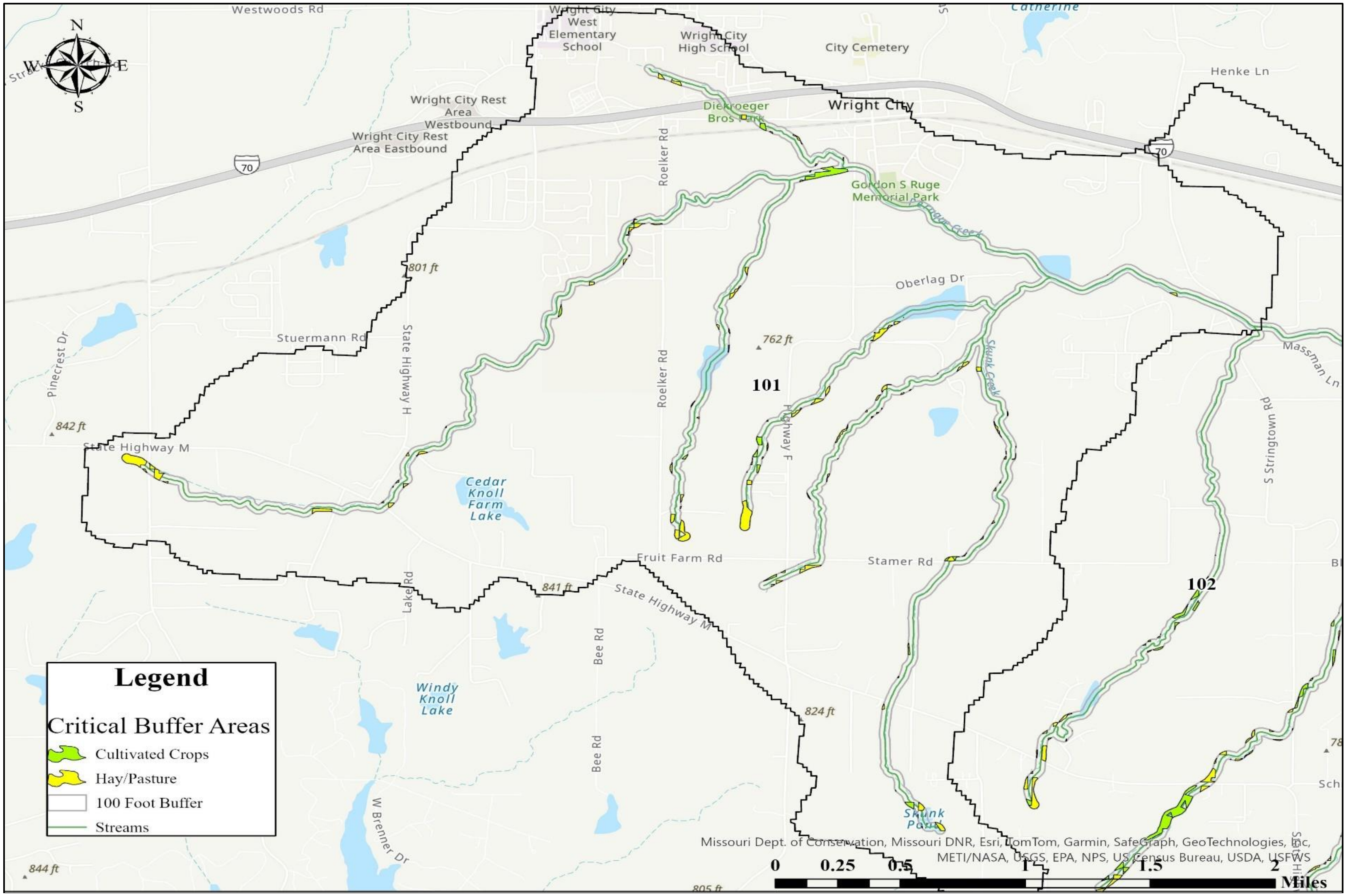
United States Environmental Protection Agency (USEPA). 1999. Protocol for Developing Sediment TMDLs. Office of Water (4503F). U.S. EPA Office of Water: Washington, D.C

United States Environmental Protection Agency (USEPA). 2002. Guidance for Quality Assurance Project Plans EPA QA/G-5. Washington, District of Columbia 20460

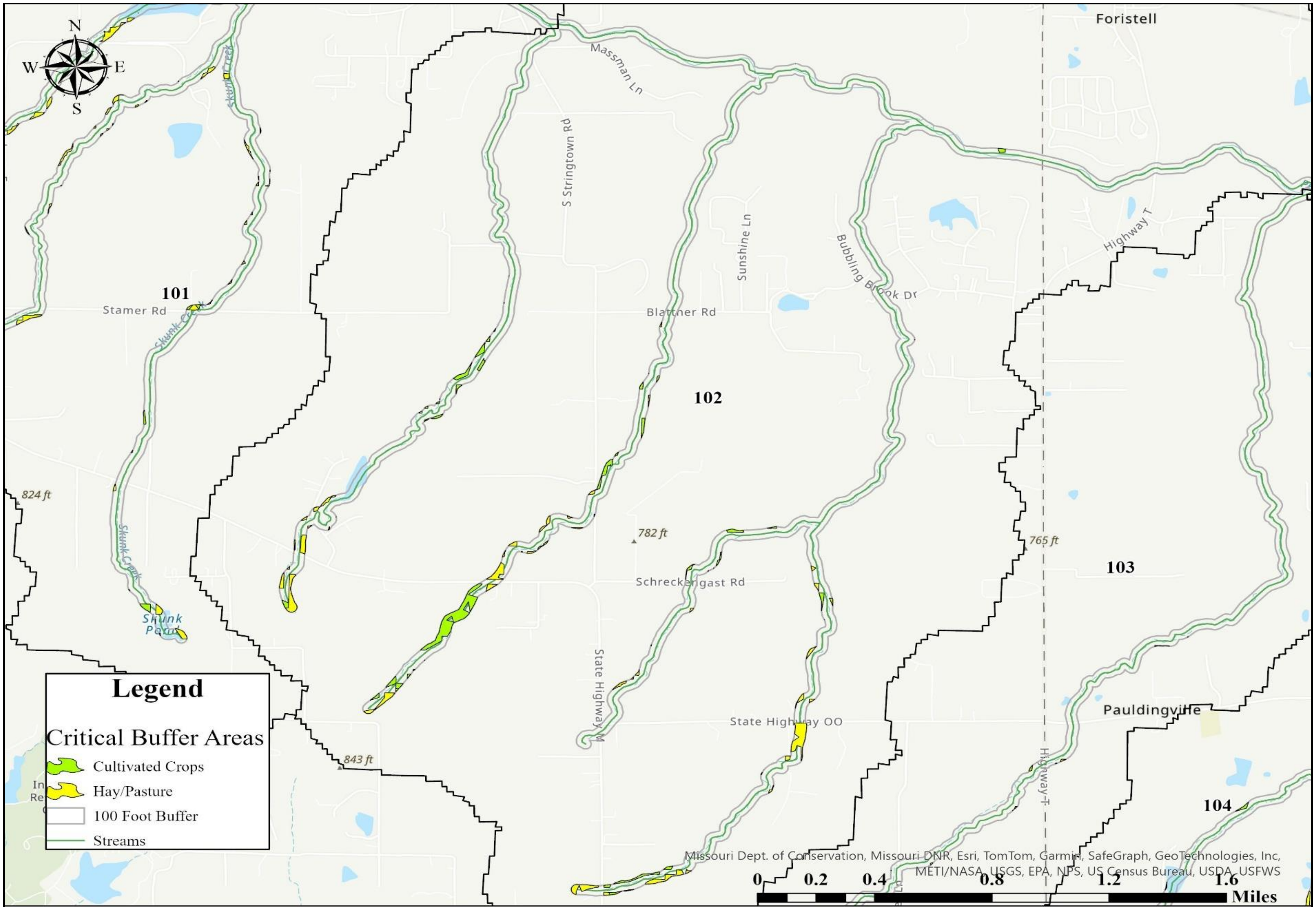
Tetra Tech, Inc. 2011. User's Guide Spreadsheet Tool for the Estimation of Pollutant Load (STEPL) Version 4.1. Prepared for U.S. Environmental Protection Agency, Washington, DC. Prepared by Tetra Tech, Inc. Fairfax, VA.

Tetra Tech, Inc and United States Environmental Protection Agency (USEPA). Accessed: July 2024. Pollutant Load Estimation Tool (PLET). https://www.epa.gov/nps/plet

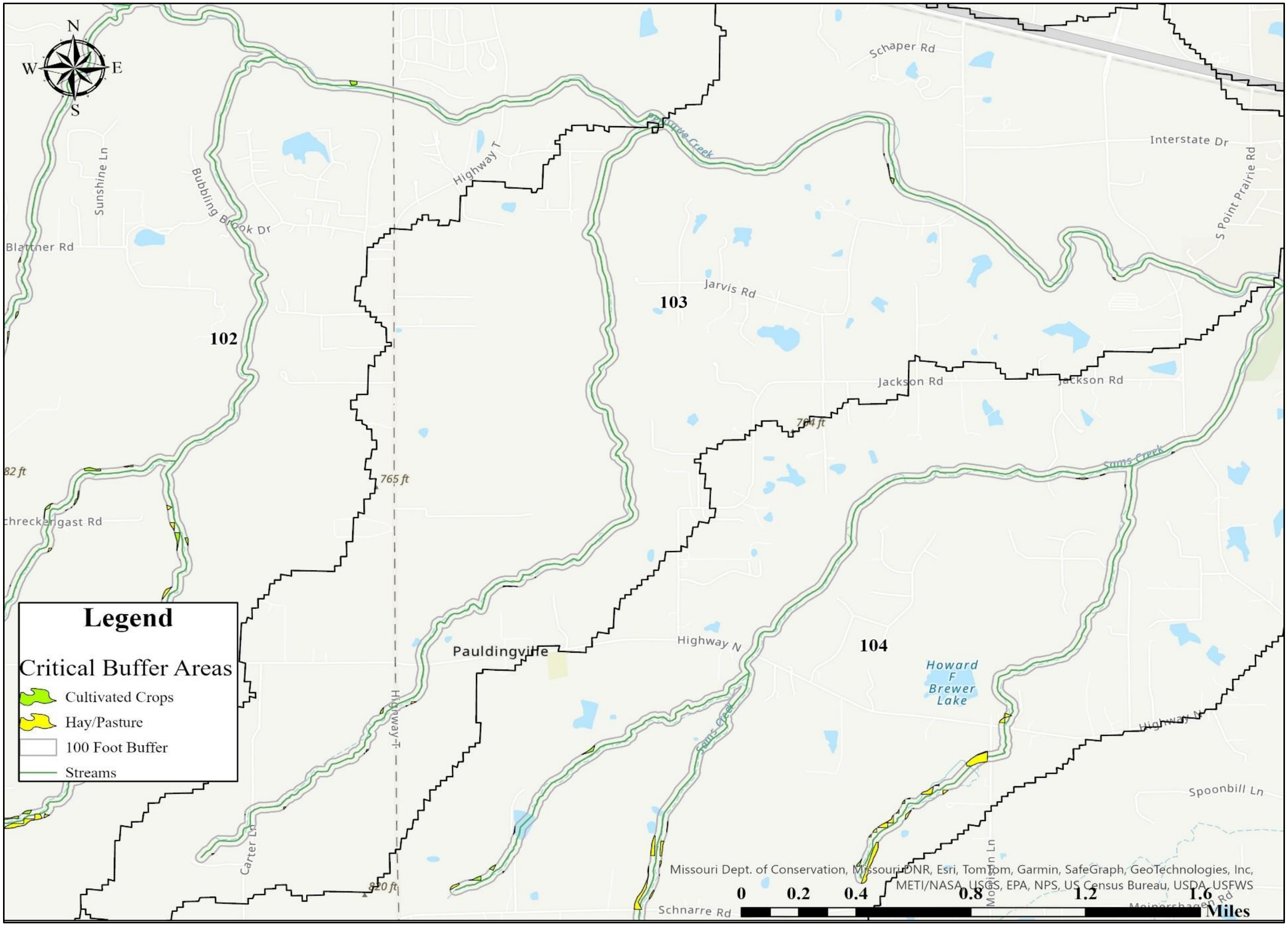
Appendix A. Sub-basin Critical Areas



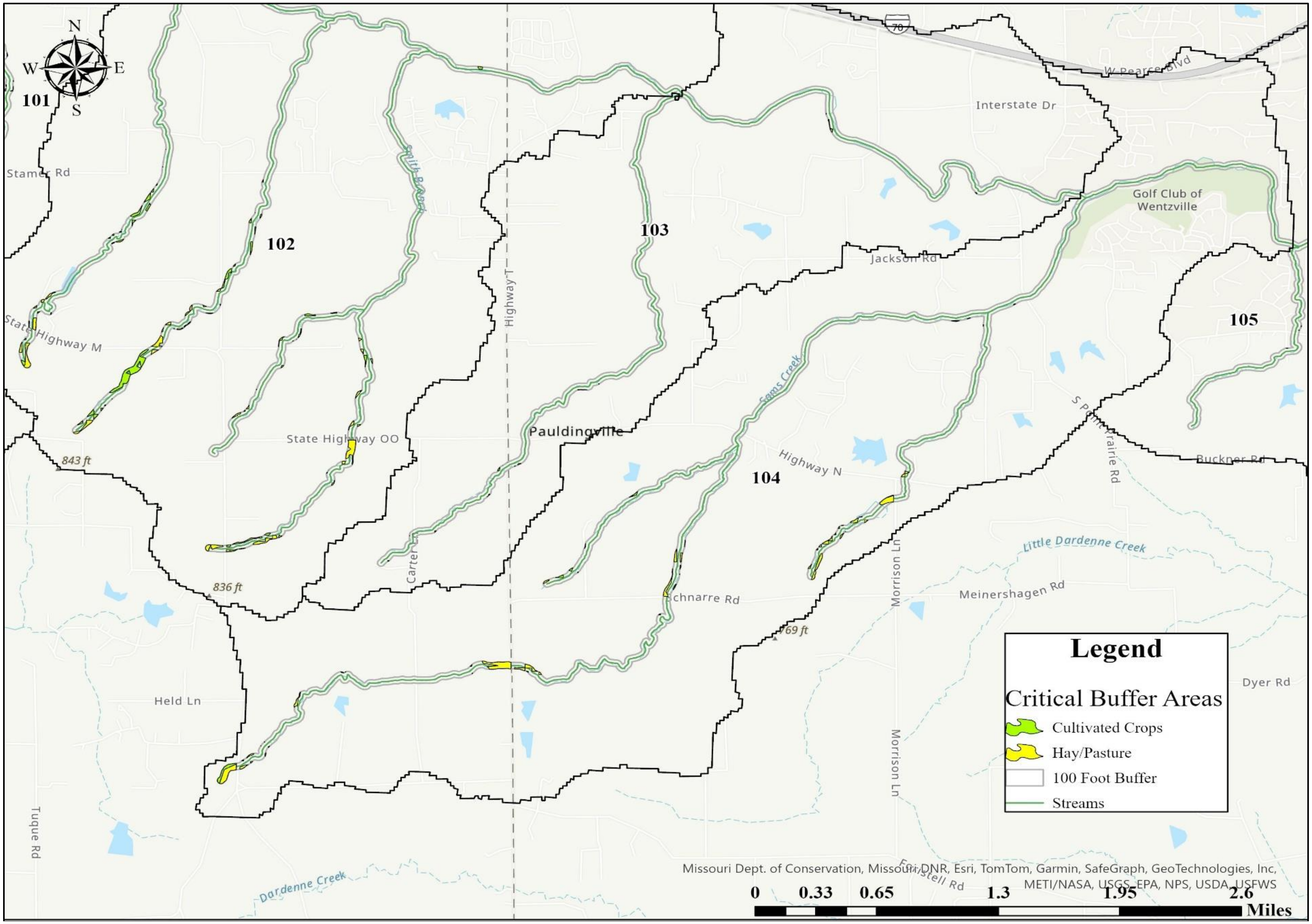
Appendix Figure 1. Sub-basin 101 Critical Areas



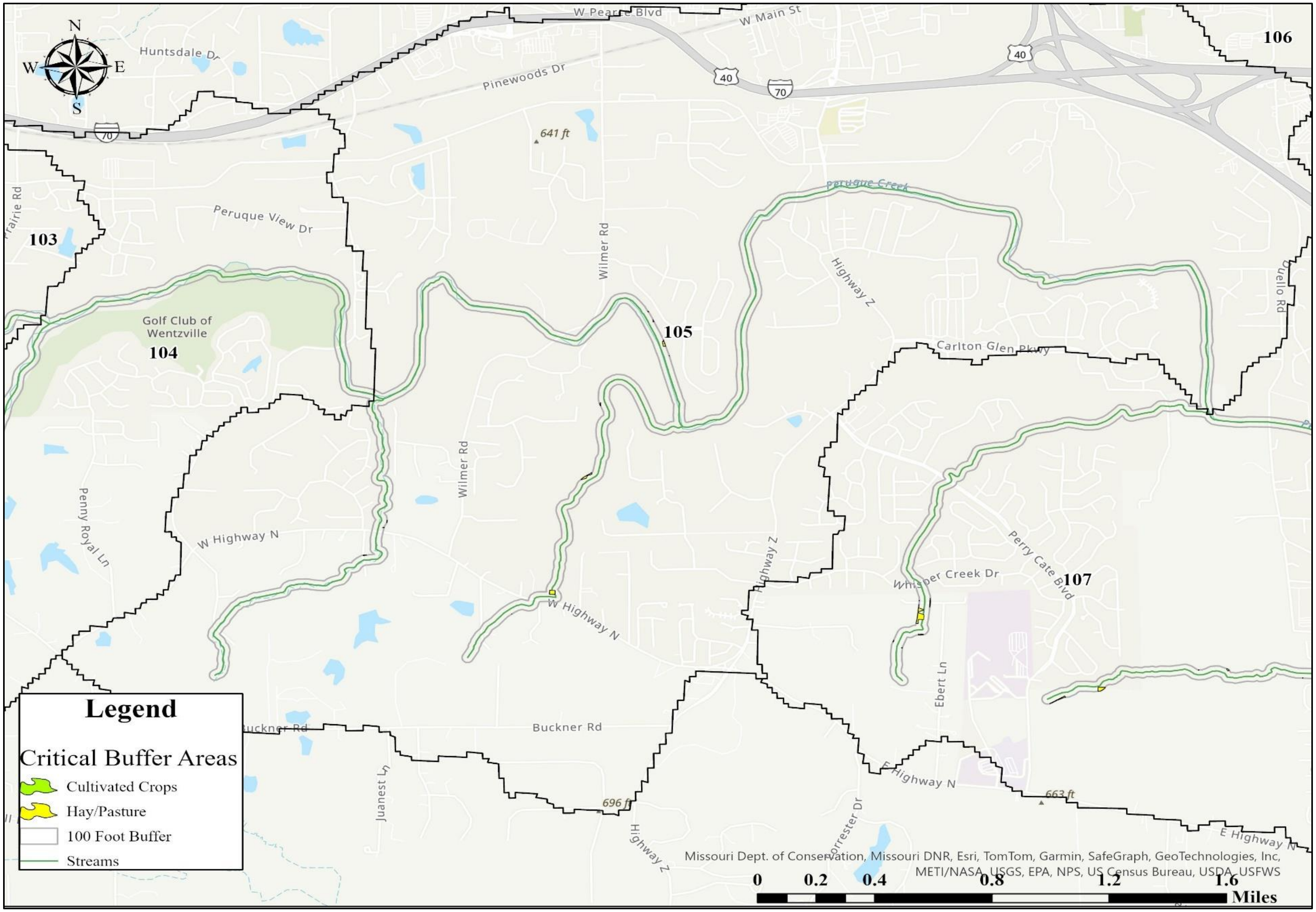
Appendix Figure 2. Sub-basin 102 Critical Areas



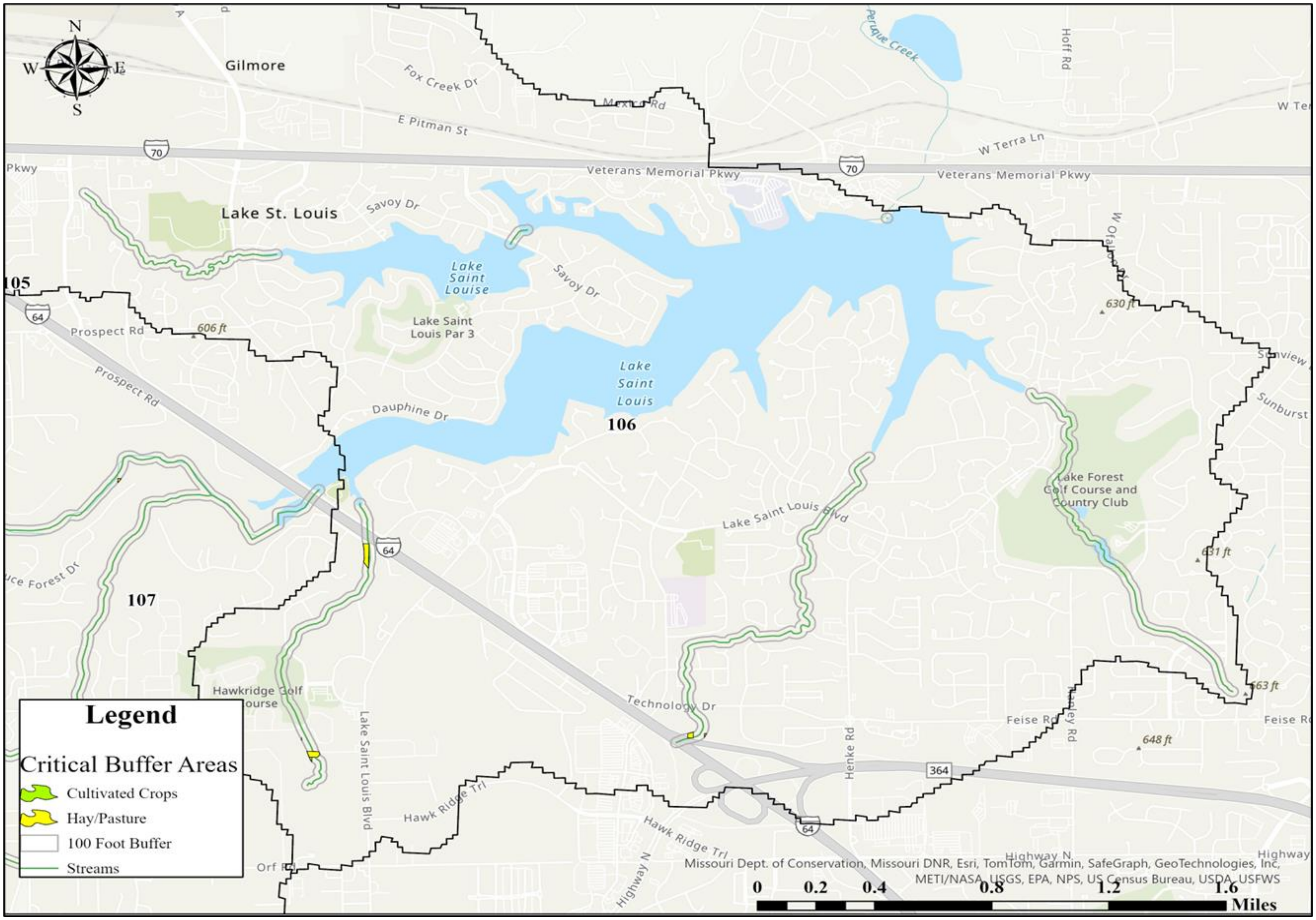
Appendix Figure 3. Sub-basin 103 Critical Areas



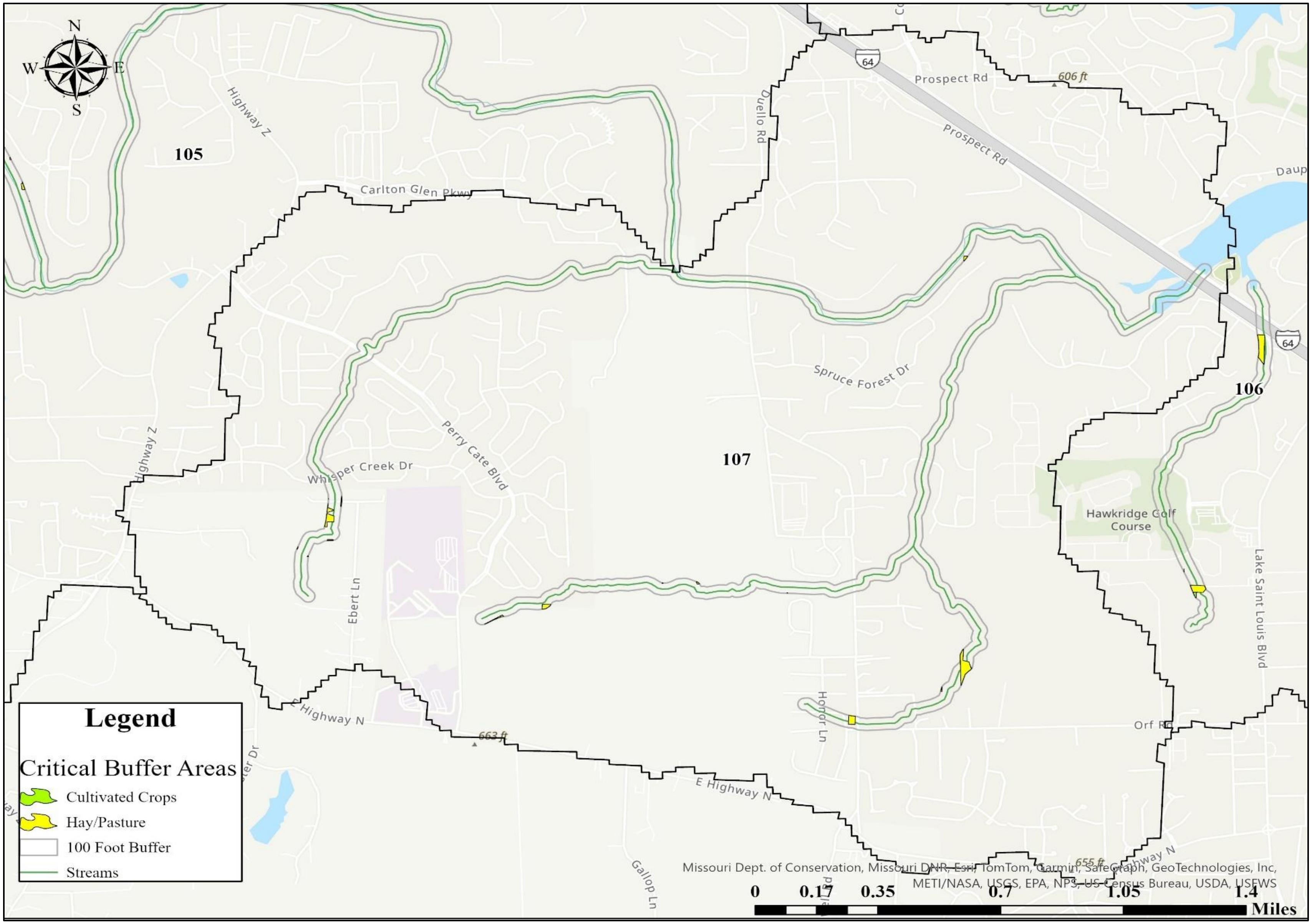
Appendix Figure 4. Sub-basin 104 Critical Areas



Appendix Figure 5. Sub-basin 105 Critical Areas



Appendix Figure 6. Sub-basin 106 Critical Areas



Appendix Figure 7. Sub-basin 107 Critical Area