Watershed Management Plan for the Cahokia-Joaquim Watershed

Image 1. Photo of a Riverboat Tour Near the St. Louis Arch. A view of the St. Louis Arch and the Mississippi River at night. (*Photo courtesy of Riverboats at the Gateway Arch)*

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Objectives

The primary objectives of this Preliminary Watershed Management Plan for the Cahokia-Joaquim Watershed are to use the best available data to address critical water supply and water quality issues, ensuring the sustainability of this vital resource now and into the future. This plan seeks to preserve and enhance water quality by identifying, assessing, and mitigating pollution sources– including urban runoff, agricultural contaminants, and industrial waste– to safeguard public health, aquatic habitats, and recreational opportunities. It also aims to balance current and future water demands across urban, agricultural, and industrial users with available resources, preparing for long-term changes driven by climate variability and socioeconomic trends. Strengthening flood resilience is also a key focus of this plan which includes strategies to reduce flood risks and impacts by enhancing natural floodplain functions, improving stormwater management, and addressing land-use practices that exacerbate flooding. Protecting and restoring critical habitats and biodiversity within the watershed is equally important, with special attention to endangered species like the Pallid sturgeon, Gray bat, and freshwater mussels, which depend on clean water and intact ecosystems.

To achieve these goals, the plan emphasizes the implementation of evidence-based best management practices (BMPs) tailored to the region's diverse land uses and pollution challenges, improving stormwater management and reducing pollutant loads. Informed decision-making can be supported by enhanced data collection, monitoring, and accessibility, ensuring that management actions are guided by reliable scientific and socioeconomic insights. This includes assessing variability in stream flow, spatiotemporal trends in pollution emissions, and the efficacy of remediation efforts. By pursuing these objectives, the Cahokia-Joaquim Watershed Management Plan provides a strategic framework to maintain and improve water quality, sustain water availability, and protect the ecological and economic health of the greater St. Louis area.

1.0 Background

1.1 Introduction

A watershed management plan is a strategic guide designed to protect and sustainably manage water resources, as well as address the interconnected environmental, social, and economic factors that impact a watershed. This plan aims to provide a comprehensive framework for preserving and enhancing water quality, flood resilience, and ecological health for the Cahokia-Joaquim Watershed, located on the border of eastern Missouri and western Illinois and encompassing the city of St. Louis, MO. Effective water management in the Cahokia-Joaqim watershed is especially critical because its waters drain directly into the Mississippi River. The health of this watershed directly affects not only local water quality and flood management, but also the condition of the Mississippi River and the ecosystems and communities downstream.

This impact extends as far as the Gulf of Mexico, where excess nutrients carried by the Mississippi River contribute to a large hypoxic zone that threatens marine life and fisheries. The recommendations included in this management plan are based on the most up-to-date scientific and economic assessments available.

1.2 Location

The Cahokia-Joaquim Watershed (HUC 07140101) is located along the Mississippi River, delineating the boundary between Missouri and Illinois (Figure 1.1). To the northwest is the confluence of the Missouri and Mississippi Rivers outside Alton, Illinois. The periodic flooding of these rivers historically contributed to the enrichment of the soil, facilitating the prosperity of Cahokia, one of the largest Native American settlements in North America (Snoflo, 2024). Currently, St. Louis serves as the largest urban center within the watershed, with a metropolitan population exceeding 2.8 million (U.S. Census Bureau, 2020).

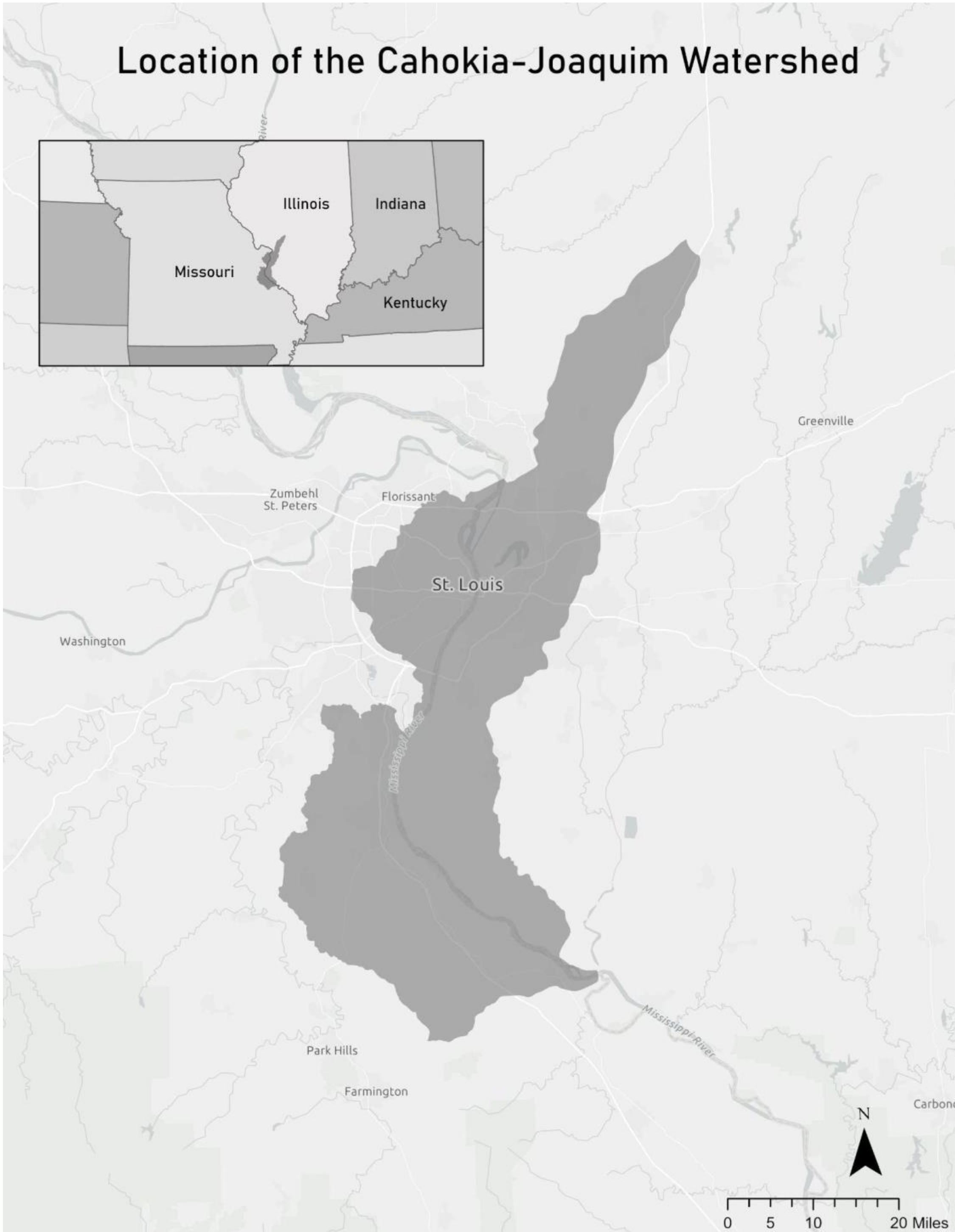

Figure 1.1. Location of the Cahokia-Joaquim Watershed (HUC 07140101). On the border of Missouri and Illinois, the Cahokia-Joaquim Watershed is bounded on the North by the confluence of the Missouri and Mississippi River

1.3 Topography

The Cahokia-Joaquim watershed generally slopes downward towards the Mississippi River at its center (Figure 1.2). Within the watershed, the maximum elevation above sea level is 255 meters, and the minimum elevation is 41 meters. The areas of highest elevation are found along the southeastern edge of the watershed. The areas with the lowest elevation are found along the river itself and some of the main tributaries that feed into it. Additionally, there is a portion of land along the eastern side of the Mississippi with a fairly low and flat elevation, which is largely used for agricultural production (Figure 1.12).

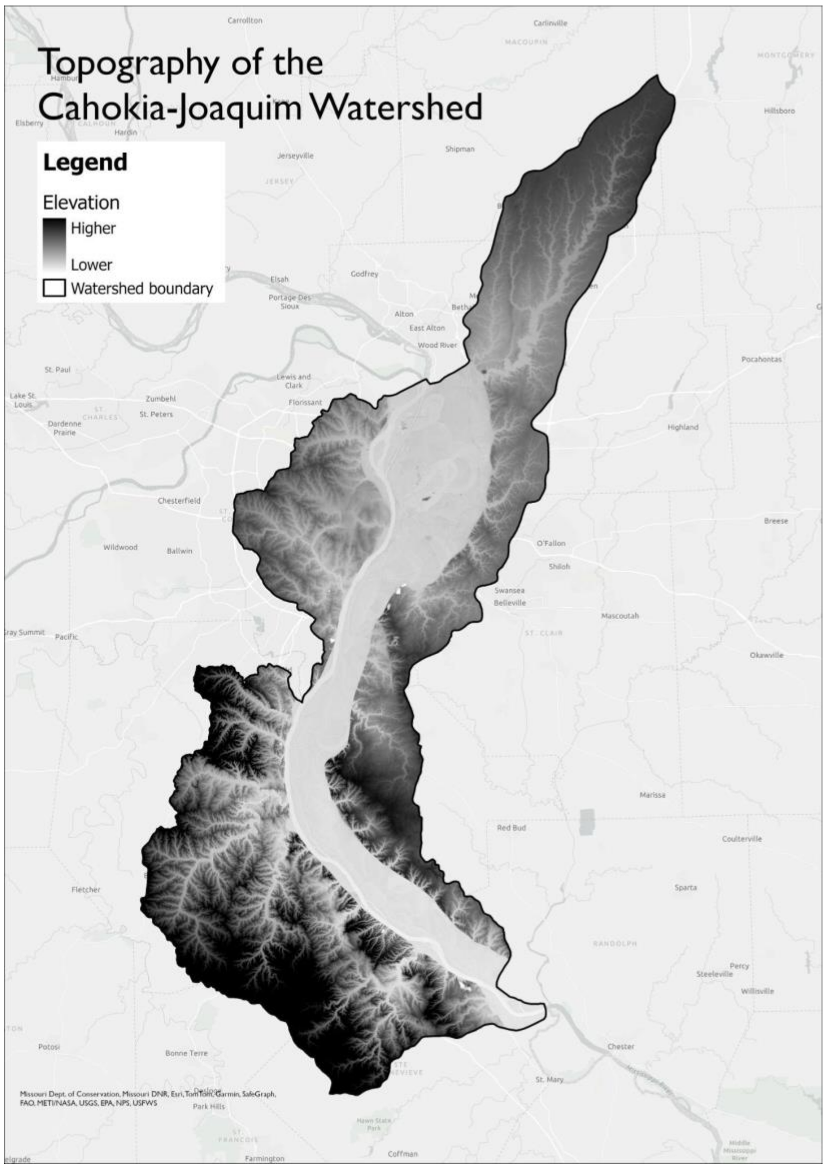

Figure 1.2. Topographical map of the Cahokia-Joaquim watershed. Elevation is shown on a grayscale, with higher elevations as darker shades and lower elevations as lighter shades. The watershed boundary is outlined in black. Map was created using 3DEP DEM data from the U.S. Geological Survey (USGS, 2020).

1.4 Climate

The St. Louis metropolitan area experiences large fluctuations in both precipitation and temperature (Figure 1.3). Precipitation amounts are highly variable, with some years recording only about 30 inches of total precipitation and others recording nearly 60 (PRISM Climate Group). In general, most precipitation falls during the spring season each year. Temperature fluctuations are often more consistent than precipitation over time. Average temperatures range from at or below freezing during the winter to at or above 80 degrees Fahrenheit (°F) during the summer.

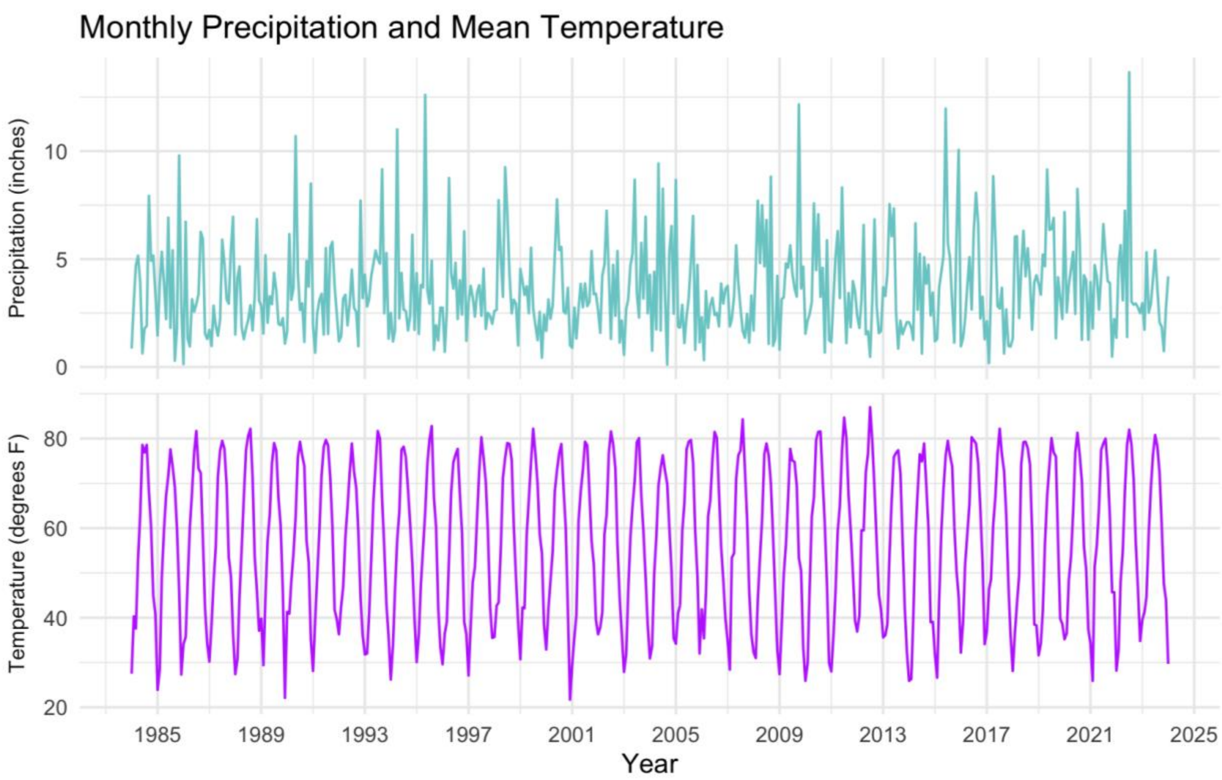

Figure 1.3. Monthly precipitation totals and monthly mean temperatures in St. Louis, MO from 1984 to 2024. Precipitation (in inches) is shown in light blue in the top panel. Average monthly temperature (in °F) is shown in purple in the bottom panel. Long term climate data were obtained from PRISM Time Series Explorer.

1.5 Geology

Alluvial deposits from the Mississippi dominate the shallow watershed in the Northern Missouri side of the watershed (Figure 1.4). These soils are incredibly fertile and allowed for the development of one of the most advanced native settlements in the United States, Cahokia (Snoflo, 2024). In Illinois, the surface geology is composed of alluvial deposits and materials from the most recent glaciation, the Wisconsin Episode (Illinois State Geologic Survey, 2001). Moving south along the Mississippi, where more geology is exposed, the extensive carbonate and silicate deposits of Missouri and Illinois become apparent (Figure 1.5). These were deposited during the Paleozoic Era between 542 and 251 million years ago, when Missouri experienced drastic sea-level changes (Washington University in St. Louis, 2020). This led to the physical deposition of rock, such as shales and sandstones, and the chemical deposition of limestones and dolomites.

One of Missouri and Illinois's most prominent geologic resources is galena, formed through significant faulting in the region (Washington University in St. Louis, 2020). Since the early 1700s, Missouri has mined galena, otherwise known as lead sulfide. Galena is also found in Northwestern Illinois, with a small town aptly named Galena becoming a hub of lead mining in the United States (Illinois Museum of Natural History, n.d.). Galena is often found in rocks deposited during the Pennsylvanian Era and is primarily used to create lead-acid batteries (Missouri Secretary of State, n.d.). Currently, Missouri is the leading smelter of lead in the United States and the second-largest lead smelting district in the world (Missouri Department of Natural Resources, 2021). The Meramec River, a tributary of the Mississippi within the watershed, runs through this lead mining area and has experienced significant lead contamination (U.S. Environmental Protection Agency, n.d.).

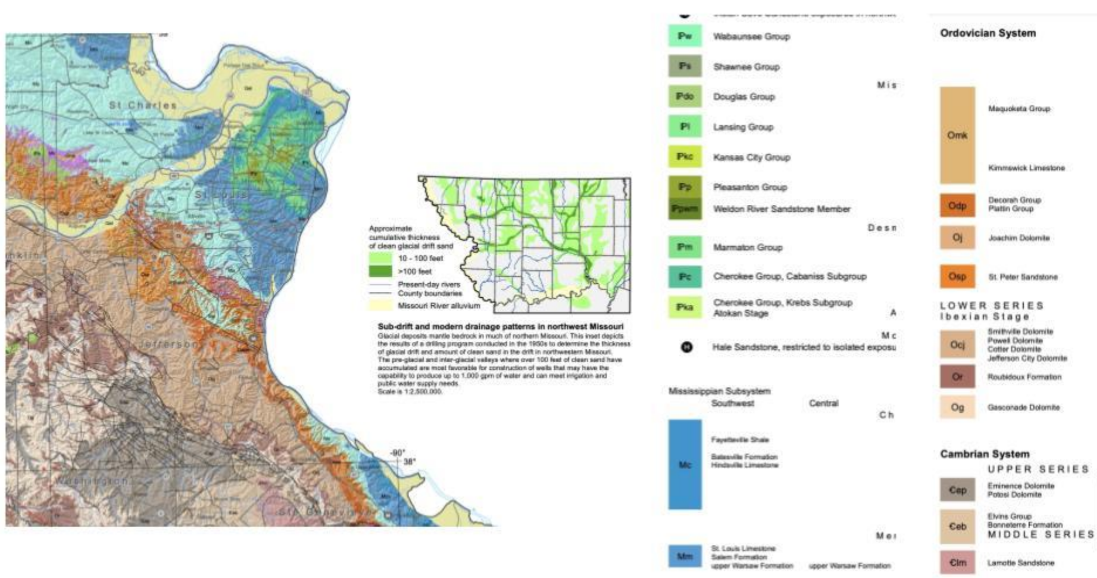

Figure 1.4. Geologic Map of Missouri Area. Map of the prominent geologic features on the Missouri side of the Cahokia-Joaquim watershed, which is dominated by limestones, shales, and sandstones from ancient oceans.

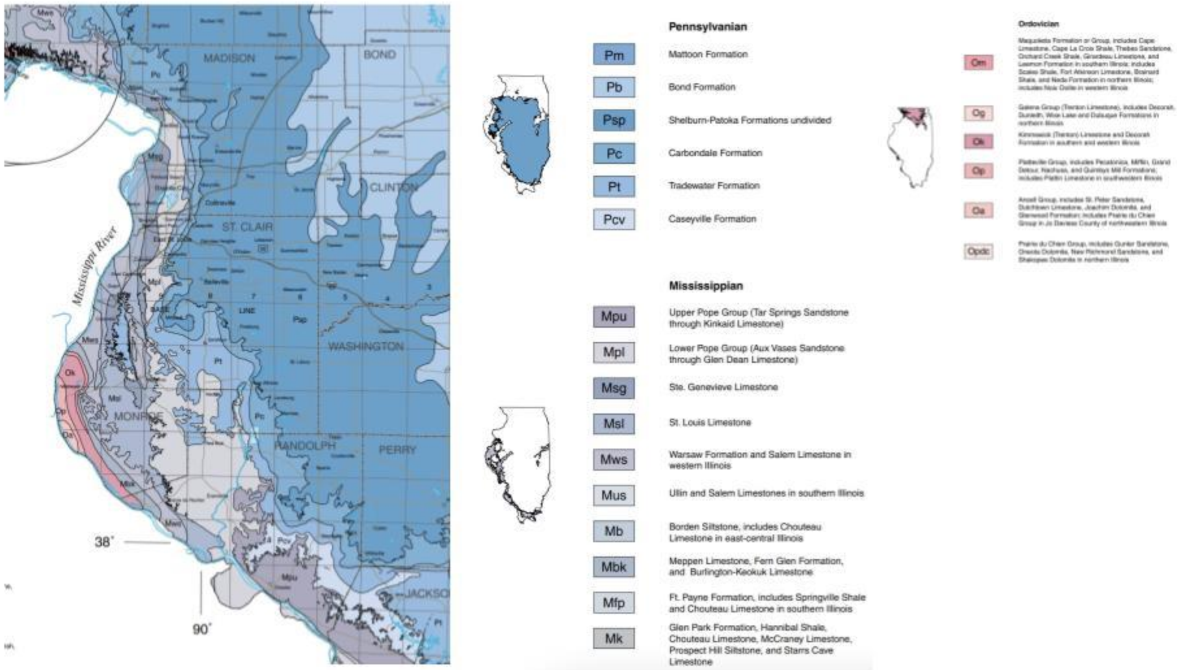

Figure 1.5. Geologic Map of Illinois Study Area. Map of the prominent geologic features on the Illinois side of the Cahokia-Joaquim watershed, dominated by limestones, shales, and sandstones.

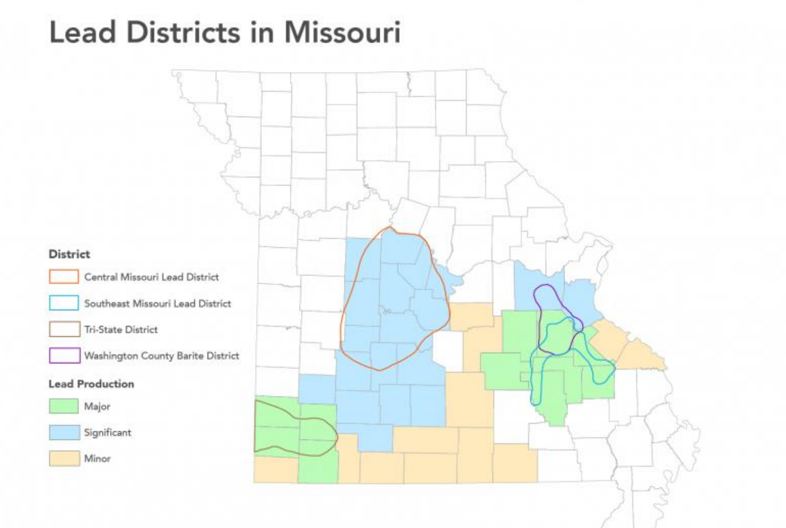

Figure 1.6. Geologic Map of Lead Smelting and Mining Areas in Missouri. Map created by the Missouri Department of Natural Resources illustrating the areas of Missouri known for lead mining and smelting, which could introduce lead contamination into the Cahokia-Joaquim watershed.

1.6 Soil Characteristics

Soil permeability along the Mississippi River is fairly low (Figure 1.7) due to the presence of silty clay and silty clay loam alongside the river (Figure 1.10). Soil along the western side of the river is more susceptible to erosion than along the eastern side (Figure 1.8). However, areas even further east from the river are also highly erodible, similar to the western portion (Figure 1.8). Many areas along the riverbed have low to very low infiltration rates (Figure 1.9). These soil characteristics indicate there may be a high risk of flooding and large volumes of runoff within the watershed during precipitation events, and corresponding risks of erosion and sediment transport.

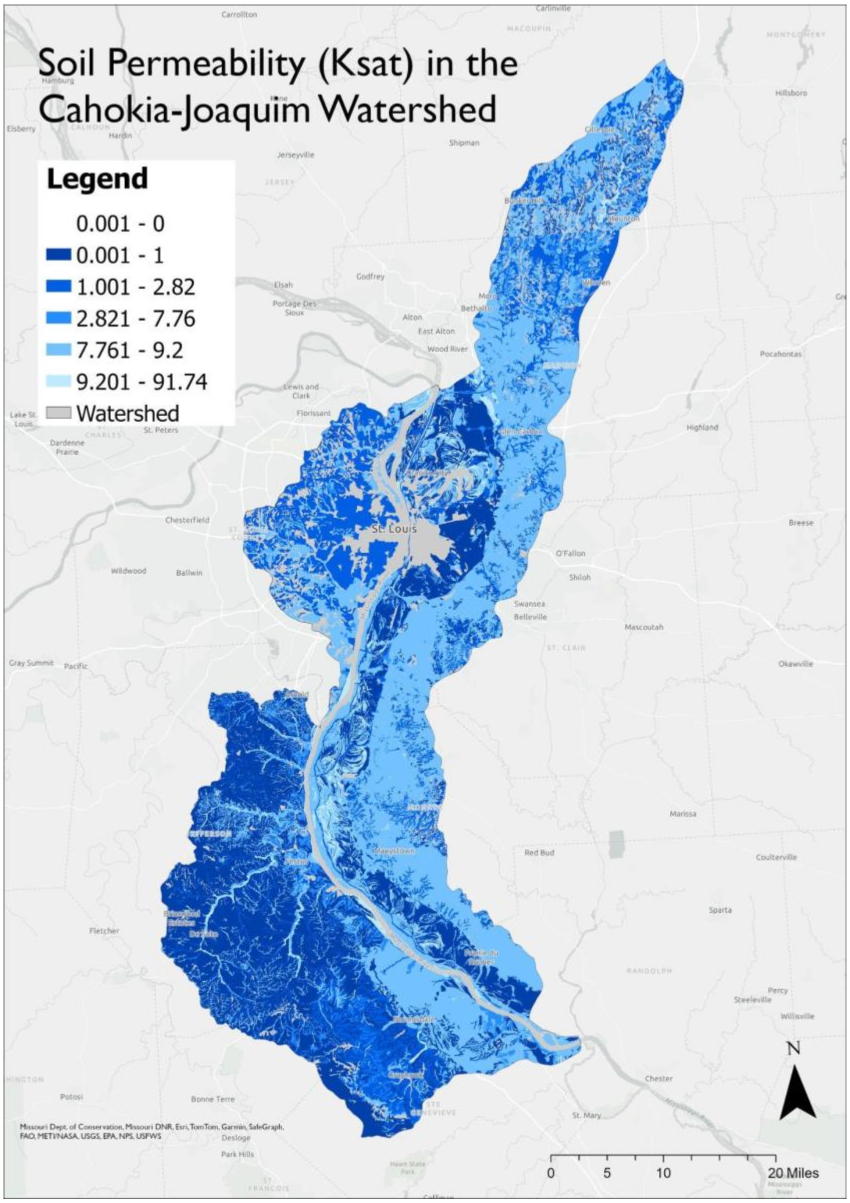

Figure 1.7. Soil permeability in the Cahokia-Joaquim Watershed. Permeability is measured by soil saturated hydraulic connectivity (Ksat). Lower permeability soils are shown in darker

blue, while higher permeability soils are shown in lighter blue. Gray areas within the watershed boundary lack adequate data.

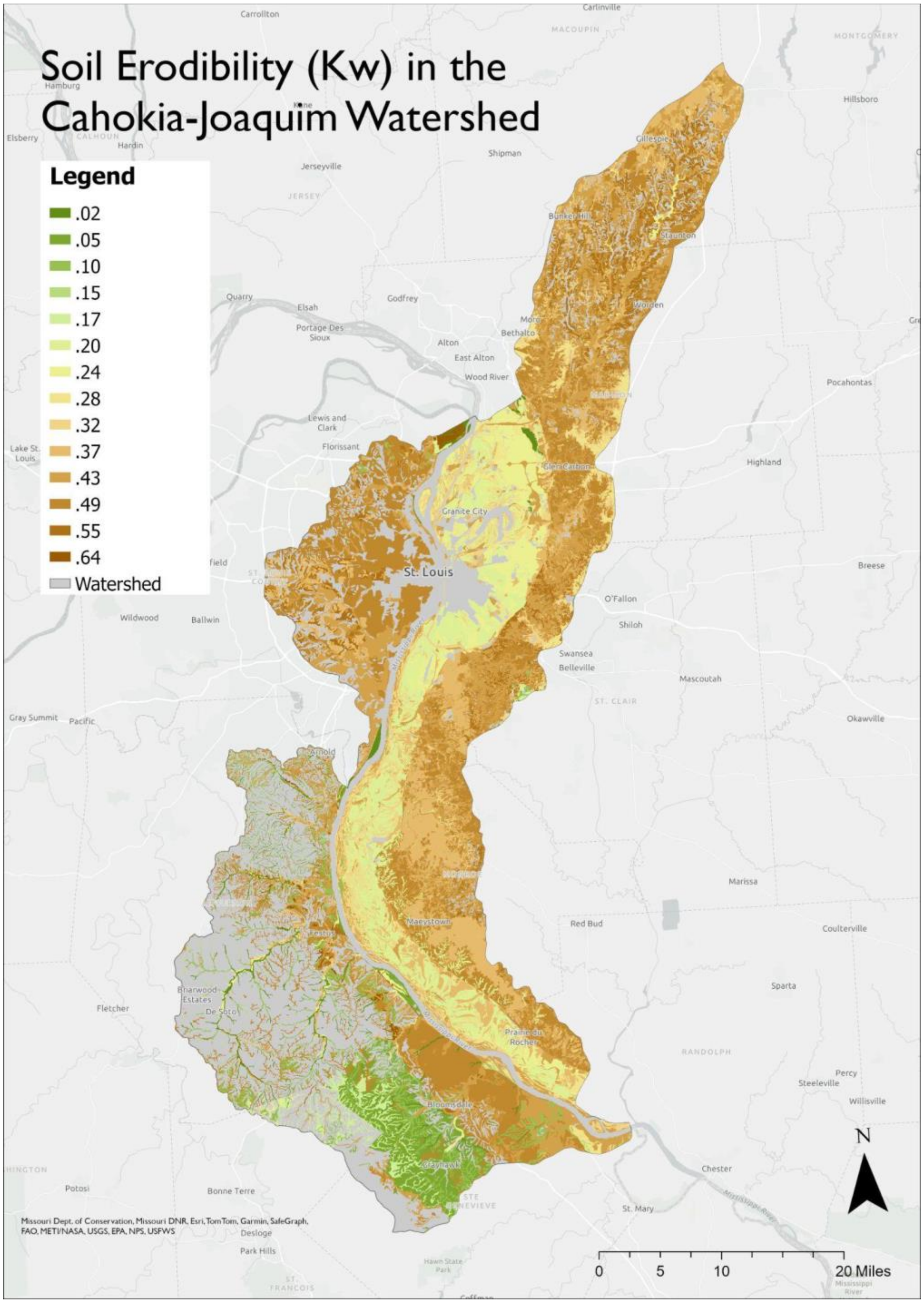

Figure 1.8. Soil erodibility in the Cahokia-Joaquim Watershed. Erodibility is quantified by the whole soil erodibility factor (Kw). More easily erodible soils are shown in brown (larger Kw), while less erodible soils are shown in green (smaller Kw). Gray areas within the watershed boundary lack adequate data.

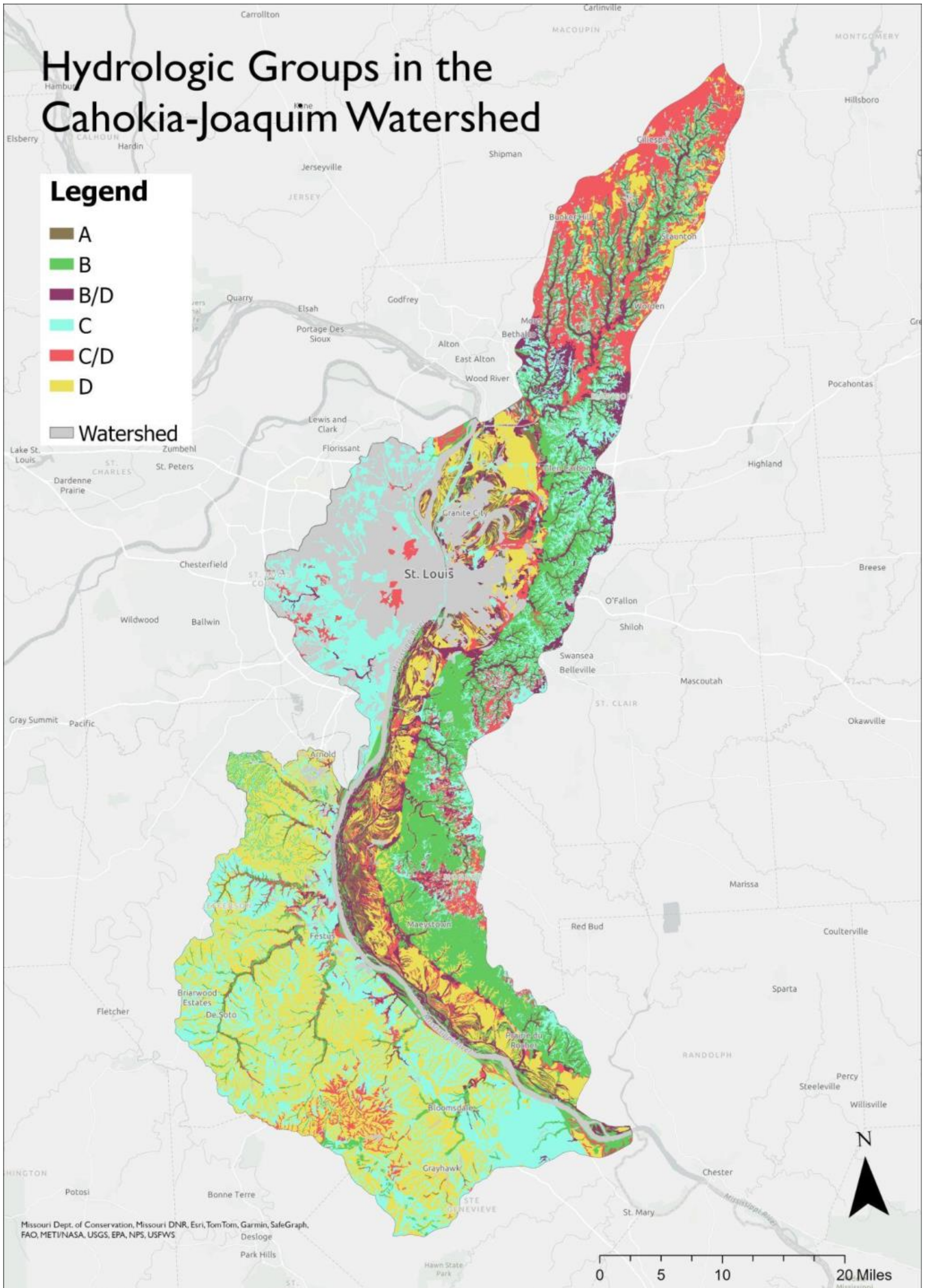

Figure 1.9. Soil hydrologic groups in the Cahokia-Joaquim watershed. Groups range from A (high infiltration, low runoff potential) to D (low infiltration, high runoff potential). Groups B/D and C/D have a very low infiltration rate and high runoff potential under natural conditions, but would have higher rates of infiltration if drained. Each group is visualized with a unique color on

the map. Gray areas within the watershed boundary lack adequate data or are too highly modified from the original state to be mapped to these hydrologic groupings.

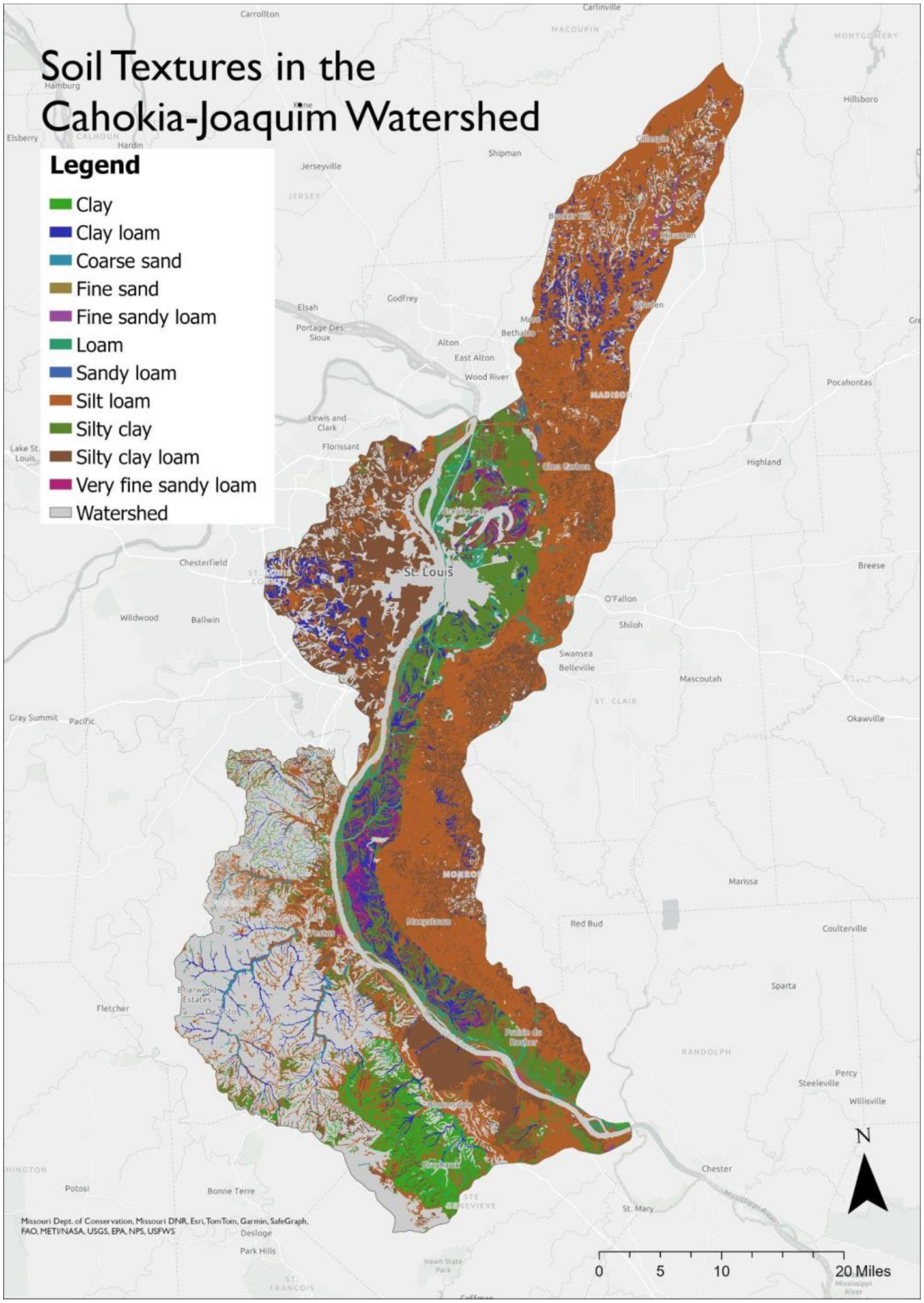

Figure 1.10. Soil textures in the Cahokia-Joaquim watershed. Most soil within the watershed is silt loam, silty clay, or silty clay loam. Each soil texture is visualized with a unique color in the map. Gray areas within the watershed boundary lack adequate data.

1.7 Hydrology

The Cahokia-Joaquim watershed is composed of hundreds of small tributaries leading into the Mississippi. One of the major tributaries is the Missouri River, the longest river in the United States, with a length of 2,540 miles (U.S. Census Bureau, 2011). Its headwaters are in Montana and drains over 529,000 square miles into the Mississippi River just North of St. Louis. Compared to the Mississippi, the Missouri River has almost three times the amount of suspended sediment, making it much more turbid (Umar et.al, 2018).

The Meramec River begins South of St. Louis in Salem, Missouri, and flows freely for 218 linear miles to its confluence with the Mississippi. While the Army Corps of Engineers attempted to erect a dam on the river in the early 1970s, the local chapter of the Sierra Club successfully fought off damming attempts (Jackson et al., 1984). The watershed surrounding the Meramec drains over 2,149 square miles (Blanc et al., 1998). This river is also impacted by mining in the Old Lead Belt, where significant storm events mobilize heavy metals, causing the Meramec to mobilize up to 27.2 tons of lead and 14.5 tons of zinc (Markland and Buckley, 2024).

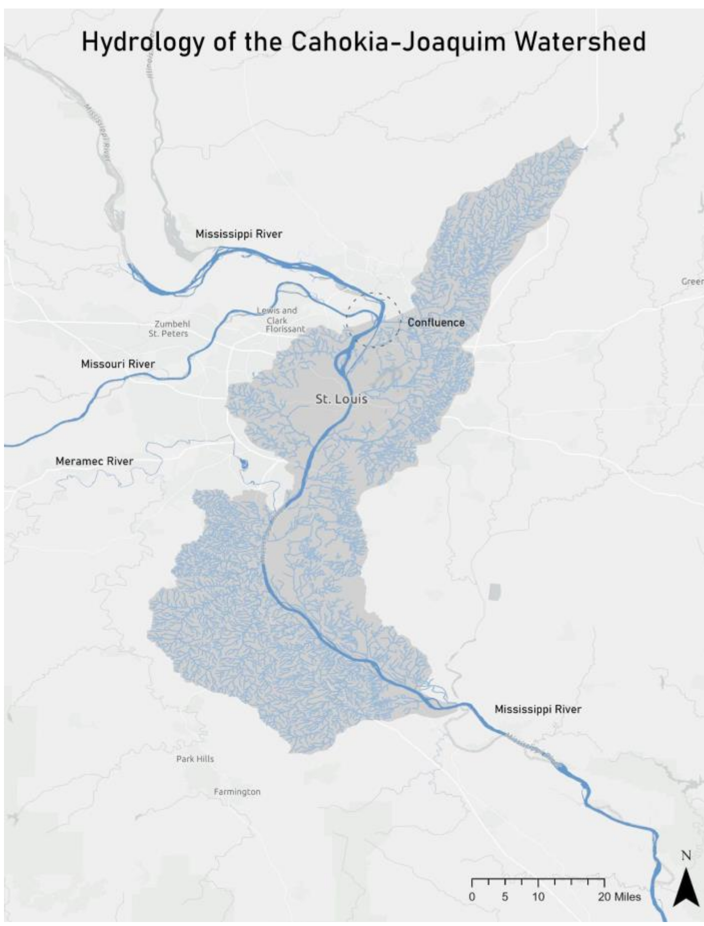

Figure 1.11. Map of Rivers in the Study Area. This map shows the major hydrologic features in the study area, including the Missouri, Mississippi, and Meramec Rivers.

1.8 Land Use

Forests, agriculture, and residential use dominate land cover type in the Cahokia-Joaquim watershed. Forest covers most of the area in the southern portion of the watershed west of the Mississippi River. Cropland and pasture span along the eastern banks of the Mississippi River and cover much of the land in the northern reaches of the watershed. Residential areas are centered around St. Louis, MO, west of the Mississippi River. Relatively low percentages of land in the Cahokia-Joaquim watershed are used for commercial or industrial use. Wetlands currently only cover about 3.44%. Surface water bodies have primarily been engineered and channelized and now cover only about 3.37% of total area in the Cahokia-Joaquim watershed (Table 1.1; Figure 1.12).

Table 1.1. Land Use in the Cahokia-Joaquim Watershed. Empirical and relative land cover type provided by National Land Cover Database (NLCD) 2019 raster.

Land Use Type	Area (Square Kilometers)	Percent Cover
Water	144.59	3.37%
Residential	1,063.32	24.76%
Commercial/Industrial	134.61	3.13%
Barren Land	19.39	0.45%
Forest	1,434.05	33.42%
Rangeland	24.12	0.56%
Cropland/Pasture	1,327.44	30.90%
Wetland	147.76	3.44%
Total	**4,295.28**	100%

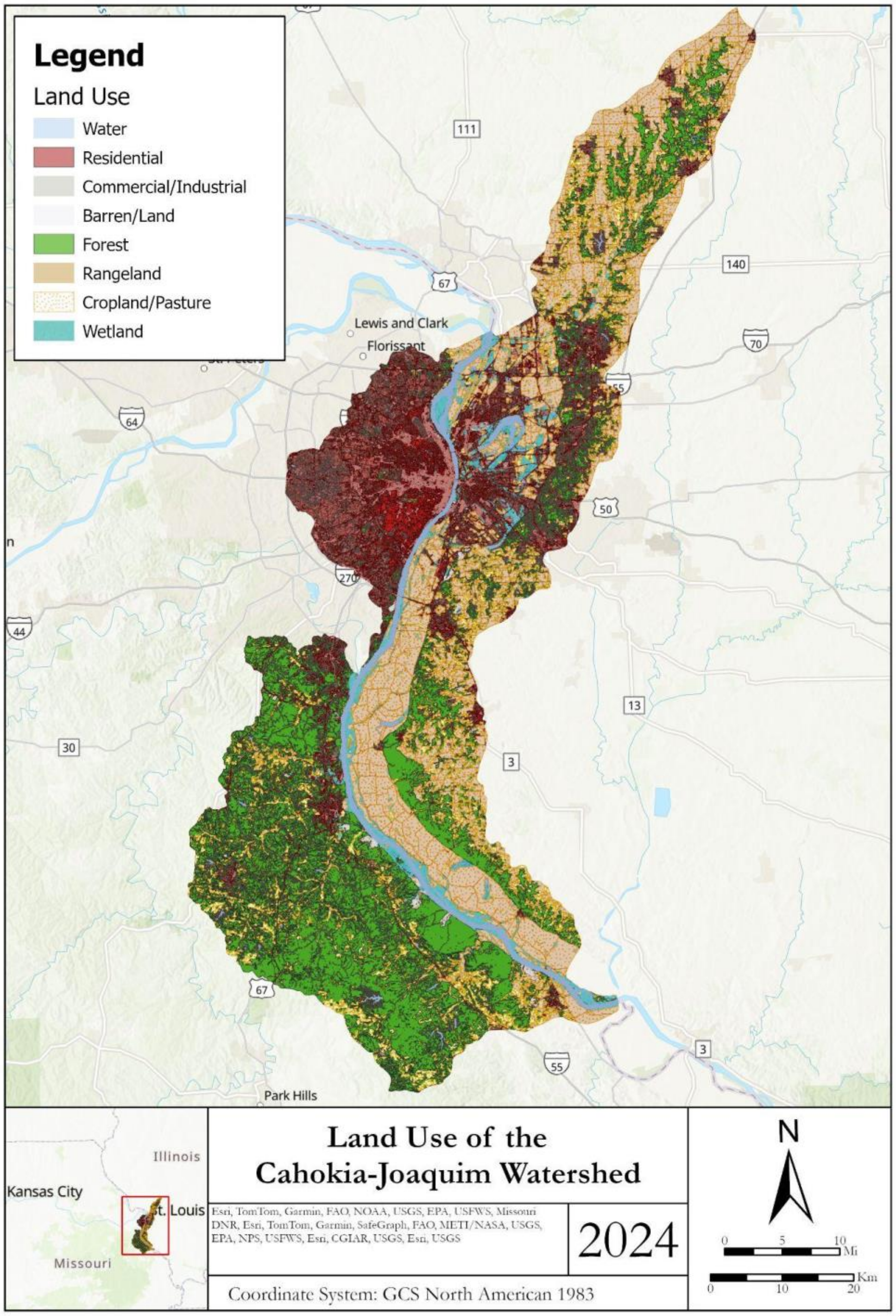

Figure 1.12. Land Use of the Cahokia-Joaquim Watershed. Forests (Green) cover about a third of the total land cover. The next most prevalent land use type is Agriculture, including Rangeland (Light Brown) and Cropland/Pasture (Light Brown Dappled). About a quarter of the watershed is Residential (Red).

1.9 Biological Assets

The Cahokia-Joachim Watershed provides habitat for hundreds of species of aquatic invertebrates, fish, migratory birds, mammals, reptiles and amphibians, and plants. Historically, the watershed comprised old-growth forests, woodlands, tall grass prairies, and wetlands that supported a variety of wildlife (Missouri Department of Conservation, n.d.). Today, the watershed is largely urbanized, and one of the primary waterways in St. Louis— the River des Peres— is channelized, partially buried, and used for sewage and stormwater runoff (The Cultural Landscapes Foundation, n.d.). As a result, wildlife is negatively impacted by water quality degradation and by loss of habitat. Migrating birds, such as the American Bittern (*Botaurus lentiginosus*), Bachman's sparrow (*Peucaea aestivalis*), and Northern Harrier (*Circus hudsonius*) rely on the ecosystem habitats in the Cahokia-Joachim watershed for nesting and hunting (Missouri Department of Conservation, n.d.). The health and size of the birds' prey populations, especially amphibians, depend on the sufficient flow and quality of freshwater in the system (Tualatin Soil and Water Conservation District, 2021).

Several species declared endangered by either the federal government or the states of Missouri and Illinois are found in the Cahokia-Joachim watershed. This includes six species of aquatic invertebrates: Ebonyshell (*Fusconaia ebena*), Elephantear (*Elliptio crassidens*), Pink Mucket (*Lampsilis abrupta*), Scaleshell (*Leptodea leptodon*), Sheepnose/Bullhead (*Plethobasus cyphyus*), and Snuffbox (*Epioblasma triquetra*). Aquatic invertebrates are useful indicators of stream quality because many species are sensitive to water pollution and may exhibit the first observable population decline in response to degraded water quality. The watershed is also home to the endangered mammals, the Gray bat (*Myotis grisescens*) and Indiana bat (*Myotis sodalis*); endangered amphibians and reptiles, Blanding's Turtle (*Emydoidea blandingii*) and Eastern Hellbender (*Cryptobranchus alleganiensis alleganiensis*); and the endangered Pallid sturgeon (*Scaphirhynchus albus*) (Missouri Department of Conservation, n.d.).

Table 1.2. Endangered Species in the Cahokia-Joaquim Watershed.

Endangered Species in the Cahokia-Joaquim Watershed	
Aquatic Invertebrates	Ebonyshell (*Fusconaia ebena*); Elephantear (*Elliptio crassidens*); Pink Mucket (*Lampsilis abrupta*); Scaleshell (*Leptodea leptodon*); Sheepnose/Bullhead (*Plethobasus cyphyus*); Snuffbox (*Epioblasma triquetra*)
Mammals	Gray bat (*Myotis grisescens*); Indiana bat (*Myotis sodalis*)
Amphibians & Reptiles	Blanding's Turtle (*Emydoidea blandingii*); Eastern Hellbender (*Cryptobranchus alleganiensis alleganiensis*)
Plants	Decurrent False Aster (*Boltonia decurrens*)
Fish	Pallid sturgeon (*Scaphirhynchus albus*)


Eastern Hellbender
Source: The Orianne Society


Blanding’s Turtle
Source: Wilton Wildlife Preserve & Park

1.10 Summary

Located in the Rust Belt, the Cahokia-Joaquim watershed has been shaped by nearly 150 years of industrialization and human activity, impacting its soils, land use, and ecological integrity. The fertile soils– historically enriched by periodic flooding of the Mississippi River– have been utilized for agriculture. However, their low permeability and high susceptibility to erosion have increased runoff and flood risk, has exacerbated sediment transport into water bodies. Lead extraction and smelting, which have historically capitalized on the region’s rich geologic deposits, particularly galena, have left a legacy of heavy metal contamination in local waterways, such as the Meramec River. Urbanization, concentrated around St. Louis, has replaced vast stretches of native forests, wetlands, and grasslands, reducing habitat availability for wildlife and further contributing to degraded water quality through channelization and stormwater runoff. These impacts have likely had cascading effects on the watershed's biodiversity, particularly on sensitive or endangered species. Furthermore, the watershed’s role as a critical drainage area into the Mississippi River underscores its broader significance, as it affects downstream ecosystems, including the Gulf of Mexico’s hypoxic zone.

2.0 Population Dynamics and Water Use

2.1 Introduction

Ensuring the sustainability of safe and reliable sources of water for all major users is a key goal of watershed planning and management. The demands for water must be balanced with the available supply, and planners must account for changes or uncertainties over long time horizons. Water supplies may come from a diversity of sources including surface water, groundwater, desalination plants, or large-scale water transport infrastructure. Likewise, many factors influence the demand for water in a given region, including population changes, water use intensity, energy and industry needs, and agricultural usage. This section examines how these elements independently and in combination shape water supply and demand in the Cahokia-Joaquim watershed.

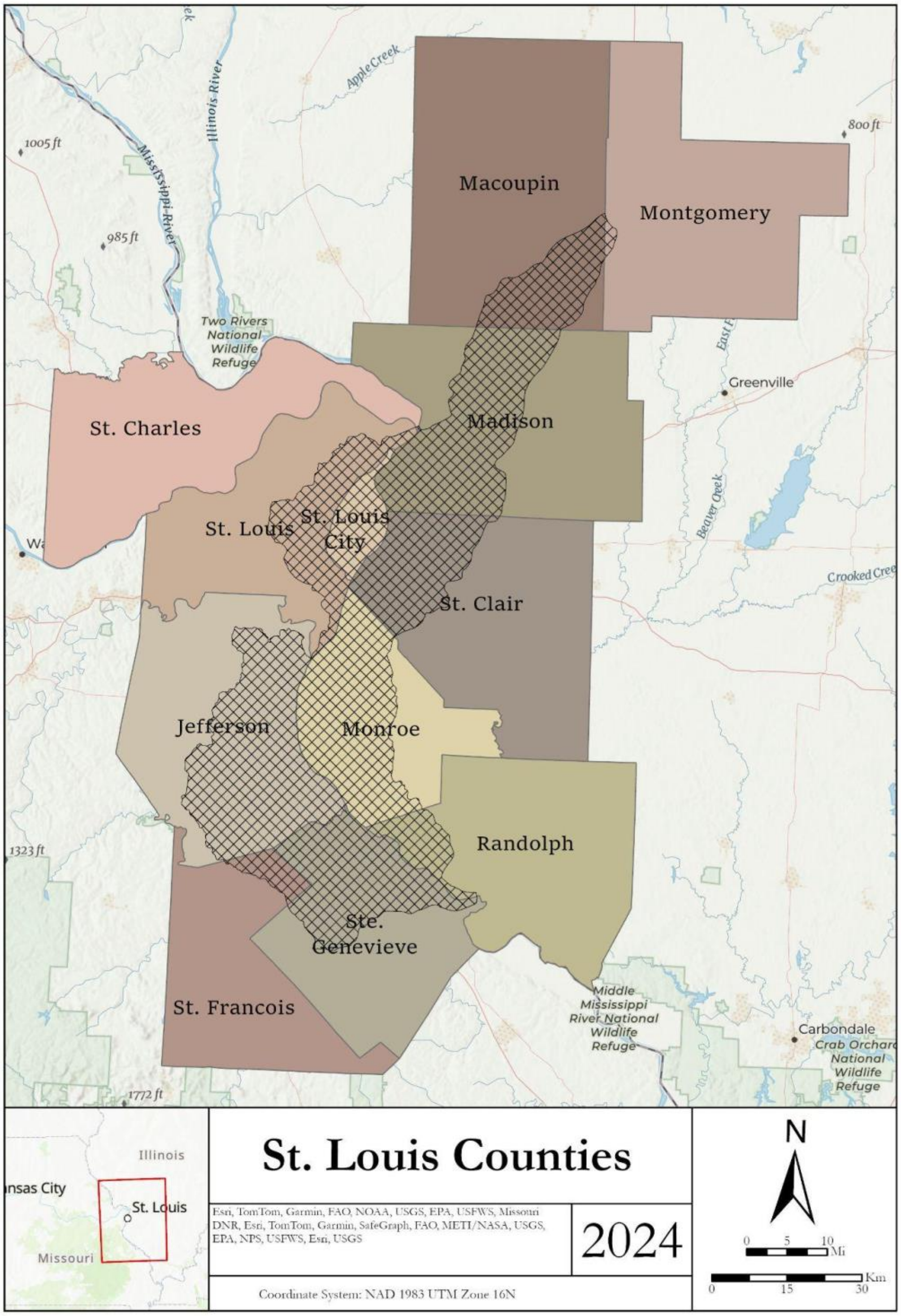

Figure 2.1. Counties of Missouri and Illinois within the Cahokia-Joaquim Watershed. This map serves as a reference for interpretation of the socioeconomic and water supply data included in this report, which is often reported at the county level.

2.2 Population and Socioeconomic Conditions

The Cahokia-Joaquim watershed encompasses 12 counties, six in Missouri and six in Illinois (Figure 2.1). The counties are of varying sizes, the largest by population being St. Louis County, MO and the smallest being Montgomery County, IL. The current population in the entire watershed is 2.7 million people. The watershed's population has grown by 7.9% overall since 1990, with an average growth rate of 0.3% per year (Table 2.1).

The St. Louis metropolitan area has a long history of racism and segregation, the effects of which can be seen in the region's demographic and socio-economic trends today (Fehler et al., 2019). St. Louis, MO, is the major city within the region. It had a population of 301,578 as of 2020, but its size has been decreasing steadily since 1990, a trend that is likely to continue (Table 2.1). This is largely due to the movement of mostly white, affluent, college-educated residents moving out of the city center and into the suburbs across Jefferson, St. Charles, St. Louis, and Monroe Counties (Table 2.2). Many of these counties are experiencing population growth while the city center and smaller, more rural counties experience declines.

Some of the major industries in the area are manufacturing, bioscience and health sciences, digital services and technology, and financial and business services (Greater St. Louis, Inc., n.d.). Given its location on the Mississippi River and at the intersection of many major highways and railroads, there is a large shipping and transportation sector as well (Greater St. Louis, Inc., n.d.-b). In addition, the St. Louis area is closely tied to the agricultural industry: it is home to many agribusiness and agricultural technology companies and in close proximity to major agricultural lands (Greater St. Louis, Inc., n.d.-a). The combined presence of industry, shipping, agriculture, and urbanization places a range of demands on the water supply and impacts water quality throughout the watershed.

Table 2.1. Populations of counties within the Cahokia-Joaquim watershed, 1990 - 2020. Data obtained from the US Census Bureau and Van Leuven (2022).

County	1990	2000	2010	2020	% Change (1990 - 2020)	Annual % Change (1990 - 2020)
Missouri						
Jefferson	171,380	198,099	218,733	226,739	32.3	1.1
St. Charles	212,907	283,883	360,485	405,262	90.3	3.0
St. Francois	48,904	55,641	65,359	66,922	36.8	1.2
Ste. Genevieve	16,037	17,842	18,145	18,479	15.2	0.5
St. Louis	993,529	1,016,315	998,954	1,004,125	1.1	0.04

St. Louis City	396,685	348,189	319,294	301,578	-24.0	-0.8
Illinois						
Macoupin	47,679	49,019	47,765	44,967	-5.7	-0.2
Madison	249,238	258,941	269,282	265,859	6.7	0.2
Monroe	22,422	27,619	32,957	34,962	55.9	1.9
Montgomery	30,728	30,652	30,104	28,288	-7.9	-0.3
Randolph	34,583	33,893	33,476	30,163	-12.8	-0.4
St. Clair	262,852	256,082	270,056	257,400	-2.1	-0.1
Total	**2,486,944**	**2,576,175**	**2,664,610**	**2,684,744**	**7.9**	**0.3**

Table 2.2. Median household income and education level for counties within the Cahokia-Joaquim watershed. Data obtained from the US Census Bureau.

County	Median Household Income ($)	% with Bachelor's Degree or Higher
Missouri		
Jefferson	81,843	25.8
St. Charles	98,390	41.9
St. Francois	55,042	16.7
Ste. Genevieve	61,215	16.4
St. Louis	81,441	48.7
St. Louis City	56,245	45.1
Illinois		
Macoupin	64,706	19.3
Madison	73,041	33.7
Monroe	100,685	37.9
Montgomery	61,796	18.2
Randolph	63,860	13.7

St. Clair	65,546	30.8
Average	**70,586**	**26.6**

2.3 Water Supply

The Cahokia-Joaquim Watershed primarily relies on surface water from precipitation and the Missouri and Mississippi Rivers. The water supply in this region is abundant, local, and independently sustainable. Groundwater is not a significant source of supply, nor is water imported, reclaimed, or recycled (St. Louis Planning and Urban Design Agency, n.d.). Almost 3,000 Mgal/day of surface water is used compared to 115.54 Mgal/day by groundwater. The only counties that utilize more groundwater than surface water are St. Francois, Ste. Genevieve and Randolph counties which have the smallest populations in the watershed (Table 2.3). Given the plentiful surface water from the nearby rivers and consistent rainfall, there is no major concern regarding lack of adequate water quantity. The main focus instead is on managing flooding and maintaining water quality for essential uses such as drinking, agriculture, and landscaping (St. Louis Planning and Urban Design Agency, n.d.).

In terms of sustainability, the watershed's primary challenge revolves around keeping the water clean enough for its intended uses. Water treatment facilities and regular monitoring systems are in place to address concerns about contamination and pollution, ensuring that the surface water remains safe for use into the future. While there is little information on groundwater levels, there is no indication of declining levels, as groundwater resources are not heavily utilized in this region. The primary water stress indicators revolve around maintaining water quality, rather than supply, to support the local population and ecosystem (Consumer Confidence Report, 2023).

Table 2.3. Total Surface and Groundwater Use of the Counties in the Cahokia-Joaquim Watershed in 2015. Data obtained from the USGS Water-Use Data-Gap Analysis Storymap.

County	2015 Surface Water Use (Mgal/day)	2015 Groundwater Use (Mgal/day)
Jefferson	965.94	12.42
St. Charles	627.63	20.12
St. Francois	0.41	6.36
Ste. Genevieve	0.30	7.87
St. Louis	542.33	3.16
St. Louis City	92.86	0.34

Macoupin	3.49	0.99
Madison	285.71	50.68
Monroe	0.22	2.33
Montgomery	427.55	2.07
Randolph	22.99	1.87
St. Clair	29.91	7.33
Total	**2,999.34**	**115.54**

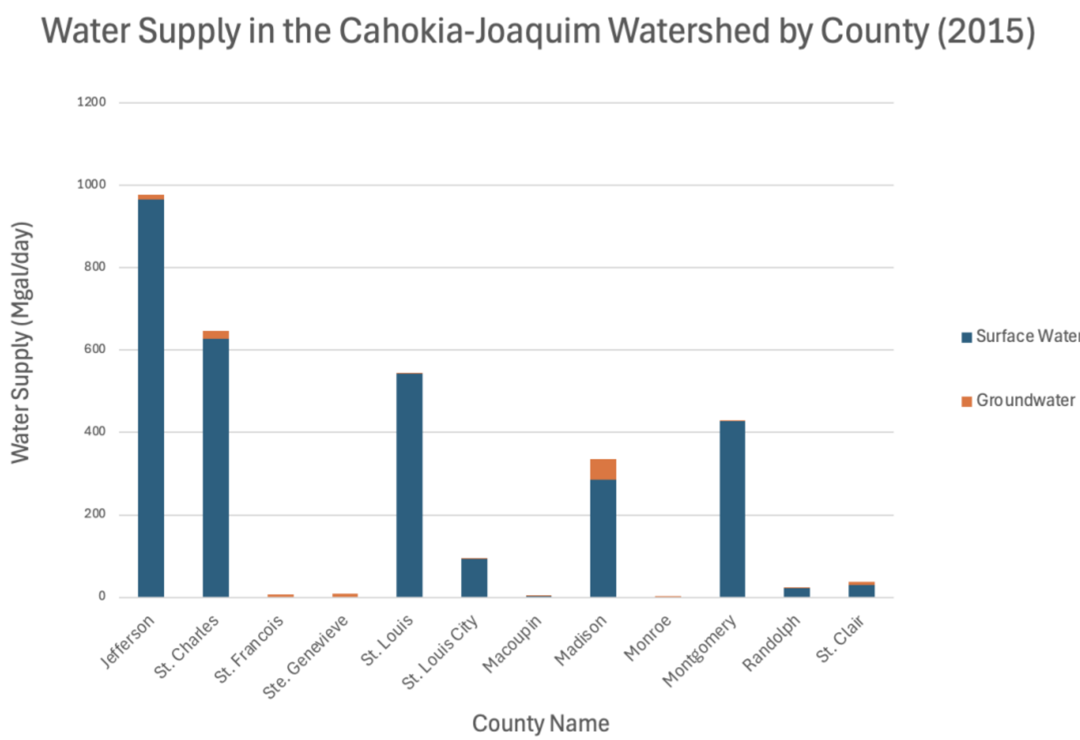

Figure 2.2. County-level Water Supply Data for the Year 2015 Provided by USGS. The heaviest water users are Jefferson, St. Charles, and St. Louis counties. All counties primarily rely on surface water to meet their water use needs, apart from St. Francois, St. Genevieve, and Monroe which rely on small amounts of groundwater withdrawal.

2.4 Overall Water Demand

As described above, the population of counties within the Cahokia-Joaquim Watershed varies drastically. This discrepancy can also be visualized in the water demanded by each county. Across most sectors, the more urbanized Missouri counties require significantly more water than the smaller, less urbanized counties in Illinois (Figure 2.3). For example, St. Louis City demands over 300 Mgal/day from public supply, while Monroe County in Illinois demands only 10 Mgal/day. This demand is also distributed among different sectors: domestic, industrial, thermoelectric, mining, and agricultural irrigation.

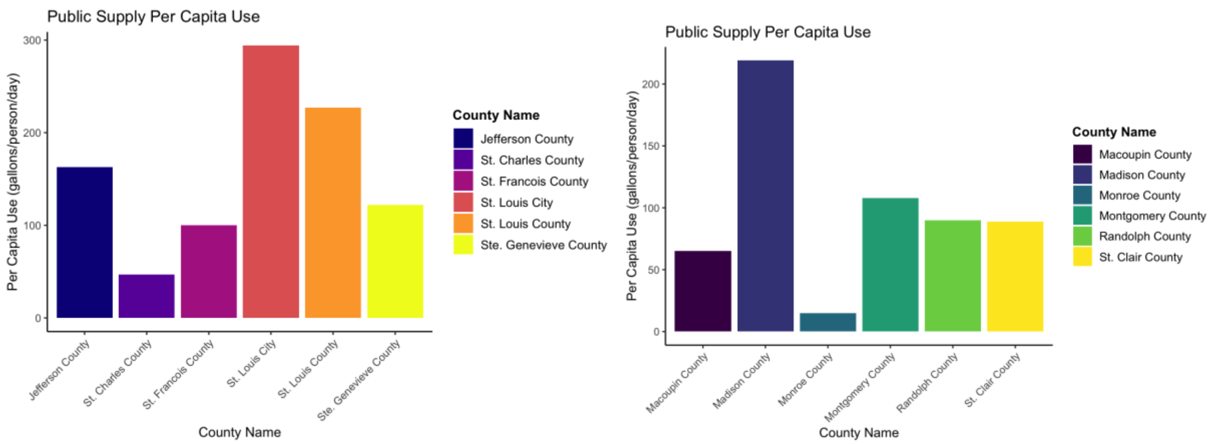

Figure 2.3. Total Demand for Water from Public Supply in the Counties in the Cahokia-Joaquim Watershed. The total amount of water demanded from public supply per capita in each of the counties that compose the watershed. Data from the USGS Water Data for the Nation.

2.4 Domestic Water Demand

The domestic self-supplied withdrawals and deliveries category applies to all water being withdrawn directly by landowners or supplied by a public utility (USGS, 2019). While four Missouri counties require over 20 Mgal/day, only two reach this threshold in Illinois: St. Clair County and Madison County (Figure 2.4). This is likely due to each county having a larger city: Belleville and Edwardsville. While one would expect St. Louis City to have the highest overall water withdrawals for domestic use, St. Louis County has the larger overall population and is home to most domestic dwellings.

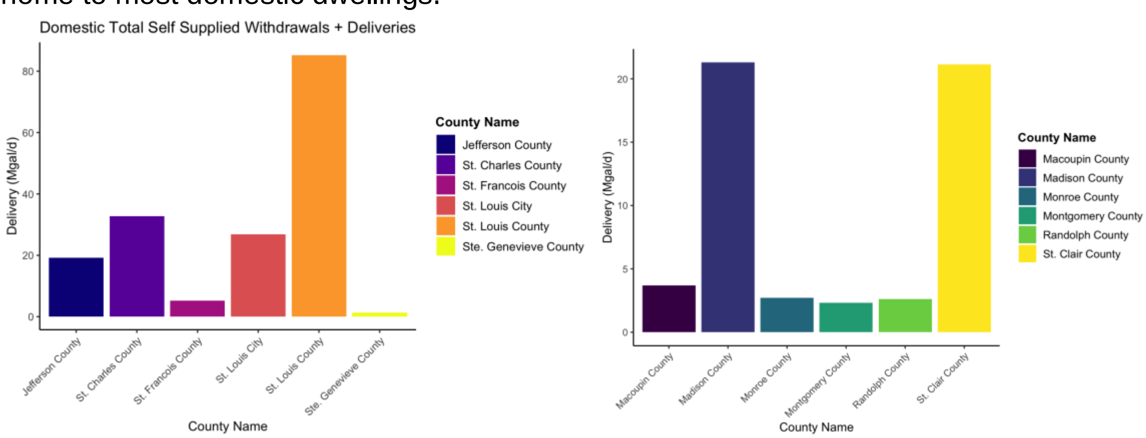

Figure 2.4. Total Domestic Water Demand in the Counties in the Cahokia-Joaquim Watershed. The total amount of self-supplied and delivered water (from public utilities)

consumed per day in each of the counties that compose the watershed. Data from the USGS Water Data for the Nation.

2.5 Water Demand from Mining

Compared to the water needed to fulfill the demand for domestic uses, the water needed for mining is minimal. Ste. Genevieve County in Missouri has the highest water use throughout the watershed, totaling 4 Mgal/day (Figure 2.5). Urban areas, such as St. Louis City and St. Charles County, have the lowest amount of mining, while less urbanized counties have between 1-4 Mgal/day appropriated to mining.

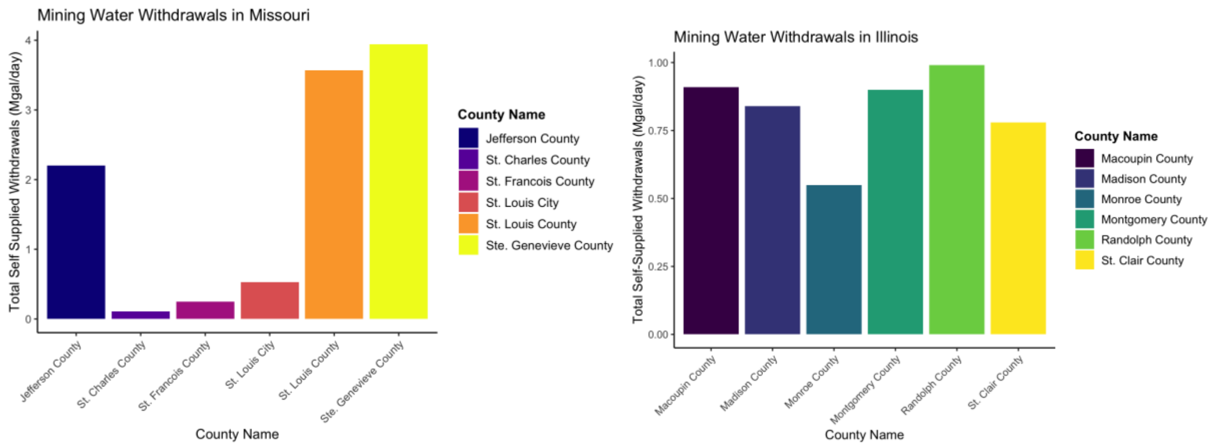

Figure 2.5. Total Water Demand from Mining in the Counties in the Cahokia-Joaquim Watershed. The total amount of self-supplied water consumed per day for the purpose of mining in the counties that compose the watershed. Data from the USGS Water Data for the Nation.

2.6 Water Demand for Power Generation

Power generation is one of the largest uses of fresh water across the watershed. The three most significant users are as follows: Jefferson County in Missouri, with 942.89 Mgal/day, St. Charles County, with 627.21 Mgal/day, and Montgomery County, with 424.85 Mgal/day (Figure 2.6). In total, the watershed withdraws 2,581.18 Mgal/day for thermoelectric power production. The consumptive use from these facilities, or the water that will not be returned to be re-used in the system, is much smaller; however, only requiring 51.99 Mgal/day in total.

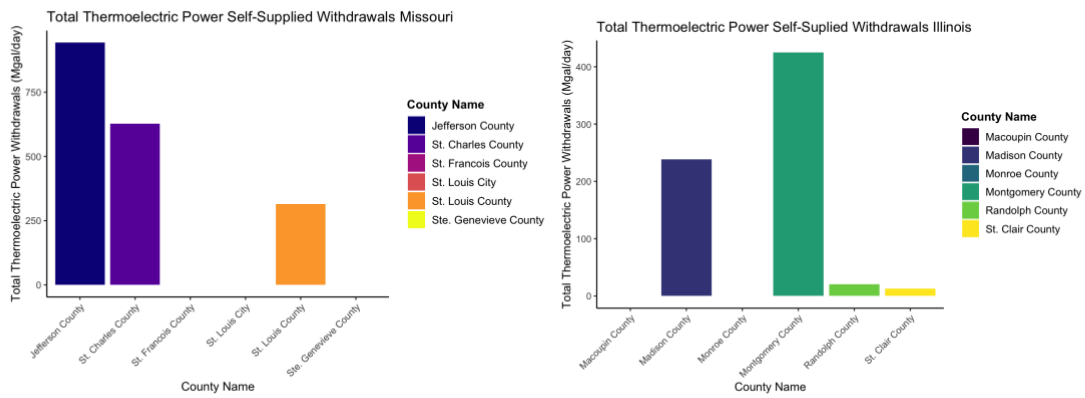

Figure 2.6. Total Water Demand from Thermoelectric Power Generation in the Counties in the Cahokia-Joaquim Watershed. The total amount of self-supplied water consumed per day for the purpose of thermoelectric power generation in the counties that compose the watershed. Data from the USGS Water Data for the Nation.

2.6 Water Demand from Irrigation

Irrigation contributes little to the overall water demand in the watershed. Missouri withdraws 2.56 Mgal/day while Illinois withdraws 2.47 Mgal/day. This withdrawal comes from surface water withdrawals and groundwater extraction, but both factor minimally into the overall water use in the watershed.

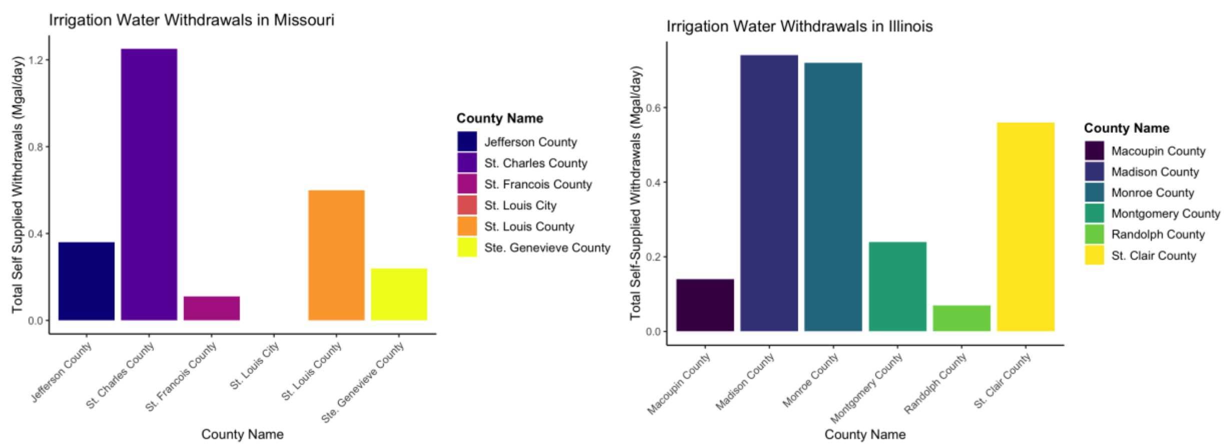

Figure 2.7. Total Water Demand from Irrigation in the Counties in the Cahokia-Joaquim Watershed. The total amount of self-supplied water consumed per day for the purpose of irrigation in the counties that compose the watershed. Data from the USGS Water Data for the Nation.

2.5 Summary

The Cahokia-Joaquim Watershed spans 12 counties across Missouri and Illinois and is characterized by distinct socio-economic and demographic trends that shape its water demands. The population of 2.7 million, largely concentrated in the St. Louis metropolitan area, has grown moderately since 1990, though with notable urban-to-suburban shifts that have impacted growth rates across counties. These shifts, influenced by historical and socio-economic factors, contribute to significant disparities in water demand between urban and rural counties. The watershed’s water supply is predominantly sourced from surface water from the Missouri and Mississippi Rivers, supplemented minimally by groundwater. With roughly 3,000 Mgal/day sourced from surface water and a comparatively low reliance on groundwater, the Cahokia-Joaquim Watershed currently faces few issues with water scarcity. However, the watershed's sustainability hinges on maintaining water quality amid increased industrial, agricultural, and urban demands. Efforts to mitigate pollution, monitor contaminants, and manage flooding are vital to ensuring a safe and sufficient water supply for both human and ecological needs. In summary, the watershed plan must prioritize water quality management while balancing diverse water demands across a socio-economically varied population to secure long-term water resource sustainability for all users.

3.0 Land Use, Zoning, and Designated Uses in the Cahokia-Joaquim Watershed

3.1 Introduction

The Cahokia-Joaquim watershed has been urbanized since the establishment of St. Louis as a major trade and industrial hub in 1823. Before the Industrial Revolution, many watersheds were characterized by pristine forests; however, in the past two centuries, urban and agricultural land use has dominated. These land uses significantly alter both the hydrology of the watershed and the quality of water entering rivers; introducing pollutants, excess nutrients, and solid waste. A comprehensive examination of water quality in the watershed is crucial for identifying present challenges, determining their sources, and establishing necessary standards for remediation.

3.2 Existing Land Use Planning

Land use planning in the Cahokia-Joaquim watershed occurs at multiple spatial scales, from the City of St. Louis itself to the broader St. Louis region. As the watershed spans two states and twelve counties, it is impacted by a variety of planning initiatives and regulations. This section describes and juxtaposes land use planning in the urban center of St. Louis and in rural St. Clair County. To conclude, this section reviews the OneSTL initiative, which has worked to unify planning across much of the watershed throughout the past decade.

3.2.1 City of St Louis, Missouri

Planning within the City of St. Louis adheres to the city’s comprehensive plan, the Strategic Land Use Plan, adopted by the city’s planning commission in 2005 and last updated in 2023. By mapping each block of the city, assessing its current and future use potential, and assigning it a strategic land use category (Figure 3.1), the city prioritizes where to enhance and preserve existing assets and where to build new developments (*Strategic Land Use Plan of the St. Louis Comprehensive Plan*, 2005).

The majority of the city is intended for residential use (yellow and orange areas, Figure 1), with elongated strips of commercial use (light pink and red, Figure 1) along major roadways and thoroughfares. Along the western outskirts of the city, many residential areas are zoned for single-family housing (Figure 3.2). As housing density increases with two-family and multi-family dwelling districts closer to downtown (Figure 3.2), impervious surface coverage likely increases which may increase stormwater runoff in those areas. Much of central downtown is occupied by key institutions (hospitals, religious centers, educational institutions) and other mixed use developments (light and dark blue, Figure 3.1), which may also generate stormwater runoff. Many areas along the major highways and the outskirts of the city are intended for business and industrial use (light and dark gray, Figure 3.1 and Figure 3.2), which may release industrial discharges into the river. Finally, much of the greenspace in the city is located in large parks away from the edge of the Mississippi (green, Figure 3.1). Greenspace can mitigate the impacts of flooding, allow for runoff to infiltrate into the ground, and improve the water quality of runoff. These areas of greenspace may provide these benefits locally, but additional open spaces alongside the riverbank may improve the quality of water entering the river even further.

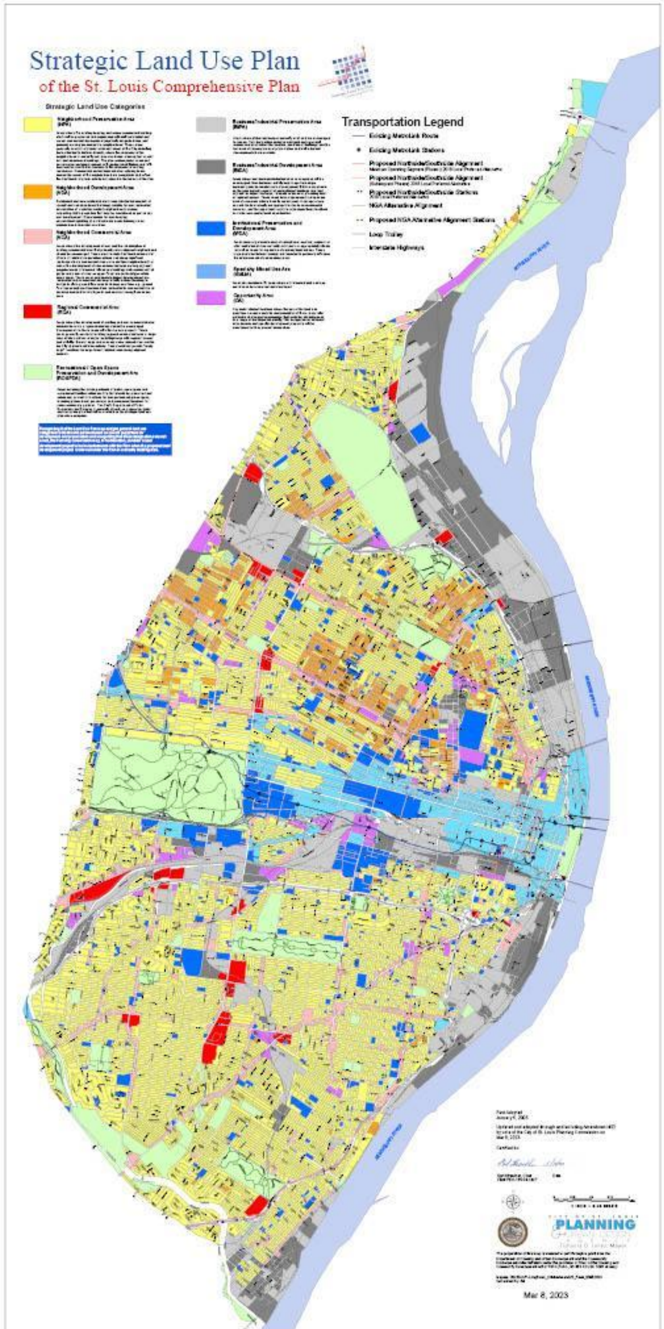

Figure 3.1. Strategic land use plan for the City of St. Louis. Each city block is assigned a strategic land use category, which include: neighborhood preservation areas (NPA), neighborhood development areas (NDA), neighborhood commercial areas (NCA), regional commercial areas (RCA), recreational/open space preservation and development areas (ROSPDA), business/industrial preservation areas (BIPA), business/industrial development areas (BIDA), institutional preservation and development areas (IPDA), specialty mixed use areas (SMUA), and opportunity areas (OA) (*Strategic Land Use Plan of the St. Louis Comprehensive Plan*, 2023).

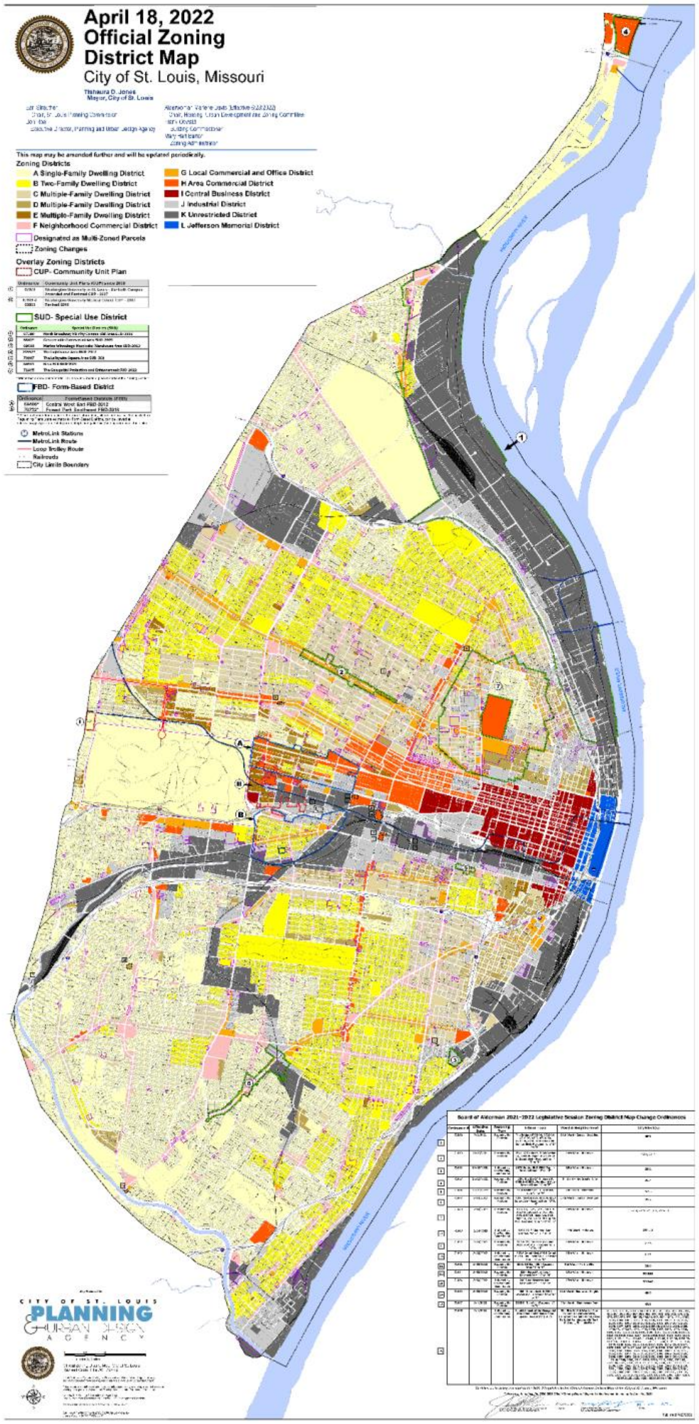

Figure 3.2. Official zoning district map for the City of St. Louis. Each city block is color-coded based upon its zoning district, including residential districts (yellows and browns), commercial and business districts (pink, orange, and reds), industrial and unrestricted districts (grays), and the Jefferson memorial district (blue) (*Citywide Zoning District Map*, 2022).

3.2.2 St. Clair County, Illinois

Across the river from St. Louis, St. Clair County contains a mixture of urban, suburban, and rural land uses. The County's zoning ordinance applies to all unincorporated areas and unzoned municipalities (Figure 3.3). Most (70%) of the county's land is used for agricultural production (*St. Clair County Comprehensive Plan, 2011*), which has implications for agricultural runoff and pollutant loads that may impact water quality. A large air force base (purple in Figure 3.3) may contribute pollutants specific to military and aeronautic operations. Significant development constraints in the area are related to steep slopes alongside the Mississippi river bluff and underlying Karst topography along the western edge of the county, associated with caves, fissures, and sinkholes.

Residential areas may expand across the county to accommodate population growth and development (yellow, Figure 3.4). In addition, a variety of infrastructure improvements to highways and transportation systems may increase the movement of people through the county, and associated roadway pollution. Despite these changes, agricultural land will likely remain a dominant feature of the landscape and a major influence on the waterways (green, Figure 3.4).

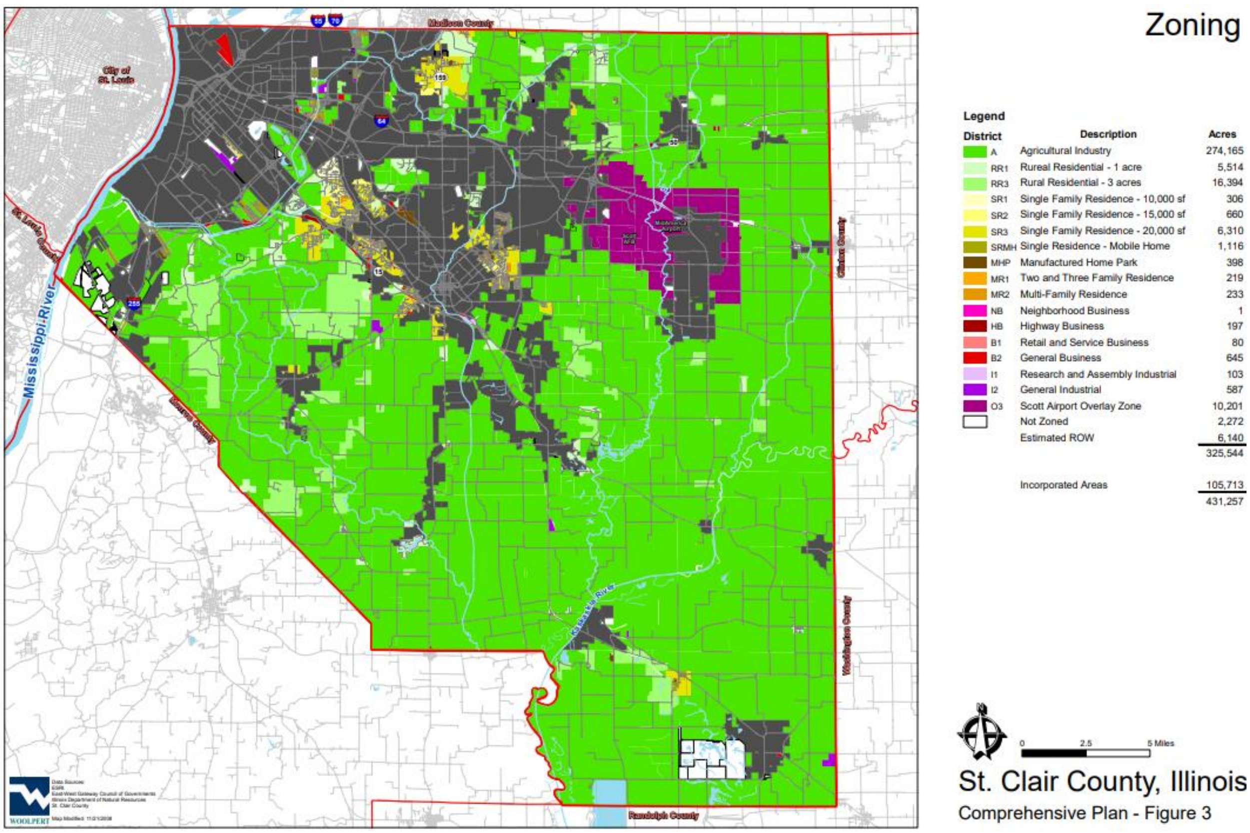

Figure 3.3. Zoning districts for unincorporated areas of St. Clair County. Each parcel of land is color-coded based upon its zoning district, including agricultural and rural residential districts (greens), single family residences (yellows), multi-family residences (oranges), businesses (pinks and reds), industrial (purples), and the airport (magenta). Dark gray areas are incorporated into the zoning districts of individual cities and not shown in detail on this map (*St. Clair County Comprehensive Plan*, 2011).

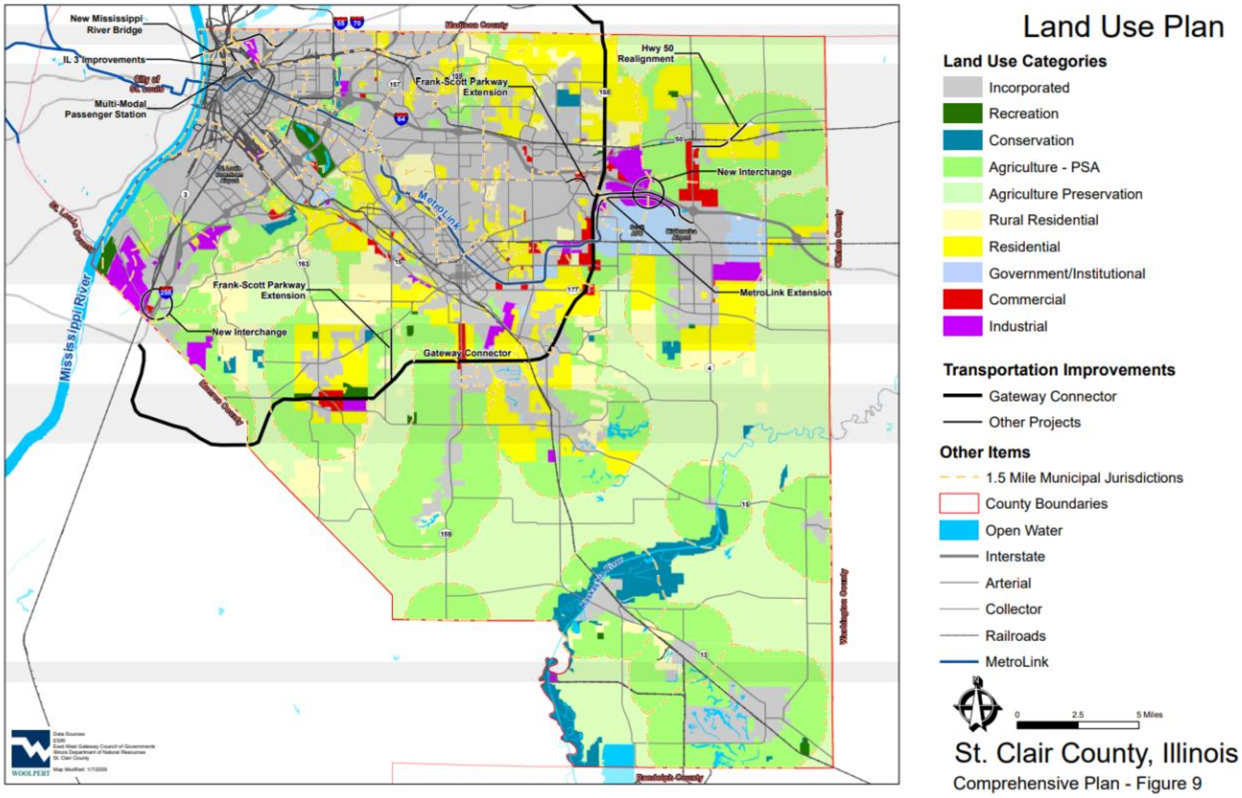

Figure 3.4. Land use plan for unincorporated areas of St. Clair County. Land use categories include recreation, conservation, agriculture, residential, commercial, and industrial. Transportation improvements and infrastructure are also shown and labeled. Light gray areas are incorporated into the zoning districts of individual cities and not shown in detail on this map (*St. Clair County Comprehensive Plan*, 2011).

3.3.3 St. Louis Region

OneSTL is a regional planning initiative that unites eight of the counties in the St. Louis metropolitan area, spanning both the Missouri and Illinois sides of the Mississippi River. OneSTL is focused on five key regional opportunities: 1) economic development, 2) social capital, 3) blue, gray & green infrastructure, 4) transportation, and 5) local communities. The OneSTL plan specifically promotes green objectives such as clean water for all citizens, increased green infrastructure for improved stormwater management, and enhanced sustainability planning for municipalities (Figure 3.5) (East-West Gateway Council of Governments, 2013). Many of these objectives are already being worked towards. For example, the Metropolitan St. Louis Sewer District requires that stormwater best management practices (BMPs) be able to capture 1.14 inches of precipitation on site, which is equivalent to the 90th percentile of daily precipitation events. In addition, they require that BMPs be utilized on new development sites in order to reduce runoff quantities for the site to their pre-construction levels, “to the maximum extent practicable” (Metropolitan St. Louis Sewer District, 2020). These stormwater retention measures are required for compliance with the St. Louis Region Phase II stormwater permit, so they apply to sites across St. Louis city and county. Given these types of regulations and the emphasis on maintaining healthy waterways throughout much of the OneSTL planning document, it is likely that the region will continue to coordinate and improve water quality within the watershed.

Goal 1:	**Protect the quality of our natural resources and environment.**
Objective:	Strengthen public understanding of the value of our natural resources in supporting healthy communities, a healthy economy and healthy citizens.
Objective:	Encourage local governments to use EWG's natural communities and ecological significance data in planning.
Objective:	Develop a culture that understands and values regional and local sustainability.
Goal 2:	**Plan for and invest in green infrastructure.**
Objective:	Increase the use of green infrastructure to improve the health of communities.
Objective:	Improve regional and site specific stormwater management.
Goal 3:	**Guarantee clean water for all citizens.**
Objective:	Improve the health of our watersheds and waterways for drinking, aesthetics, and recreation.
Objective:	Promote rainscaping as a way individual property owners can help to reduce stormwater runoff and improve water quality.
Goal 4:	**Exceed clean air standards.**
Objective:	Maintain priority focus on clean air for the region.
Objective:	Prioritize public investments, encourage private activities, and educate individuals on actions that reduce greenhouse gas emissions and improve air quality.
Goal 5:	**Provide increased access to nature for all citizens.**
Objective:	Link neighborhoods to natural areas, parks, recreational amenities, and gardens.
Goal 6:	**Promote municipal sustainability planning.**
Objective:	Educate community leaders about the benefits of implementing environmental best practices, sustainability plans, and other tools.
Objective:	Improve tree canopy.
Goal 7:	**Protect open areas.**
Objective:	Conserve agricultural and forest resources, cultural sites and open space.

Figure 3.5. Green goals for the St. Louis region as stated in the OneSTL plan. Specific objectives are referenced for each overarching goal. Each objective consists of discrete strategies, which are aligned and matched with appropriate organizations to implement the strategy within the St. Louis region (East-West Gateway Council of Governments, 2013).

3.2 Zoning Limitations

Due to the high yearly rainfall in the watershed, the governments of Missouri and Illinois are particularly concerned with controlling flooding along the Mississippi. In St. Louis alone, over 700 miles of levees (89 total) protect the city against 100-year flooding events (St. Louis District Army Corps of Engineers, n.d.). While the flood protection in the Cahokia-Joaquim watershed is close to the river and primarily consists of embankments and levees, a community in Northern St. Charles County has a different solution (St. Louis District of Army Corps of Engineers, n.d.).

After a major flood in 2019, where over 100 levees were breached and 1.2 million acres were inundated, landowners ceded their land (Figure 3.6) to the Nature Conservancy to create a new river setback (The Nature Conservancy, 2021). This change of zoning is theorized to improve flood resiliency of the surrounding areas and prevent further riverside development. While a solution such as this is unlikely to occur on the more urbanized Missouri side of the watershed, it could feasibly happen on the less populated section in Illinois.

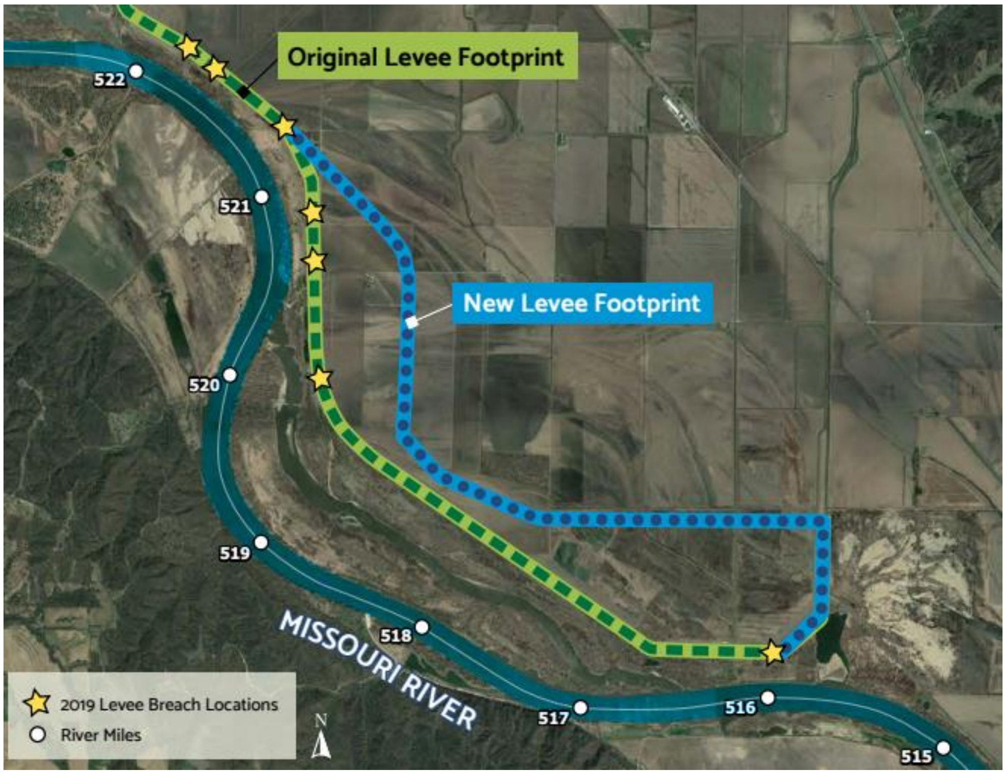

Figure 3.6. Levee Breaches and New River Setback along Missouri River. Just North of St. Charles County is an example of a new river setback created by purchasing farmers' lands to allow for a wider floodplain and the construction of a new set of levees to prevent future flooding (The Nature Conservancy, 2021)

To prevent flooding, Missouri and Illinois have also established standards through the State Emergency Management Agencies and Department of Natural Resources, respectively to limit development on the edge of the river. The regulatory floodway refers to the river channel and adjacent lands required to pass the base flood discharge, otherwise known as the discharge during a 100-year flood (Missouri SEMA, 2020-2021). There is also the floodway fringe, an area that could be developed under specific circumstances (Figure 3.7). For Missouri, this area can be developed if one can prove there will be no further rise in the elevation the peak flood reaches, while in Illinois a rise of 0.1m is allowed (Missouri SEMA 2020-2021; Illinois DNR 2001). This flood zoning around rivers limits the development of areas adjacent to rivers to prevent flooding of homes and the surrounding area.

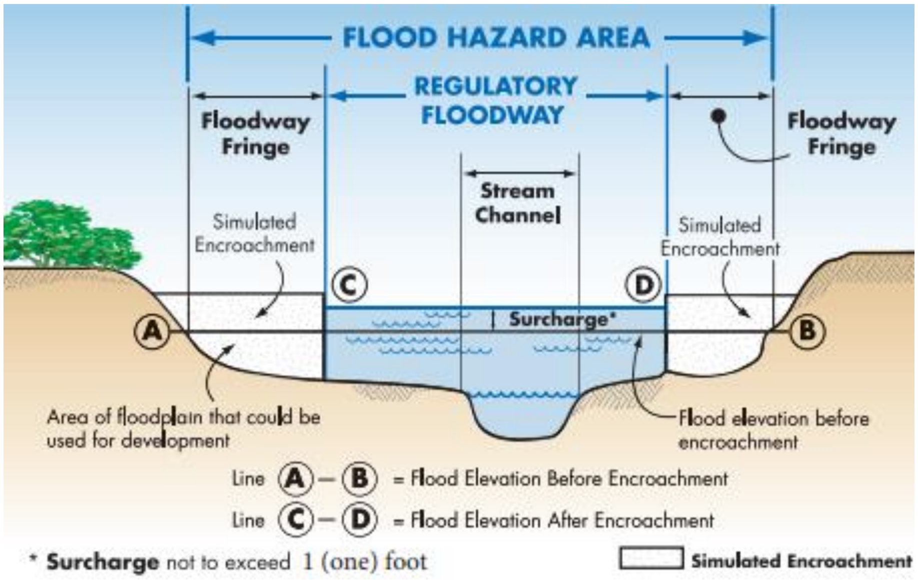

Figure 3.7. Flood Hazard Area Diagram. The regulatory floodway refers to the area required to pass the base flood, while the floodway fringes can be developed if they meet specific standards (Missouri SEMA, 2020-2021).

3.3 Specific Designated/Beneficial Uses

Drinking water in the city of St. Louis, MO – the most populated urban area in the Cahokia-Joaquim watershed – is provided by two water purification plants, the Chain of Rocks Plant and Howard Bend Treatment Facility, that primarily draw surface water from the Missouri river and each produce 150 Mg/day of clean drinking water. The Chain of Rocks Plant is located on the Mississippi River, but mainly draws from water flowing in from the Missouri River before the two bodies fully mix together (St. Louis Water Division, n.d.). The Howard Bend Treatment Facility is located on the Missouri River. Both industrial and agricultural water supply in the Cahokia-Joaquim watershed draws from the Missouri, Mississippi, and Meramac rivers. The Missouri and Mississippi rivers are each designated for recreation, water supply, irrigation, navigation, and wildlife habitat. The Meramec River is designated for recreation, trout fishing, drinking water, and urban waters (Missouri Department of Natural Resources, 2023).

There are thirty-seven 303(d) listed impaired water bodies in the Cahokia-Joaquim watershed, twenty-three in Illinois and fourteen in Missouri. In Illinois, the most common designated use for impaired waterbodies include fish consumption and aquatic life, followed by aesthetic quality. In Missouri, the most common designated uses for impaired water bodies include whole body contact recreation and protection of warm water aquatic habitat, followed by secondary contact recreation (Figure 3.8; Table 3.1).

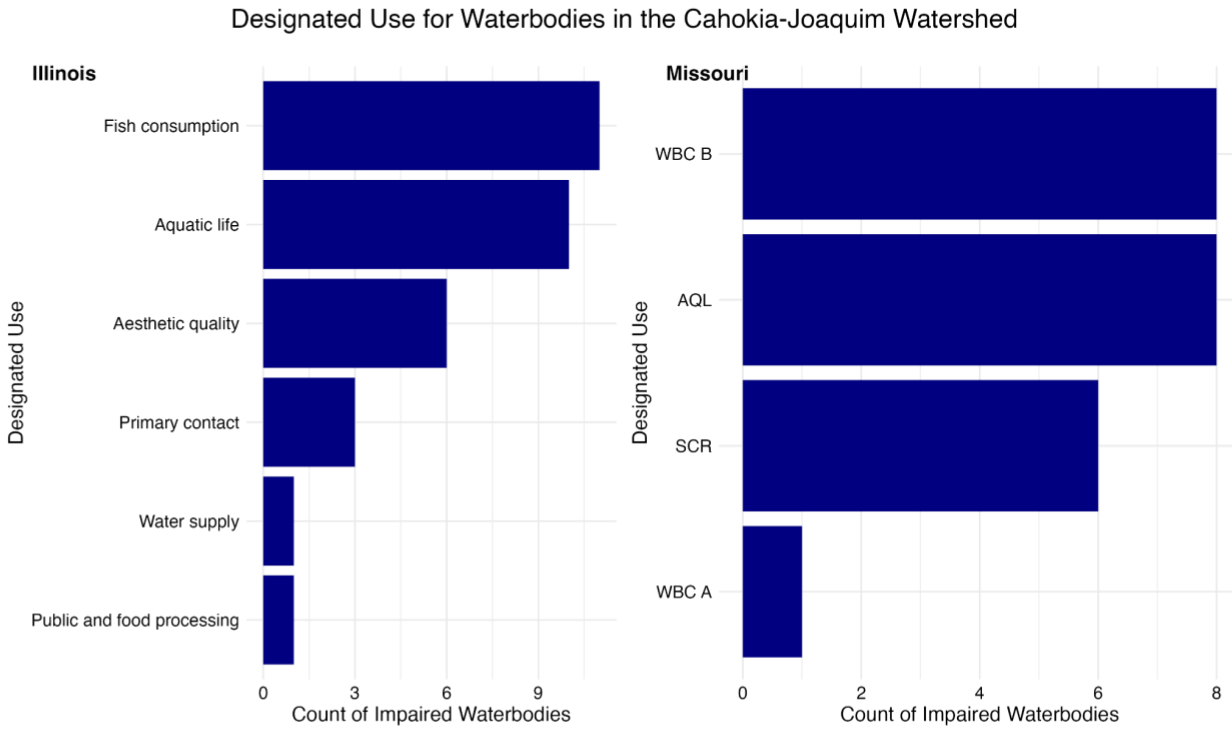

Figure 3.8. Data on designated use in Illinois water bodies provided by the Illinois Environmental Protection Agency. Data on designated use in Missouri water bodies provided by Missouri Department of Natural Resources. Abbreviations for Missouri designated uses are defined as follows: Whole Body Contact Recreation B (WBC B), Protection of Warm Water Aquatic Life (AQL), Secondary Contact Recreation (SCR), Designated Public Swimming Areas (WBC A).

Table 3.1: Data on designated use in Illinois water bodies provided by the Illinois Environmental Protection Agency. Data on designated use in Missouri water bodies provided by Missouri Department of Natural Resources.

Designated Use of Impaired Water Bodies in the Cahokia-Joaquim Watershed	
Waterbody	**Designated Use**
Illinois	
Cahokia Creek	Primary contact
	Fish consumption
STAUNTON	Aesthetic quality
	Fish consumption

Mt. Olive New	Fish consumption
Mt. Olive Old	Fish consumption Public and food processing Water supply
Mississippi River	Fish consumption
	Primary contact
Cahokia Canal	Aquatic life Primary contact
Canteen Creek	Aquatic life
Schoenberger Creek North	Aesthetic quality
Dot creek	Aesthetic quality
	Aquatic life
Chain of rocks canal	Fish consumption
Cahokia diversion channel	Aquatic life
	Fish consumption
HORSESHOE (MADISON)	Aesthetic quality Fish consumption
Canal #1	Aquatic life
Stookey Creek	Aquatic life
Harding Ditch	Aquatic life
Frank Holten 1	Fish consumption
Frank Holten 2	Fish consumption
Frank Holten 3	Fish consumption
Indian Creek	Aquatic life
Holiday Shores Creek	Aquatic life
Holiday shores	Aesthetic quality
Waterloo Creek	Aquatic life
TOWER (MADISON)	Aesthetic quality

Missouri

Waterbody	Designated Use
Black Creek	Protection of Warm Water Aquatic Life (AQL)
Deer Creek	Protection of Warm Water Aquatic Life (AQL)
	Designated Public Swimming Area (WBC A)
Engelholm Creek	Whole Body Contact Recreation B

	Secondary Contact Recreation
Gravois Creek	Protection of Warm Water Aquatic Life (AQL)
Gravois Creek Tributary	Whole Body Contact Recreation B
Lake Wauwanoka	Protection of Warm Water Aquatic Life (AQL)
Maline Creek	Protection of Warm Water Aquatic Life (AQL)
Martigney Creek	Whole Body Contact Recreation B
	Secondary Contact Recreation
River des Peres	Protection of Warm Water Aquatic Life (AQL)
	Whole Body Contact Recreation B
	Secondary Contact Recreation
River des Peres tributary	Protection of Warm Water Aquatic Life (AQL)
	Secondary Contact Recreation
	Whole Body Contact Recreation B
Sugar Creek	Secondary Contact Recreation
	Whole Body Contact Recreation B
Twomile Creek	Whole Body Contact Recreation B
Watkins Creek	Protection of Warm Water Aquatic Life (AQL)
Watkins Creek tributary	Secondary Contact Recreation
	Whole Body Contact Recreation B

3.4 Water Quality Criteria Specific to Designated Uses

The cause of impairment for 303(d) listed water bodies in the Cahokia-Joaquim watershed varies significantly by state. The portion of the watershed east of the Mississippi River in Illinois has more agriculture and industry than the western portion of the watershed in Missouri which is largely urban, residential, or forest. This is apparent in the pollutants found in the impaired water bodies in each state (Illinois EPA, 2024; Missouri Department of Natural Resources, 2022). Maximum contaminant levels for each of the pollutants listed for impaired surface water bodies in the Cahokia-Joaquim watershed are listed and described in Table 3.2.

In Illinois, phosphorus is the most common cause of impairment, followed by total suspended solids (TSS), polychlorinated biphenyls (PCBs), several commonly used pesticides, and mercury (Figure 3.9; Table 3.3). Total suspended solids (TSS) are solid particles found in water that are unable to settle nor dissolve. TSS have consequences on aquatic life due to increased turbidity, decreasing sunlight penetration into deeper waters, and the potential of TSS including toxic compounds. Contamination of polychlorinated biphenyls (PCBs) is likely from industrial and/or agricultural sources. PCBs are used as coolants and lubricants in electrical equipment, caulks and paints for building materials and plastics, as well as extenders for pesticides. The federal safe drinking water standard for PCBs is 500 parts per trillion (ppt), because even at low concentrations, PCBs can cause a variety of health issues – especially in children who consume contaminated drinking water (Illinois EPA, 2024; U.S. EPA, 2024). Pesticides commonly found in impaired water bodies in the Illinois side of the Cahokia-Joaquim watershed include: Toxaphene, Mirex, Heptachlor, Endrin, Dieldrin, and Aldrin (Figure 3.9; Table 3.3).

In Missouri, the primary source of water pollution is urban runoff and sewage, and the most common contaminants are E. coli and Chloride (Figure 3.9; Table 3.3). The source of E. coli is likely due to leakage of sewage systems into the impaired surface water bodies, and the likely source of chloride is due to anti-microbial water treatments and urban runoff. It is common practice in this region to salt roads during the winter months, and the salts are then carried into surface waters and contribute to water pollution (Missouri Department of Natural Resources, 2022; U.S. EPA, 2024).

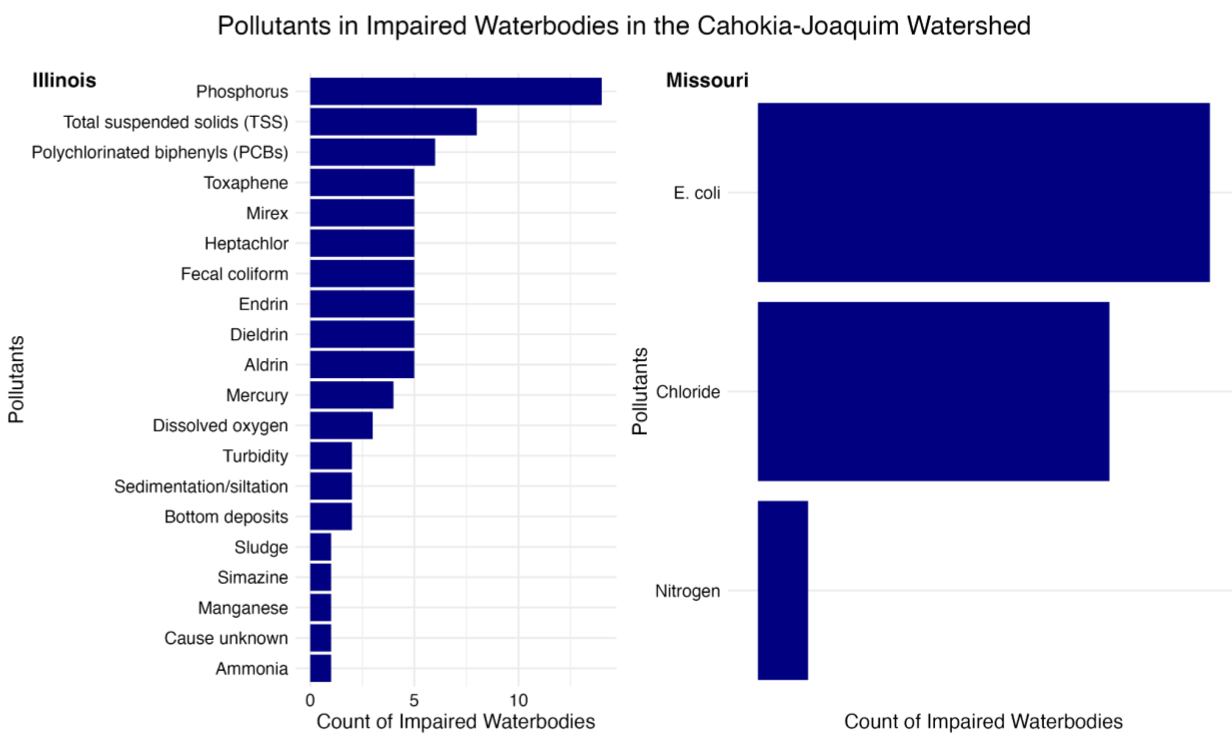

Figure 3.9. Data for pollutants in Illinois water bodies provided by Illinois Environmental Protection Agency. Data for pollutants in Missouri water bodies provided by the Missouri Department of Natural Resources.

Table 3.2: Safe drinking water levels for contaminants found in water bodies of the Cahokia-Joaquim watershed provided by the U.S. Environmental Protection Agency standards of

maximum contaminant levels (MCLs) for drinking water, National Academy of Sciences recommendations.

Pollutant	Maximum Contaminant Level (MCL)	Health effects	Common sources
PCBs	0.0005 mg/L	Skin changes; thymus gland problems; immune deficiencies; reproductive or nervous system difficulties; increased risk of cancer	Runoff from landfills; discharge of waste chemicals
Toxaphene	0.003 mg/L	Kidney, liver or thyroid problems; increased risk of cancer	Runoff/leaching from insecticide used on cotton and cattle
Heptachlor	0.0004 mg/L	Liver damage; increased risk of cancer	Residue of banned termiticide
Fecal coliform/ E. coli	5.0% by volume	Indicator of potentially harmful bacteria	Coliforms are naturally present in the environment; as well as feces; fecal coliforms and E. coli only come from human and animal fecal waste
Endrin	0.002 mg/L	Liver problems	Residue of banned insecticide
Mercury	0.002 mg/L	Kidney damage	Erosion of natural deposits; discharge from refineries and factories; runoff from landfills and croplands
Nitrogen	Nitrite as N (1 mg/L) Nitrate as N (10 mg/L)	Infants below the age of 6 months who drink water containing nitrogen in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome	Runoff from fertilizer use; leaking from septic tanks, sewage; erosion of natural deposits
Simazine	0.004 mg/L	Tremors; damage to testes; kidneys, liver and thyroid; gene mutations	Industrial and agricultural runoff
Mirex	0.00003 mg/L	Oncogenic effects including tumors in liver, adrenal gland, and kidney	Agricultural runoff
Phosphorus	0.05 mg/L for streams discharging into reservoirs	No evidence for negative health effects, but contributes to eutrophication and TSS	Agricultural fertilizer runoff; human sewage discharges; manufacturing and detergents
Chloride	250 mg/L Secondary MCL	Eye/nose irritation; stomach discomfort	Water additive used to control microbes; runoff from road salting

Ammonia	National Academy of Sciences recommends 0.5 mg/L	Long-term ingestion may damage internal organs	Decaying organic matter; Waste, agricultural or feedlot runoff
Manganese	0.3 mg/L Recommended limit for children older than one years old and adults by MN Dept. of Health	Neurological, learning, and behavioral problems in infants	Environmental degradation of soils and rocks
TSS	No legally enforceable limit	Varies depending on contents of suspended solids	Algae, fertilizer runoff, sewage, urban runoff, erosion
Dieldrin	0.0 mg/L	Potential risk for cancer	Agricultural and industrial runoff
Aldrin	0.0 mg/L	Potential risk for cancer	Agricultural and industrial runoff

Table 3.3: Data for pollutants in Illinois water bodies provided by Illinois Environmental Protection Agency. Data for pollutants in Missouri water bodies provided by the Missouri Department of Natural Resources.

Pollutants in Impaired Water Bodies in the Cahokia-Joaquim Watershed	
Waterbody	**Pollutant**
Illinois	
Cahokia Creek	Aldrin
	Dieldrin
	Endrin
	Heptachlor
	Mirex
	Toxaphene
	Fecal coliform
STAUNTON	Total suspended solids (TSS)
	Mercury
Mt. Olive New	Mercury
Mt. Olive Old	Mercury
	Simazine
Mississippi River	Mercury

	Polychlorinated biphenyls (PCBs)
	Aldrin
	Dieldrin
	Endrin
	Heptachlor
	Mirex
	Toxaphene
	Fecal coliform
Cahokia Canal	Phosphorus
	Sedimentation/siltation
	Total suspended solids (TSS)
	Fecal coliform
Canteen Creek	Phosphorus
	Total suspended solids (TSS)
Schoenberger Creek North	Bottom deposits
	Phosphorus
	Sludge
	Turbidity
	Ammonia
	Dissolved oxygen
	Manganese
Dot creek	Bottom deposits
	Phosphorus
	Turbidity
	Dissolved oxygen
Chain of rocks canal	Polychlorinated biphenyls (PCBs)
Cahokia diversion channel	Phosphorus

	Aldrin
	Dieldrin
	Endrin
	Heptachlor
	Mirex
	Toxaphene
HORSESHOE (MADISON)	Phosphorus
	Total suspended solids (TSS)
	Aldrin
	Dieldrin
	Endrin
	Heptachlor
	Mirex
	Polychlorinated biphenyls (PCBs)
	Toxaphene
Canal #1	Phosphorus
Stookey Creek	Phosphorus
Harding Ditch	Fecal coliform
Frank Holten 1	Aldrin
	Dieldrin
	Endrin
	Heptachlor
	Mirex
	Polychlorinated biphenyls (PCBs)
	Toxaphene
	Phosphorus
	Total suspended solids (TSS)

Frank Holten 2	Polychlorinated biphenyls (PCBs)
	Phosphorus
	Total suspended solids (TSS)
Frank Holten 3	Polychlorinated biphenyls (PCBs)
	Phosphorus
	Total suspended solids (TSS)
Indian Creek	Cause unknown
Holiday Shores Creek	Phosphorus
Holiday shores	Total suspended solids (TSS)
	Fecal coliform
Waterloo Creek	Dissolved oxygen
	Phosphorus
	Sedimentation/siltation
TOWER (MADISON)	Phosphorus

Missouri

Waterbody	Pollutant
Black Creek	Chloride
Deer Creek	Chloride
	E. coli
Engelholm Creek	E. coli
Gravois Creek	Chloride
Gravois Creek Tributary	E. coli
Lake Wauwanoka	Nitrogen
Maline Creek	Chloride
Martigney Creek	E. coli
River des Peres	Chloride
	E. coli
River des Peres tributary	Chloride
	E. coli
Sugar Creek	E. coli
Twomile Creek	E. coli
Watkins Creek	Chloride
Watkins Creek tributary	E. coli

3.5 Summary

In summary, the waterways in the Cahokia-Joaquim watershed are designated for a variety of uses that benefit the public, including fish consumption, aquatic habitat protection, and recreation. Unfortunately, many of the water bodies face impairment, either from urban runoff and sewage on the Missouri side of the Mississippi River, or from agricultural and industrial runoff on the Illinois side. Common water quality issues for urban waterways include the presence of E. coli and chloride, while water quality for more rural waterways is impacted by pesticides, PCBs, and TSS. Land use planning efforts across the region do seem to account for flood risks and water quality issues, but given the current impairment of many water bodies, it seems that efforts do not yet sufficiently address these issues.

4.0 Climate, River Discharge, and Water Quality Monitoring Data

4.1 Introduction

It is important to monitor the flow rates and the water quality of rivers in the Cahokia-Joaquim Watershed in order to inform management actions. River discharges can vary daily, seasonally, and due to large-scale climatic shifts. Because of this, it is often useful to assess discharge rates in tandem with other meteorological factors. This can provide information about how drought or heavy precipitation may be expected to impact river flows, which is crucial for water resource managers. In addition, ongoing monitoring of water quality provides critical information on contaminant levels in the water and can be used to alert authorities if levels are above safety thresholds. These data can be used to identify and mitigate sources of contamination and to protect public health. One of the functions of the USGS, NOAA, and the EPA is to collect reliable data on river flows, meteorology, and water quality and make it available to the public. The transparency and accessibility of this monitoring data enables managers, non-profits, decision makers, and members of the public to form an accurate assessment of ongoing issues.

4.2 Meteorology

Climate data were collected from two monitoring stations in the Cahokia-Joaquim Watershed: the St. Louis Science Center in Missouri and the Cahokia Airport in Illinois. These stations are located relatively close to one another, just across the Mississippi River near the St. Louis area (Figure 4.1, Table 4.1). While it would be ideal to have stations distributed throughout the Mississippi River watershed, such data were unavailable.

Each station recorded three climate variables: precipitation, maximum daily temperature, and minimum daily temperature. Visual analysis of these indicators suggests that the watershed experiences significant seasonal variation. Due to its central U.S. location, the watershed is influenced by warm air from the Gulf of Mexico in the summer and cold, dry air from Canada in the winter (NOAA, n.d.). This results in warm, wet summers and colder, drier winters. The majority of annual precipitation in St. Louis occurs during the summer months, totaling approximately 863.6 mm (Figure 4.2). Measured maximum daily temperatures range from 38°C to -16°C, while minimum daily temperatures range from 24°C to -25°C (Figures 4.3, 4.4).

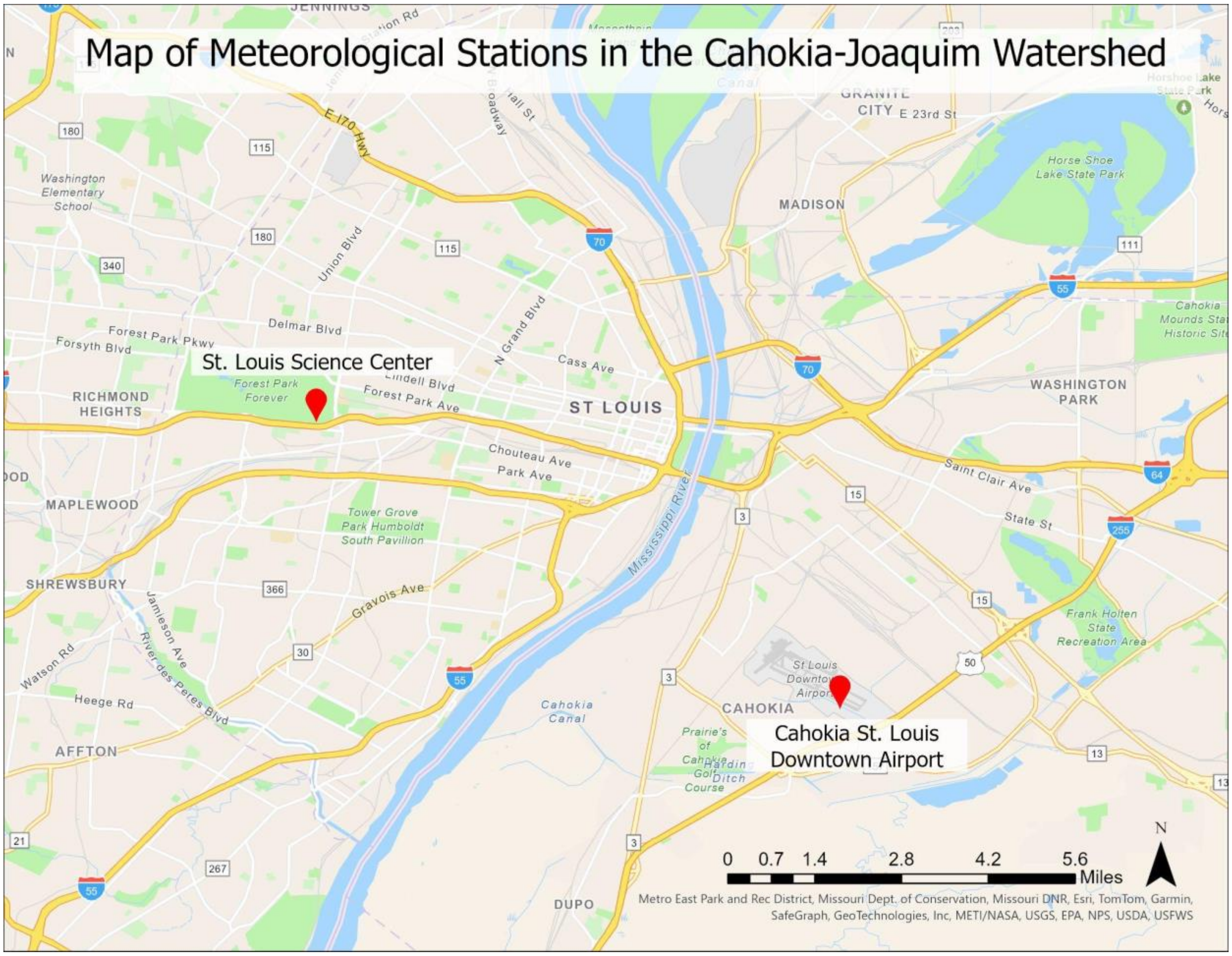

Figure 4.1. Map of NOAA Meteorological Stations in the Cahokia-Joaquim Watershed. There were two stations in the watershed that collected precipitation and temperature data, one in Missouri and one in Illinois.

Table 4.1. Table of NOAA Meteorological Stations. Site numbers, locations, record lengths, and data coverage for the two meteorological stations in the Cahokia-Joaquim Watershed.

Site Name	Site ID Number	Latitude	Longitude	Record Start	Record End	Data Coverage
St. Louis Science Center	GHCND:USC00237452	38.63079	-90.27077	8/1/1968	10/20/2024	79%
Cahokia St. Louis Downtown Airport	GHCND:USW00003960	38.56402	-90.1487	6/8/1977	10/20/2024	99%

Figure 4.2. Precipitation from 2000-Present at the Cahokia Airport and Science Center. Fluctuations of precipitation are visible, with one year on record having almost .1 meters of rainfall in a short period of time.

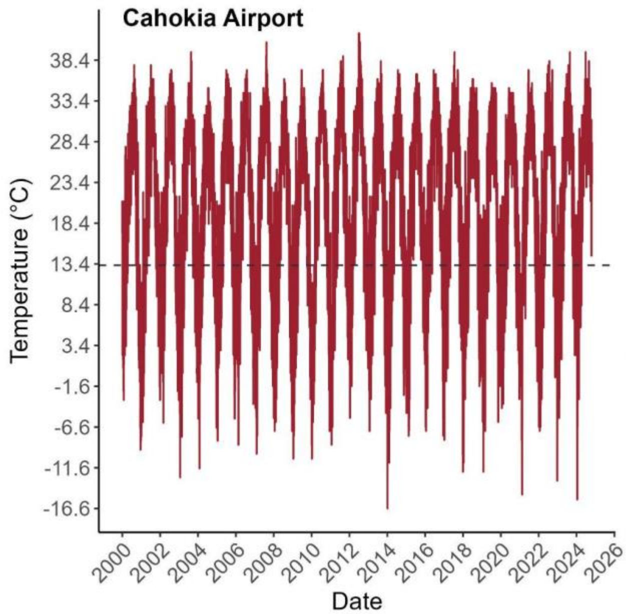

Figure 4.3. Maximum Temperature Fluctuations from 2000-Present at the Cahokia Airport and Science Center. Since Missouri is in the Northern inland United States, it experiences significant changes in temperature throughout the year, with maximum daily temperatures ranging from almost -12 C to 39 C on average each year. The average maximum temperature is shown with a dotted line.

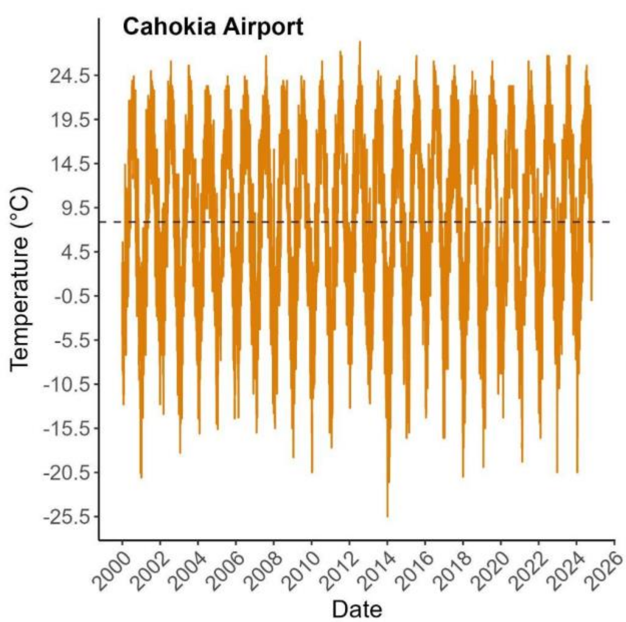

Figure 4.4. Minimum Temperature Fluctuations from 2000-Present at the Cahokia Airport and Science Center. Since Missouri is in the inland United States, it experiences significant

changes in temperature throughout the year, with minimum daily temperatures ranging from almost -20 C to 25 C each year. The average minimum temperature is shown with a dotted line.

4.3 Flow Monitoring

Discharge data was collected for three flow gauge stations within the Cahokia-Joaquim Watershed. One is located along the Mississippi River, one along the River des Peres through the city of St. Louis, and one along Indian Creek on the northern Illinois side of the watershed (Table 4.2, Figure 4.5). The diversity of locations within the watershed enables the construction of a more complete understanding of river discharges in the system.

As demonstrated in Table 4.3, the mean daily discharge varies widely across locations, from 1.0 m^3/s in Indian Creek to 6,472.3 m^3/s in the Mississippi River. The effect of several large storms can be seen in both the precipitation and flow data. For example, high rainfall in late 2015 to early 2016 can be seen in Figure 2 above and corresponding high discharge rates can be seen in Figure 4.5 below. Interestingly, this relationship does not always seem to be consistent. High precipitation amounts in July 2022 (Figure 4.2) resulted in flash flooding in the St. Louis area (NOAA’s National Weather Service, n.d.), but this only seems to be reflected in the gauge station data on River des Peres (Figure 4.5).

Table 4.2. USGS flow monitoring gauge stations in the Cahokia-Joaquim Watershed. The USGS site ID number, the site latitude and longitude, and the period of record retrieved are shown for each station.

Site Name	Site ID Number	Latitude	Longitude	Record Start	Record End
River des Peres at St. Louis, MO	7010097	38°33'33.3"	90°16'59.8"	2/8/2002	10/23/24
Mississippi River at St. Louis, MO	7010000	38°37'44.4"	90°10'47.2"	1/1/2000	10/22/24
Indian Creek at Wanda, IL	5588000	38°50'30"	90°01'59"	1/1/2000	10/22/24

Table 4.3. Mean, minimum, and maximum daily discharge rates for USGS gauge stations in the Cahokia-Joaquim Watershed. Values taken over the range of recorded dates as specified in Table 2 above.

Site Name	Mean Daily Discharge (m^3/s)	Min Daily Discharge (m^3/s)	Max Daily Discharge (m^3/s)
River des Peres at St. Louis, MO	2.2	0.0	274.7

Mississippi River at St. Louis, MO	6,472.3	1,529.1	26,363.1
Indian Creek at Wanda, IL	1.0	0.0	96.3

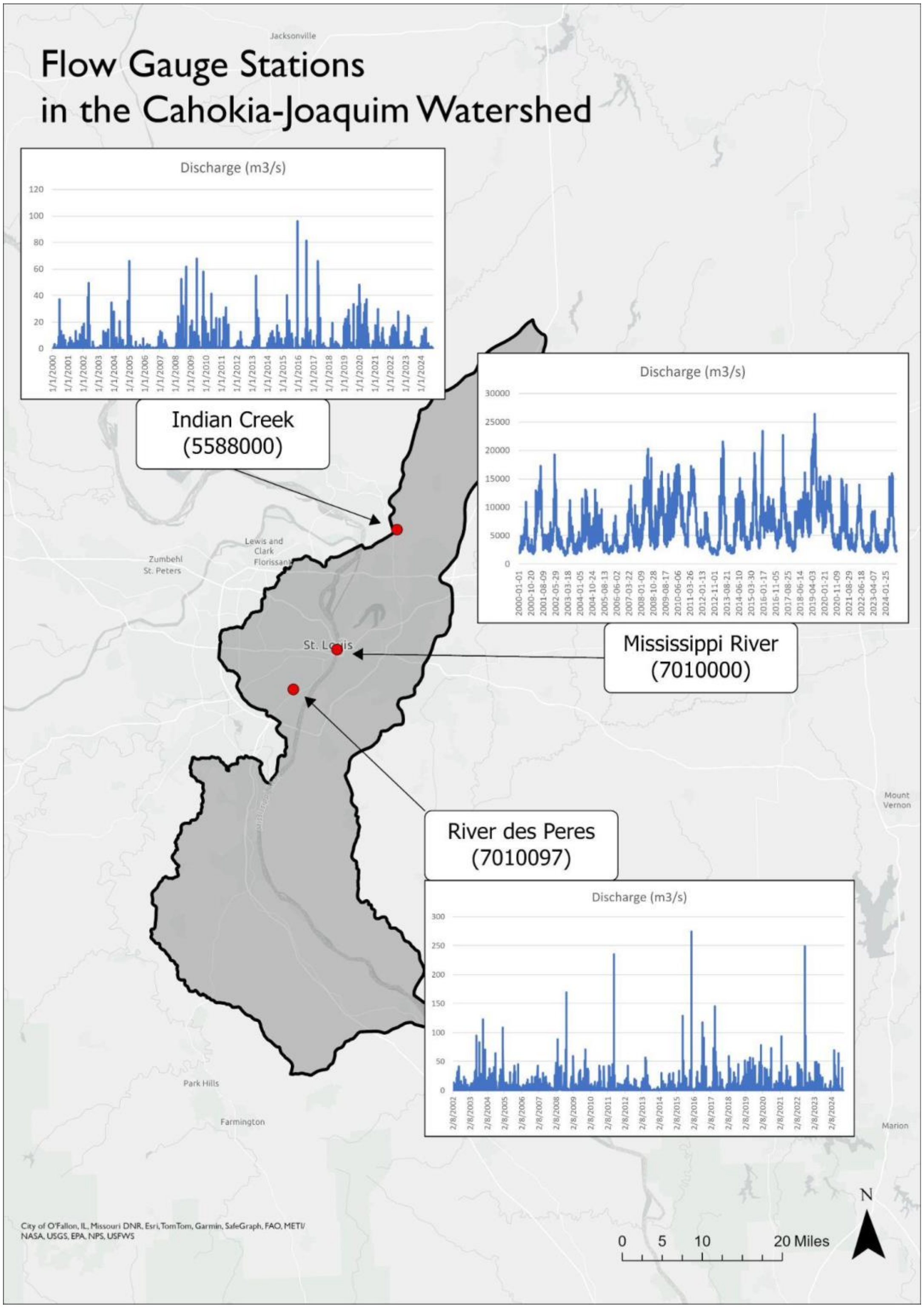

Figure 4.5. Map of Flow Gauge Stations in the Cahokia-Joaquim Watershed. River discharge data was obtained from three USGS flow gauge stations. Hydrographs showing discharge in m^3/s for ~20 year periods are shown for each gauge station.

4.4 Current Water Quality Monitoring

Each of the chemical compounds analyzed in this section, apart from lead, were selected based on their classification as pollutants under Section 303(d) of the Clean Water Act for the Cahokia-Joaquim watershed impaired designated water bodies (Illinois EPA, 2024; Missouri Department of Natural Resources, 2022). However, mirex, a pesticide and known cause for impairment, was excluded from time-series analysis due to insufficient data.

Nitrogen compounds generally trend below the maximum contaminant level (MCL), with fewer and less extreme outliers over time (Figure 4.6). Fecal coliform and E. coli levels, while also tending towards safe limits, showed greater variability before 2010 but have since exhibited fewer exceedances and have approached safer levels more consistently (Figure 4.7). Turbidity has remained steady throughout the analyzed period, typically falling below 200 NTU with intermittent peaks nearing 1000 NTU (Figure 4.8). Simazine, primarily from agricultural runoff, frequently exceeded its MCL until peaking around 2014, after which concentrations declined. Mercury, in contrast, presents an upward trend, often surpassing its MCL of 0.002 mg/L, with concentrations as high as 1.0 mg/L (Figure 4.9). While lead is not listed as an impairment cause in the watershed, it was included due to local mining activity and potential health risks. Figure 4.10 shows that lead levels, initially as high as 7.5 mg/L in the early 2000s, have decreased in frequency but continue to show isolated exceedances above the 0 MCL standard (U.S EPA; National Aquatic Resources Survey).

Total suspended solids, although consistently high in the early 2000s, now exceed the 500 mg/L MCL less frequently and with less severity, indicating gradual improvement (Figure 4.11). Chloride levels remain fairly constant, frequently exceeding the 250 mg/L MCL due to road salting and microbial control additives, while manganese consistently surpasses its MCL, presenting a potential risk to infants and other sensitive populations (Figures 4.12, 4.13) (Minnesota Department of Health; National Aquatic Resources Survey). Dieldrin, another hazardous pesticide, showed exceedances only in the early 2000s, with no recorded exceedances in the last decade (Figure 4.14). Figures 4.16, 4.17, and 4.18 show that concentrations of endrin, aldrin, and heptachlor remain below MCLs, although endrin and heptachlor data are absent in recent years, limiting current assessment (National Aquatic Resources Survey, 2024).

Table 4.4: Various public and private institutions in both Missouri and Illinois are responsible for collecting and recording water quality data in the Cahokia-Joaquim watershed. Data provided by EPA National Aquatic Resources Survey (NARS) in November, 2024.

Organization	Total Water Quality Measurements In the Cahokia-Joaquim Watershed 2000-2024
Illinois EPA	293,258

USGS Illinois Water Science Center	20,684
USGS Missouri Water Science Center	37,902
Illinois RiverWatch Network (Volunteer)	8,943
EMAP- Great Rivers Ecosystems	16,576
EPA National Aquatic Resources Survey (NARS)	4,260
Illinois Department of Agriculture	2,091
USEPA, Office of Water, Office of Science and Technology	2,482
American Water Company (Illinois)	1,455
US Army Corps of Engineers St. Louis District	2,920
Upper Mississippi River Restoration - Long Term Resource Monitoring	6,168
Midwest Envir. Consultants	6,086
Missouri Dept. of Conservation	863
EPA R7	1,634
Missouri Dept. of Natural Resources	20,765
North American Lake Management Society	144
St. Louis University	24,112
Univ. of Missouri, Columbia	13,307
Washington University, St. Louis	6,937

Table 4.5: Target contaminants refers to pollutants found in section 303(d) listed impaired water bodies in the Cahokia-Joaquim watershed. The total measurements column refers to the number of data observations recorded for each target contaminant in the Cahokia-Joaquim watershed between 2000 and 2024. Data provided by EPA National Aquatic Resources Survey (NARS) in November, 2024.

Target Contaminant	Total Measurements in the Cahokia-Joaquim Watershed between 2000-2024

Nitrogen	3,256
Total suspended solids (TSS)	8,844
Chloride	6,212
Nitrate	3,017
Nitrite	2,247
Manganese	7,531
Escherichia coli	1,812
Fecal Coliform	2,574
Turbidity	5,751
Nitrate + Nitrite	1,600
Ammonia-nitrogen	3,230
Lead	2,978
Mercury	1,081
Dieldrin	451
Ammonia	77
Aldrin	110
Heptachlor	131
Endrin	84
Mirex	63
Simazine	404
Toxaphene	13

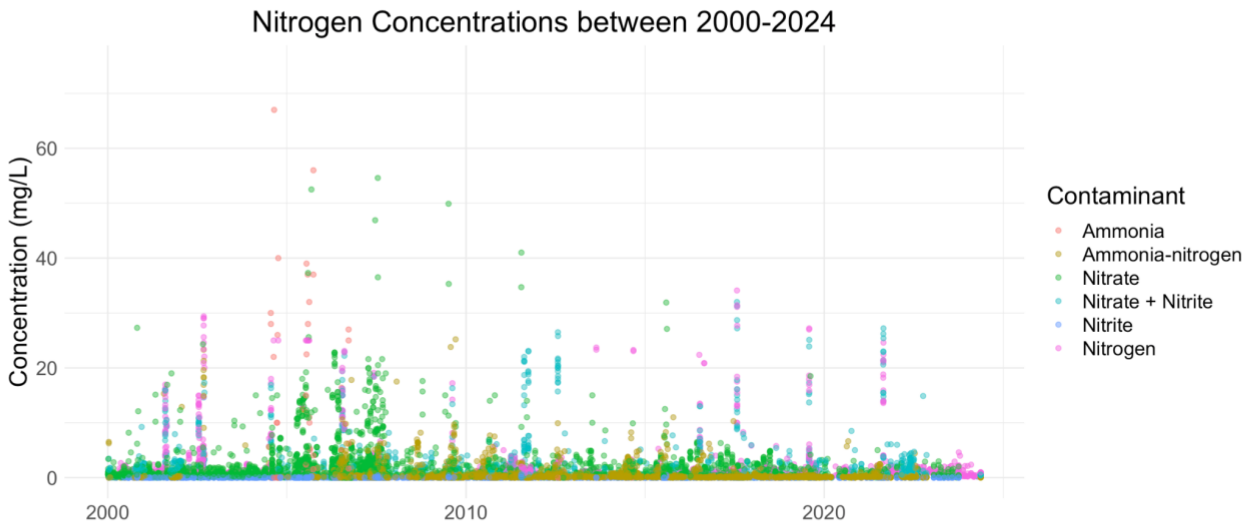

Figure 4.6. There are several types of measurements of nitrogen levels in surface waters in the Cahokia-Joaquim watershed, including Ammonia, Ammonia-nitrogen, Nitrate, Nitrate + Nitrite, and Nitrogen. MCL for Nitrite as N is 1 mg/L, for Nitrate as N is 10 mg/L, and for Ammonia the National Academy of Sciences recommends a limit of 0.5 mg/L (U.S. EPA; MN Department of Health). Ammonia is represented by the red and yellow points, Nitrate by the green, and Nitrite by the dark blue. Nitrate + Nitrite together are shown as light blue and Nitrogen is represented by the pink points. Data in the figure is provided by EPA National Aquatic Resources Survey (NARS) in November, 2024.

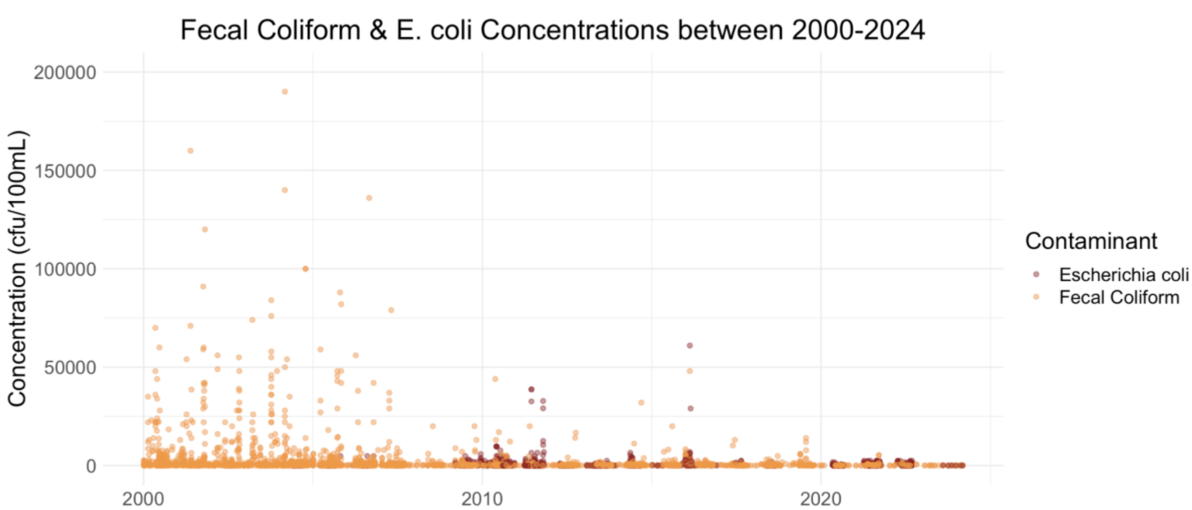

Figure 4.7. Fecal coliform and E. coli concentrations above 5% by volume can be indicative of potentially harmful bacteria in the water. (U.S. EPA) Data in the figure is provided by EPA National Aquatic Resources Survey (NARS) in November, 2024.

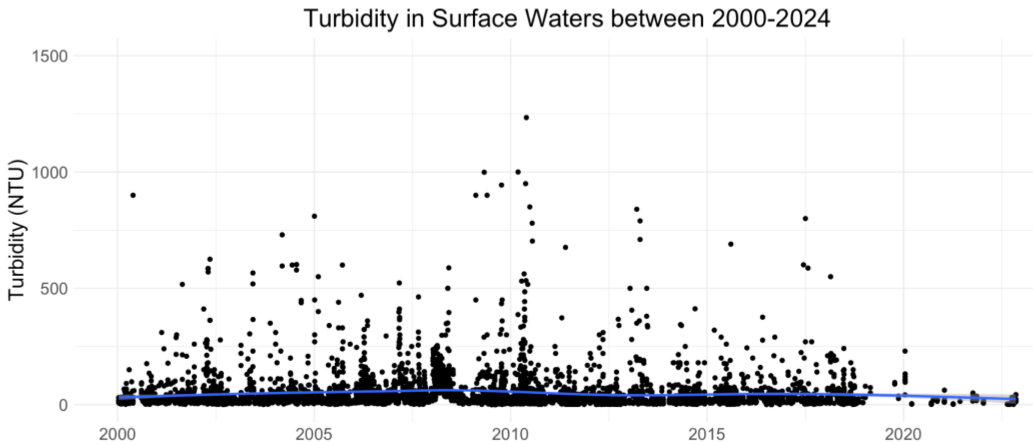

Figure 4.8. Turbidity is measured in Nephelometric Turbidity Units (NTU). Higher values indicate that water is cloudier and lower values indicate greater clarity and visibility. The blue line represents the trend of average turbidity between 2000 and 2024. Data in the figure is provided by EPA National Aquatic Resources Survey (NARS) in November, 2024.

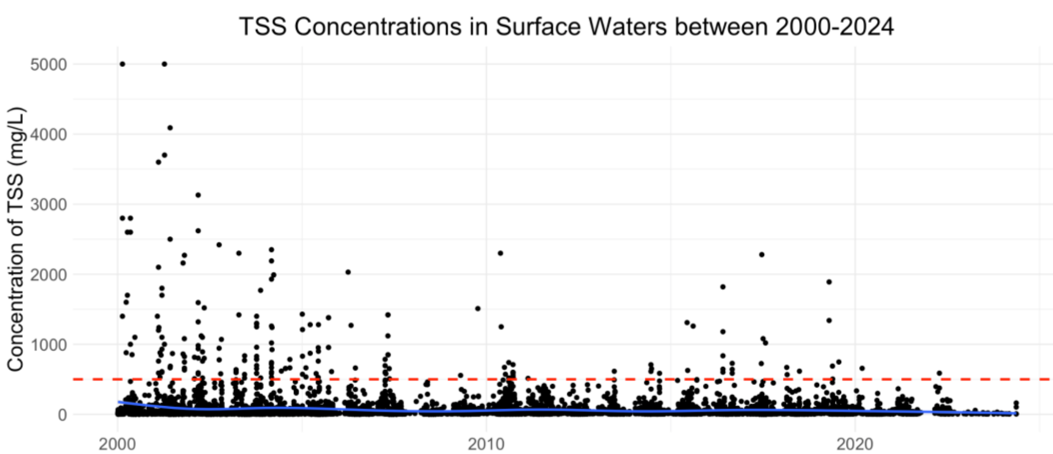

Figure 4.9. Total suspended solids (TSS) measures the amount of solid material present in the water column that is incapable of dissolution or sorption. The U.S. EPA has not established a maximum contaminant level (MCL) for TSS, but the red dashed line located at 500 mg/L represents a recommended secondary standard for industrial effluent and irrigation runoff (U.S. EPA). The blue line represents the trend of average TSS between 2000 and 2024. Data in the figure is provided by EPA National Aquatic Resources Survey (NARS) in November, 2024.

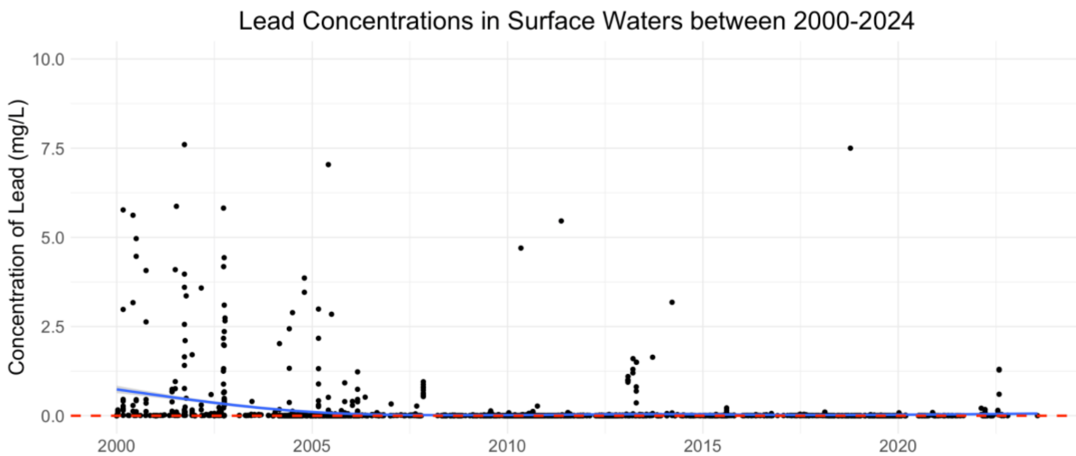

Figure 4.10. Lead was not listed as a contaminant for any of the section 303(d) listed impaired water bodies in the Cahokia-Joaquim watershed, but mining is common in the region. The red dashed line represents the MCL for lead, 0.00. (U.S EPA) The blue line represents the trend of average lead levels in surface waters between 2000 and 2024. Data in the figure is provided by EPA National Aquatic Resources Survey (NARS) in November, 2024.

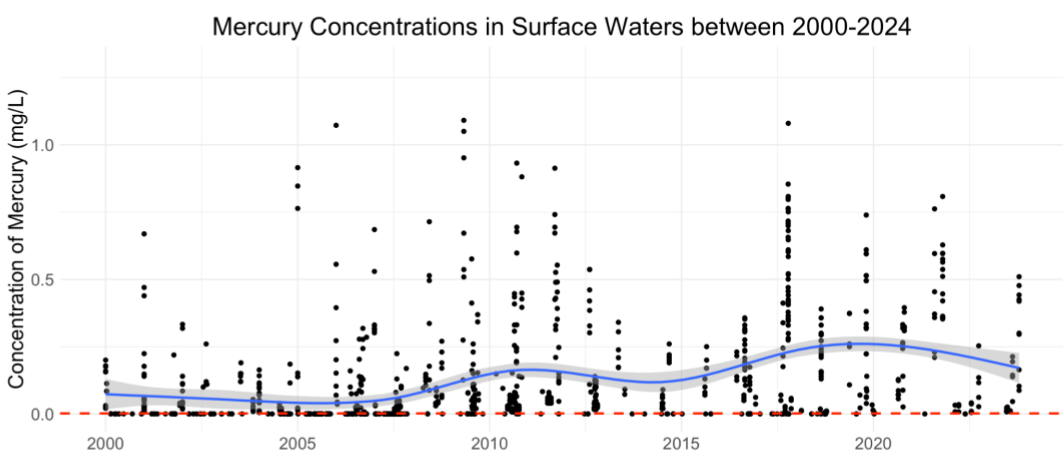

Figure 4.11. Mercury has an MCL of 0.002 mg/L shown by the dashed red line. (U.S. EPA) Surface water quality measurements in the Cahokia-Joaquim watershed, shown in by the black points in the plot, frequently surpass the MCL. The blue line represents the trend of average mercury between 2000 and 2024. Data in the figure is provided by EPA National Aquatic Resources Survey (NARS) in November, 2024.

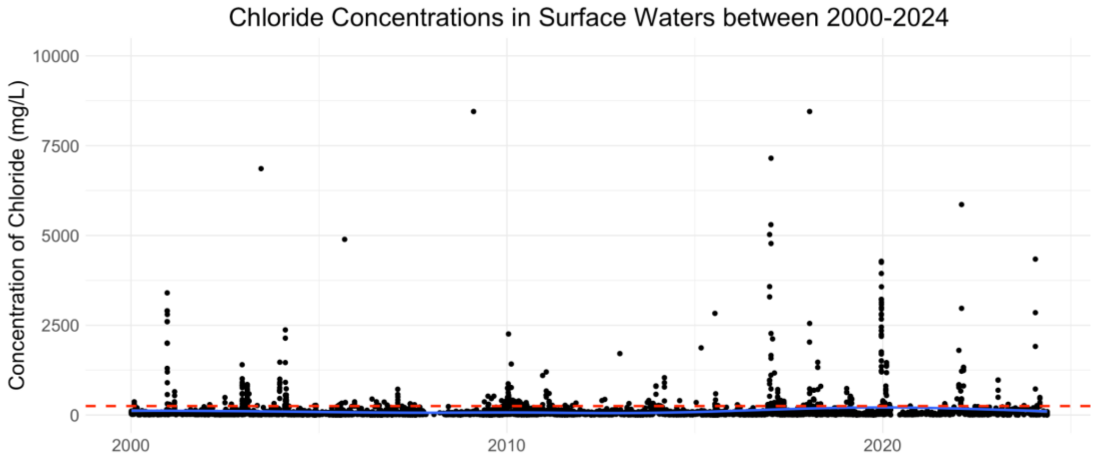

Figure 4.12. Chloride is used as a water additive to control microbes and is also introduced to surface waters via runoff after road salting. The MCL for chloride is 4 mg/L, shown in the figure as the red, dashed line. (MN Department of Health) The blue line represents the trend of average chloride between 2000 and 2024. Data in the figure is provided by EPA National Aquatic Resources Survey (NARS) in November, 2024.

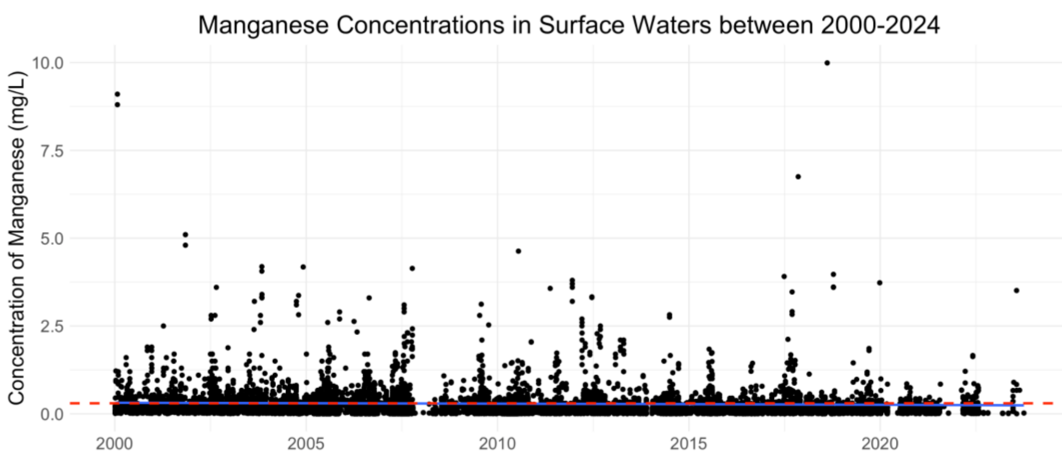

Figure 4.13. The recommended MCL of manganese for infants is 0.1 mg/L, and for people over the age of one years old, it is 0.3 mg/L. (MN Department of Health) The red dashed line in the figure represents the 0.3 mg/L MCL for children older than one years old and adults. The blue line represents the trend of average manganese between 2000 and 2024. Data in the figure is provided by EPA National Aquatic Resources Survey (NARS) in November, 2024.

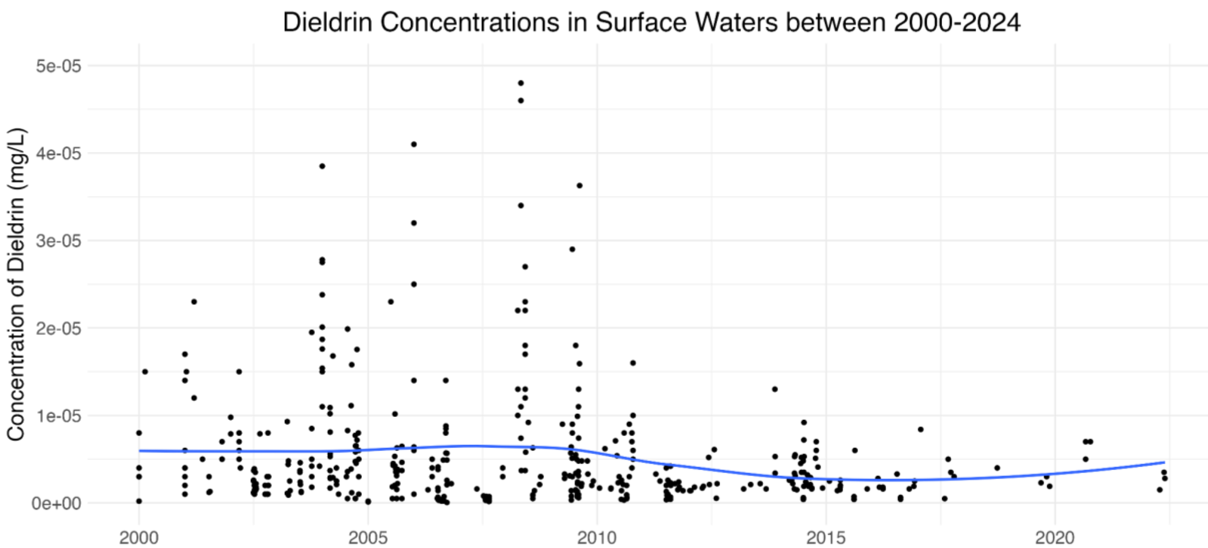

Figure 4.14. Dieldrin is a potent carcinogen with an MCL of 0.0 mg/L. The blue line represents the trend of average dieldrin between 2000 and 2024. Data in the figure is provided by EPA National Aquatic Resources Survey (NARS) in November 2024.

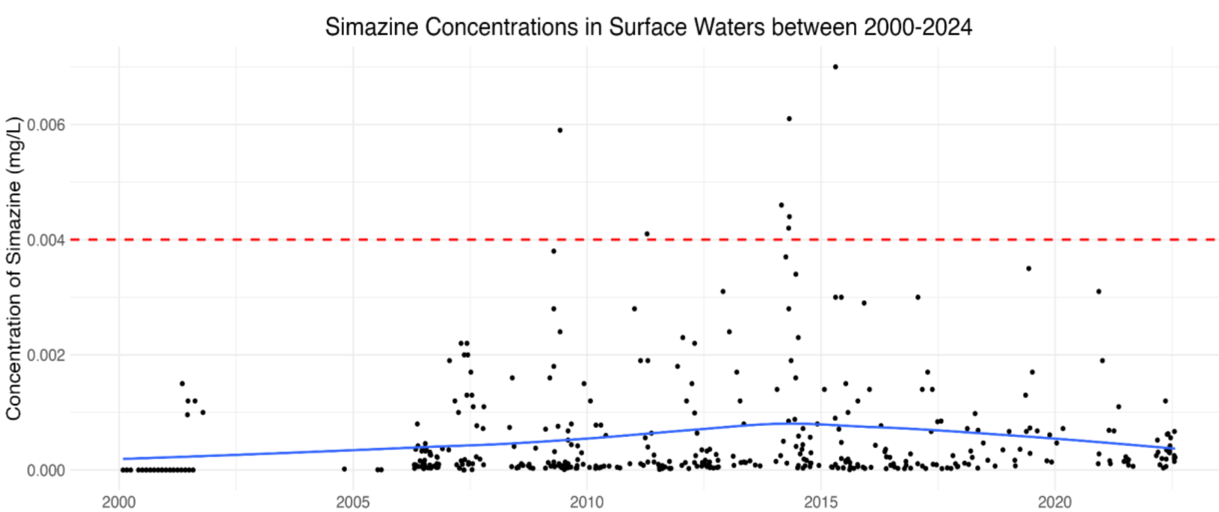

Figure 4.15. Simazine is introduced to surface water via industrial and agricultural runoff; the MCL for simazine is 0.004 mg/L as shown on the red dashed line in the figure. (U.S. EPA) The blue line represents the trend of average simazine between 2000 and 2024. Data in the figure is provided by EPA National Aquatic Resources Survey (NARS) in November, 2024.

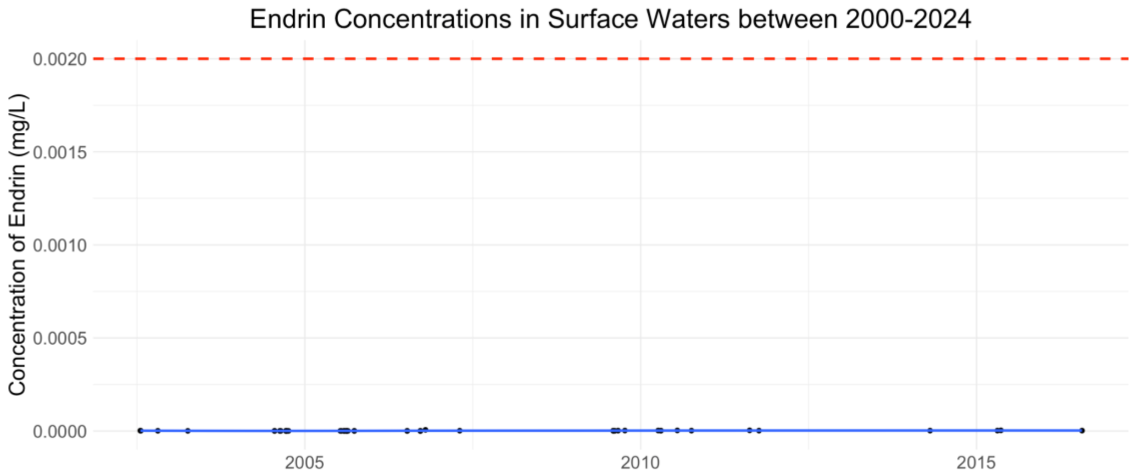

Figure 4.16. Endrin is a residue of banned insecticides and has an MCL of 0.002 mg/L, represented below as the red dashed line (U.S. EPA) The blue line represents the trend of average endrin between 2000 and 2024. Data in the figure is provided by EPA National Aquatic Resources Survey (NARS) in November, 2024.

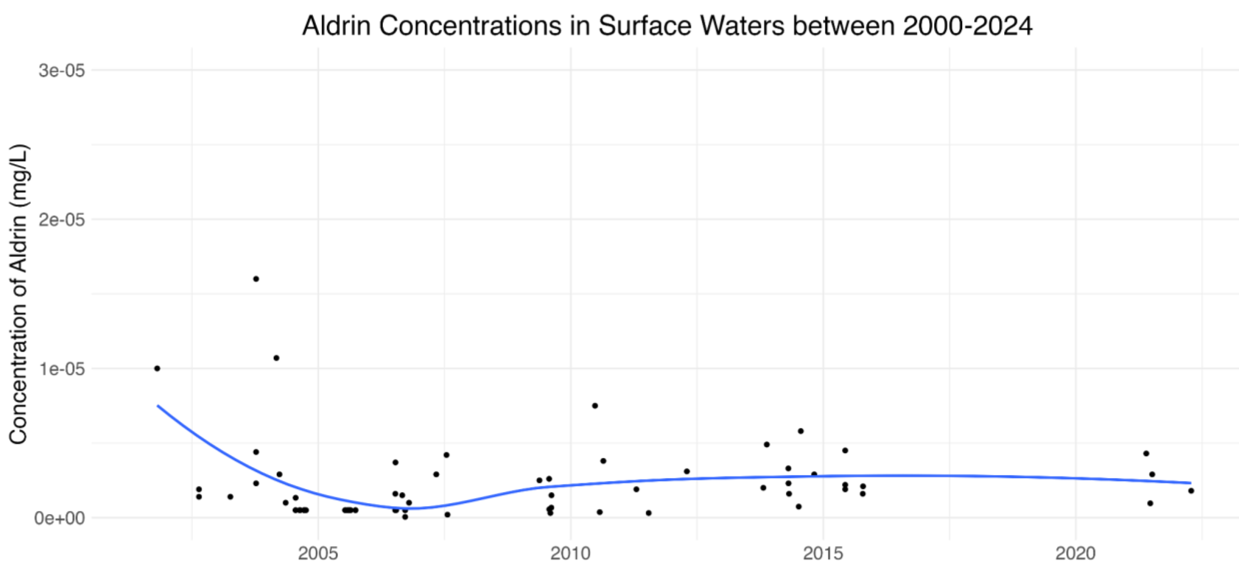

Figure 4.17. Aldrin is a potent carcinogen with an MCL of 0.0 mg/L.The blue line represents the trend of average aldrin between 2000 and 2024. Data in the figure is provided by EPA National Aquatic Resources Survey (NARS) in November, 2024.

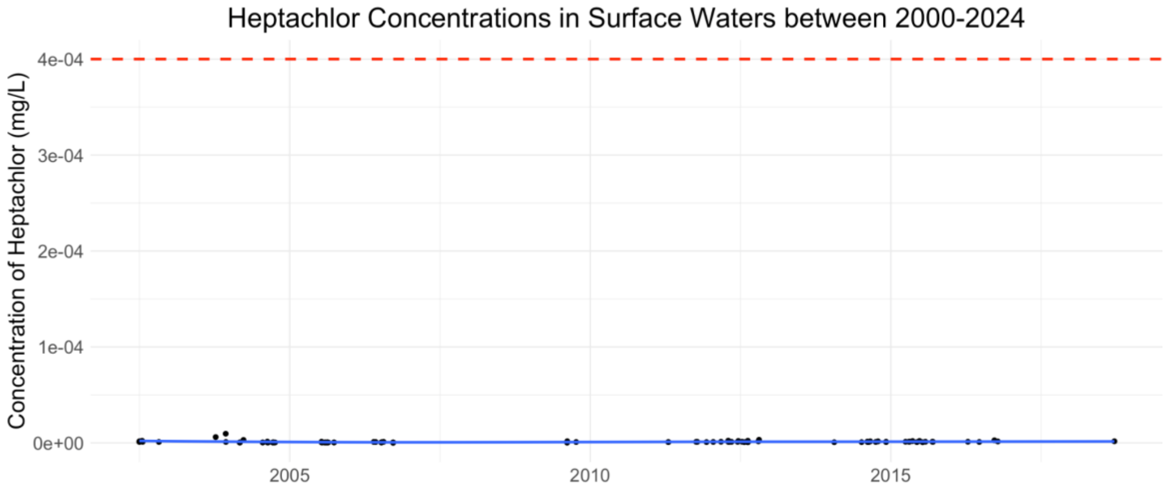

Figure 4.18. Heptachlor is a residue of a banned termiticide and has an MCL of 0.0004 mg/L as shown as the red dashed line in the figure below. (U.S. EPA) The blue line represents the trend of average heptachlor between 2000 and 2024. Data in the figure is provided by EPA National Aquatic Resources Survey (NARS) in November, 2024.

4.5 Monitoring Gaps

Meteorological data for the Cahokia-Joaquim Watershed were limited. Only two stations measured all three required variables within the watershed and recorded precipitation data for the period from 2000 to 2024. Unfortunately, temperature data for the St. Louis Science Center site are limited, covering only the years 2002 to 2020, likely due to the COVID-19 pandemic. While the two stations represent both states within the watershed, their close proximity limits the scope of the analysis of broader climate trends.

Water quality data for the Cahokia-Joaquim watershed is limited in regard to public accessibility and reporting consistency. The available datasets lacked detailed metadata, including the coordinates of the surface water sampling locations, precluding spatial analysis of pollutants in the surface waters of the Cahokia-Joaquim watershed. Additionally, Mirex—a pesticide linked to oncogenic effects including tumor formation in liver, adrenal gland, and kidney tissues— lacked a sufficient number of recorded measurements for a time series, despite Mirex being listed as a cause for impairment in several section 303(d) listed impaired water bodies in the watershed. Given the high toxicity of Mirex (MCL of 0.00003 mg/L), monitoring should be frequent, and the results accessible to the public. Moreover, water quality data collection across this watershed is conducted by multiple organizations that employ varied units, methodologies, and instrumentation, and no central database currently consolidates these datasets. This lack of standardized data sharing creates additional barriers and time constraints for integrative assessments of water quality trends and potential health risks in the region.

4.6 Summary

The Cahokia-Joaquim Watershed experiences significant changes throughout the year. Hot, wet summers result in higher discharges into local streams and rivers, contributing to major flood events such as the flood of July 2022. In contrast, colder, drier winters dominated by snowfall lead to lower, less variable discharge levels. Flow variability across the rivers in the watershed is substantial, with the average flow of the River Des Peres being only 0.03% of the average flow of the Mississippi. A notable water quality exceedance is mercury, which has consistently exceeded its maximum contaminant level (MCL) since 2000. Other water quality indicators, such as lead, have not regularly exceeded MCL standards, and the frequency of exceedances has decreased in recent years. Pollutants like chloride peak during the winter months due to consistent road salting, a persistent issue complicated by public safety concerns.

While this data provides valuable insight into the climate, rivers, and water quality of the watershed, the limited scope of the available data makes it difficult to draw definitive conclusions. The lack of location-specific water quality data and the challenges in compiling such information make it hard to pinpoint the sources of pollutants. Additionally, given the close proximity of the two meteorological stations, extrapolating trends beyond the immediate area remains challenging. To build a more comprehensive understanding, further data collection and analysis would be necessary.

5.0 Point and Nonpoint Source Impacts

5.1 Introduction

Understanding the source of pollutants in a water body is a crucial step before attempting to remove them or prevent future releases. Pollution can generally be categorized into two broad types: point source and non-point source pollution. Point source pollutants originate from a single, identifiable source, such as a wastewater treatment plant or a confined animal feeding operation (Inslee, 2024). These sources are relatively easy to monitor and regulate, as the facilities are required to apply for permits and meet specific standards for their effluent discharges. Implementing stricter laws or increasing penalties for exceedances can incentivize better management practices. In contrast, non-point source pollution, which includes runoff from urban areas or agricultural lands, is much more challenging to identify and control. The numerous factors contributing to pollutants in stormwater complicate efforts to implement effective policies or technologies to reduce pollutant loads. To better understand the sources and magnitude of both point and non-point source pollution in the Cahokia-Joaquim watershed, data from two U.S. EPA tools—the Enforcement Compliance History Online (ECHO) and the Pollution Load Estimation Tool (PLET)—will be analyzed.

5.2 Point Sources

Major point source facilities in the Cahokia-Joaquim watershed are mostly located along the Mississippi River (Figure 5.1). A major point source facility is a site that emits pollutants above a regulatory threshold set by agencies such as the U.S. Environmental Protection Agency (EPA), often contributing significantly to air or water pollution. Whereas a non-major point source facility emits pollutants below this threshold and generally has a less significant impact on environmental quality. Of the major point source facilities, the largest emitter is the St. Louis Sewer District Bissell Point Wastewater Treatment Plant, which releases over 30,000,000 pounds of pollution each year, including total suspended solids (TSS), biological and chemical oxygen demand, nitrogen, and phosphorus (Figure 5.2).

High levels of TSS reduces water clarity, harms aquatic habitats, and can disrupt fish's ability to consume oxygen. Elevated biological oxygen demand (BOD) or chemical oxygen demand (COD) signifies the presence of organic pollutants and leads to oxygen depletion that can harm or kill aquatic life. Excess nitrogen and phosphorus contribute to eutrophication, causing algal blooms that reduce dissolved oxygen, block sunlight, and disrupt aquatic ecosystems. Together, these pollutants can significantly impair water quality, biodiversity, and ecosystem health. Other common pollutants from major point sources in the region include chlorides and sulfates (Figure 5.3). Of the top ten major point source facilities in the watershed, five are wastewater treatment plants (Figure 5.2). Others include the City of Edwardsville in Illinois and Mississippi Lime, a leading manufacturer of calcium products and calcium-based solutions.

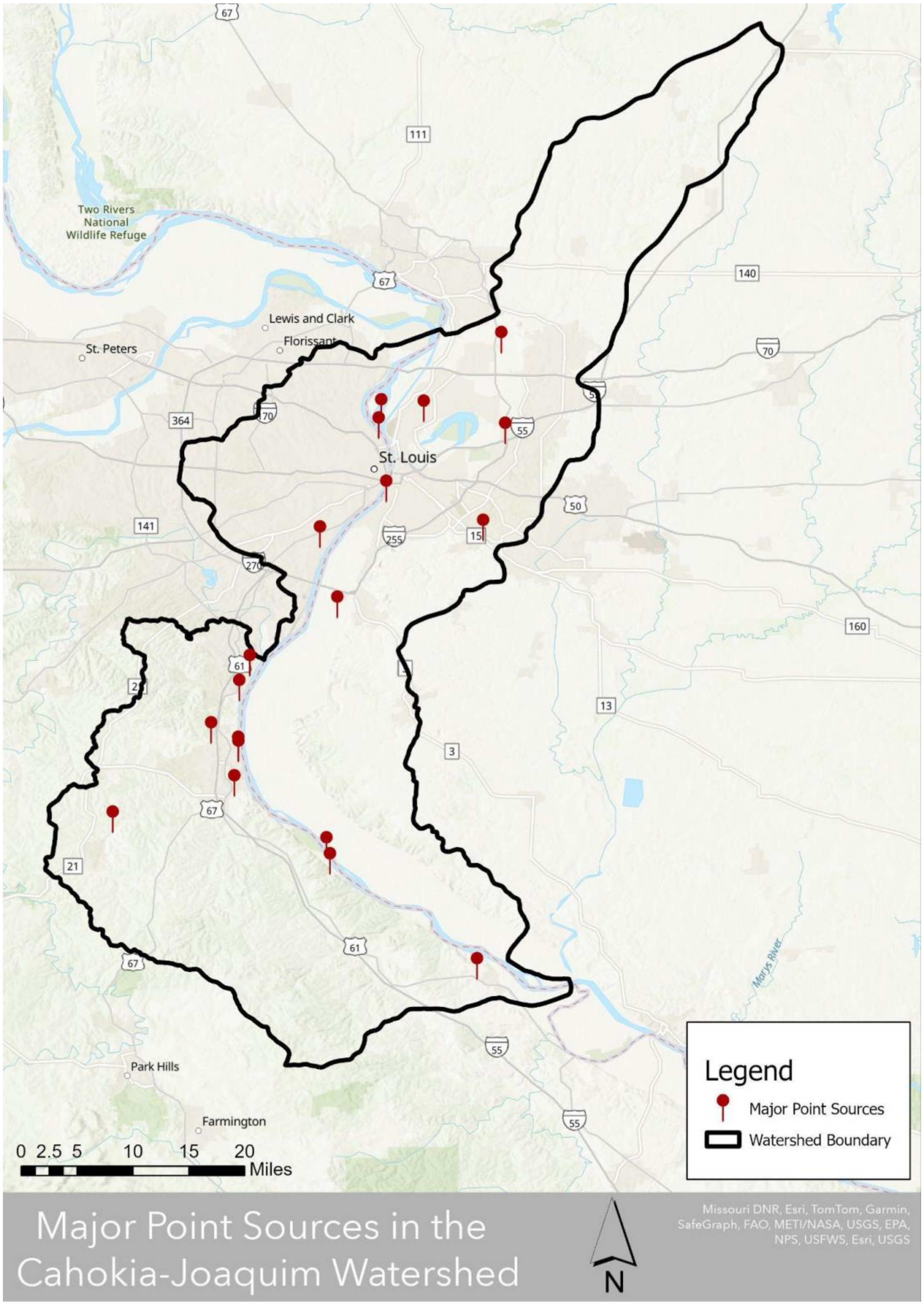

Figure 5.1. Major Point Sources in the Watershed. Locations of major point sources of water pollution in the Cahokia-Joaquim Watershed including facilities in both Missouri and Illinois. Data provided by the U.S. EPA Enforcement and Compliance History Online (ECHO)

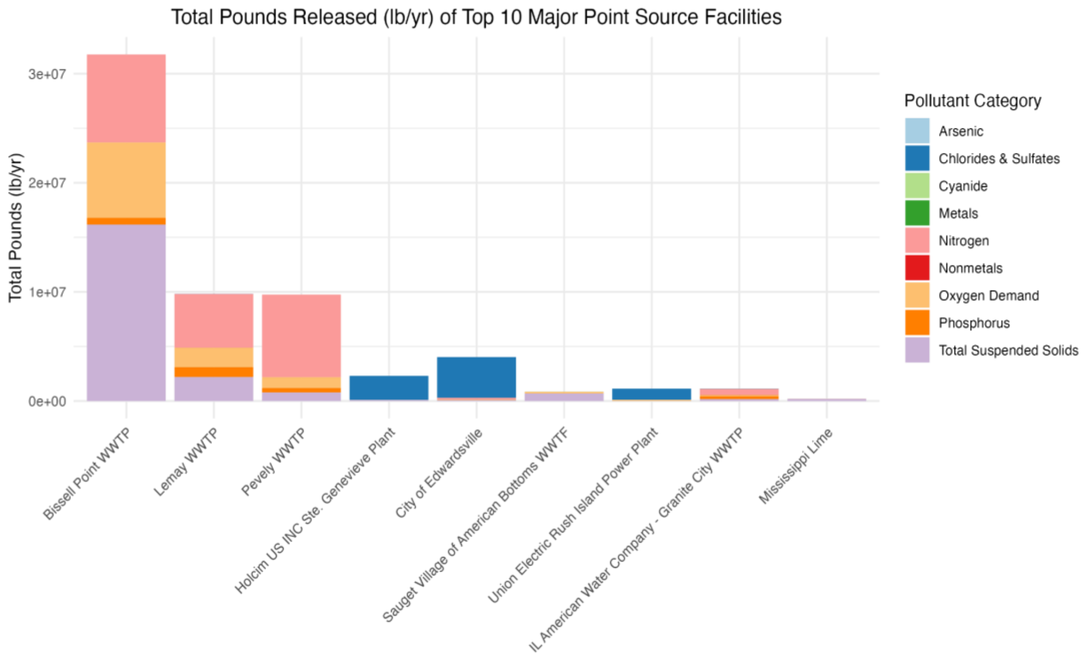

Figure 5.2. Top 10 Major Point Source Releases. The total pounds released yearly from the ten major point source facilities with the greatest annual pollution emissions. The most common pollutant groups include total suspended solids (purple), Nitrogen (pink), Oxygen demand (yellow), and chlorides & sulfates (blue). Data provided by the U.S. EPA Enforcement Compliance History Online (ECHO).

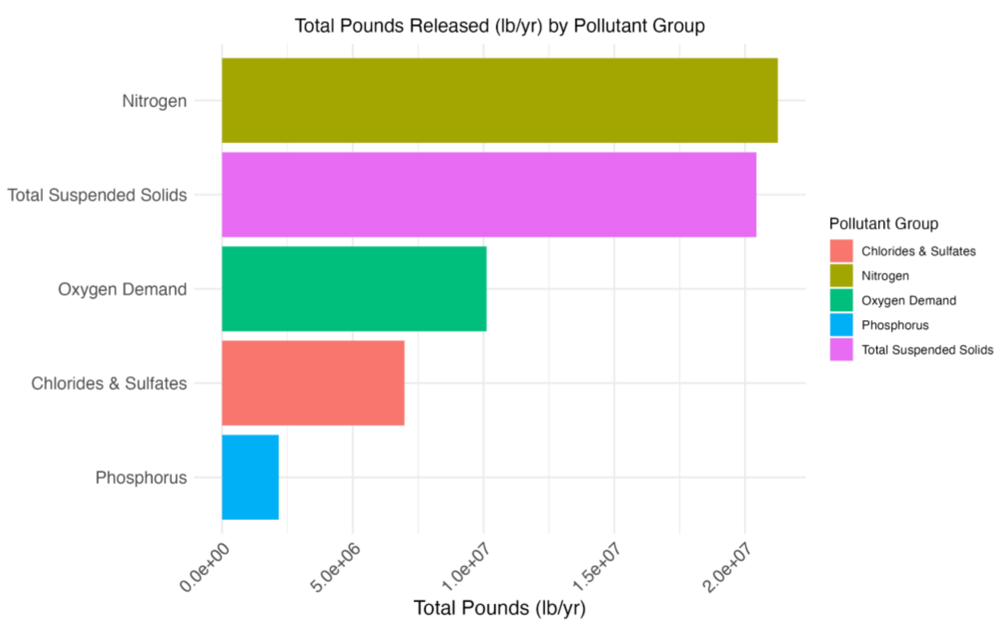

Figure 5.3. Total Pounds/Year of Five Major Pollutants Released by Major Point Sources The five most prevalent types of pollutants in major point source facilities in the Cahokia-Joaquim watershed includes Nitrogen (olive green), Total Suspended Solids (pink), Oxygen Demand (dark green), Chlorides & Sulfates (red), and Phosphorus (blue). Data provided by the U.S. EPA Enforcement Compliance History Online (ECHO).

5.3 Nonpoint Sources

The Cahokia-Joaquim Watershed contains a diversity of land use types, which contribute non-point source loads to the waterways. To best capture this diversity, we explored three distinct groups of subwatersheds (HUC-12 level) within the broader watershed (Table 5.1). These groups correspond to three regions: the city of St. Louis, the region in southern Missouri, and the region in Illinois, across from St. Louis. The St. Louis region is highly urbanized, the southern Missouri region is fairly rural, and the Illinois region contains a mixture of urban and agricultural lands. Non-point sources within this region include urban areas, cropland, septic systems, and groundwater. St. Louis and Illinois have the highest non-point source loads, while southern Missouri has comparably lower loadings across the board (U.S. EPA PLET).

As seen in Table 5.1, major contributors to nitrogen loadings include the River Des Peres and Schoenberger Creek-Mississippi River in St. Louis City, Fourche a Du Clos in southern Missouri, and all three sub-watersheds in Illinois. In St. Louis City and Illinois, the nitrogen loads are mostly from urban areas, though in Illinois, cropland contributes a large portion as well. Groundwater contributes less nitrogen in those regions (Figure 5.4).

Similarly, those six sub-watersheds are major contributors to the phosphorus load. For each region, most of the phosphorus is from cropland areas, followed by urban areas. Groundwater contributes a small amount of phosphorus, while septic systems contribute an almost negligible amount (Figure 5.4).

The single most significant contributor of BOD loads is the Schoenberger Creek-Mississippi River in St. Louis City, with much of that BOD coming from urban areas. Illinois and southern Missouri similarly have the majority of BOD loadings come from urban areas (Figure 5.4).

The largest sediment load is from the Judys Branch-Cahokia Creek subwatershed in Illinois, followed by Schoenberger Creek-Mississippi River, followed by the other two Illinois subwatersheds. The majority of the sediment load in Illinois is from cropland, while most of the sediment load in the St. Louis City region is from urban areas (Figure 5.4).

Table 5.1. Nonpoint Source Loads by Watershed. Loads for nitrogen, phosphorus, biochemical oxygen demand (BOD), and sediment at the HUC-12 watershed scale. Three HUC-12 watersheds were selected for analysis from each of the three regions within the Cahokia-Joaquim Watershed: St. Louis City, Southern Missouri, and Illinois regions. Data from U.S. EPA PLET.

Watershed Name (HUC-12 Code)	N Load (lbs/year)	P Load (lbs/year)	BOD Load (lbs/year)	Sediment Load (tons/year)
St. Louis City				
Maline Creek-Mississippi River (071401010401)	69,468.87	10,000.99	79,187.32	3,304.18
River Des Peres (071401010506)	132,805.55	17,680.45	413,223.07	2,483.57
Schoenberger Creek-Mississippi River (071401010403)	354,104.41	51,061.95	1,178,751.61	7,854.15
Southern Missouri				
Brickleys Hollow-Mississippi River (071401010905)	32,270.97	4,065.26	23,986.62	1,288.77
Establishment Creek (071401010908)	43,277.3	5,830.99	36,593.87	1,890.85
Fourche a Du Clos (071401010906)	117,955.6	12,286.3	139,407.39	2,640.97
Illinois				
Judys Branch-Cahokia Creek (071401010301)	171,788.38	28,373.82	425,193.85	8,861.17
Schoolhouse Branch-Cahokia Creek (071401010303)	138,406.52	20,415.01	318,740.42	6,028.24
Canteen Creek (071401010302)	105,071.8	15,612.77	200,832.04	5,219.98

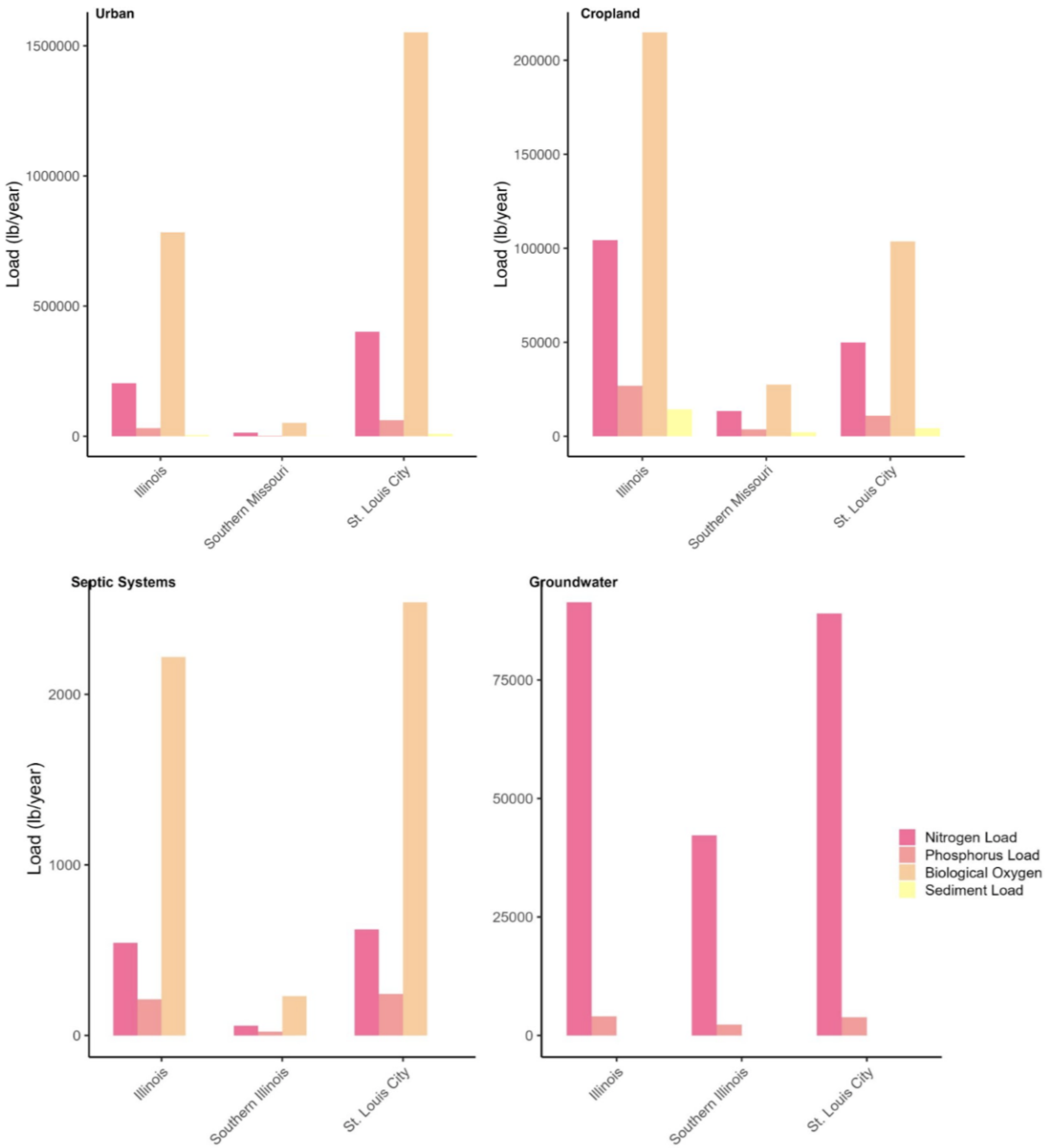

Figure 5.4. Nonpoint Source Pollution from Urban Areas, Cropland, Septic Systems, and Groundwater. While croplands contribute to the N, P, BOD, and sediment loads, urban areas, especially St. Louis City, contribute the most to the sediment load. Septic systems contribute minimally to the overall pollution load of the region compared to urban areas or croplands but primarily contribute phosphorus. Groundwater primarily contributes N and P, likely due to infiltration of water used for irrigation in the area. Data from U.S. EPA PLET.

5.4 Summary

This analysis of the Cahokia-Joaquim watershed shows the contributions of point and nonpoint source pollution to the region's water quality challenges. Major point sources, such as wastewater treatment plants, dominate pollutant loads with significant releases of total suspended solids, nutrients like nitrogen and phosphorus, and biological oxygen demand, which collectively degrade aquatic ecosystems. In contrast, non-point source pollution varies across subwatersheds, with urban runoff and cropland identified as key contributors to nutrient and sediment loads. Urban areas in St. Louis account for substantial nitrogen, phosphorus, and sediment loadings, whereas cropland was the primary source of sediment load in Illinois. By quantifying these contributions and identifying regional patterns, this study provides a foundation for addressing water quality issues in the watershed through targeted mitigation efforts.

6.0 Urban Stormwater Analysis & Recommended Best Management Practices

6.1 Introduction

Best management practices (BMPs) for stormwater management aim to reduce stormwater pollutant loads before the water enters major waterways. BMPs are a proactive approach to managing both the quantity and quality of stormwater runoff. There are a wide variety of BMPs that can be adopted, though each has different pollutant reduction efficiencies, costs, and siting considerations. To identify the size and extent of BMPs required, it is important to conduct an urban stormwater analysis. This type of analysis uses long-term precipitation data to calculate the frequency of all storm events and the frequency of major storm events (those exceeding 2.5 cm of precipitation). The majority of BMPs can only work properly with precipitation under this 2.5 cm threshold. To recommend BMPs for the Cahokia-Joaquim Watershed, we identified the major pollutants in the area, modeled one approach to BMP implementation, and assessed the resulting pollutant reductions. We chose to model the implementation of one highly efficient BMP in each different land use type (urban, cropland, and forest) in each of three regions of the watershed (St. Louis City, Southern Missouri, and Illinois). We applied each BMP to 30% of the land area.

6.2 Urban Stormwater Analysis

In the Cahokia-Joaquim watershed, two stations measure precipitation data: the Cahokia Airport station and the St. Louis Science Center station. These stations are only 9 miles apart, so the data they collect may not be fully representative of the entire watershed, which spans approximately 85 miles from the northernmost to the southernmost points.

Between 2000 and 2024, the two stations recorded between 2,417 and 2,828 storm events, resulting in a storm frequency of 26% to 30% for the region (Table 6.1). The majority of best management practices (BMPs) are only capable of treating or effectively handling storms with an average rainfall of less than 2.5 cm, which account for just 3% of the storms in the region (Figure 6.1). Implementing BMPs to manage stormwater in the region would be highly effective, as they could address 97% of the storm events.

Table 6.1. Stormwater Exceedances for Cahokia Airport and Science Center Precipitation Data. The 2.5 cm threshold is used by many Best Management Practices (BMPs), which is exceeded by roughly 3% of the storms in the Cahokia-Joaquim watershed. This suggests that BMPs will be effective for most rainfall events in the area.

	Cahokia Airport	Science Center
Total Number of Storms	2828	2417
Storm Frequency	31%	26%
# of Storms < 2.5 cm	2554	2138
# of Storms >2.5 cm	274	279
Frequency of Storms >2.5 cm	3%	3%

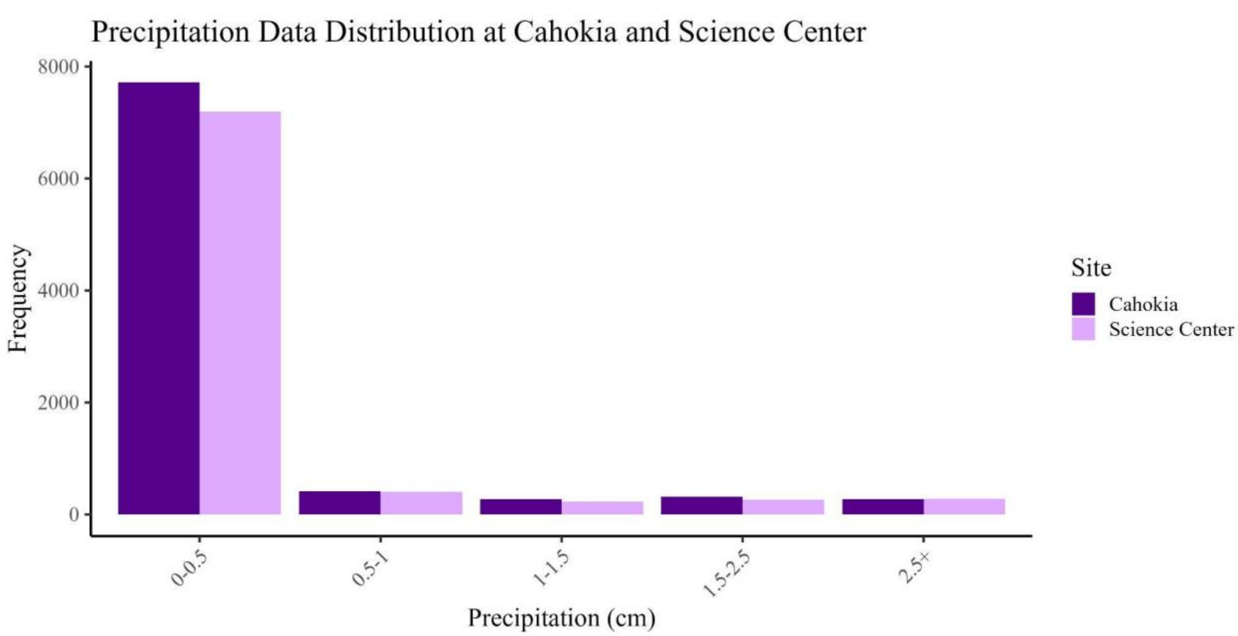

Figure 6.1. Distribution of Precipitation Data from Cahokia Airport and Science Center. Most precipitation events in the Cahokia-Joaquim watershed are between 0 and 0.5 cm, much lower than the threshold for most BMPs.

6.3 Recommended Best Management Practices

6.3.1 St. Louis City

This region of the watershed consists of the Maline Creek-Mississippi River, Schoenberger Creek-Mississippi River, and River des Peres subwatersheds. This area is highly urbanized, though it contains some cropland on the outskirts of the city (Figure 6.2). Within the urban areas, major pollutants of concern are BOD and sediment. Thus, the BMP selected for the urban areas of this region was infiltration trenches. They are highly effective at removing BOD and sediments from runoff, and have a relatively small footprint, meaning that they can be sited adjacent to roads and parking lots in dense urban areas (EPA, 2021). In the region's cropland areas, the major non-point source pollutants are nitrogen and sediment. We recommended implementing streambank stabilization and fencing in these areas because it reduces erosion and thus is highly efficient at nitrogen, phosphorus, and sediment removal. If these BMPs were implemented across 30% of the region's urban and cropland areas, they would result in a total sediment reduction of 17%, a total BOD reduction of 13%, and a nitrogen reduction of 8%. Individual reductions for each subwatershed are shown in Table 6.2.

6.3.2 Southern Missouri

The sub-watersheds selected from the Southern Missouri subregion include Brickley's Hollow, Establishment Creek, and Fourche à du Clos. This region is dominated by forests, with minimal urban areas or cropland (Figure 6.2). Compared to the St. Louis and Illinois subregions, this area has significantly less pollution from nitrogen and phosphorus, as well as lower biological oxygen demand. However, it still experiences a high sediment load entering the watershed. Given these factors, the BMP selected for this region is specifically designed for forests, with the primary goal of reducing sediment load in water. The majority of forest BMPs focus on reducing road erosion, but the BMP with the highest efficiency for sediment removal involves site preparation techniques that include applying and crimping straw, seeding alfalfa and grasses, and planting native plants. If this practice were implemented across 30% of the three selected watersheds, sediment from non-point source pollution could be reduced by 10-20% (Table 6.2).

6.3.3 Illinois

The Illinois Region includes the Judys Branch-Cahokia Creek, Schoolhouse Branch-Cahokia Creek, and Canteen Creek subwatersheds, which collectively span diverse land uses, including urban areas and cropland. In the cropland-dominated areas, nitrogen and sediment are the primary non-point source pollutants. To address these issues, the BMP selected was streambank stabilization and fencing, a practice with a mean, minimum, and maximum efficiency of 0.75 for nitrogen management. Urban areas within the region contribute significantly to biological oxygen demand (BOD) in runoff, leading to the selection of extended wet detention systems as the BMP for these areas. This BMP achieves a BOD removal efficiency of 0.72 and can be implemented adjacent to urban infrastructure. BMP implementation was modeled across 30% of the region: 435 acres in Judys Branch watershed, 463 acres in Schoolhouse Branch watershed, and 244 acres in Canteen Creek watershed. These practices are projected to result in substantial reductions in nitrogen, sediment, and BOD loads, improving water quality across the region (Table 6.2).

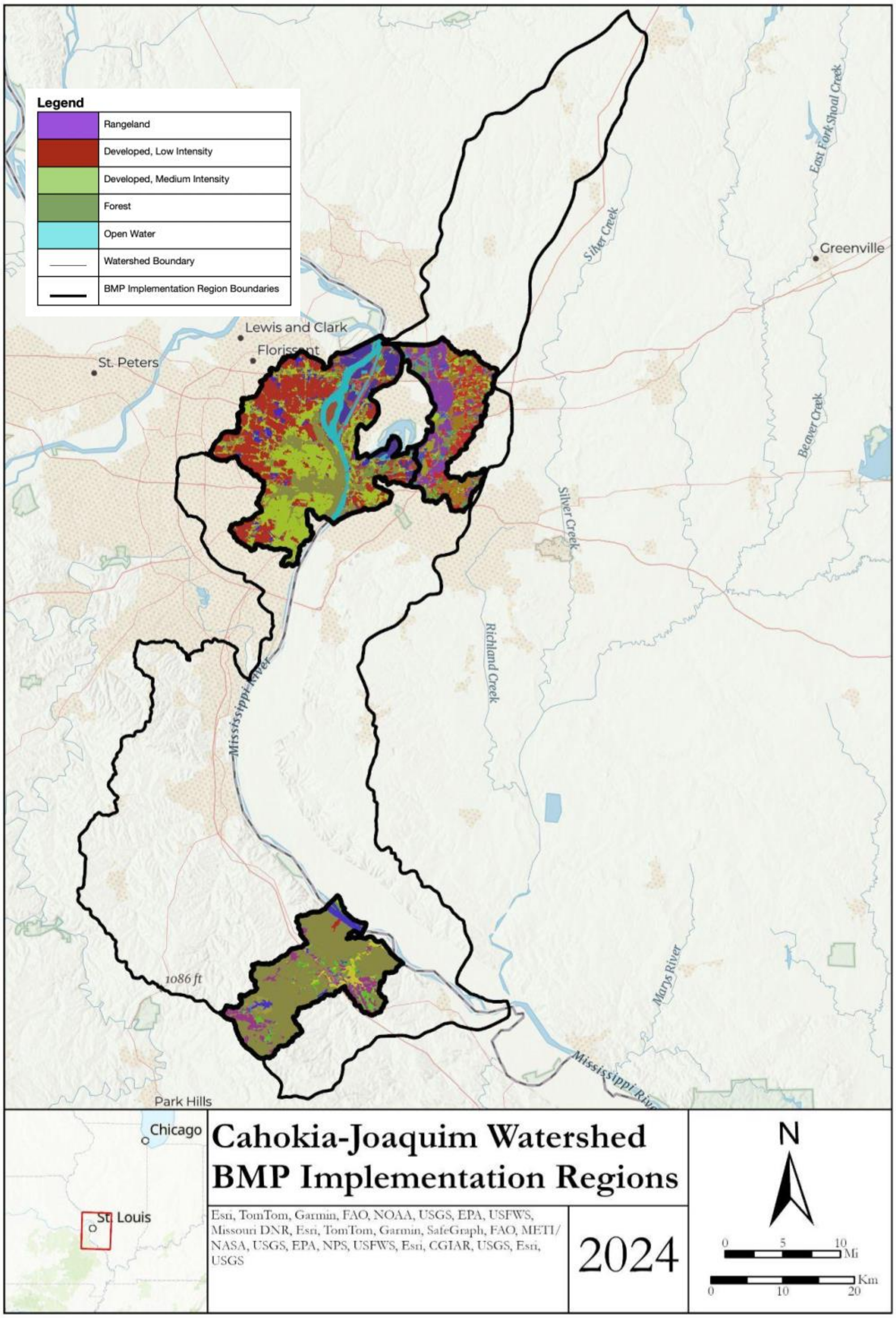

Figure 6.2. Locations and Land Use of Selected BMP Implementation Regions in the Cahokia-Joaquim Watershed. Regions were selected based on land use to encompass urban, agricultural, and forested areas within the watershed.

Table 6.2. Best management practices and modeled load reductions for three regions in the Cahokia-Joaquim Watershed. Load reductions calculated using EPA's Pollutant Load Estimation Tool (PLET).

Watershed Name (HUC-12 Code)	BMPs Selected	N Load Reduction	P Load Reduction	BOD Load Reduction	Sediment Load Reduction
St. Louis City					
Maline Creek-Mississippi River (071401010401)	Cropland: Streambank Stabilization and Fencing Urban: LID / Infiltration Trench	11.76%	18.3%	6.01%	22.5%
River Des Peres (071401010506)		5.62%	7.68%	11.49%	12.3%
Schoenberger Creek-Mississippi River (071401010403)		7.96%	10.21%	13.68%	15.91%
Southern Missouri					
Brickleys Hollow-Mississippi River (071401010905)	Forest: Straw, Crimp, Seed, Fertilizer, Transplant	1.4%	4.28%	3.77%	10.96%
Establishment Creek (071401010908)		1.42%	4.06%	3.36%	10.16%
Fourche a Du Clos (071401010906)		0.87%	3.2%	1.47%	12.09%
Illinois					
Judys Branch-Cahokia Creek (071401010301)	Cropland: Streambank Stabilization and Fencing Urban: Extended Wet Detention	7.72%	11.43%	3.9%	17.03%
Schoolhouse Branch-Cahokia Creek (071401010303)		5.09%	9.15%	3.61%	16.32%
Canteen Creek (071401010302)		3.51%	6.14%	1.9%	12.21%

6.4 Summary

Effective stormwater management in the Cahokia-Joaquim watershed requires targeted implementation of best management practices (BMPs) tailored to the region's diverse land uses and pollution challenges.The Cahokia-Joaquim watershed experiences a wide range of storm intensities, with major storms exceeding 2.5 cm of precipitation accounting for only 3% of recorded events between 2000 and 2024. This means that 97% of storm events fall within the range suitable for effective BMP implementation, highlighting the potential for impactful stormwater management. The primary recommended BMPs include infiltration trenches for urban areas, streambank stabilization and fencing for cropland, and sediment-focused site preparation practices for forested regions. These BMPs align with existing land-use characteristics and complement ongoing efforts to reduce key pollutants such as nitrogen, sediment, and BOD. Urban subwatersheds, particularly those with high impervious surfaces, require urgent BMP implementation to mitigate BOD and sediment loads. Meanwhile, cropland-dominated subwatersheds, such as those in the Illinois region, necessitate targeted efforts to address nitrogen and sediment runoff. Forested subwatersheds in the Southern Missouri subregion, though less impacted by nutrient pollution, still demand attention to sediment load management. By prioritizing BMP deployment in these high-need areas, the watershed’s overall water quality can be significantly improved.

7.0 Recommendations

7.1 Flooding

St. Louis experiences significant rainfall each year, with annual totals ranging between 76 and 152 millimeters (PRISM Climate Group). While the majority of this rainfall comes from smaller events, typically between 0 and 0.5 centimeters, the city remains vulnerable to catastrophic flooding events (Figure 6.1). These major floods highlight the critical need for effective flood prevention strategies to protect urban areas from the potentially devastating impacts of rising water. Without such measures, these floods can cause widespread damage by displacing families, damaging infrastructure, and disrupting daily life.

In response to this threat, St. Louis has relied heavily on levees as the primary means of flood control along the Missouri and Mississippi Rivers. These levees, installed by the Army Corps of Engineers, are designed to keep floodwaters at bay by raising the riverbanks above the base flood elevation or the 100-year flood level (Missouri State Emergency Management Agency, 2020-2021). However, despite their role in flood prevention, levees face several challenges, including aging infrastructure and the risk of catastrophic failure (D’Angelo et al., 2020). Many residents have grown overly confident in the levee system's ability to protect them, leading to a lack of preparedness in the event of a failure (D’Angelo et al., 2020).

This vulnerability underscores the need for a more comprehensive approach to flood prevention, incorporating strategies like preventing development in regulatory floodways and expanding floodplains. Restricting construction in flood-prone areas, especially the river channel and adjacent lands required to pass base flood discharge, can preserve critical buffer zones and reduce the potential for exacerbating flooding (Criss and Luo, 2016). Additionally, expanding floodplains through measures such as levee setbacks shown in the St. Charles case study described above can help restore natural flood buffers, increasing the city's resilience to future flood events (The Nature Conservancy, 2021). These strategies, alongside levee maintenance, form a crucial part of St. Louis’s flood prevention efforts, ensuring the city is better equipped to handle the growing threat of flooding.

7.2 Water Quality

To address water quality challenges in the Cahokia-Joaquim Watershed's urban areas, we recommend the implementation of extended wet detention ponds and infiltration trenches. Extended wet detention ponds are engineered basins designed to temporarily hold stormwater runoff for an extended period, allowing for sedimentation and biological uptake of nutrients. This method effectively reduces pollutant loads with an efficiency of 55% for total nitrogen, 69% for total phosphorus, 72% for Biological Oxygen Demand (BOD), and 86% for total suspended sediment (TSS) (MDEQ 1999). In areas where space is limited, infiltration trenches provide a viable alternative. These are narrow, gravel-filled channels designed to capture runoff and promote its infiltration into the soil, enhancing groundwater recharge while filtering pollutants. Though their efficiency for BOD and sediment is unquantified, infiltration trenches are effective in reducing total nitrogen by 55% and total phosphorus by 60% (MDEQ 1999).

For agricultural areas, we recommend implementing streambank stabilization and fencing to reduce soil erosion, a primary source of nitrogen, phosphorus, and sediment in surface waters. Streambank stabilization involves techniques such as planting vegetation or using riprap to prevent soil displacement along waterway banks, while fencing prevents livestock from accessing and destabilizing streambeds. These measures are highly effective, with a pollutant reduction efficiency of 75% for total nitrogen, phosphorus, and sediment (U.S. EPA 1993). In forested areas, where road erosion contributes to sediment loads, we recommend applying straw crimping combined with seeding of alfalfa and grasses. These methods stabilize exposed soils by anchoring straw into the ground and promoting vegetation growth, which reduces erosion and sedimentation in adjacent waterways. To ensure comprehensive watershed management, we emphasize the need for increased frequency and transparency in water quality monitoring, particularly for carcinogenic pesticides listed under the Clean Water Act Section 303(d) such as Mirex, Aldrin, Endrin, Dieldrin, Heptachlor, and Simazine.

7.3 Environmental Justice

Alongside the scientific recommendations, summarized above, for how to manage flooding and water quality issues in the watershed, environmental justice must be a key focus of how these recommendations are implemented. Without an explicit focus on justice, water management practices may inadvertently continue to exacerbate existing inequalities.

The city of St. Louis, as well as the surrounding suburban and rural areas, have been shaped by structural racism. Legacies of racist practices, such as redlining, restrictive covenants, and urban renewal programs, have led to long-term disinvestment in neighborhoods of color, such as North St. Louis (Fehler et al., 2019). This has contributed to higher rates of poverty and environmental health issues, alongside aging infrastructure and abandoned properties (Reed et al., 2019). As a result, many of these communities are more vulnerable to flooding and water quality issues. For example, levees built to protect wealthier communities end up diverting flood waters elsewhere, increasing the height and extent of flooding in less protected areas (Song, 2018). Additionally, compared to the southern half of the city, more people in North St. Louis live below the poverty line and lack health insurance (Hernandez, 2021). Accordingly, they are less able to access quality healthcare, invest in household measures to protect water quality, or obtain infrastructure upgrades from the city, thus making them more vulnerable to the impacts of poor water quality.

Even recently, there is evidence that water management policies in the Cahokia-Joaquim Watershed have failed to be equitably implemented. Project Clear was a settlement reached between EPA and the Metropolitan Sewer District (MSD) in 2011. MSD agreed to conduct $4.7 billion of wastewater system upgrades due to Clean Water Act violations from combined sewer overflows. The pilot projects for Project Clear focused on prioritizing green infrastructure (GI) in North St. Louis while investing in more robust wastewater treatment plant upgrades in other regions. Although GI has water quality benefits, it was primarily implemented in North St. Louis as a cost-saving measure, resulting in lower investment in the area compared to other regions. Additionally, there was minimal effort to monitor the benefits of GI or to create economic opportunities for residents through its installation and maintenance. This approach effectively bypassed the North St. Louis region's need for critical gray infrastructure investments and failed to address existing economic inequalities (Heck, 2019). Furthermore, MSD has been prioritizing removing combined sewer overflows in the broader St. Louis County rather than those inside the city itself, again disinvesting in urban communities (Metropolitan St. Louis Sewer District, 2020a).

In light of longstanding and recent environmental justice challenges, we propose the following recommendations for equitable water management. First, prioritize North St. Louis for water quality monitoring and flood control measures. This area, home to many predominantly Black communities, has faced systemic disinvestment and deprioritization, with aging water infrastructure. Its low elevation additionally increases flood risks. Second, allocate dedicated funding for disadvantaged areas to ensure that water management projects in low-income communities are implemented with the same frequency and standards as those in more affluent areas. Third, actively engage with communities to understand their specific needs and preferences regarding water and wastewater infrastructure. Finally, integrate best management practices (BMPs) with economic development by creating local jobs in wastewater treatment, as well as in the repair and maintenance of green infrastructure, fostering both environmental and economic benefits.

7.4 Collaboration

The Cahokia-Joaquim Watershed is located in the heart of the Mississippi River Basin. Local water quality is impacted by policy and plans in upstream areas. Likewise, its own local water management strategies have impacts downstream on communities further south in the basin. To the extent that it is possible, we recommend that entities within the Cahokia-Joaquim Watershed look for opportunities to collaborate with other water management organizations in the Mississippi Basin. Some of these include the Mississippi River Collaborative or the Science-Based Targets Network for Freshwater, to name a few. Collaboration outside the boundaries of the watershed may help address water quality issues more holistically.

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