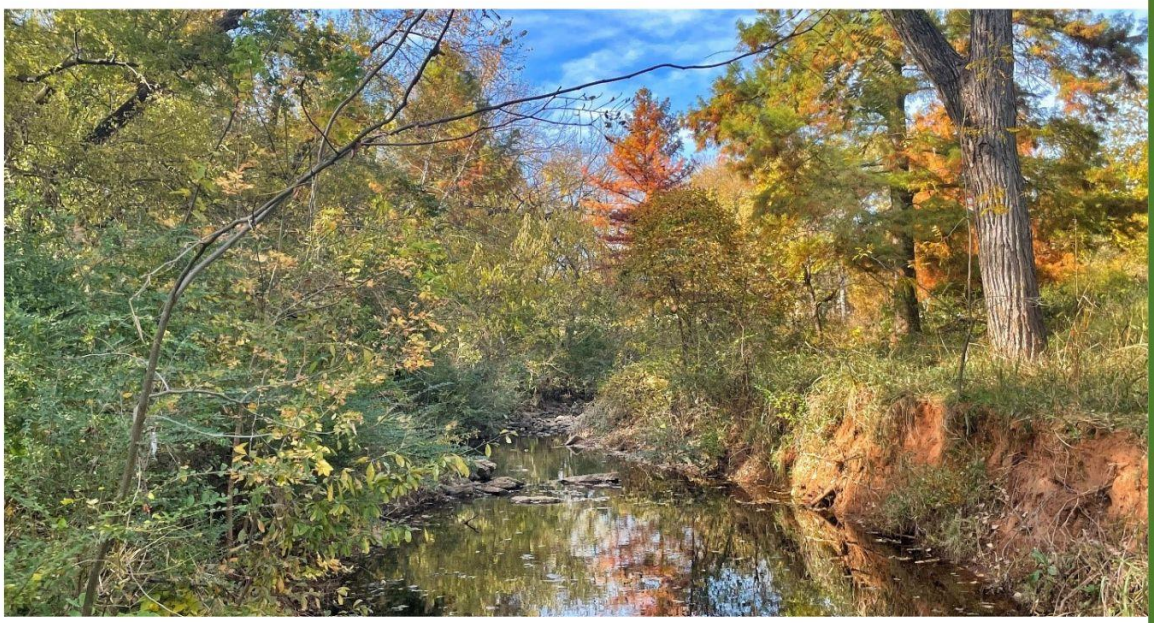
MARCH 2023

Bishop Creek Watershed Based Plan



In Partnership with:
Friends of Bishop Creek
Oklahoma Conservation Commission
City of Norman

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1. Introduction

The purpose of this watershed based plan (WBP) is to document strategies and best management practices (BMPs) to improve the ability of Bishop Creek, pictured in Figures 1, 2, and 3, to support a thriving ecological community and provide an opportunity for citizens of Norman to enjoy a healthy urban stream. Practices which improve ecological functioning will also prevent future degradation of Bishop Creek as development continues in the watershed.

Figure 1 Fall photograph of Bishop Creek by Karen Chapman.

1.A. Impetus for the WBP Process

The impetus for the development of this plan originated in the community. Bishop Creek and a tributary to Bishop Creek were listed on the 2020 Integrated Report's (IR's) 303(d) list as impaired for fishes bioassessment (ODEQ, 2020). The tributary listing was a new listing. Bishop Creek had previously been listed and delisted for fishes bioassessment. Shortly after the 2020 IR was released, a Blue Thumb volunteer, Karen Chapman, reached out to Dr. Rebecca Bond, Blue Thumb Water Quality Education Program Director at the Oklahoma Conservation Commission (OCC), and asked what needed to be done to develop a total maximum daily load (TMDL) to address the fishes impairment. Karen has monitored Bishop Creek for years and continues to do so. In response to her request, one of OCC's technical experts, Dr. Joseph Dyer, analyzed the available Bishop Creek data. The analysis indicated the

fishes impairment is an artifact of the assessment protocol rather than an ecologically meaningful impairment. Further details about why the assessment protocol is not appropriate for Bishop Creek will be explained later in this document. After Dr. Dyer's assessment, Dr. Bond reached out to Karen and offered to develop a WBP for Bishop Creek. As this plan was being developed, Bishop Creek (OK520610010180_00) was delisted for fishes bioassessment and a new listing was added for macroinvertebrates bioassessment (ODEQ, 2022). An unnamed tributary to Bishop Creek (OK520610010181_00) remains on the 2022 303(d) list for fishes bioassessment. Although it is the opinion of the stakeholder group that the past and current listings for fishes bioassessment are not ecologically meaningful, the stream is clearly impacted by development in the watershed, a compromised riparian area and a pervasive problem with trash. At this time, the ecological significance of the new listing for macroinvertebrates is unknown. Despite these uncertainties, the stakeholder group wanted to develop this watershed based plan because stakeholders understand that Bishop Creek, like most urban streams, is negatively impacted by nonpoint source pollution, impervious surfaces and altered flows.

Figure 2 Clockwise from top left: a section of eroding bank; trash removed from Bishop Creek; trash in Bishop Creek. Photos by Karen Chapman

Watershed based plans are effective management tools when the community is informed, engaged and motivated to protect or restore a creek. Without an engaged community, WBPs are rarely implemented. The Bishop Creek stakeholders group was informed and engaged throughout the development of this plan. Members brought personal experience with the stream and extensive knowledge of water quality management to the planning process. Eleven stakeholders were involved in developing this plan including stormwater professionals from the Cities of Norman and Noble, two former City of Norman Councilwomen, a representative of the Cleveland County Conservation District, a University of Oklahoma professor, and a representative of Norman's Department of Parks and Recreation, among others. Comments from stakeholders demonstrate their knowledge of Bishop Creek and their commitment to improving the health of the stream:

My relationship with Bishop Creek began in 2014 when my family started gathering in Eastwood Park every Sunday morning with other families with small children. Bishop Creek runs through the center of Eastwood Park and my children loved playing in the creek, searching for interesting rocks, and catching small fish. Bishop Creek is a rare place in the city of Norman where it is possible to interact directly with nature. As I spent more time near the creek, I observed the abundance of wildlife that depends on the creek. Multiple species of turtles, heron, and fish are just some of the more spectacular animals I regularly see in the creek. In the past few years, I have learned more about the relationship between Bishop Creek and stormwater runoff. Bishop Creek is one of Norman's major drainage channels that takes stormwater out of the city and into the Canadian River. I started monitoring Bishop Creek as a Blue Thumb volunteer in 2019. I have observed how stormwater runoff carries lawn fertilizers or salts that are used to de-ice roads into Bishop Creek. I have also observed how variation in streamside ecology impacts downstream erosion. In order to preserve Bishop Creek as habitat for wildlife, a place to engage with nature, and functional stormwater infrastructure, it is necessary to carefully manage the creek bed ecosystem. I would like to see a buffer zone, similar to the no-mow zone in Eastwood Park, on as much of the creek as possible. I would like to see new opportunities for residents to engage with the creek and learn about its function as habitat and infrastructure, like the proposed stormwater education park near where Bishop Creek intersects Alameda Avenue.
–Dan Mains

Bishop Creek is a beautiful spring-fed creek that flows through urban Norman. Urban creeks face unique challenges due to anthropogenic activity and Bishop Creek is no exception. Among these challenges: non-point source pollution from stormwater runoff. According to a 2016 map created by the city of Norman's GIS team, impervious surface comprises 35.6% of the Bishop Creek watershed. Although I monitor an area of Bishop Creek in the Jimmie Austin OU Golf Course as a Blue Thumb volunteer, I focus a lot of my attention on a section that flows through Eastwood Park. I've been removing trash from this section for 10 years now. This is a never-ending job. The following are ways in which trash enters creeks (from the EPA website): litter from garbage and recycling bins; litter from cars and trucks; illegal dumping; in-creek dumping; pedestrian litter; illegal encampments; wind; and storm drains. Bishop

Creek is impacted by all of these. In April 2022, I removed 272.65 pounds of trash from the Eastwood Park section of Bishop Creek. Bishop Creek was channelized upstream from Eastwood Park years ago, and this contributes to the erosion in the Eastwood Park section and downstream. Installing a creek boom where the concrete channel ends would be one way to reduce the trash downstream from the concrete channel. Eastwood Park is a jewel in core Norman, and it's located right across the street from Lincoln Elementary School. Near the foot bridge, along the banks of Bishop Creek, is a pollinator garden that was established for the second graders at Lincoln Elementary. This is part of their outdoor science curriculum. The children living in this area love to play in the park and also in Bishop Creek. They deserve to play in a creek that's not overrun with garbage. Trash quickly turns a safe place to play, learn, and explore into an unsafe place. Creeks are outdoor classrooms for our children. What do we want to see in our children's outdoor classrooms? Children learn so much from exploring their natural environment and learning about the species of wildlife and plant life in and around creeks. Urban creeks provide a way for us to "get away from it all" in the middle of a city, if only for a little while. They have a positive impact on our wellbeing. This is another reason they should be cherished and protected and why educating residents and city officials on the impact of non-point source pollution and how to reduce it in their lives is so crucial. Thankfully, the city of Norman's Parks and Recreation Department agreed to a no-mow zone along the Eastwood Park section of Bishop Creek several years ago. Although good news, this is only a small section of Bishop Creek. According to ODEQ's 2020 303(d) list, the waterbody size of Bishop Creek is 7.82 miles. That's a lot of riparian area that needs to be protected. The Bishop Creek watershed is one of the largest—if not the largest—watershed in urban Norman. Preserving and protecting the Bishop Creek watershed would be a proactive way to promote watershed awareness in the city of Norman and Cleveland County in general. Norman's Water Quality Protection Zone (WQPZ) was put in place to protect tributaries of Lake Thunderbird, which completely leaves out tributaries of the Canadian River. These tributaries (Bishop Creek is one) urgently need a WQPZ as well. Advocating for a creek isn't easy. Creeks aren't cute and fuzzy. Creeks can't reach out and hug us. Creeks don't have eyes filled with the pain of basic unmet needs. Creeks speak a language we don't readily understand. But consider this: Water is life, and there are many species of terrestrial and aquatic life living in and around a creek. By protecting and preserving one creek, think of the lives you're saving.
-Karen Chapman

I taught summer programs at a local natural history museum for 13 years, and Bishop Creek was an important part of these programs. Green, shady, and filled with wildlife, it was a respite from the hot, dry Oklahoma summer. Primarily though, it was valuable because it offered opportunities to teach so many different things: Reptiles? There were four species of turtles, and four species of snakes that were easily seen and abundant enough that you could count on finding them for the kids to observe. Birds? While pointing out an owl pellet on the banks of the creek, I looked up and could point out the Barred Owl that produced the pellet. Fish? There were minnows in abundance, bass, sunfish and sunfish nests everywhere, small catfish, mosquito fish, and many others. Ecology? The kids could readily observe the effect of Highway 9, which crosses

the creek, and the effect of oil wells along the bank of the creek on the water quality of the creek. Geology? Well, that is pretty much clay and sandstone, but the kids would ask about sudden changes in water temperature when we waded near an area where springs and seeps spill into the creek. History? We found two buffalo skulls and numerous bison bones that had cut marks on them from Native American activity. Math? The kids could look up our starting and ending position on a topo map, find the elevations, and determine how many feet the drainage had dropped in that area we traveled. You name it, you could use Bishop creek as a teaching tool. And it was cool and beautiful in a wild way, a beauty even an 8-year-old boy could admire.

What do I want for the creek? The wildlife has declined markedly in the years since I was wading the creek with classes. The lower fish populations are easy to notice and everything that feeds on them is reduced in consequence. I would like to see an end to parking lots and streets draining DIRECTLY into the creek, with no swales or other devices to moderate oily runoff. I would like to see less sedimentation, from construction and activity along the creek, and I would like to see mowing the sides of the creek stopped. This happens at the corner of Lindsey and Classen. The steep creek banks are regularly mowed, I think because the U-Haul lot wants to be visible. Development is coming closer and closer to the southern reaches of the creek, and I would like to see large setbacks to keep backyards at a distance from the creek. The natural vegetation along the creek needs to be preserved. I would like to see the creek protected and cherished for the asset it is.
–Roberta Pailes

As these comments demonstrate, Bishop Creek is deeply valued as a place for urban wildlife to thrive and urban residents to relax and interact with nature. The community not only values the creek but is knowledgeable about changes that would improve the health of the ecological community that lives in and around the creek.

1.B. Required Elements for this WBP

Because fishes bioassessment listings are not believed to be ecologically meaningful impairments and because the ecological significance of the new macroinvertebrate listing is unknown, this WBP was developed as an alternative protection plan ("5-alt") rather than a traditional nine-element restoration plan. Most protection plans are developed for pristine streams or high-quality waters. Bishop Creek is an unusual candidate for a protection plan since the impacts of urbanization on the stream are apparent. This plan would be more appropriately called an anti-degradation and improvement plan.

The required elements for an alternative protection plan are:

1. Identification of the causes or sources of non-point source (NPS) impairment, water quality problem, or threat to unimpaired/high quality waters;
2. Watershed project goal(s) and explanation of how the proposed project(s) will achieve or make advancements towards achieving water quality goals;
3. Schedule and milestones;
4. Proposed management measures (including a description of operation and maintenance requirements); and

5. Water quality results monitoring component (USEPA, 2013).

This plan will address each of these elements. The WBP is intended to be a living document that will be updated as continued monitoring documents the effectiveness or ineffectiveness of management actions in the watershed.

2. Watershed Characterization

2.A. Climate

Climate in central Oklahoma is mild in the spring and fall, hot in the summer and cool or cold in the winter. Aquatic systems are most likely to be stressed during the hot season due to extreme temperatures and drought. In Norman, the hot season is typically June through September. Average daily high temperatures range from 49°F in January to 92°F in July and August (usclimatedata.com). Average low temperatures range from 27°F in January to 71°F in July (usclimatedata.com) Extreme temperatures (over 100°F in the summer and less than 10°F in the winter) are not uncommon. Average monthly precipitation ranges from 1.15 inches in January to 5.52 inches in June (usclimatedata.com). Average annual precipitation is 38.9 inches (usclimatedata.com).

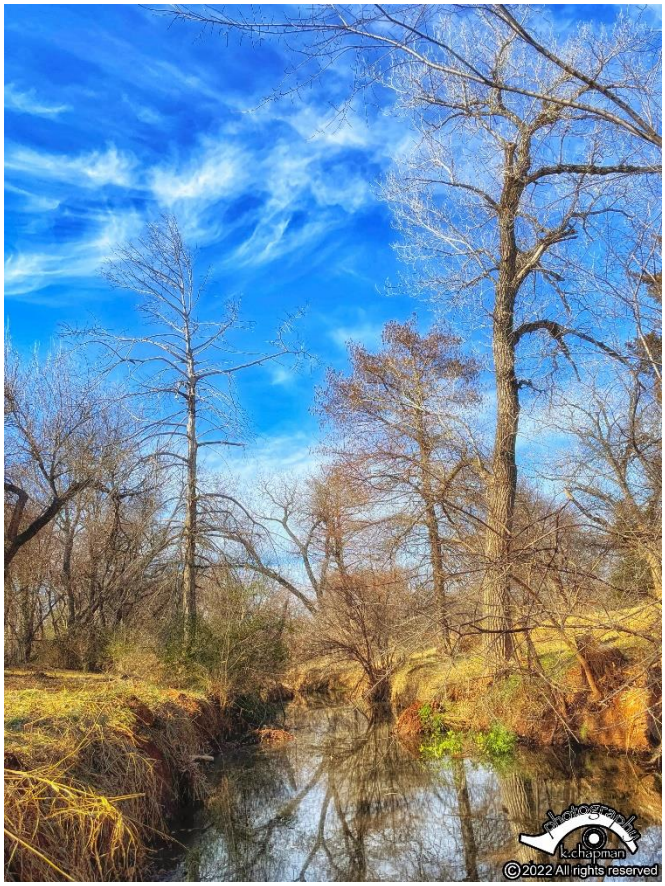

Figure 3 Winter photograph of Bishop Creek by Karen Chapman

Most of Oklahoma has not warmed in the past 50 to 100 years (USEPA, 2016). Although temperatures have not increased on average throughout most of the state, soils have become drier, annual rainfall has increased, and more precipitation falls during intense rain events (USEPA, 2016). Eastern Oklahoma has cooled in the past century, likely due to a combination of natural cycles and sulfates in the air. Sulfates are air pollutants that reflect sunlight back into space. Sulfate emissions are declining, so the cooling trend in eastern Oklahoma is unlikely to continue (USEPA, 2016).

According to the South Central Climate Adaptation Science Center, climate in Oklahoma will likely change in the following ways by mid-century (2036-2065):

1. Annual average high temperatures will increase by 5°F
2. 24 more days per year with a high temperature of 100°F or greater
3. Annual average low temperatures will increase by 5°F

4. 26 fewer days per year where the temperature drops below freezing (southcentralclimate.org)

The predicted changes (above) assume a continuation of current emissions. A significant decrease in emissions would result in smaller changes from current average climate conditions. Higher temperatures are expected to increase the intensity of naturally occurring droughts in Oklahoma, which will put increased stress on water resources, particularly in agricultural communities (ncis.org), and increase the risk of wildfires (USEPA, 2016). Additionally, extreme precipitation events are expected to increase. Extreme precipitation events carry an increased risk of flooding, soil erosion and degraded surface water quality (ncis.org).

2.B. Demographic Data

According to the United States Census Bureau, the projected 2021 population of Norman is 128,097. This is a 0.7% increase over the 2020 population. 75.9% of residents self-identify as white, 4.9% as black or African American, 4.2% as American Indian or Alaska Native, and 4.4% as Asian. The median value of owner-occupied housing is $184,300. 93.7% of adult residents have a high school degree and 44.1% of adult residents have a bachelor's degree. The median household income is $58,111 and 16.9% of residents are in poverty (census.gov).

2.C. Environmental Justice: Justice40 Initiative

Figure 4 depicts a map of the watershed generated with a data layer from the Justice40 Initiative. The goal of the Justice40 Initiative is to provide 40 percent of certain federal funding sources to disadvantaged communities. The initiative focuses on the following key areas: climate change, clean energy and energy efficiency, clean transit, affordable and sustainable housing, health burdens, training and workforce development, the remediation and reduction of legacy pollution, and the development of clean water infrastructure. For more information, please visit Justice40.

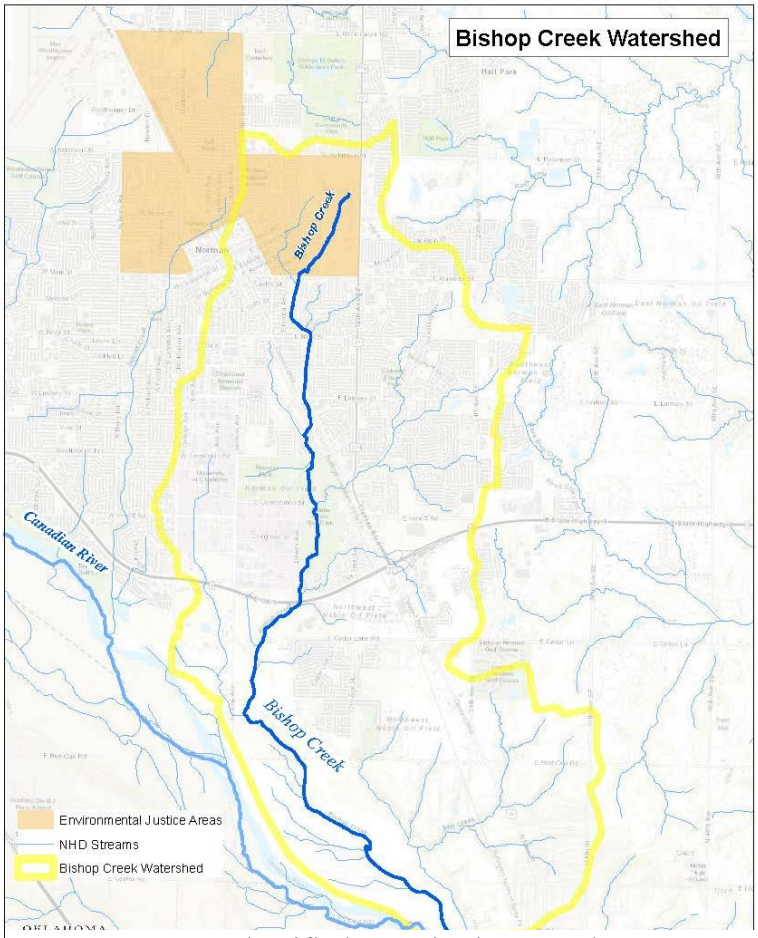

Figure 4 Areas identified as "Disadvantaged" using the Justice40 data

The highlighted areas in Figure 4 are areas identified as "disadvantaged" using the Justice40 data layer. A census block is disadvantaged if it is

above the threshold for one or more environmental or climate indicators and above the threshold for socioeconomic indicators. For example, a community is identified as disadvantaged for clean transit if it is at or above the 90th percentile for diesel particulate matter and above the 65th percentile for low income and 80% or more of the adults 15 years and older are not enrolled in higher education. Figure 4 depicts areas that may be eligible for priority funding under programs included in the Justice40 Initiative.

EJ Screen

The Environmental Protection Agency (EPA) uses EJScreen, an online mapping and screening tool, to compare environmental justice (EJ) indices statewide and nationwide. (Using the "Reports" tool, users may also compare data regionally.) The tool calculates and compares 12 EJ indices. Each index is a combination of a single environmental indicator and two demographic indicators: percent people of color and percent low-income in a census block group. EJ Indices are higher in block groups with a higher environmental indicator and large numbers of low-income and/or minority residents. The tool highlights block groups that contribute most toward the nationwide (or statewide) disparity in that environmental factor. Disparity is defined as the difference between the environmental indicator's average value among these demographic groups and the average in the US population. For more information on the EJScreen tool, please see www.epa.gov/ejscreen. It is important to note that the environmental and demographic estimates used by EJScreen become less reliable when examining small areas, such as a census block. It is best practice to summarize data within a larger area, such as several census blocks.

Figures 5-7 were generated using the Reports tool in EJ Screen. In the figures, "Selected Area" is the City of Norman and "Region" refers to EPA Region 6 (Oklahoma, Texas, New Mexico, Arkansas and Louisiana). The figures help visualize the significance of indices and indicators in the City of Norman compared with average indices and indicators for the state, region and nation. EJ Indices for lead paint, hazardous waste proximity and underground storage tanks are greater than the 50th percentile when compared to state, regional and national data. Indices for 2017 diesel particulate matter and traffic proximity are greater than the 50th percentile compared to state and national data. Residents of Norman may be exposed to the following pollutants at a rate higher than the 50th percentile relative to the state, regional and nation: particulate matter 2.5, ozone, 2017 diesel particulate matter, 2017 air toxics cancer risk, 2017 air toxics respiratory hazard index, risk management program facility proximity, hazardous waste proximity and underground storage tanks. Residents of Norman may be exposed to traffic-related pollutants at a rate higher than the 75th percentile when compared to state data. Socioeconomic indicators that may disproportionately impact Norman residents include low income and linguistic isolation.

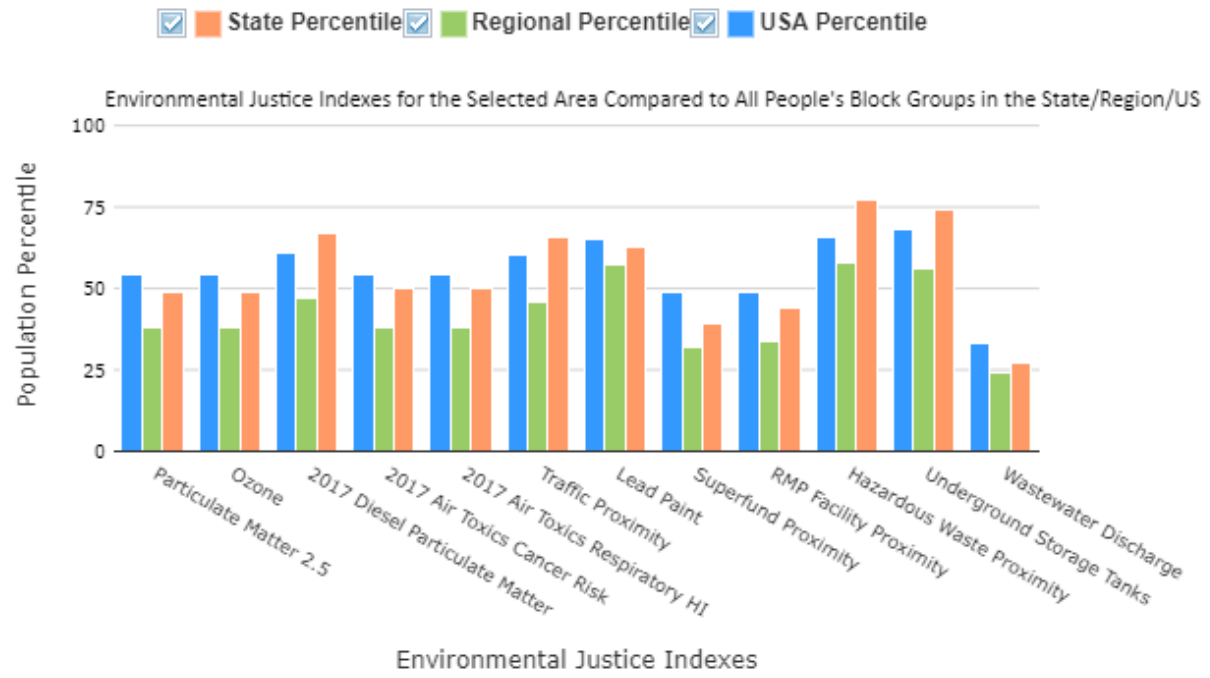

Figure 5 Norman EJ indices compared to state, regional and national indices

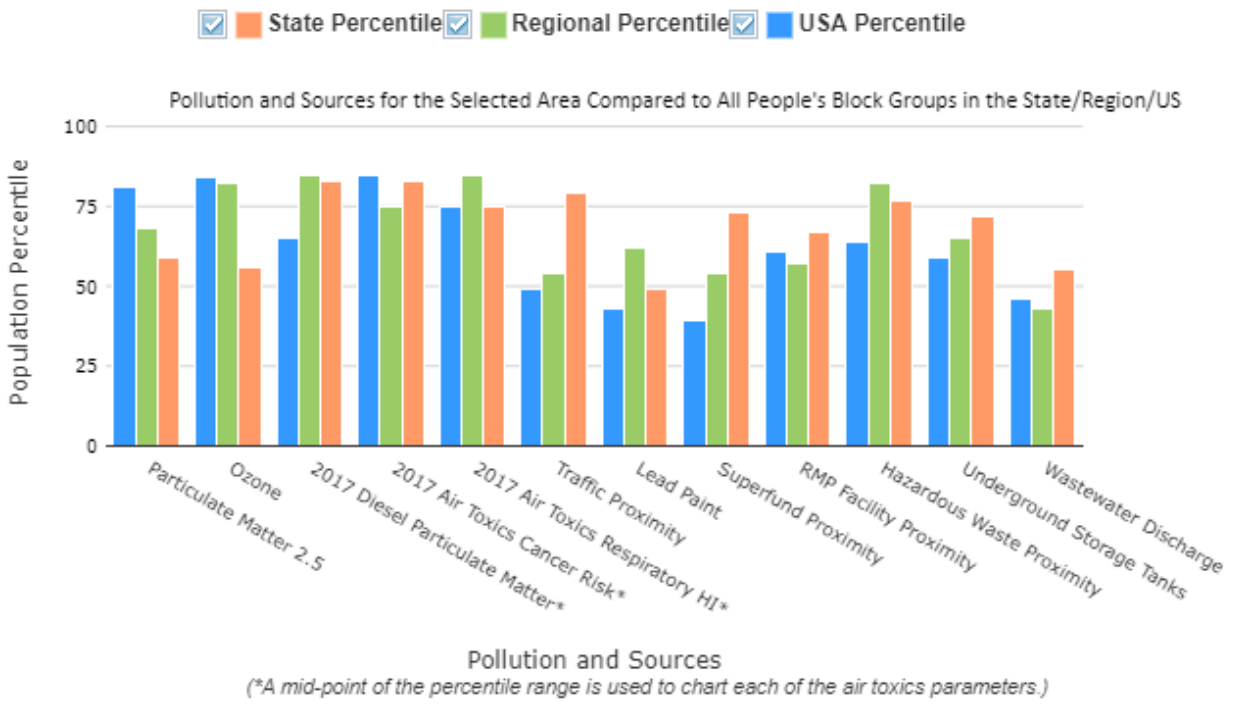

Figure 6 Norman pollution sources compared to state, regional and national pollution sources

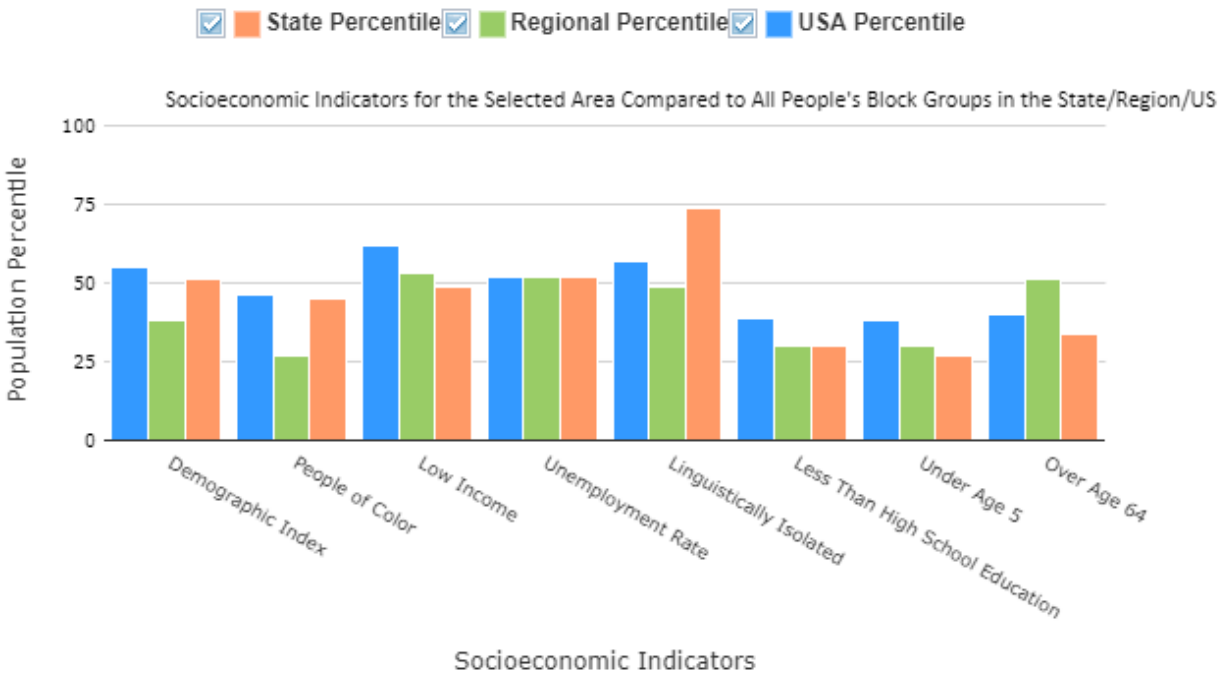

Figure 7 Norman Socioeconomic indicators compared to state, regional and national indicators

2.D. Hydrology

The Bishop Creek watershed drains an area of approximately 37 km^2 and the mainstem of Bishop Creek is approximately 12.56 km (7.82 mi) long (Chapman, 2019). Most of the watershed falls within the boundary of the City of Norman. The southern portion of the watershed is outside of the city boundary and is primarily agricultural. The headwaters of the mainstem originate near Griffin Park and flow south to its confluence with the Canadian River. Please see Figure 8 for a map of the mainstem of Bishop Creek and the Bishop Creek Watershed within the larger HUC 12 watershed, and Figure 9 for a map of Bishop Creek and its associated tributaries.

2.E. Ecoregions

Bishop Creek is in the Level III Central Great Plains ecoregion (27) and the Level IV Cross Timbers Transition ecoregion (27o)(Woods et al, 2005), see Figure 10. According to Woods et al (2005), the natural vegetation of the ecoregion includes mixed grass prairie, cross timbers and tall grass prairie. As a result of human disturbance, the abundance of upland trees has increased greatly in the last 200 years, and many riparian areas and wetlands have been modified or lost. Streams tend to be incised and have muddy or rocky substrates (Woods et al, 2005).

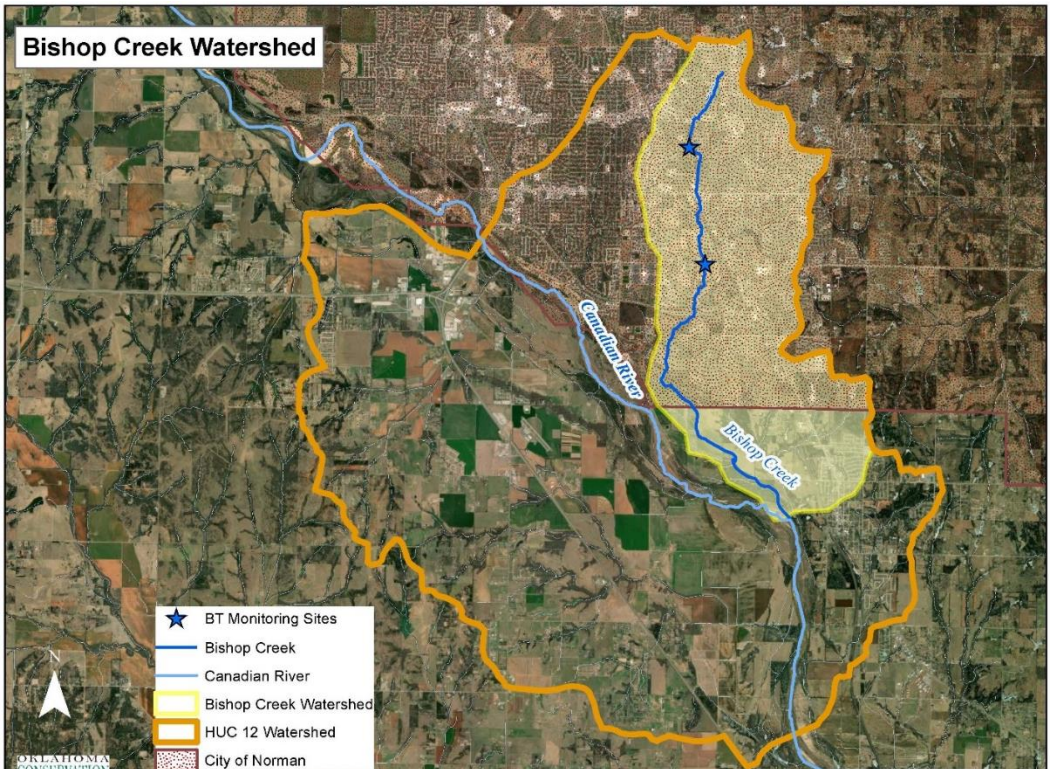

Figure 8 Map of the Bishop Creek watershed within the HUC 12 watershed

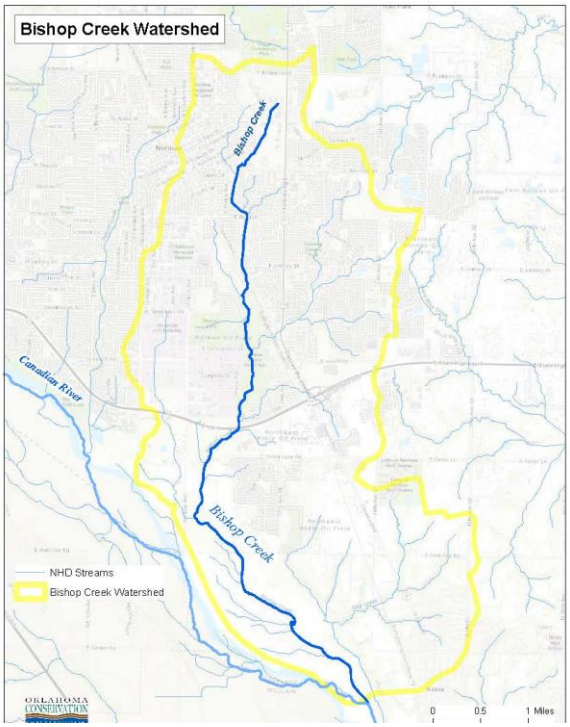

Figure 9 Bishop Creek and its associated tributaries from the National Hydrology Dataset.

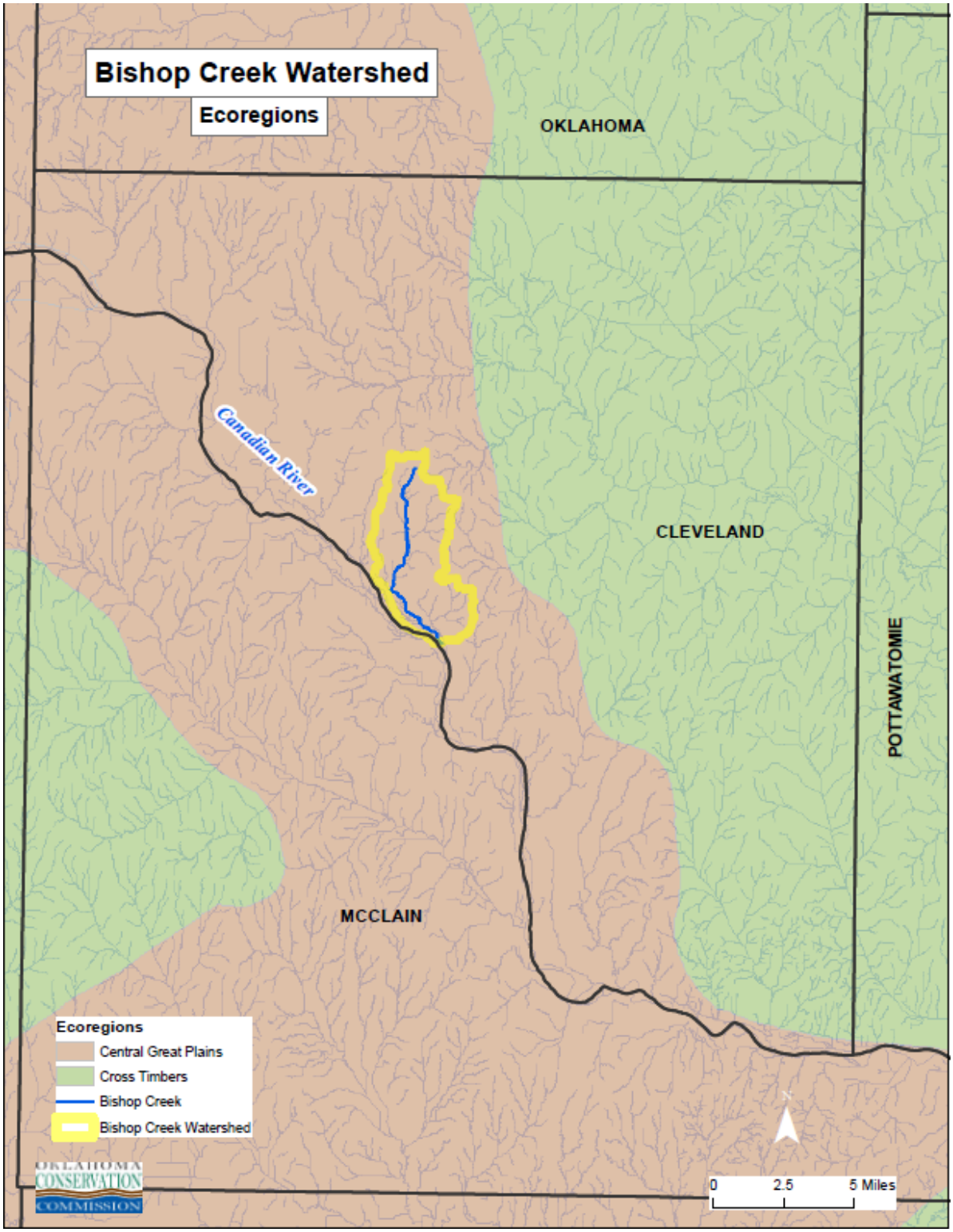

Figure 10 Ecoregions surrounding Bishop Creek watershed

2.F. Soils and Topography

Most of the area between the North Canadian and the Canadian Rivers is a high, flat paleoterrace that was created by water spreading across the area and depositing sediment during the Pleistocene. Prior to settlement, this area was a productive prairie. The native soils are silty loams deposited on top of clay subsoils. Undisturbed prairie in this region likely had a 10-15% runoff rate during significant rain events. Because the area is flat, water moved slowly, depositing heavy soil particles first and then progressively smaller particles as it slowed. Today most of this area is highly developed. Runoff from paved areas is 100%; runoff from heavily managed green spaces like turfgrass lawns and parks is about 80%. Consequently, Bishop Creek is receiving much more water than it would have pre-development. In addition, slopes in developed areas of Norman have been altered to quickly shed water from areas that were originally flat. Because surfaces and slopes have been extensively modified, native soils are no longer driving fluvial geomorphic processes in most of the Bishop Creek watershed. Soil health practices may not be able to significantly impact stream dynamics in most of the Bishop Creek watershed. An exception may be the area between the Canadian River and the escarpment that rises to the flat terrace. This area is the flood plain of the Canadian River and before settlement would have included wetlands. Soil health practices in this area might have the potential to reclaim some of the ways Bishop Creek would have functioned prior to development (G. Scott, personal communication, June 20, 2022). See Table 1 for acres and percentages of each soil type in the watershed and Figure 11 for a map of watershed soils.

Table 1 Number of acres and percentage of each soil type within the Bishop Creek watershed

Soil Type	Acres	Percentage of Watershed Area
Bethany-Pawhuska complex, 1 to 5 percent slopes	20.71	0.21
Bethany silt loam, 0 to 1 percent slopes	318.15	3.22
Bethany silt loam, 3 to 5 percent slopes	9.61	0.10
Chickasha-Seminole complex, 3 to 5 percent slopes, gullied	441.50	4.47
Coyle-Lucien complex, 3 to 12 percent slopes	178.48	1.81
Coyle and Zaneis soils, 3 to 5 percent slopes, severely eroded	186.11	1.89
Dale silt loam, 0 to 1 percent slopes, rarely flooded	106.04	1.07
Derby-Slaughterville complex, 1 to 5 percent slopes	156.83	1.59
Derby loamy fine sand, 15 to 30 percent slopes	8.98	0.09
Derby loamy fine sand, 15 to 35 percent slopes	28.61	0.29
Derby loamy fine sand, 3 to 15 percent slopes	484.12	4.91
Devol fine sandy loam, 3 to 5 percent slopes	215.17	2.18
Doolin silt loam, 1 to 3 percent slopes	18.83	0.19
Gaddy fine sand, 0 to 1 percent slopes, frequently flooded	142.28	1.44
Gaddy loamy fine sand, 0 to 1 percent slopes, occasionally flooded	16.49	0.17
Goodnight loamy fine sand, 1 to 5 percent slopes	5.20	0.05
Goodnight loamy fine sand, 5 to 15 percent slopes	35.45	0.36
Gracemont silt loam, 0 to 1 percent slopes, occasionally flooded	118.51	1.20

Soil Type	Acres	Percentage of Watershed Area
Grant-Kingfisher complex, 5 to 8 percent slopes, eroded	39.33	0.40
Grant-Urban land-Huska complex, 1 to 5 percent slopes	160.98	1.63
Grant silt loam, 1 to 3 percent slopes	343.23	3.48
Grant silt loam, 3 to 5 percent slopes	358.64	3.63
Hawley fine sandy loam, 1 to 3 percent slopes, rarely flooded	533.56	5.41
Huska silt loam, 1 to 3 percent slopes	215.70	2.19
Konawa and Teller soils, 3 to 8 percent slopes, eroded	166.21	1.68
Konawa loamy fine sand, 3 to 5 percent slopes, gullied	269.32	2.73
Lela clay, 0 to 1 percent slopes, rarely flooded	69.99	0.71
Lovedale fine sandy loam, 1 to 3 percent slopes	220.89	2.24
Lucien-Coyle complex, 3 to 8 percent slopes	18.67	0.19
Lula silt loam, 1 to 3 percent slopes	23.85	0.24
Masham-Ashport frequently flooded complex, 0 to 20 percent slopes	579.04	5.87
Miscellaneous water	5.23	0.05
Norge silt loam, 5 to 8 percent slopes	31.34	0.32
Norge silt loam, 5 to 8 percent slopes, eroded	6.80	0.07
Oil waste land-Huska complex, 1 to 8 percent slopes	355.10	3.60
Port silt loam, 0 to 1 percent slopes, frequently flooded	82.87	0.84
Renfrow-Pawhuska complex, 3 to 5 percent slopes, eroded	146.01	1.48
Renfrow silty clay loam, 3 to 5 percent slopes, eroded	1329.04	13.47
Seminole loam, 1 to 3 percent slopes	245.58	2.49
Slaughterville fine sandy loam, 1 to 3 percent slopes	32.41	0.33
Steedman-Lucien complex, 15 to 25 percent slopes	180.02	1.82
Steedman-Lucien complex, 3 to 15 percent slopes	282.53	2.86
Tabler silt loam, 0 to 1 percent slopes	61.00	0.62
Taloka-Urban land complex, 0 to 3 percent slopes	5.94	0.06
Tribbey fine sandy loam, 0 to 1 percent slopes, frequently flooded	104.95	1.06
Urban land	416.73	4.22
Vanoss silt loam, 0 to 1 percent slopes	37.32	0.38
Vanoss silt loam, 1 to 3 percent slopes	160.26	1.62
Verdigris silt loam, 0 to 1 percent slopes, occasionally flooded	3.81	0.04
Water	62.95	0.64
Westsum-Shidler-Apperson complex, 3 to 12 percent slopes	12.40	0.13
Westsum silty clay loam, 3 to 5 percent slopes	174.75	1.77
Wolco-Dwight complex, 0 to 3 percent slopes	215.61	2.19
Wynona silty clay loam, 0 to 1 percent slopes, occasionally flooded	208.42	2.11
Zaneis loam, 3 to 5 percent slopes, eroded	215.47	2.18
Total	**9867.02**	**100.00**

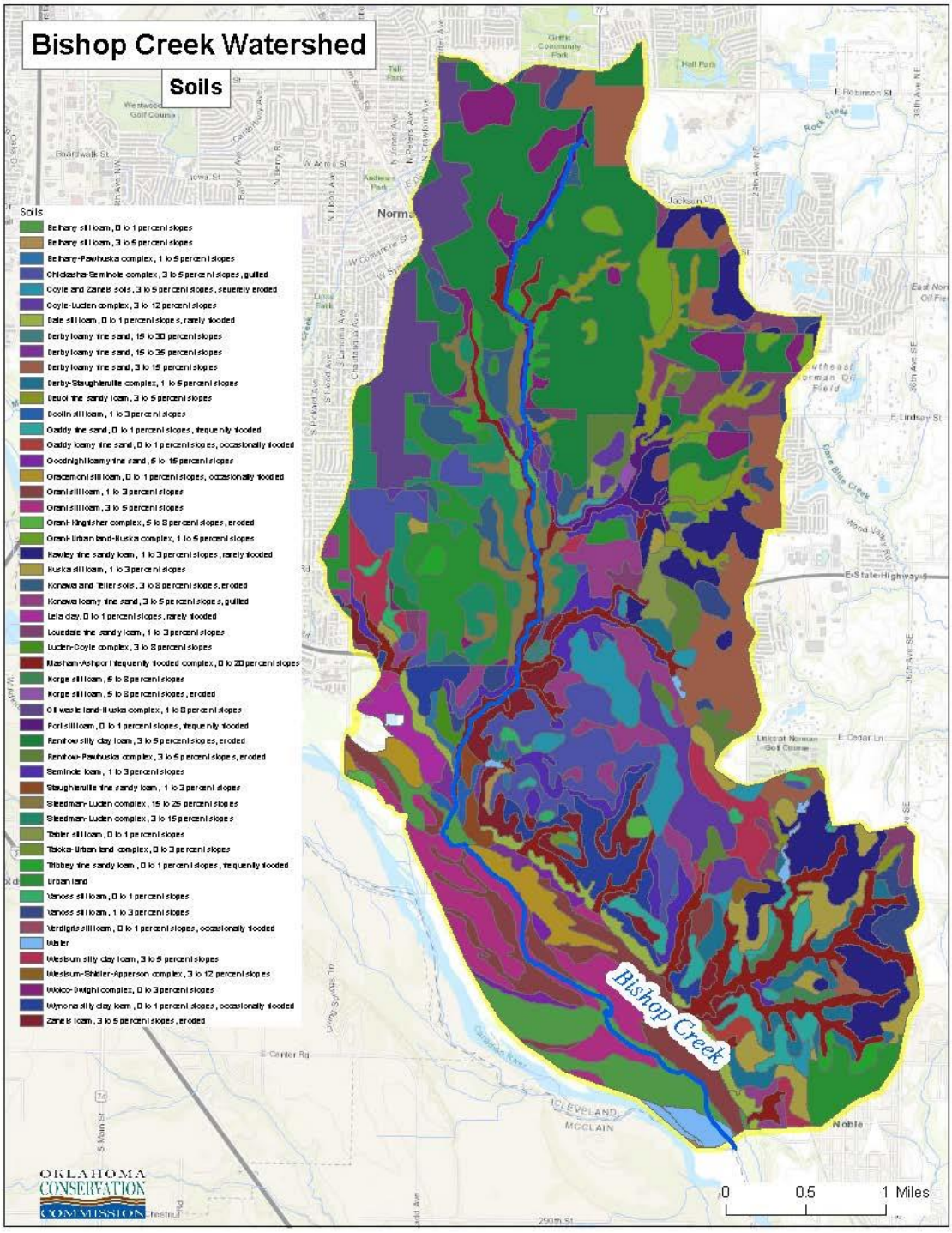

Figure 11 Soil types within the Bishop Creek watershed

2.G. Land Use

Please see Figure 12 for a map of land uses within the watershed and Table 2 for acreages and percentages of each land use. The watershed is comprised of 61.1% developed area and 18.8% grassland/herbaceous area. Figure 13 gives some indication as to the change in developed area

over time. Please see Figure 14 for a map of impervious surfaces. The watershed is 37.3% impervious surfaces (Chapman, 2017 and K. Chapman, personal communication, June 1, 2022).

Bishop Creek likely suffers from many impacts common to urban streams including decreased infiltration and increased surface water runoff, increased magnitude of high flows, increased flashiness, decreased low flow magnitude, and impaired riparian vegetation. For more information on the effects of urbanization on streams please visit USEPA. Cascading effects from these conditions may include bank erosion, higher water temperatures, impacts from nonpoint source pollutants such as automotive fluids and yard chemicals, scouring, sedimentation and reduced diversity in fish and macroinvertebrate communities.

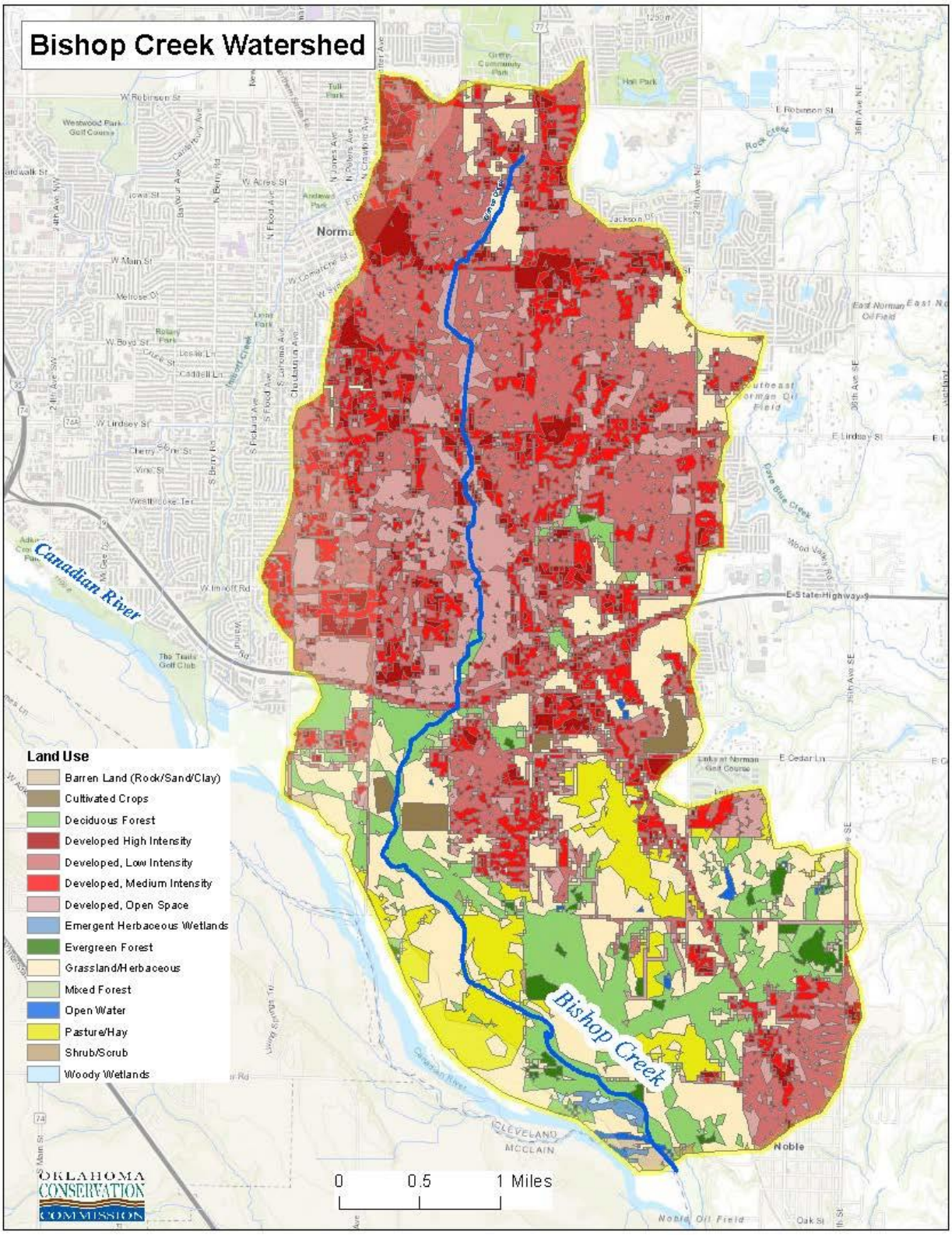

Figure 12 Land uses within the Bishop Creek watershed

Table 2 Table 2 Land use acres and percentages within the Bishop Creek watershed

Type	Sum (Acres)	Percentage of Watershed Area
Barren Land (Rock/Sand/Clay)	33.07547234	0.335212
Cultivated Crops	86.0500206	0.872097
Deciduous Forest	1047.600711	10.61719
Developed High Intensity	531.9960901	5.391657
Developed, Low Intensity	2733.366132	27.70203
Developed, Medium Intensity	1461.850669	14.81552
Developed, Open Space	1400.437386	14.19311
Emergent Herbaceous Wetlands	26.13940358	0.264917
Evergreen Forest	99.29620406	1.006344
Grassland/Herbaceous	1789.868146	18.1399
Mixed Forest	43.46763065	0.440534
Open Water	27.23896831	0.276061
Pasture/Hay	552.0110493	5.594504
Shrub/Scrub	28.85053457	0.292393
Woody Wetlands	5.775971559	0.058538
Totals	**9867.024389**	**100**

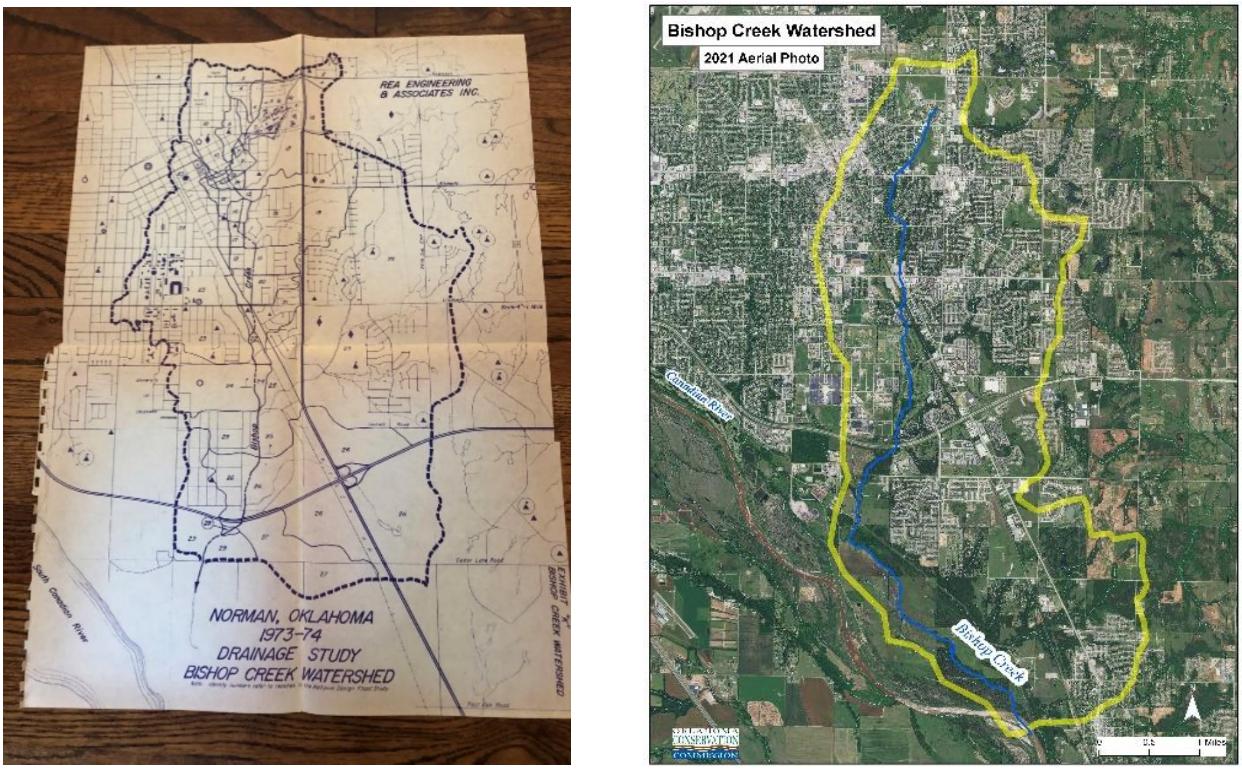

Figure 13 An image of a 1973-1974 map of the watershed depicting development at that time compared to a 2021 aerial photograph depicting current development.

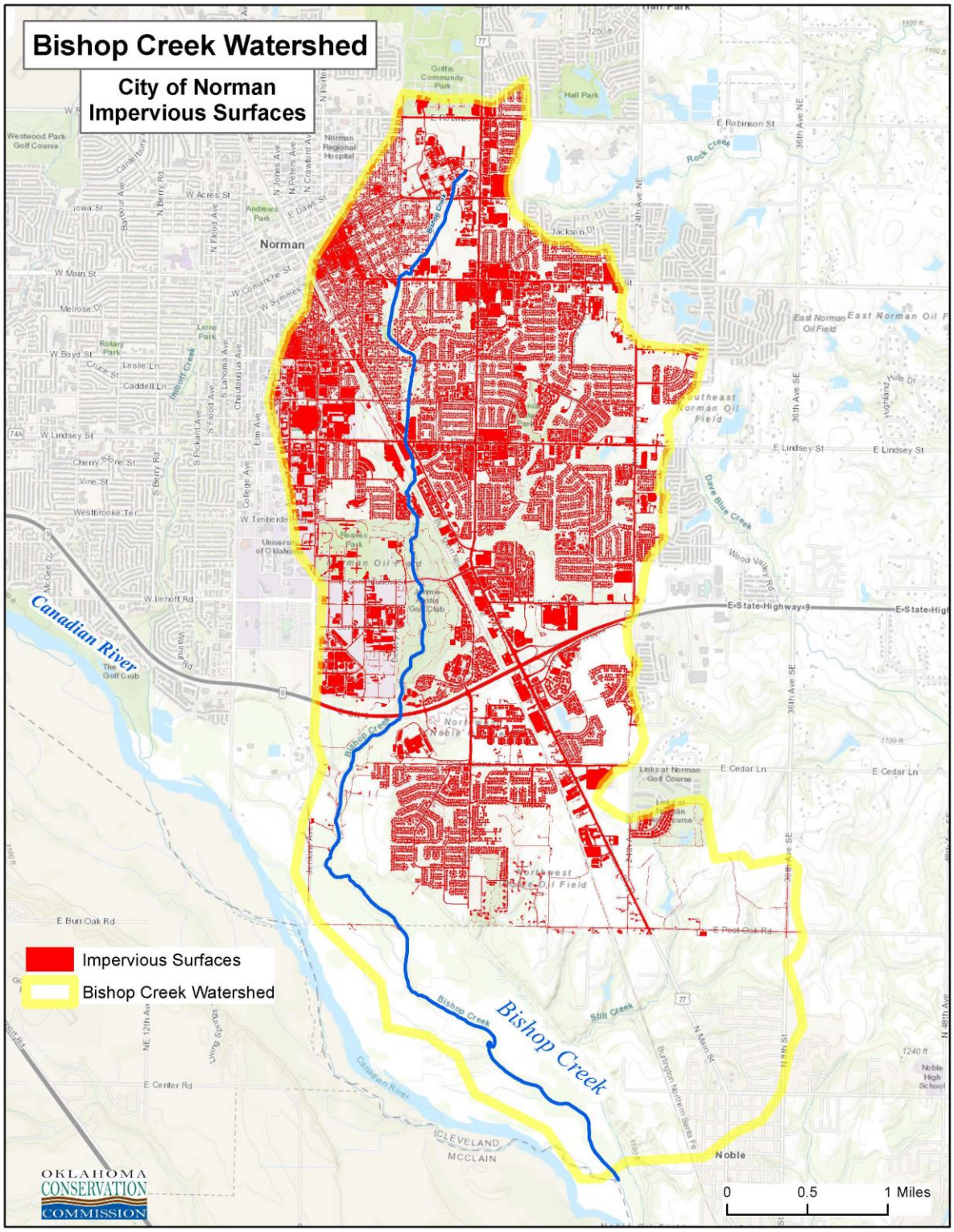

Figure 14 Impervious surfaces in the Bishop Creek watershed. Note: This map was created from a City of Norman dataset. The dataset did not extend south of Post Oak Road.

3. Identification of Causes and Sources of Impairment

3.A. History of 303(d) Listings

According to Section 305(b) of the Clean Water Act, states are required to submit an assessment of state waters to the EPA biennially. A part of this assessment includes submission of a list of impaired waters (otherwise known as the 303(d) list). A waterbody is impaired if existing data demonstrate that one or more designated uses are not being supported. The beneficial uses that apply to Bishop Creek are irrigation agriculture, aesthetics, the warm water aquatic community (WWAC) subcategory of the fish and wildlife propagation use, and primary body contact recreation (PBCR)(OAC 785:45-5-3). Bishop Creek is currently listed for macroinvertebrate bioassessment and an unnamed tributary to Bishop Creek is listed for fishes bioassessment; in the past it has been listed for bacteria and pesticides. Please see Table 3 for a summary of past and current 303(d) Listings. All listings except the 2022 listing for fishes bioassessment and the second 2020 listing for fishes bioassessment pertain to Bishop Creek (OK520610010180_00). The 2022 listing for fishes bioassessment and the second 2020 listing for fishes bioassessment pertains to an unnamed tributary of Bishop Creek (OK520610010181_00).

Table 3 History of 303(d) listings for Bishop Creek (OK Waterbody ID OK520610010180_00 and OK520610010181_00)

IR Cycle	Cause	Potential Sources	Impacted Use
2022	Macroinvertebrate bioassessment	Unknown	WWAC
2022	Fishes bioassessment (unnamed tributary)	Unknown	WWAC
2020	Fishes bioassessment	Unknown	WWAC
2020	Fishes bioassessment (unnamed tributary)	Unknown	WWAC
2018	Macroinvertebrate bioassessment	Same as for 2016	WWAC
2016	Macroinvertebrate bioassessment	Same as those listed above for fishes bioassessment, plus drought-related impacts and source code 72	WWAC
2014	Chloropyrifos, fishes bioassessment	Chloropyrifos: unknown Fishes bioassessment: 1. Grazing in riparian area 2. Highway/ road/ bridge runoff 3. Impacts from land application of wastes 4. Non-irrigated crop production 5. On-site treatment systems 6. Petroleum/ natural gas production activities (legacy) 7. Rangeland grazing 8. Residential districts 9. Wildlife other than waterfowl 10. Unknown	WWAC

IR Cycle	Cause	Potential Sources	Impacted Use
2012	Chloropyrifos	Unknown	WWAC
2010	Chloropyrifos, fecal coliform	Unknown	PBCR, WWAC
2008	Chloropyrifos, fecal coliform	Unknown	PBCR, WWAC
2006	Chloropyrifos, fecal coliform	Unknown	PBCR, WWAC
2004	Chloropyrifos	Unknown	PBCR, WWAC
2002	Pathogens, Pesticides	Unknown	PBCR, WWAC

The potential sources listed in Table 3 are identified in the associated IR, but do not shed much light on actual likely sources. Chloropyrifos is an organophosphate insecticide used to control several pests including termites, mosquitos, and roundworms, please see NPIC for more information, and likely possible sources include commercial, residential or municipal use. Bishop Creek is no longer listed for chloropyrifos. Fecal coliform is a bacterium that lives in the intestines of warm-blooded animals. Fecal coliform is an indicator of fecal contamination. The fecal coliform water quality standard for PBCR was removed from the 2012 and subsequent IRs and streams that were listed for pathogens based only on fecal coliform data were removed from the 303(d) list. Although Bishop Creek is no longer listed for pathogens, it is likely that Bishop Creek is impaired for *E. coli* because most urban streams in Oklahoma are impaired for *E. coli*. Possible sources include domestic pets, wildlife, on-site septic systems, sanitary sewer overflows, and illicit discharges. Bishop Creek has not been monitored for bacteria since 2017.

Bishop Creek was first listed for fishes bioassessment in 2014. It was delisted in 2016 and remained off the 303(d) list until 2020. In 2020, Bishop Creek was relisted and a tributary to Bishop Creek was listed for the first time for fishes bioassessment. Bishop Creek was delisted for fishes bioassessment in 2022 and an unnamed tributary of Bishop Creek remains on the list for fishes bioassessment. It is the opinion of the OCC that current and past impairments for fishes are an artifact of the assessment and listing protocol, rather than a true biological impairment. In 2021, Dr. Joseph Dyer, a member of the Rotating Basin team, completed an in-depth assessment of the Bishop Creek data. Based on his analysis, a stream of Bishop Creek's size is unlikely to score well on the fish index of biotic integrity (IBI) based on size alone. Bishop Creek is a first order stream with a watershed size of less than 40 km^2. OCC reference streams, to which the Bishop Creek fish community is compared for an impairment determination, are third and fourth order streams with watersheds varying from 500 to 5,000 km^2. Headwater streams naturally experience a higher level of disturbance than higher order streams (i.e., OCC reference streams) and are rarely, if ever, at equilibrium. Available habitat fluctuates widely based on precipitation. If a collection is completed during a wet period, the IBI will likely be higher because Bishop Creek offers more habitat during wet years. The converse is true of dry periods. Additionally, the loss or gain of one or two species between collections can disproportionately affect the IBI, especially if the species lost/gained is an intolerant species. With Bishop Creek, the species that disproportionately affects the IBI is the

suckermouth minnow. Collections which include the suckermouth minnow tend to result in a "undetermined" assessment for FWP; collections that do not include the suckermouth minnow tend to result in an "impaired" assessment. In addition to the disproportionate effect of one species on the IBI, the chemical, macroinvertebrate, and habitat data do not point toward an impairment, leaving natural variability in the fish assemblage of a small stream as the most likely explanation for the "impairment."

Bishop Creek was listed for macroinvertebrate bioassessment in 2016 and 2018 and was added as a new listing in 2022. In general, macroinvertebrate collections seem to be improving at the Constitution site. It is possible that macroinvertebrate assessments may be subject to some of the same difficulties regarding stream size as fish assessments. OCC is currently reviewing reference criteria to ensure they are appropriate for all streams assessed by OCC.

When biological communities are impaired (fish or bugs), the most likely source of impairment is lack of available habitat due to land management activities. Although portions of Bishop Creek have poor habitat, the assessed portions score well in comparison to reference conditions. Please see the section below for more detailed information about the fish, macroinvertebrate and habitat data.

3.B. Summary of Available Data

Oklahoma Water Resources Board.

The Oklahoma Water Resources Board (OWRB) conducted a short study of Bishop Creek from September of 2011 through June of 2012. Data were collected six times. Four of the data collection events occurred during baseflow conditions and two occurred during high flow conditions. The following parameters were measured: water temperature, dissolved oxygen (DO), pH, specific conductivity, salinity, total dissolved solids (TDS), turbidity, total alkalinity, and hardness. One of the DO values does not meet the water quality criterion for dissolved oxygen. However, this does not necessarily mean that the creek was failing to support the WWAC beneficial use with respect to dissolved oxygen because there are not enough DO values to assess use (minimum of 10 measurements).

The data indicate that alkalinity, hardness, salinity, TDS and specific conductivity are lower during high flow events, likely due to the reduced influence of groundwater during a high flow event. Turbidity is higher during high flow events, as expected, but the criterion for turbidity only applies during baseflow conditions.

Oklahoma Conservation Commission.

Blue Thumb volunteers have monitored Bishop Creek continuously since 2003. Most of the data have been collected at two sampling locations: Constitution Street and Eastwood Park.

Chemical Data.

Because Blue Thumb test kits are less precise than methods approved by the Environmental Protection Agency (EPA), we do not report these chemical data to the Oklahoma Department of Environmental Quality (ODEQ) for inclusion in the IR; Blue Thumb chemical data are not used for listing or delisting decisions. Blue Thumb data are used for screening purposes and for education and outreach. When data are significantly above or below the applicable water quality standards (WQS) criterion, ODEQ is notified to investigate. However, for the purposes of this discussion, Blue Thumb data will be compared to the applicable WQS. Please see Table 4 for a list of screening values and WQS criteria.

Table 4 Threshold values for referral to ODEQ and WQS criteria

Screening Parameters	**Threshold**	**WQS Parameters**	**Criteria**
Dissolved Oxygen	< 3 mg/L	Dissolved Oxygen	April 1-June 16: 6.0 mg/L June 16-March 31: 5.0 mg/L
pH	< 5 ; > 10	pH	6.5 < pH < 9.0
Nitrate	> 10 mg/L	Nitrate/Nitrate	Nutrient criteria do not apply to Bishop Creek
Orthophosphate	> 1 mg/L	Total Phosphorus	Nutrient criteria do not apply to Bishop Creek
Chloride	> 441 mg/L	Chloride	255/353 mg/L (yearly mean standard/single sample standard)
E. coli	N/A	*E. coli*	126 CFU/100 mL (geomean)

Please see Figure 8 for a map of active Blue Thumb monitoring locations in the Bishop Creek watershed, noted by blue stars. Blue Thumb volunteers collect data at Bishop Creek: Constitution and Bishop Creek: Eastwood Park. We have data from June of 2009 to the present for Constitution; for Eastwood Park, we have data from February 2012 to the present. In addition, there are two sites at which volunteers used to collect data: Bishop Creek: Lindsey Street and Tributary to Bishop Creek: Basket 12. For Lindsey Street, we have data from November 2010-May 2011; for the Tributary to Bishop Creek, we have data from March of 2017-December of 2019.

Blue Thumb data indicate that dissolved oxygen often fails to meet the WQS criterion. Datasets for Constitution, Eastwood Park and Tributary to Bishop Creek each contain DO values below the criterion. The WQS states that the waterbody fails to meet the criterion for DO if more than 10% if of the measured values are below the applicable criterion; a minimum of 10 measurements are required for the assessment. See Table 4 for a table of the annual number of DO measurements as well as the number and percentage of DO measurements that failed to meet the criterion for Bishop Creek at Constitution and Eastwood Park.

Table 5 Summary of dissolved oxygen data for Bishop Creek

Year	Total Number of Measurements	Number of Measurements that Failed to Meet the Criterion	Percentage of Measurements that Failed to Meet the Criterion
Bishop Creek at Constitution			
2009	7	1	14
2010	7	2	29
2012	4	2	50
2013	8	1	13
2014	11	5	45
2015	3	1	33
2016	12	2	17
2017	20	0	0
2018	11	3	27
2019	10	2	20
2020	2	0	0
2021	9	4	44
2022	10	5	50
Bishop Creek at Eastwood Park			
2012	11	3	27
2013	11	1	9
2014	10	6	60
2016	10	5	50
2017	11	2	18
2018	5	1	20
2019	2	0	0
2020	12	5	42
2021	12	6	50
2022	11	4	36

In 2014, oil and grease were observed at Bishop Creek: Constitution and Bishop Creek: Eastwood Park. In 2014, the creek would not have supported the criterion for oil and grease (present during fewer than 10% of the observations), but there has only been one observation of oil and grease since 2014.

Macroinvertebrate Data.

Please see Tables 6 and 7 for a summary of Blue Thumb macroinvertebrate data at Constitution and Eastwood Park, respectively. The total score is a multimetric index of biotic integrity that combines indices used to assess community characteristics such as richness, diversity, tolerance, and evenness. Proportion of reference is a comparison of a stream's IBI score to the average regional reference IBI. For a detailed description of the calculation of the total score, please refer to the Continuing Planning Process document (ODEQ, 2012). Attainment status for each sample was determined using Table 18 in the Continued Planning Process document (ODEQ, 2012). A minimum of four samples collected over at least a two-year period are required for an assessment. A maximum of 10 collections over a five-year period may be used in a single assessment. For this reason, a single sample assessment decision does not necessarily equate to the assessment decision for the reporting period.

Table 6 Macroinvertebrate data for Bishop Creek at Constitution

Year	Season	Score	Proportion of Reference	Sample Assessment Decision
2021	Winter	18	.82	Attaining
	Summer*	18	.69	Undetermined
2019	Winter	26	1.18	Attaining
	Summer	24	.75	Undetermined
2018	Winter	18	.82	Attaining
	Summer	24	.75	Undetermined
2017	Winter	30	1.36	Attaining
	Summer	20	.63	Undetermined
2016	Winter	10	.45	Not Attaining
2015	Winter	8	.36	Not Attaining
	Summer	14	.44	Not Attaining
2014	Winter	10	.45	Not Attaining
2013	Winter	10	.45	Not Attaining
	Summer	6	.19	Not Attaining
2011	Winter	16	.80	Undetermined
2010	Winter	18	.90	Attaining
2009	Summer	12	.43	Not Attaining
2007	Winter	16	.80	Undetermined
2006	Winter	12	.60	Undetermined
	Summer	4	.14	Not Attaining

Table 7 Macroinvertebrate data for Bishop Creek at Eastwood Park

Year	Season	Score	Proportion of Reference	Sample Assessment Decision
2021	Winter	8	.36	Not Attaining
	Summer*	6	.23	Not Attaining
2020	Summer	12	.38	Not Attaining
2019	Winter	20	.91	Attaining
2018	Winter	6	.27	Not Attaining
	Summer	20	.63	Undetermined
2017	Winter	16	.73	Undetermined
	Summer	16	.50	Undetermined
2015	Winter	16	.73	Undetermined
	Summer	16	.50	Undetermined
2014	Winter	20	.91	Attaining
	Summer	22	.69	Undetermined
2013	Winter	8	.36	Not Attaining
	Summer	10	.31	Not Attaining

Bishop Creek was not listed for macroinvertebrates in 2020 but was added as a new cause in 2022. Macroinvertebrate collections at Constitution seem to be improving over time; collections from Bishop Creek at Eastwood Park are rarely attaining. It is possible that the

reference conditions used for the macroinvertebrate IBI are not appropriate for Bishop Creek because the watersheds of reference streams are at least an order of magnitude larger than the Bishop Creek watershed and therefore offer significantly more available habitat, but the analysis to make a definitive assessment of the appropriateness of comparing macroinvertebrate reference condition data to Bishop Creek data has not been completed.

Fish Data.

Blue Thumb has completed eight fish collections in the Bishop Creek watershed. Please see Table 8 for a summary of assessment decisions for the Fish and Wildlife Propagation (FWP) use. For a detailed description of the assessment process, please refer to the Continuing Planning Process document (ODEQ, 2012). As in the assessment of macroinvertebrate data, up to five years of data can be used in an assessment, so a single sample assessment decision does not always equate with the final assessment decision for the reporting period. In cases where multiple samples are used in the assessment, support status is based upon the majority of sample assessments. If no majority exists, support status is undetermined for the reporting period.

The OCC uses two different protocols to analyze fish data. Internal assessments are completed using the Oklahoma Index of Biotic Integrity (OKIBI) process. This is the process used to analyze Blue Thumb fish data and the basis for assessments volunteers receive in their data packages. The second process is the Oklahoma Biocriteria (OKBIOCRIT) process which is outlined in the Oklahoma Administrative Code Use Support Assessment Protocols (OAC 785:46-15) with clarification supplied by the Continuing Planning Process document (ODEQ, 2012). The Oklahoma Administrative Code requires that listing and delisting decisions are based upon the OKBIOCRIT protocol unless:

1. There are no biocriteria established for the ecoregion in which the collection was made (far southeastern Oklahoma and the area around the Wichita Mountains in Comanche County); or
2. The OKBIOCRIT protocol results in an assessment of “undetermined”.

The OKIBI protocol is considerably more conservative than the OKBIOCRIT process. Differences in the two methods of analyses, combined with the previously discussed complications arising from using reference criteria developed for larger streams, sometimes result in different assessment decisions for the same collection or collections.

Table 8 Summary of assessment decisions for Fish and Wildlife Propagation (FWP) use

Site Name	IR Waterbody ID	Collection Date	Collection Year	OKBIOCRIT Assessment Decision	OKIBI Assessment Decision	Final IR Assessment Decision
Bishop Creek: Constitution	OK520610010180_00	8/10/2005	2005	Not Assessed	Undetermined	Not Applicable
Bishop Creek: Constitution	OK520610010180_00	8/25/2009	2009	Undetermined	Undetermined	Undetermined
Bishop Creek: Constitution	OK520610010180_00	7/26/2011	2011	Undetermined	Not Attaining	Not Attaining
Bishop Creek: Eastwood Park	OK520610010180_00	6/29/2012	2012	Undetermined	Not Attaining	Not Attaining
Bishop Creek: Constitution	OK520610010180_00	9/9/2014	2014	Undetermined	Not Attaining	Not Attaining
Bishop Creek: Constitution & Eastwood Park	OK520610010180_00	6/12/2018 & 6/18/2018 (Averaged)	2018	Attaining	Undetermined	Attaining
Bishop Creek: Tributary	OK520610010181_00	6/8/2018	2018	Undetermined	Not Attaining	Not Attaining

Habitat Data.

Please see Table 9 for a summary of the habitat data for assessed portions of Bishop Creek. The assessed areas of habitat score at least 90% of the reference score.

Table 9 Summary of habitat data

Site	Date	Habitat Score	Proportion of Reference
Bishop Creek: Constitution	6/12/2018	70.3	.91
Bishop Creek: Constitution	9/9/2014	86.2	1.11
Bishop Creek: Constitution	8/25/2009	84.8	1.07
Bishop Creek: Constitution	8/10/2005	71.6	.92
Bishop Creek: Eastwood Park	6/29/2012	72.4	.93
Bishop Creek: Eastwood Park	6/18/2018	74.5	.96
Bishop Creek: Lindsey	7/26/2011	84.3	1.07
Bishop Creek: Tributary	6/8/2018	76.2	.98

3.C. Data Gaps

Blue Thumb data indicate a problem with dissolved oxygen. Because Blue Thumb chemical data are collected using screening-level Hach test kits, these data are not appropriate for assessment purposes. Also, Blue Thumb volunteers collect DO data if water is present, but OCC recognizes that DO samples collected from pools during periods of drought are not appropriate for assessment purposes. For these reasons, DO data should be collected at Bishop Creek using a multiprobe or digital titration, both EPA-approved methods. To address this gap, we will seek to borrow a multiprobe from OCC's Rotating Basin program and train a Blue Thumb volunteer to collect at least 10 months of dissolved oxygen data on Bishop Creek. City of Norman staff may help with this effort.

Because Bishop Creek is an urban stream, it is likely impacted by *E. coli*. Blue Thumb offers volunteers the opportunity to collect *E. coli* data during the recreation season, but the method used by Blue Thumb is not EPA-approved. We intend to address this data gap by asking a volunteer to collect *E. coli* data according to Blue Thumb procedures in 2024. If the results indicate a problem with bacteria, the City of Norman may elect to collect *E. coli* samples and have them analyzed with an EPA-approved method.

Further investigation should also be made regarding the appropriateness of comparing Bishop Creek macroinvertebrate data to Central Great Plains reference conditions because reference streams drain watersheds much larger than the Bishop Creek watershed. This investigation is currently underway at OCC within the Rotating Basin Program.

4. Watershed Project Goals

The watershed project goals identified by the stakeholder group include the following:

1. Improve the riparian area along Bishop Creek. Although the riparian area along the monitored segments of Bishop Creek scores well for habitat, many unassessed areas along the creek have a poor riparian area. Improving sections of degraded riparian area will improve water quality by removing some pollutants before they reach the creek, decreasing summer water temperatures and improving habitat for macroinvertebrates and fish. Improving riparian habitat will also increase infiltration and reduce flooding. Increased infiltration may increase streamflow during dry periods.
2. Reduce the amount of trash that reaches Bishop Creek. Trash is unsightly, poses a threat to wildlife and can clog stormwater infrastructure. Some types of trash increase bacteria loads and organic waste decreases dissolved oxygen levels as it decays. Plastic debris can break down into microplastics which are ingested by wildlife. Microplastics are becoming ubiquitous in the environment and the impacts upon wildlife and humans are not fully understood.
3. Increase water infiltration in the watershed. Increasing infiltration will reduce the flashiness of Bishop Creek and may improve flow during dry periods. Low flow is linked to low dissolved oxygen and may also be an underlying cause of undetermined or impaired beneficial use support for biological assessments.
4. Reduce the amount of bacteria from domestic pets that reaches the stream. Although we do not have recent *E. coli* data for Bishop Creek, most urban streams are impaired for *E. coli*. Some strains of *E. coli* are harmful to humans. Potential causes of *E. coli* in urban streams vary widely and include animal and human sources.
5. Collect DO and *E. coli* data to determine beneficial use support status for these parameters. Further characterization of the stream will allow us to implement practices that will have the most beneficial impact on Bishop Creek.

5. Proposed Best Management Practices

The best management practices (BMPs) detailed here relate to each of the watershed project goals identified in the previous section. Most of the land in the Bishop Creek watershed is privately owned and implementing BMPs will require voluntary agreements with landowners. Table 10 documents city-owned land in the watershed, and types of management measures that would be appropriate and feasible at those locations. Some BMPs such as educational signage can be used to address multiple issues including trash, infiltration and bacteria.

5.A. Improve Riparian Habitat

The easiest and most cost-effective way to improve riparian habitat along Bishop Creek is to extend the no-mow zone that was established for Eastwood Park. Because most of the property along the creek is privately owned, extending the no-mow zone would necessitate voluntary agreements with landowners. We might be able to incentivize voluntary agreements by providing native seeds or seedlings or educational signage. Improved riparian area does not exacerbate trash, but sometimes trash becomes more visible because it becomes trapped in riparian vegetation before it reaches the creek. We could help incentivize voluntary no-mow zones by arranging periodic creek cleanup events to remove trash from riparian areas.

Operation and Maintenance of Riparian Habitat Improvement Projects

Operation and maintenance (O & M) of riparian habitat improvement projects will depend upon the goal of the project. If the goal is to extend the no-mow zone, O & M will be minimal and mostly involve trash removal. If the goal is to establish a native zone of vegetation, O & M will be more involved and likely involve watering and replanting of native species and removal of invasive species, in addition to regular trash removal.

5.B. Reduce Trash

Efforts to reduce trash will focus on three areas: (1) public education, (2) creek cleanups and (3) BMPs that capture trash before it enters the creek or retains trash after it enters the creek. The City of Norman will launch an extended public education effort in the watershed about the impact of trash on Bishop Creek, the extent of the problem and actions that will reduce trash in the creek.

The City of Norman will seek to form partnerships that support a sustained effort to remove trash from Bishop Creek and its riparian area. Potential partners include Keep Oklahoma Beautiful, Norman high schools and student groups at the University of Oklahoma. Upstream of Eastwood Park, homeless encampments contribute to the trash problem. These sources might be reduced by installing educational signs about the impacts of litter on the creek. Periodic trash cleanups (in addition to Karen Chapman's ongoing effort) could be used to support voluntary no mow zones. Trash pickups along Bishop Creek could be part of the annual Great American Clean Up event (annually, March-June).

Trash capture technologies could be used to reduce the amount of trash that reaches Bishop Creek and keep the trash that does enter the creek from flowing further downstream. Trash capture technologies include curb inlet covers, catch basin outlet screens, catch basin hoods, catch basin fabric inserts, linear radial devices, hydrodynamic separators, netting systems, litter booms, Bandalong litter traps and trash traps; refer to EPA for more information. To ascertain which technologies are most effective, research projects could be implemented in areas where trash technologies are installed. Small research projects would further the opportunity to partner with students at Norman high schools and the University of Oklahoma. The student research projects could be overseen by City of Norman stormwater staff to ensure that data collected are appropriate to guide management decisions.

Operation and Maintenance of Trash Reduction BMPs

To be effective, trash pickups require marketing, coordination, staffing and record keeping. Signage will periodically need to be repaired or replaced. All trash capture technologies necessitate that waste be periodically removed and disposed of properly. The ease and frequency of removal vary among capture technologies. Trash capture infrastructure also requires inspection and periodic repair. The City of Norman will be responsible for these O & M tasks.

5.C. Increase Infiltration

BMPs to improve infiltration can be implemented in the stormwater collection system, or individually in homeowners' yards. Green spaces in the headwaters of Bishop Creek will be targeted to increase infiltration efforts because improvements in the headwaters may improve flows throughout the watershed. Efforts in the stormwater collection system could include

infiltration basins, artificial wetlands and replacing concrete drainages with grassed drainages. Because the Bishop Creek watershed is within a municipal separate storm sewer system (MS4), stormwater practices can be funded with Clean Water Act ∫319 funds only if the practices are not required by the permit or the stormwater management plan.

Individual homeowners can implement practices in their yards that improve infiltration. Homeowners can direct downspouts to permeable areas of their lawns rather than concrete surfaces, install raingardens, replace monoculture turf grass with a plant community with deeper roots that allows for more infiltration, raise mowers to a higher cutting height, replace impervious surface with pervious pavers and install pollinator plots or other native plantings that intercept and infiltrate runoff. Many of these practices are encouraged through the Yard by Yard Community Resiliency Program, a partnership between OCC, the Oklahoma Association of Conservation Districts and Friends of Blue Thumb. Infiltration can be increased immediately adjacent to the creek by restoring sections of impaired riparian area. The most cost-effective option would be to extend no-mow zones. Restoration of impaired areas with native plants (grasses, shrubs and trees) would improve infiltration but may not be a cost-effective option.

Operation and Maintenance of BMPs to Improve Infiltration

Structural BMPs such as infiltration basins, artificial wetlands and grassed drainages each require specific O & M procedures. Possible O & M tasks include removal of sediment, removal of problematic vegetation, mowing, trash removal, dike repair and repair of inlet or outlet structures. The City of Norman would be responsible for these tasks. Efforts to increase infiltration in privately owned yards also require maintenance. Sediment occasionally needs to be removed from rain gardens, invasive species need to be managed, and hydrophilic species may need watering during drought. Rain barrels should be disconnected and emptied in the winter to avoid damage from freezing. Debris should be removed periodically from gutters and rain barrel screens. Invasive species should be removed from pollinator plots and plots should be mowed annually. The Yard by Yard Community Resiliency Program can advise homeowners regarding the O & M of BMPs to improve infiltration in privately owned yards.

5.D. Improve Dissolved Oxygen

As discussed in **Parts 3.B Summary of Available Data** and **3.C Data Gaps** of this document, Bishop Creek may be impaired for dissolved oxygen. Common causes of dissolved oxygen impairments include excess nutrients and low flow. The data do not indicate that Bishop Creek is impaired for nutrients so efforts to improve dissolved oxygen will focus on efforts to improve infiltration and summer flows. See **Part 5.C Increase Infiltration** for BMPs that may improve dissolved oxygen and the *Operation and Maintenance of BMPs to Improve Infiltration* section for a description of associated O & M tasks.

5.E. Reduce Bacteria

The City of Norman is required to conduct investigations to track down illicit discharges of human waste to the stormwater system. Consequently, this plan will not include practices to address illicit discharges. The other likely source of *E. coli* in the watershed is domestic animals. BMPs that address bacteria pollution include infiltration practices (bioinfiltration, infiltration basins, permeable pavement and sand filters) as well as practices that intercept runoff (filter strips and green roofs, for example). According to Clary, Leisenring, Hobson and

Strecker (2020), bioretention, wetland basins, retention ponds, media filters and dry extended detention basins are most effective at reducing bacteria concentrations. Because we do not currently have *E. coli* data on Bishop Creek, this WBP focuses on the less expensive option of reducing bacteria pollution through public education. The Watershed Treatment Model, see the 2013 documentation for more information, predicts that an effective pet waste education program can reduce the bacteria loading from pet waste by 75% (see Bond, 2020 for example calculations using the formulas built into the model). An effective pet waste education program should include the following elements:

1. Pet waste ordinances
2. Pet waste disposal stations
3. Education and outreach

The City of Norman has a pet waste ordinance (Chapter 3, Article 4, Section 3-409), but the ordinance only applies to public spaces and a fine is not specified for violation of the ordinance, so the ordinance likely has a limited impact. The outreach and education BMP will include installing pet waste stations in public places in the watershed that do not currently have pet waste stations and providing education about picking up pet waste in yards.

Operation and Maintenance of BMPs to Reduce Bacteria

Structural BMPs to reduce bacteria, such as wetland basins and retention ponds require O & M practices specific to each BMP. Because we do not have data that indicate bacteria are problematic, there is currently no intention to install structural BMPs to treat bacteria, and hence maintenance of structural BMPs is not addressed here. Rather, we are operating under the assumption that Bishop Creek is impaired for bacteria because this is true of most urban streams. BMPs will focus on an effective pet waste disposal program. In addition to education, an effective pet waste disposal program will require maintenance of disposal stations, such as emptying waste bins, refilling bag dispensers and repairing stations as needed. The City of Norman will be responsible for these tasks.

Table 10 Summary of city-owned properties within Bishop Creek watershed

Name	Address/Location	Comments	Potential for BMP Implementation				
			Improve Riparian Habitat	Reduce Trash	Increase Infiltration	Reduce Bacteria	Improve Dissolved Oxygen
Griffin Park	1001 E Robinson St, Norman, OK 73071	Griffin Park is a heavily used sports park featuring soccer and baseball fields. Ephemeral drainage channels along street and parking areas could be converted to native vegetation and educational signage can be incorporated. Watershed clean-up events are frequently held in this park.		X	X	X	X
Frances Cate	333 N Carter Ave, Norman, OK 73071	Frances Cate features a new fitness court north of the north parking lot. The north parking lot also has a curb cut which allows stormwater to drain east where a rain garden and educational signage can be incorporated. The creek channel is mostly cattails with little erosion in this park. No mow zones or native vegetation could be incorporated.	X	X	X	X	X
Faculty Heights Park	1017 E. Lindsey St.	While this park is not located along Bishop Creek, opportunities exist for educational signage, a pet waste station and possibly a pollinator garden.		X	X	X	X
Main Street (stormwater maintenance area)	S Cockrel Ave and E Comanche St, Norman, OK 73071	This stormwater maintenance area only contains channelized flow. However, existing vegetation consists primarily of Bermuda turf grass which could be converted to native grasses to increase infiltration.			X		X
Matoon Stormwater Park	S Carter Ave and Alameda St, Norman, OK 73071	Park has not been completed yet but is slated to include pervious pavement, rain gardens, and outdoor classroom space. Educational signage can be tailored to Bishop Creek.	X	X	X		X
McGeorge Park	631 E Eufaula St, Norman, OK 73071	This park only contains channelized flow; however, educational signage could be incorporated.		X		X	
Kiwanis Park	635 Sherwood Dr, Norman, OK 73071	This park experiences low to ephemeral flow. Native vegetation and education signage could be incorporated.	X	X	X	X	X
Eastwood Park	1001 S Ponca Ave, Norman, OK 73071	This park contains a no mow zone, with educational signage, as well as a community maintained pollinator garden.	X	X	X	X	X
Earl Sneed Park	1381 Classen Blvd, Norman, OK 73071	While this park is not located along Bishop Creek, opportunities exist for educational signage.		X		X	

Name	Address/Location	Comments	Potential for BMP Implementation				
			Improve Riparian Habitat	Reduce Trash	Increase Infiltration	Reduce Bacteria	Improve Dissolved Oxygen
Colonial Estates Park	1641 E Lindsey St, Norman, OK 73071	This park contains a disc golf course and over half a mile of an unnamed tributary to Bishop Creek. While some portions of the channel are experiencing extreme erosion and would greatly benefit from stream bank restoration, no mow zones and native vegetation has been strongly opposed by the disc golf community. However, educational signage can be incorporated, and water quality may also benefit from additional pet waste stations adjacent the neighboring apartment complex.	X	X	X	X	X
Colonial North (stormwater maintenance area)	Sinclair Dr and Biloxi Dr, Norman, OK 73071	This area extends north from Colonial Estates Park; native vegetation and educational signage could be incorporated.	X	X	X	X	X
Colonial South (stormwater maintenance area)	Extending south from Colonial Estates Park to Woodcreek Park, Norman, OK 73071	Stormwater maintenance crews mow approximately 5 feet on either side of the creek channel. There are also several drainage flumes from the dumpsters and parking lots. Native vegetation, with fencing, and educational signage could be incorporated.	X	X	X	X	X
Woodcreek Park	1509 Concord Dr, Norman, OK 73071	This residential park could benefit from educational signage.		X		X	
Oak Tree South Park	2881 Oak Tree Ave, Norman, OK 73072	Education signage could be incorporated.		X		X	
Reeves Park	2501 Jenkins Ave, Norman, OK 73072	This popular park features sport fields, playgrounds, and hosts several events throughout the year. The park is currently under construction, but opportunities exist for native vegetation and educational signage.		X	X	X	X
Eagle Cliff Park	3901 Eagle Cliff Dr, Norman, OK 73072	This residential park could benefit from educational signage.		X		X	
Songbird Park	Burma Ct and Skyler Way, Norman, OK 73072	This residential park could benefit from educational signage.		X		X	

6. Schedules and Milestones

Summary of Planned Tasks for FY 2024-2028, refer to Table 11 for more details.

1. Establish no-mow zones or restore riparian areas in five additional parks or city-owned maintenance areas in the watershed
2. Negotiate no-mow agreements with 25 private landowners immediately adjacent to the creek
3. Host seven cleanup events
4. Certify 50 yards in the watershed in the Yard by Yard Program
5. Monitor at least quarterly at Constitution and Eastwood Park in 2024 and 2025. Monitor at least quarterly at Constitution, Eastwood Park and Colonial Estates Park in 2026-2028. Monitor for bacteria during the recreation season (2024-2028)
6. Install trash capture BMP in Eastwood Park
7. Restore a section of riparian area in, or around, Colonial Estates Park
8. Complete post-BMP implementation monitoring in Eastwood Park (2026-2028) and Colonial Estates Park (2027-2028)
9. Install educational signage in four parks
10. Install fifteen additional pet waste disposal stations on city-owned property in the watershed
11. Install educational signage regarding trash management at a site regularly used by the homeless
12. Strengthen education program about pet waste management
13. Host educational event for children
14. Host watershed festival
15. Update watershed based plan

Table 11 2023-2027 schedule of tasks to progress toward watershed project goals

Activity	Responsible Party(ies)	Fiscal Year and Measurable Goal				
		2024	2025	2026	2027	2028
Establish a no mow zone in a city park and/or restore riparian area.	City of Norman	Establish a no mow zone	Establish a no mow zone	Establish a no mow zone	Restore riparian area	Restore riparian area
Negotiate voluntary no-mow agreements with private landowners immediately adjacent to Bishop Creek	City of Norman	5 homeowners	5 homeowners	5 homeowners	5 homeowners	5 homeowners
Install additional pet waste stations on city-owned property in the watershed.	City of Norman	3 stations	3 stations	3 stations	3 stations	3 stations
Strengthen educational efforts about pet waste management.	City of Norman	Develop and/or update utility inserts, ads, and flyers to address pet waste	Install educational signage	Install educational signage	Install educational signage	Install educational signage
Host watershed event(s) in the Bishop Creek watershed.	City of Norman	1 cleanup event	1 cleanup event 1 educational event	2 cleanup events	2 cleanup events	1 cleanup events 1 watershed festival
Monitor at least quarterly at parks within the watershed.	Blue Thumb volunteer(s)	Constitution and Eastwood Parks	Constitution and Eastwood Parks. Recruit volunteer(s) to monitor in Colonial Estates Park.	Constitution, Eastwood Parks, and Colonial Estates Parks.	Constitution, Eastwood Parks, and Colonial Estates Parks.	Constitution, Eastwood Parks, and Colonial Estates Parks.
Develop bacteria monitoring program.	OCC and Blue Thumb volunteer(s)	Recruit volunteer(s) to conduct monitoring	Monitor during the recreational season	Monitor during the recreational season	Monitor during the recreational season	Monitor during the recreational season
Certify yards in the watershed in the Yard by Yard Program.	OCC and Cleveland CCD	10 yards	10 yards	10 yards	10 yards	10 yards
Develop program to reduce trash within the watershed.	City of Norman	Install educational signage in one area of the watershed frequently used by the homeless	Research most effective trash capture technology and monitoring methods for Eastwood Park	Apply for supplemental ∫319 funding to install trash capture BMP in Eastwood Park	Install trash capture BMP in Eastwood Park. Begin monitoring program to evaluate effectiveness of BMP	Continue to monitor BMP effectiveness

7. Water Quality Monitoring to Demonstrate Program Results

7.A. Program Goal: Improve Riparian Habitat

A habitat assessment will be conducted according to OCC standard operating procedures (SOPs) at each site under consideration for habitat improvement or restoration. Only sites that score as "poor" or "fair" will be selected for BMP implementation related to improvement of riparian habitat. Effectiveness monitoring will include reassessing habitat every three to five years for 25 years. An improvement in condition (i.e., from "poor" to "fair" or "good"; or from "fair" to "good" or "excellent") will be considered a successful implementation effort.

One of the goals for improving riparian habitat is to improve the fish and macroinvertebrate communities in Bishop Creek. Under normal circumstances, comparisons of pre-restoration bug and fish metrics with post-restoration bug and fish metrics would be used to assess whether riparian restoration projects were beneficial to aquatic organisms. Because we believe our assessment protocol is not appropriate for the Bishop Creek fish community and may or may not be appropriate for the macroinvertebrate community, we will not attempt to compare pre- and post-restoration fish and bug metrics at this time. Macroinvertebrate and fish collections are routine aspects of the Blue Thumb Program, so these data will be available for future analyses. Bug collections are completed twice annually at each Blue Thumb site; fish collections are completed every three to five years, as are habitat assessments. Please see OCC standard operating procedures for detailed descriptions of biological collection methodologies.

7.B. Program Goal: Reduce Trash

A monitoring program for trash capture devices is two-fold and does not require establishing baseline conditions in quite the same way as for other pollutants. Effectiveness of the BMP itself is demonstrated by its ability to capture and retain trash. Baseline conditions are established by repeated observations of trash at a site and ideally by some quantification of trash (weight, volume or item count). In the case of Bishop Creek, the persistent presence of trash is established by observations recorded on the Blue Thumb data collection sheets or/mobile data application. At Eastwood Park, baseline data are further established by Karen Chapman's efforts at quantifying the amount of trash removed from the creek each month. Since April 2022 Karen has recorded the weight of trash she removes from the creek. She typically does this monthly. Beyond demonstrations of the effective capture of trash, trash programs typically attempt to demonstrate the effectiveness of litter reduction education efforts in the watershed. If the education program is effective, less trash should be captured in the device over time.

A trash capture device will be considered for sites where at least 50% of trash observations by Blue Thumb volunteers are "medium" or "high." This is a subjective assessment. Prior to selecting a site for implementation of a trash capture device, a stormwater specialist from the City of Norman will confirm the assessment of a "medium" or "high" presence of trash. Following implementation, trash will be removed from the capture device at the frequency recommended by the manufacturer; the weight of captured trash will be recorded each time the trash is removed. The trash capture BMP will be considered successful if it captures trash. The education BMP will be considered effective if the amount of trash captured is reduced by 30% within five years of installing the device. The amount of trash removed will be calculated annually.

7.C. Program Goal: Increase Infiltration

Ideally, successful implementation of infiltration projects would be demonstrated by higher summer instream flows. We do not currently collect flow data on Bishop Creek, nor do we have the resources to do so. Furthermore, it is probable that the implementation required to achieve increased summer flows is well beyond the implementation planned for the first five years of this project. Even if implementation projects (certifying yards in the Yard by Yard Program) do not achieve increased summer flows, they will reduce the amount of stormwater that leaves participants' yards. Success for this metric will be demonstrated by the number of yards certified.

7. D. Improve Dissolved Oxygen

An increase in flow would likely result in an increase in summer dissolved oxygen levels. Low dissolved oxygen levels are typically recorded during periods of low flow. Although we do not expect to see measurable change in summer dissolved oxygen levels resulting from planned implementation, dissolved oxygen is a regularly monitored parameter for the Blue Thumb Program, so if improvement occurs, monitoring is in place to document improvement. For details of monitoring procedures, please see Blue Thumb SOPs regarding the collection and analysis of dissolved oxygen samples.

7.E. Program Goal: Reduce Bacteria

In this document, we have assumed that levels of *E. coli* exceed the water quality standard in Bishop Creek because that is the case for most urban streams in Oklahoma and nationwide. Bacteria monitoring is optional in the Blue Thumb Program and is not currently being collected in the Bishop Creek watershed. During the summer of 2024, we will establish baseline bacteria data for Bishop Creek following Blue Thumb SOPs. The effectiveness of a pet waste education program will be demonstrated by a reduction in bacteria over time. A 30% reduction in the average number of *E. coli* colonies over five years will be considered successful. The average will be calculated annually based on 10 sampling events. If the 2024 colonies are "too numerous to count", the education effort will be considered successful if the levels drop to the point where they can be quantified within five years of implementation of the education effort. The Coliscan Easygel method used by Blue Thumb is a screening-level assessment method. These data are not appropriate for beneficial use assessment and will not be included in the IR.

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