Chapter 3 Water Quality

Introduction

Water quality in Texas is routinely assessed and monitored under programs administered by TCEQ in accordance with the federal Clean Water Act (CWA). Water quality standards are defined in the Texas Surface Water Quality Standards (TSWQS) and state that water quality conditions must be met to support and protect their designated uses and water quality criteria in accordance with the Environmental Protection Agency (EPA) associated rules and the CWA, sections 305(b) and 303(d). Texas surface water quality is evaluated every two years, for these evaluations the surface water segments are broken into smaller segments called assessment units (AUs).

Under Section 303(d) of the CWA, administered by the EPA (40 CFR Section 130.7), states are required to identify waters (AU segments) that do not meet water quality standards for their reported uses to be listed (often called the 303(d) List). Uses are broadly described as aquatic life use, recreation, domestic water supply, and oyster waters. Rowlett Creek segment ID is 2080B, and AU ID 2080B_01 was first listed in 2014 with impairment for bacteria in the water, per TCEQ. Water quality indicators described in the TSWQS include bacteria, dissolved solids, dissolved oxygen and nutrients, metals, and organics. All activities, both human and natural, that occur within a watershed's boundaries can influence water quality in the receiving water body. As a result, an effective management strategy that addresses water quality issues in a watershed's receiving water body must examine all human activities and natural processes within that watershed.

Data Acquisition

Long-term continuous water quality data was acquired through TCEQ Surface Water Quality Monitoring Information System (SWQMIS) during the Rowlett Creek watershed characterization. An analysis of water quality historical and collected data at five locations (Figure 3-1) in Rowlett Creek was performed. The watershed was divided into five subwatersheds (also called subbasins) to better understand the sources and the causes of water quality impairments. Continuous long-term flow data was only available at the United States Geological Survey (USGS) station which matches Site 5. Accordingly, a Soil & Water Assessment Tool (SWAT) model was calibrated and validated and a flow time series for the Sites 1 to 4 were generated. Data for *E. coli*, nitrate/nitrite, Ammonia-N, Total Kjeldahl Nitrogen (TKN), total phosphorus (TP), and total suspended solids (TSS) was obtained from historical data collected by the cities and some samples collected during this project. Details of these historical measures are included in the Rowlett Creek watershed characterization used to develop this watershed protection plan are attached in the appendices. These parameters were used to develop load duration curves for each of the five subwatersheds. Load duration curves are used to compare against TSWQS and Nutrient Screening Levels defined by TCEQ, these are outlined in the following subsections.

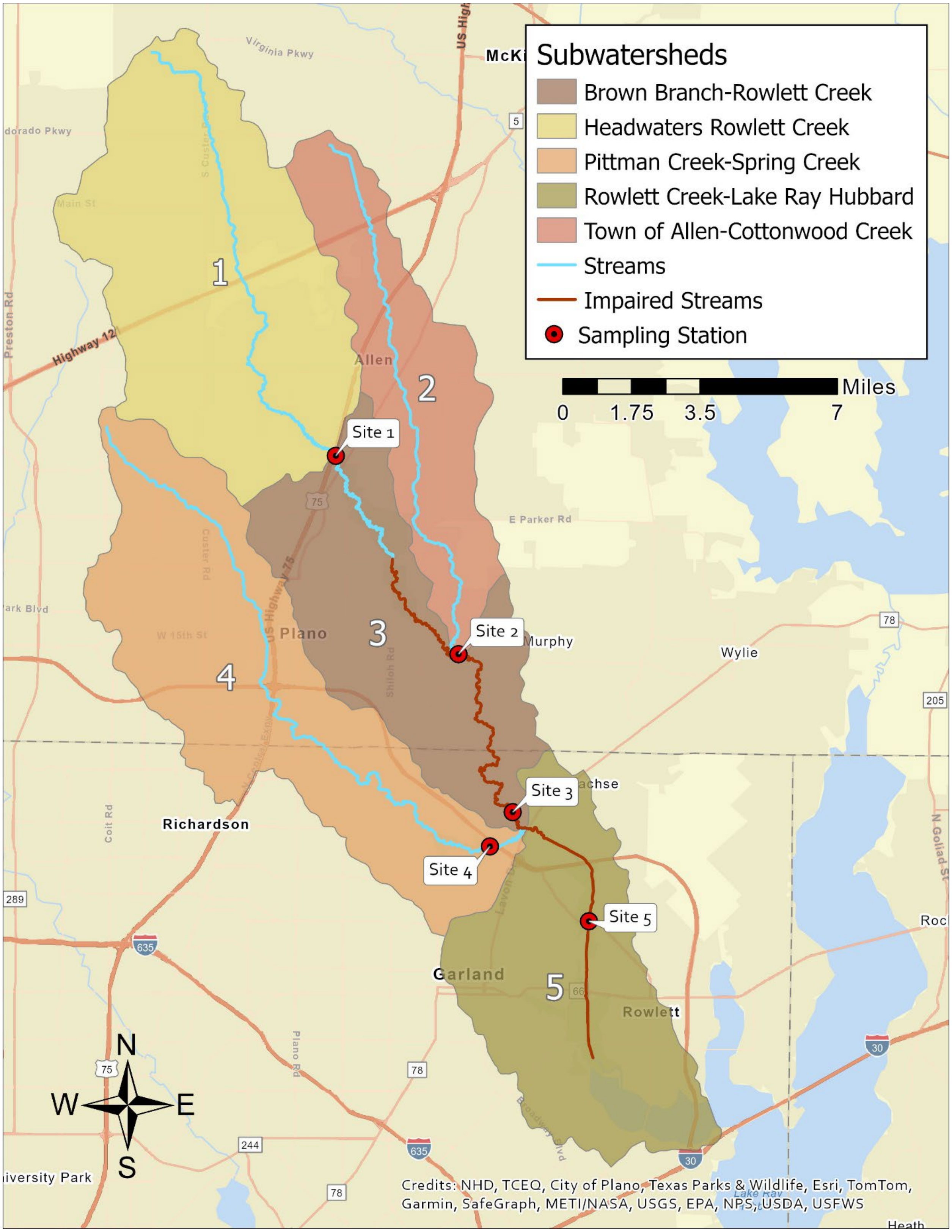

Figure 3-1. Surface water sampling stations from SWQM network.

Bacteria

Escherichia coli (*E. coli*) bacteria is an indicator of fecal contamination in freshwater. Concentrations are monitored because it suggests the presence of other disease-causing pathogens that lead to human illness. The higher the concentration of *E. coli* the greater the possibility that there will be more toxic *E. coli* strains, other bacteria or viruses that can be ingested while swimming, wading or boating in waterbodies. Additionally, the presence of pathogens in a waterway may cause decreased levels of dissolved oxygen (DO) and degrade aquatic habitats. *E. coli* bacteria is found in warm-blooded animals so contributions can be attributed to related sources. If the waste is excreted in the open then, during a rain event, it can be picked up by stormwater runoff and be either channeled into surface water and/or ground water or directly deposited into the waterbody.

Contributing sources include wildlife, livestock, pets, urban and agriculture runoff, and malfunctioning on-site sewage facilities (OSSFs) and wastewater treatment plants (WWTP), and direct discharge from WWTPs. Additionally, some natural fertilizers can contain these fecal contributing pathogens carried by stormwater runoff in both urban and agricultural lands. The Rowlett Creek watershed is an intensely developed urban landscape. Therefore, nearly all the contributing sources of bacteria can be linked to human activity for this watershed and not significantly from wildlife sources. For the Rowlett Creek segment, TCEQ designates the presumed use to be primary contact recreation and therefore assessed to that use standard. This standard sets a maximum geometric mean for E. coli to 126 cfu/100 ml (colony forming units), which is equivalent to 126 MPN/100 ml (most probable number) and was used in this project.

Nutrients

Nitrogen and phosphorus are limiting nutrients in the aquatic environment. They are essential for aquatic plants and algae but can also cause detrimental effects in riverine and reservoir ecosystems if found in overabundance. The excess nutrients can result in algae blooms, indicated from measurements of chlorophyll a (the green pigment) concentrations as an index of phytoplankton biomass. Significant increases in algae harm habitat and food resources necessary for other aquatic life and deplete the water of dissolved oxygen (DO), creating what are called hypoxic zones. This effect can kill fish and destroy their habitat, impairing the recovery of the freshwater ecosystem without intervention. Stormwater runoff carries residential and agricultural fertilizers that are full of nutrients. Runoff can also carry animal waste and pollutants from sanitary sewer overflows that also contain nutrients to contribute to overloading in waterways. Further, Wastewater Treatment Plants (WWTP) effluent could be a source of nutrients in some waterbodies.

The water quality parameter of total nitrogen is composed of nitrate, nitrite and total Kjeldahl nitrogen (TKN). Nitrate is very abundant as an inorganic, oxidized form of nitrogen and nitrite is not as common as an inorganic, oxidized form of nitrogen. TKN contains organic nitrogen and ammonia, the inorganic form of nitrogen. Total phosphorus (TP) is a parameter used to analyze a water sample for all forms of phosphorus. Forms of phosphorus include organic and inorganic forms as well as dissolved and particulate forms. Though individual criteria for these parameters are not currently established by the TCEQ, the impacts of these nutrients are monitored through concentrations of chlorophyll a such that excessive aquatic vegetation growth does not impede the intended water use, in this case recreational use.

Dissolved Oxygen

Dissolved Oxygen (DO) is a physiological requirement of aquatic communities. DO refers to the amount of oxygen gas mixed in water. Oxygen enters water directly by absorption from the atmosphere called diffusion, and from aquatic plant photosynthesis released oxygen. Aquatic environments depend on available DO in the water to support the life of plants, algae, fish, and aquatic invertebrates. DO levels do naturally fluctuate in an ecosystem and are influenced by both temperature and nutrient concentrations, albeit indirectly. Moreover, seasonal changes can impact the levels of DO because the change in water temperature also influences the amount of DO in the water such that warm water holds less DO than cold water. Especially in climates such as Texas where the summers are hot, it is expected to see lower DO in the water during the summer. With increasing air temperatures in the summer months that can extend beyond historical summer trends, it is expected to further limit the DO available seasonally.

The amount of DO in the water column is also impacted by decomposition processes and primary productivity. Though aquatic plants contribute oxygen to the water body, overabundant plant growth stimulated by excess nutrient runoff will reduce DO. When plant growth is excessive it utilizes much of the oxygen for respiration and subsequently for its later decomposition. Decomposition of organic waste (e.g., dead plants and algae, lawn clippings, animal waste, and sewage) contribute to low DO levels because the process of decomposition consumes the DO. Additionally, embedded sediments can prevent DO from freely passing through the sediment layers of the water body floor where some aquatic organisms survive. As DO levels decline aquatic species requiring greater DO concentrations die first, this includes larger game fish such as bluegill, bass, and trout, and eventual degradation of the habitat itself and the health of all the organisms within. Given DOs importance, DO is the main water quality parameter to determine a waterbody's habitat suitability. DO concentrations below the criterion of 4.0 mg/L are deemed inadequate for water quality parameters to support a functioning habitat.

Other Parameters

Other water quality parameters can be measured to give a more detailed picture of a waterbodies quality for supporting aquatic life and human general uses. Including but is not limited to, water temperature, specific conductance, pH, and TSS.

The temperature of water is directly associated with aquatic organisms' physiological processes. As described in an earlier section, DO decreases in the water column as the temperature increases. This results in an increased oxygen demand by the aquatic community and subsequent stress on higher-level organisms. Further, rapid variations in water temperature are more detrimental to aquatic species since their ability to flee is limited.

Specific conductance is best described as the effectivity of a liquid conducting electricity and a standard temperature of 25°C. Conductivity increases in a waterbody when ionic dissolved solids levels increase. Nutrients and salts make up ionic dissolved solids. Reduced water quality occurs when ionic dissolved solids, specifically nutrients, increase and DO subsequently decreases.

Water pH is the potential hydrogen of the water and is also referred to as acidity and basicity. A healthy aquatic waterbody falls within a pH range of 6.5 to 9.0 and is considered neutral if the pH is 7.0. Values less than 7.0 would classify the body as acidic whereas values greater than 7.0 would classify the waterbody as alkaline.

TSS are suspended particles in a water column that, when sampled, are not capable of passing through a specific pore sized filter. Solids are made up of organic matter, such as algal, and micro-organisms, as well as inorganic matter, includes soil sediments due to erosion.

Flow

Streamflow is the amount and rate of water, in volume per second (m^3/s), carried by streams and rivers. Streamflow, much like other water quality parameters, is best compared to individual historical records. Changes in flow can affect water supplies, water quality, aquatic habitat, health of aquatic life, and riparian plants. Flows do fluctuate naturally with precipitation events that come from seasonal changes. However, they can be impacted by human activity, such as changes in land cover. Conversion of natural landscapes to urban concrete infrastructure can increase runoff that in turn increases streamflow. These impacts can be exacerbated from the recent changes in precipitation trends. Streams are interconnected and do have impacts on water quality and quantity downstream. From a water quality perspective, streamflow influences pollutant concentrations and how they travel downstream or accumulate at certain locations.

The watershed was divided into five subwatersheds to better understand the sources and the causes of water quality impairments. Continuous long-term flow data was only available at the USGS station which matches Site 5. Accordingly, a SWAT model was calibrated and validated, and a flow time series was generated for the Sites 1 to 4. The final results of the calibration of the Rowlett Creek Watershed at the USGS Station location, shown in Figure 3-2. The results show good match with the observed data. The goodness-of-fit measures results (Table 3-1) present a good rating for the RSR and NSE and satisfactory for the PBIAS. These results allow us to use the SWAT model to extract flow time series for the outlets of the five subwatersheds studied.

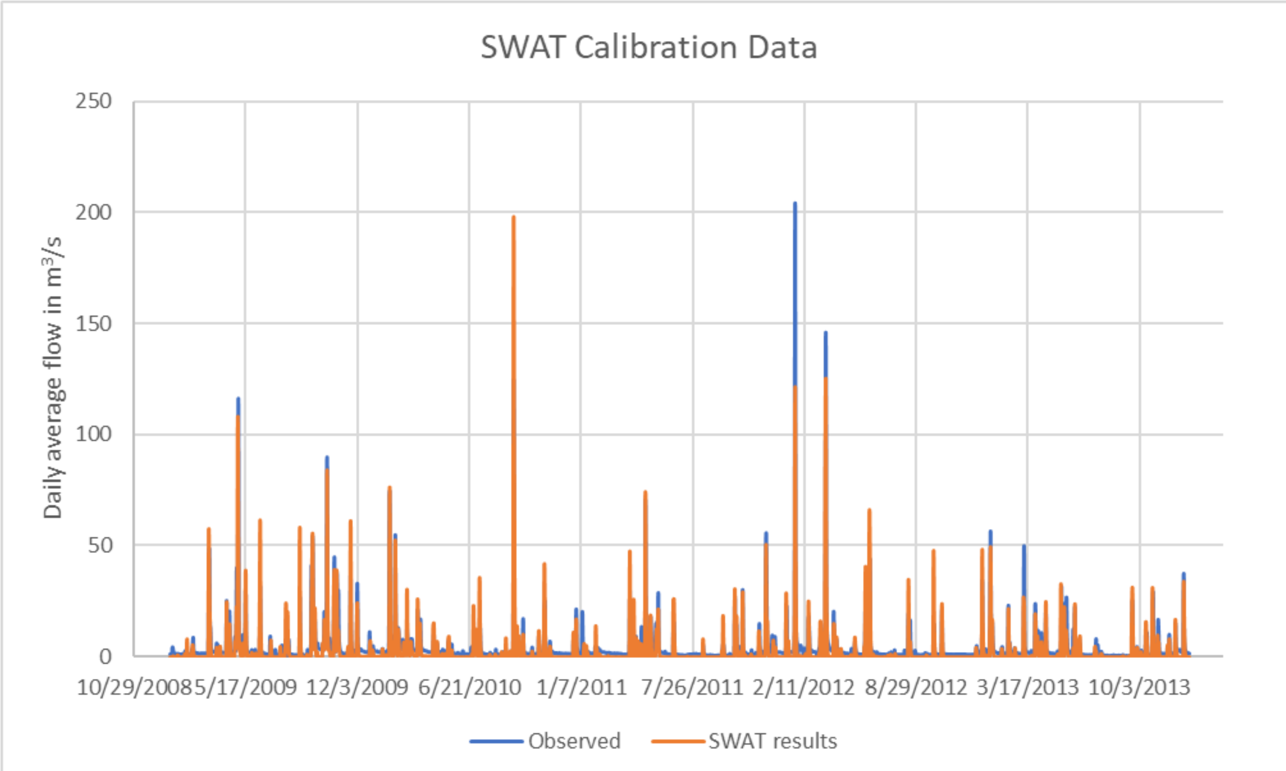

Figure 3-2. SWAT Model results compared with observed data at the Rowlett Creek USGS Station.

Table 3-1. Goodness-of-fit results for final calibration of the SWAT model

RSR	**0.60**
NSE	**0.65**
PBIAS	**15.97**

Potential Nonpoint Sources of Water Quality Issues

Nonpoint source (NPS) pollution results when rainwater drains from land as runoff, it carries with it the existing pollutants on the land and in the soil into the drainage systems, streams, rivers, wetlands, and lakes. NPS pollution comes from many diffuse sources from the landscape and is the most common source in urban watersheds. Potential sources contributing bacteria in the Rowlett Creek watershed were identified through a variety of avenues including stakeholder input, local experience in the watershed from project partners and conducting watershed reconnaissance surveys. The potential sources described in this subsection are not a comprehensive list, but rather the ones relevant to the watershed and identified by the stakeholders.

Domestic Pets

Dogs and cats can contribute significant quantities of *E. coli* to a watershed if their waste is not properly disposed of and allowed to remain on the ground, this is especially true for urban watersheds due to the high density of these pets. Picking up after dogs and disposing of cat litter boxes in municipal solid waste effectively removes this source from a watershed. However, a considerable amount of pet waste, especially from dogs, is left in parks, yards or near homesteads in rural areas and can enter waterways during runoff events. Because dogs and cats are most often associated with people, the highest potential

E. coli loading areas are near population centers in the watersheds. A national survey conducted by the American Veterinary Medical Association 2024 report suggests there are approximately 0.68 dogs per household in the U.S. (AVMA, 2024). The population of domestic pets is estimated for the watershed based on number of households reported in the Census and average number of pets per household estimated by the American Veterinary Medical Association.

Feral, or stray, cat populations have gained considerable interest with concerns for bird predation and disease transfer however, they also pose to be considerable contributors of bacterial pollution in a watershed. With U.S. feral cat population estimates of 32 million and approximately 76% living in urban areas and on the rise according to the National Feline Research Council (Rowan et al., 2019), in addition with trap neuter and return programs being used to manage populations, feral cats could be a notable source in urban watersheds and have been considered in some other watershed plans (MPCA et al., 2014). In the Dallas-Fort Worth metroplex (DFW) there is an estimated 350,000 feral cats reported in a 2016 Dallas Morning News article (Rajwani & Tsiaperas, 2016). One study in Chicago estimated that there were 0.5 feral cats per household, since populations in DFW have reportedly only been on the rise the estimation of numbers in the subwatersheds will use 0.5 feral cats per household. This follows how the estimation of dogs were counted in the watershed, see Table 3-2.

Wildlife and Feral Hogs

Wildlife contribute *E. coli* bacteria loading through direct deposition of fecal matter into streams while wading or wallowing in riparian areas and through fecal deposition across the landscape. Indirect contributions can also occur from fecal matter being transported through runoff. Feral hogs create extensive land disturbance in riparian and upland areas that can contribute to increased soil erosion and pollutant runoff. However, feral hog populations in the lands of the watershed are almost nonexistent due to its extensive urban development, see Figure 2-3.

Domestic Livestock

Cattle, goats, horses, pigs, and sheep are all potential *E. coli* bacteria loading contributors in the watersheds. Livestock estimates derived from USDA Census of Agriculture (USDA & NASS, 2022) county population data and stakeholder input were used to estimate potential *E. coli* loads. Spatial distribution of relative *E. coli* loading potential for each type of livestock was calculated and combined to produce the total potential livestock *E. coli* load across the watersheds. The estimated numbers can be found in Table 3-2.

Table 3-2. Estimated number of animals for each subwatershed and the watershed totals.

Subwatershed ID	Estimated Animal Count						
	Chickens	Cows	Horses	Pigs/Hogs	Sheep	Dogs*	Feral Cats**
1	84	245	28	5	21	39,173	28,698
2	57	166	19	4	14	15,577	11,412
3	33	70	7	1	6	19,666	14,408
4	11	20	2	1	2	41,082	30,097
5	75	111	9	1	9	19,477	14,269
Total	260	612	65	12	52	134,975	98,884

*Estimated as 0.68 dogs per household

** Estimated as 0.5 feral cats per household

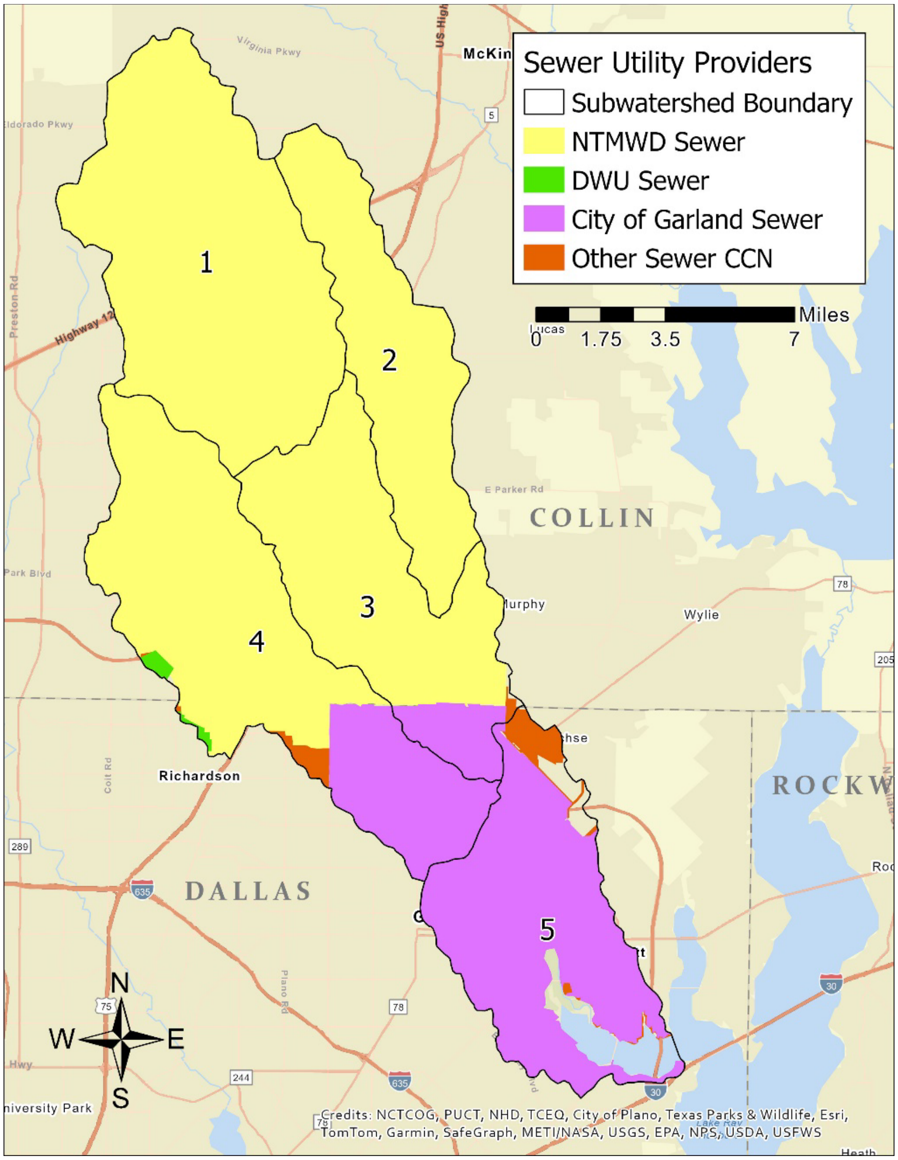

Figure 3-3. Sewer (wastewater) service areas provided under a Certificate of Convenience and Necessity (CCN) issued by the Public Utility Commission of Texas. Data provided by the North Texas Council of Governments (NCTCOG) and the Public Utility Commission of Texas (PUCT).

On-Site Sewage Facilities

The current use and installation of on-site sewage facilities (OSSFs) in this watershed is highly limited due to the connection of homes to centralized sewage treatment facilities throughout almost all of the watershed. Many factors affect the efficiency of OSSFs, including the soil properties of the soil absorption field. Other factors impact OSSF function, including lack of maintenance and damages. If routine maintenance is neglected, the system may malfunction and discharge improperly treated wastewater into the ground or on the surface. The majority of older OSSFs in the watershed use a conventional septic tank and subsurface soil absorption to treat discharged wastewater. In these systems, wastewater is first passed through a septic tank, which separates solids and liquid before dispersing effluent into a soil absorption field where wastewater is further treated by percolating through the soil (USEPA 1980).

The use of OSSFs is highly limited due to the transformation of rural to urbanized land over the past several decades, with a current coverage of 75% developed (Table 2.2). Urban areas are provided wastewater services through municipality infrastructure, in this case majority of the area is provided by the City of Garland and North Texas Municipal Water District (Figure 3-3). It can be estimated that less than 5% of the area is not covered by a municipal sewer network. Thus, contributions of OSSFs in the Rowlett Creek watershed can be deemed minimal enough to not measure as a quantifiable source at this scale.

Potential Point Sources of Water Quality Issues

Point source pollution is the discharge of pollutants from a single and identifiable origin point. These types of discharges to Texas surface water are permitted and monitored by the Texas Pollutant Discharge Elimination System (TPDES) regulatory program, which is authorized through the National Pollutant Discharge Elimination System (NPDES) program. Wastewater treatment plant (WWTP) operations are common permit holders of discharges to surface water. Other permitted discharges include stormwater discharges by industrial and construction sites, and from municipal separate storm

Permitted Wastewater Discharges

Municipal wastewater is treated by WWTPs before ultimately being released back as effluent into a nearby water body. These discharges of the treated effluent are permitted releases are tested and reported to TCEQ, the permitter, for the bacteria, nutrients, and other pollutant indicators. These reports indicate if the WWTP is meeting their permit discharge levels. If the discharge exceeds their permit the facility may need improvements to infrastructure or expansion to meet increasing wastewater intake.

There is one WWTP facility within subwatershed 3 permitted to discharge into AU 0820B , the Rowlett Creek WWTP shown in Figure 3-3. Measured levels of *E. coli* in effluent at the Rowlett Creek Regional WWTP are far below the state standard. It is therefore unlikely that the WWTP is a source of excessive *E. coli* in the watershed. Additionally, the Rowlett Creek WWTP is currently undergoing upgrades to their facilities to increase capacity at peak flow. The North Texas Municipal Water District (NTMWD), owner and operators, completed the majority of these upgrades in November 2021.

Unauthorized Discharges

Unauthorized discharges of wastewater can occur from municipal, industrial, and recreational sources that can occur directly into a water body or the land, where it ultimately enters the water through runoff. These discharges contribute to bacterial pollution and excess nutrients, hence instances must be reported to TCEQ and addressed by the party responsible for the discharge. Sanitary sewer overflows (SSOs) are a type of unauthorized discharge of untreated or partially treated wastewater from any point in a sewer system. Most common causes of SSOs include blockages, sewer defects that overload the system, power failures, line breaks, poor design, and vandalism. These discharges can be either single instance events, such as in the case of storm design failure during extreme rainfall events, or can be continuous discharges, such as sewer line breaks.

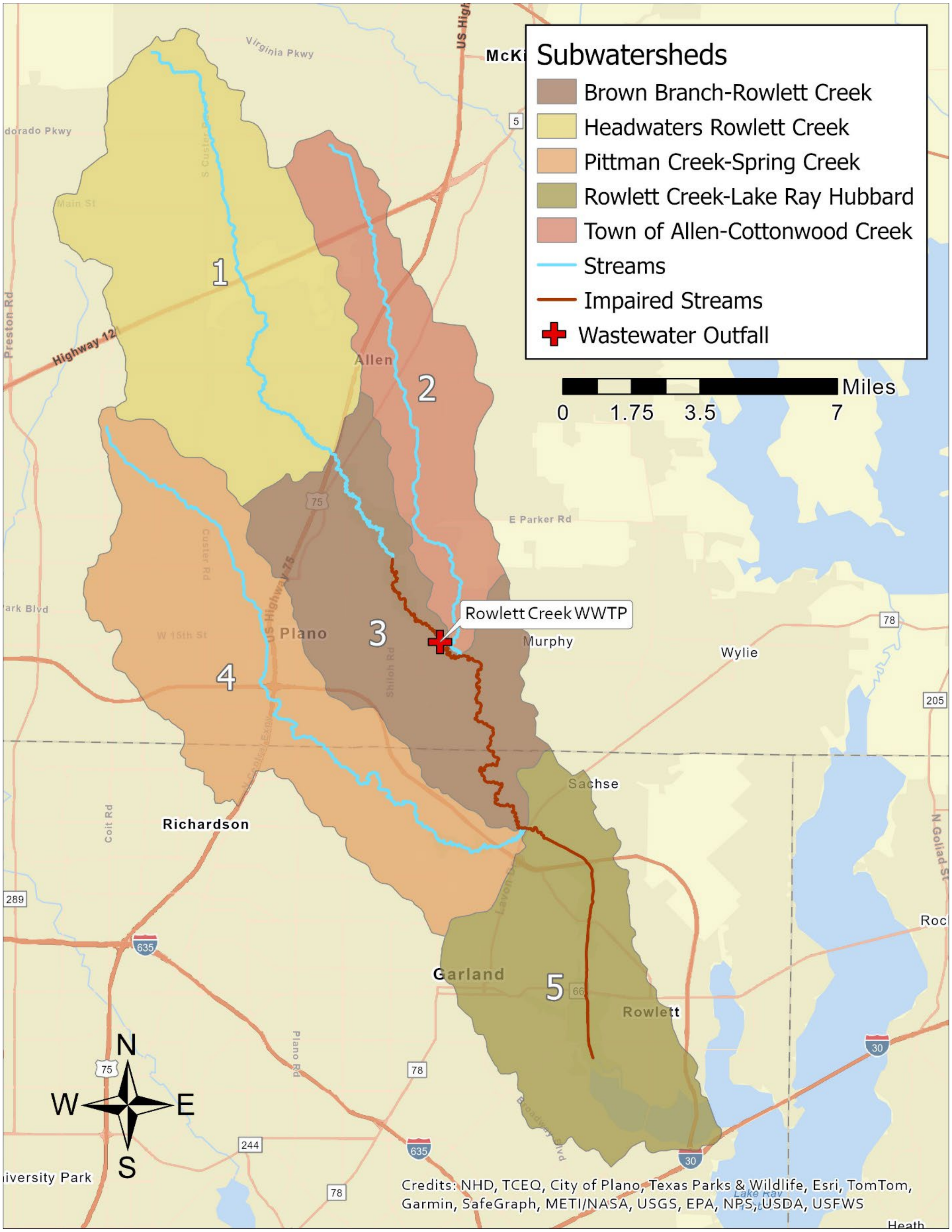

Figure 3-4. The WWTP located in the Rowlett Creek watershed.

Permitted Stormwater Discharges

Some urban activities (construction, industrial, and Municipal separate storm sewer systems (MS4)) are permitted to discharge stormwater due to the size and the point source nature of the operations discharge through the TPDES program. These permits are designed to manage stormwater runoff and reduce the amount of pollution discharged. MS4s are regulated stormwater operations that discharge stormwater into water bodies, these are separate from sanitary sewer systems which receive treatment before being discharged discussed above. MS4 permits are designed to:

- Control stormwater runoff in a way that protect waterways from pollution
- Maintain and upgrade stormwater systems as needed
- Monitor water quality of stormwater runoff
- Apply treatment or pollution removal techniques when necessary

MS4 permits are categorized as either medium to large Phase I or small Phase II permits based on population. There are three Phase I MS4 permit holders in the Rowlett Creek watershed: City of Dallas, City of Garland, and the City of Plano. There are two Phase II MS4 permits for: City of Frisco, and City of Allen. Given the highly urbanized area in this watershed, there are several industrial and construction permits that are active and will occur in the future which can contribute to increased TSS in waterways.

Table 3-3. Summary of potential pollutant sources for bacteria.

Pollutant Source	Source Type	Potential Impact	Potential Causes
Urban Stormwater Runoff	Non-point	Untreated stormwater discharged carrying bacteria, nutrients, etc. directly into waterways	Increased runoff from impervious surfaces
			Lack of education on urban runoff impacts
			Excessive application of pesticides and fertilizers
			Disposing chemicals in storm drains
Domestic Pets	Non-point	Bacteria and nutrients directly deposited or through runoff into streams, and transfer of disease	Lack of proper waste disposal at home and in public areas
			Increased runoff from impervious surfaces
			Lack of education on pet waste impacts
Wildlife and Feral Hogs	Non-point	Bacteria, nutrients, and sediments directly deposited or through runoff into streams	Fecal matter direct deposition
			Erosion from degraded riparian zones
Domestic Livestock	Non-point, Point	Bacteria and nutrients directly deposited or through runoff into streams	Pasture manure runoff
			Overgrazing or overstocking
			Direct deposition into streams
OSSFs	Non-point, Point	Untreated sewage runoff into streams contributing bacteria and nutrients.	Poorly functioning or failing systems
			Improper design or abandonment

Permitted Discharges	Point	Untreated stormwater discharged carrying chemicals, sediments, nutrients, and bacteria directly into waterways	Construction related sediment runoff with storm events
			Transportation and manufacturing facilities, scrapyards, and other industrial activities
WWTPs and SSOs	Point	Untreated or partially treated sewage discharged or through runoff into streams contributing bacteria, nutrients, etc.	Aging infrastructure and lack of routine maintenance
			Overflow during large rain events
			Power failures

Water Quality Summary

Rowlett Creek watershed is mostly urban and because of this, most pollution in the watershed comes from that picked up from overland flow due to impervious surfaces. Since the primary water quality concern for Rowlett Creek is bacteria impairment, reducing surface bacteria pollution and reducing overland flow by reducing runoff will have the greatest impact on reducing bacteria. Potential surface bacteria pollution in Rowlett Creek watershed likely includes pet waste, wildlife waste, and permitted discharges from WWTPs (Table 3-3).