Appendix B: Technical Memorandum for Population, Water Demand, and Interbasin Transfer Projections

Hazen and Sawyer
4011 WestChase Blvd, Suite 500
Raleigh, NC 27607 • 919.833.7152
Firm License No. C-0381

TECHNICAL MEMORANDUM

To:
Mike Wagner
Public Utilities Director
Town of Fuquay-Varina

Copies:
File

From:
Hazen and Sawyer

Date:
June 2025

Subject:
Population, Water Demand, and Interbasin Transfer Projections
Town of Fuquay-Varina Water Supply and Interbasin Transfer
Appendix to Environmental Impact Statement

1. Introduction

Population, water demand, and interbasin transfer (IBT) projections were developed to support the Town of Fuquay-Varina's request for a transfer of water from the Cape Fear River basin (2-3) to the Neuse River basin (10-1). This analysis supports the Purpose and Need in the Environmental Impact Statement (EIS). The planning window for the IBT is 30 years using 2025 as the beginning of the planning period. This Technical Memorandum documents the assumptions and methodology for the projection analyses.

The Town of Fuquay-Varina is located in southern Wake County. The Town's service area consists of municipal Town limits and extraterritorial jurisdiction (ETJ). The Town's service area abuts the Wake-Harnett County line. The Wake-Johnston County line is to the east of the service area. The service area extends north to the west of U.S. 401. The interbasin transfer (IBT) boundary between basin 2-3 (Cape Fear) and basin 10-1 (Neuse) is located almost through the center of the Town's service area, following U.S. 55 to Judd Parkway and Holland Road and then turning south along U.S. 55 toward the Wake-Harnett County line. Exhibit 1 provides the location of the Town's municipal limits, ETJ, and IBT boundary. The Town's Urban Services Area extends east from the ETJ to the Wake-Johnston County line south of Highway 42, approximately 1.1 miles east of the ETJ north of Highway 42, and approximately 1 mile west of the ETJ in the southwest corner of the Town's service area near the Wake-Harnett County line.

2. Data Sources

Hazen compiled data from several sources to evaluate population, water, and interbasin transfer projections. Data was compiled from the Town's Local Water Supply Plans (LWSP), a *Water Capacity Study* (WithersRavenel | Freese and Nichols, 2017), population data from the North Carolina Office of State Budget and Management (OSBM), and American Community Survey data from the U.S. Census Bureau. The Town provided billing data for 2019. A summary of account data over multiple years was compiled from the Town's LWSPs.

The Town's Geographic Information System (GIS) Department was contacted to obtain the most recent GIS shapefiles of the water distribution system, wastewater collection system, and municipal boundaries. The Town provided a GIS database that designated parcels that are physically located in either the Neuse or the Cape Fear River basins along with current water and sewer lines. The database designates the terminal treatment facility for each sewer area. Wake County provided GIS data for well locations and parcels served by septic. Parcels were categorized by the number of vacant and non-vacant parcels located in the Neuse and Cape Fear basins for water distribution and sewer service. Table 1 provides the data sources used for the GIS analysis, population projections, and water demand projections.

Table 1: Data Sources Used for GIS Analysis, Population Projections, and Water Demand Projections

Data	Source
American Community Survey block group data, 2010 – 2018	United States Census Bureau
Town of Fuquay-Varina service area population, 1997, 2002, 2006, 2009 – 2020	Local Water Supply Plans prepared by Town of Fuquay-Varina for North Carolina Division of Water Resources
Municipal and County population data	North Carolina Office of State Budget and Management
Water and sewer infrastructure GIS data	Town of Fuquay-Varina GIS Department
Traffic Analysis Zone (TAZ) data, 2045 projections	Capital Areas Metropolitan Planning Organization (2018)
Town of Fuquay-Varina customer account data, 2000 – 2015.	Town of Fuquay-Varina Finance Department
Town of Fuquay-Varina utilities billing data, 2019.	Town Finance Department
Wake County Tax Parcels	Wake County GIS Property Mapping Team
Average persons per single-family residential account	Vickers, Amy, 2001. Handbook of Water Use and Conservation: Homes, Landscapes, Businesses, Industries, Farms, First Edition

3. Summary of Water and Wastewater Infrastructure

Section 3 provides a summary of the Town's water and wastewater infrastructure. Exhibits 2 and 3 provide an illustration of the Town's water and sewer infrastructure, respectively. Exhibits 2 and 3 also illustrate the location of parcels on private wells and septic systems in the service area, respectively.

3.1 Service Area Characterization

Table 2 provides a summary of the number of parcels on water and sewer service in the municipal boundary and ETJ. Approximately 5,000 non-vacant parcels are on private wells in the Town's service area. Approximately 5,200 non-vacant parcels are on a septic system in the service area, of which approximately 208 and 438 non-vacant parcels are on water lines and septic in the Neuse and Cape Fear, respectively. The fraction of the Town's current water demand in the Neuse River and Cape Fear River basins is approximately 62 percent and 38 percent, respectively.

Hazen

Table 2: Summary of Water and Sewer Data in Fuquay-Varina Service Area

Description	Parcel Count
Number of parcels	21,879
Number of non-vacant parcels	18,873
Number of non-vacant parcels in Neuse	12,951
Number of non-vacant parcels in Cape Fear	5,922
Sewer Summary	
Number of parcels on sewer lines	13,337
Number of non-vacant parcels on sewer lines	11,452
Number of non-vacant parcels to Harnett County North Regional WWTP	6,058
Number of non-vacant parcels on Terrible Creek WWTP lines [1]	4,986
Number of non-vacant parcels on Brighton Forest WWTP lines	408
Number of non-vacant parcels on sewer in Neuse	7,273
Number of non-vacant parcels on sewer in Cape Fear	4,884
Number of non-vacant parcels on sewer, total	12,157
Water Summary (Fuquay Varina Lines)	
Number of Parcels on Fuquay-Varina water lines	12,735
Number of non-vacant parcels on Fuquay-Varina water lines	11,358
Number of non-vacant parcels on Fuquay-Varina water lines in Neuse	7,180
Number of non-vacant parcels on Fuquay-Varina water lines in Cape Fear	4,178
Water Summary (Harnett County Lines)	
Number of Parcels on Harnett County water lines	397
Number of non-vacant parcels on Harnett County water lines	300
Number of non-vacant parcels on Harnett County water lines in Neuse	0
Number of non-vacant parcels on Harnett County water lines in Cape Fear	300
Total Water Summary (Fuquay-Varina and Harnett County)	
Number of parcels on water lines	13,132
Number of non-vacant parcels on water lines	11,658
Number of non-vacant parcels on water lines in Neuse	7,180
Fraction of demand in Neuse	62%
Number of non-vacant parcels on water lines in Cape Fear	4,478
Fraction of demand in Cape Fear	38%
Water Lines on Septic Summary	
Number of non-vacant parcels on water line and septic in Neuse	208
Number of non-vacant parcels on water line and septic in Cape Fear	438
Number of non-vacant parcels on water line and septic, total	646

Hazen

Table 2: Summary of Water and Sewer Data in Fuquay-Varina Service Area

Description	Parcel Count
Well Systems on Sewer Summary	
Number of non-vacant parcels using wells on sewer, Neuse	142
Number of non-vacant parcels using wells on sewer, Cape Fear	298
Number of non-vacant parcels using wells on sewer, total	440

[1] Approximately 512 non-vacant parcels are geographically located in the Cape Fear hydrologic boundary but legislatively located in the Neuse River basin per General Statute § 143-215.22L.

3.2 Water Distribution

The Town owns and operates the water distribution system in the majority of the service area. Harnett County provides water service to 397 accounts in the southern end of the Town's service area near the Wake-Harnett County line. The Town's water distribution system network includes approximately 250 miles of water line, three pump stations, one ground storage tank, and two elevated storage tanks.

Finished water is delivered to the Town via three bulk finished water wholesale purveyors. Harnett County supplies the Town from the primary connection at the Wake County groundwater storage tank and pump station located at Fleming Road. The secondary connection point with Harnett County is at U.S. 401 near the Wake County and Harnett County border. Raleigh Water's connection to the Town's distribution system is at U.S. 401 and Ten Ten Road. The connection point with Johnston County is located at Highway 42 and Mount Pleasant Church Road.

3.3 Wastewater Collection and Treatment

The Town's collection system has been designed based on the hydrologic basin boundary between the Neuse and Cape Fear River basins. The Town currently conveys all produced wastewater in the Cape Fear River basin portion of the Town's service area to Harnett County's North Regional Wastewater Treatment Plant (WWTP) for treatment and discharge. The North Harnett Regional WWTP discharges to the Cape Fear River via National Pollutant Discharge Elimination System (NPDES) permit NC0021636. The Town conveys the majority of produced wastewater in the Neuse River basin to the Terrible Creek WWTP for treatment and discharge. The Terrible Creek WWTP was expanded to a maximum month capacity of 3 million gallons per day (mgd) in 2018 and is currently being expanded to 6 mgd. A small fraction of produced wastewater (i.e., 0.117 mgd) in the Neuse River basin is treated at the Town of Fuquay-Varina's Brighton Forest WWTP, which serves single family homes in the Brighton Forest Subdivision. The Town of Fuquay-Varina has never had the ability to transfer raw wastewater between the Cape Fear and Neuse River basins.

The Town previously owned and operated the 1.2 mgd Kenneth Branch WWTP. The Kenneth Branch WWTP was located in the Cape Fear portion of the Town's service area. The Kenneth Branch WWTP discharged to Kenneth Creek as authorized by NPDES permit NC0028118. The Kenneth Creek receiving stream is a tributary to Neals Creek, which is tributary to the Cape Fear River upstream of the Town of Lillington. In March 2008, the Town decommissioned the Kenneth Branch WWTP and rescinded the NPDES permit NC0028118 (NCDENR, 2008). The Town of Fuquay-Varina deeded the property to the

Wake County Public School System in 2022. The Wake County Public School System is constructing middle and elementary schools on this property.

3.4 Interlocal Agreements for Bulk Finished Water and Wastewater Allocation

Table 3 provides a summary of the Town of Fuquay-Varina's Interlocal Agreements (ILAs) with neighboring communities for bulk finished water supply and wastewater allocation. The summary includes the contract amount, expiration date, and comments regarding the likelihood of contract renewal. The Town of Fuquay-Varina has signed temporary interlocal lease agreements with Raleigh Water, Harnett County, and Johnston County for the purchase of bulk finished water. The Town of Fuquay-Varina signed an ILA with Harnett County for the purchase of wastewater allocation in the North Harnett Regional WWTP. The following sections provide a summary of the interlocal agreements.

Table 3: Summary of Town of Fuquay-Varina's Interlocal Agreements for Water Supply and Wastewater Capacity

Supplier	Contract Value	Service	Comment
Johnston County	1.5 mgd	Water	Contract expires in 2049. Town does not anticipate a contract renewal.
Raleigh Water	0.75 mgd	Water	Contract expired in 2021.
Raleigh Water	1.75 mgd	Water	Town signed new contract for 1.75 mgd until 2035. Contract renewal is not anticipated per correspondence with Raleigh Water.
Harnett County	2 mgd	Water	Contract expires in 2040. Town anticipates a contract renewal in 2040.
Harnett County	2 mgd	Water	The Town has negotiated an additional 2 mgd with contract expiring in 2032.
Harnett County	2.6 mgd	Wastewater	Contract expires in 2040 and automatically renews for an additional 40 years. The Town is working with Harnett County for the purchase of the Town's additional 3.4 mgd wastewater allocation in the North Harnett Regional WWTP (NC0021636) for a total of 6 mgd.
City of Sanford	6 mgd	Water	Contract expires in 2122 with option to renew for another 99 years. The Town's LWSP lists water supply from the City of Sanford as follows: 8 mgd in 2045, 10 mgd in 2050, and 11 mgd in 2055.

3.4.1 Wastewater Allocation

The Town signed an ILA with Harnett County for the purchase of wastewater allocation in the North Harnett Regional WWTP in 2000. Per the ILA, the Town does not have any right of ownership in the North Harnett Regional WWTP. Therefore, the Town of does not own actual treatment capacity in the Harnett County wastewater treatment facility. The Town's ILA with Harnett County allows the Town of Fuquay-Varina to increase the Town's wastewater allocation in the North Harnett Regional WWTP by an additional 3.4 mgd, for a total of 6 mgd. The ILA expires in 2040 and automatically renews for an additional 40 years. Harnett County issued a Letter of Intent (Harnett County, 2021) to the Town of Fuquay-Varina that confirms the Town of Fuquay-Varina's participation in the North Harnett Regional WWTP expansion project. The Town and Harnett County executed an amendment to the ILA in 2023 for the Town's purchase of the additional 3.4 mgd of capacity.

The Town's ILA with Harnett County also included a 15-mile interceptor to convey wastewater flow from the Town's service area in the Cape Fear watershed to the North Harnett Regional WWTP. Per a 201 Facilities Plan for the Town of Fuquay-Varina and Harnett County (Marziano and Minier, 2002), a 36-inch interceptor was proposed from the former Kenneth Branch WWTP site. The Town of Fuquay-Varina owns the 36-inch diameter interceptor segment in Wake County. The Town of Fuquay-Varina's ownership of the interceptor terminates at the meter vault at the Wake and Harnett County line. Harnett County owns the remaining 42 and 48-inch diameter interceptor segments from the meter vault to a pump station located on the north side of the Cape Fear River. The pump station pumps raw wastewater to the North Harnett Regional WWTP located on the south side of the Cape Fear River.

The Town and Harnett County interceptor was designed and constructed in accordance with applicable design criteria in the 1996 version of the Minimum Design Criteria for the Permitting of Gravity Sewers (DWR) to meet the capacity needs of the proposed project in 2000. The hydraulic capacity of the Town of Fuquay-Varina's allocation in the interceptor is 6 mgd average day flow with a hydraulic peak flow of 12 mgd. The capacity of the 36-inch interceptor was confirmed with a hydraulic model.

3.4.2 Bulk Finished Water

The Town has not secured a permanent water supply source. The Town does not own a raw water intake, water treatment infrastructure, or purchased permanent water supply capacity from a neighboring community. The Town has historically signed temporary ILAs with neighboring communities for wholesale finished water.

The Town signed an ILA with Harnett County for the purchase of a bulk finished water allocation in the Harnett County Regional WTP over a 50-year term. The first ILA was signed in 1989 and specified a finished water allocation of 1 mgd. A second ILA was signed in 1999 and specified an additional 1 mgd of allocation, for a total allocation of 2 mgd to the Town of Fuquay-Varina. The Town of Holly Springs was also included in the 1999 agreement. The 1989 and 1999 ILAs expire in 2040. Per the ILA, the Town of Fuquay-Varina does not have any right of ownership or title to the Harnett County Regional WTP. The Town has the right to expand the Harnett Regional WTP only in expansion increments specified by Harnett County. The Town must purchase a minimum of 100,000 gallons per day (gpd). Per the 1989 ILA, Harnett County reserves the right to curtail water supply proportionally to Harnett County customer restrictions or in emergency situations.

The 1999 ILA with Harnett County included a 36-inch finished water transmission line and an increase in the finished water pumping capacity at the Harnett County Regional WWTP. The Town does own real property in the 36-inch finished water transmission main and finished water pump station at 5 mgd and 2.609 mgd, respectively. Harnett County owns the property associated with the project.

In 2022, the Town negotiated with Harnett County for an additional 2 mgd increase in water allocation until 2032. This additional 2 mgd of allocation was not included in the IBT calculations. The Town's agreement with Harnett County is a temporary measure to provide water to the Town to mitigate the anticipated extended timing of construction of the City of Sanford's Water Filtration Facility (WFF) and the associated finished water transmission main. The Town will not utilize the temporary lease agreement for the additional 2 mgd of water allocation from Harnett County once the City of Sanford's WFF expansion project is completed.

The Town signed a temporary ILA with Raleigh Water for the purchase of bulk finished water in 2021. The Town's first ILA with Raleigh Water was signed in 2000 and expired in 2021. The 2021 ILA allows the Town to purchase up to 1.75 mgd until 2035. The ILA states that the agreement is intended to provide a short-term supply of water until the Town can secure another water supply. The ILA states that Raleigh Water has the right to deny the Town of Fuquay-Varina water service in the event that water cannot be supplied without negatively impacting City of Raleigh customers.

The ILA between the Town of Fuquay-Varina and Johnston County is for the purchase of up to 1.0 mgd average day and up to 1.5 mgd peak. The ILA specifies that the Town of Fuquay-Varina's supply will be reduced in the event of an extended water shortage or water supply is unavailable to Johnston County. The rate of reduction for the Town is stated in the ILA to be the same as for Johnston County's other bulk finished water customers. The ILA has a contract expiration date of 2049. Per correspondence with Johnston County, the Town understands that the ILA with Johnston County will not be renewed after 2049.

The Town of Fuquay-Varina signed an ILA with the City of Sanford for the purchase of 6 mgd. Per the ILA, the Town of Fuquay-Varina has a right of ownership in the City of Sanford's WTP per the formula specified in the ILA. The Town of Fuquay-Varina has the right to future expansion of the water treatment infrastructure. The ILA also specifies that water conservation measures must be followed if stipulated by the City of Sanford or the State of North Carolina.

4. Water Billing

4.1.1 Water Consumption Charges

The Town of Fuquay-Varina has implemented a uniform rate structure for water consumption charges inside and outside corporate limits. The minimum base water rate increases based on meter size (i.e., larger meters are charged a higher minimum base rate). Water users pay a rate per 1,000 gallons consumed beyond the minimum base rate. Therefore, customers are charged for the water consumed based on actual metered use. The rate structure applies to base water meters and irrigation meters. Per the Town's Code of Ordinances Part 5, Chapter 1, Article B, water users outside of corporate limits are assessed rates double of the corporate limit rate. The Town of Fuquay-Varina's rate structure does not inhibit water conservation. Per Sections 2 of this EIS, the Town of Fuquay-Varina exhibits some of the lowest total per capita water use rates in the Cape Fear River basin.

4.1.2 Leak Detection

In July 2018, the Town of Fuquay-Varina initiated a conversion of the Town's monthly drive-by Automated Meter Reading (AMR) system to an advanced meter reading system, or Advanced Metering Infrastructure (AMI) system. The AMI system provides hourly reading through a fixed radio network. The Town of Fuquay-Varina has approximately 250 miles of water line, over half of which is greater than 20 years old. The AMI system provides Town of Fuquay-Varina staff real-time usage information to enhance and promote water conservation, reduce water leaks in the system, and improve operational efficiency.

Town staff receive leak alerts from the AMI system that staff investigates daily. The conversion to the AMI system provides 720 water meter readings in each billing cycle in lieu of the one monthly reading currently collected with the existing AMR technology. Therefore, the Town of Fuquay-Varina's customers are more informed about water use in the monthly water bill. The AMI system will assist with minimization and control of spikes in water use, which will ultimately help control the maximum month and maximum day demand and associated peaking factors.

5. Population

5.1 Historic Population

Population data for the Town was obtained from several sources and is summarized in Table 4. Historic data was collected from the Town's Local Water Supply Plans (LWSP), the Office of State Budget and Management (OSBM), and the American Community Survey (ACS) from the U.S. Census Bureau. The Town's 2023 population is estimated at 43,500 people per the Town's LWSP. The population in the service area grew at an annual rate ranging from 3.8 percent to 8.3 percent since 2009 based on a five-year moving average. A five-year moving average was used to smooth out the year-over-year variability in growth. The majority of the Town's growth has occurred in the last 15 years, so a five-year moving average was selected to describe the annual growth in lieu of another metric (i.e., a ten-year moving average). The OSBM and ACS data reported a slightly lower population than the LWSP population between 2016 and 2018. Figure 1 illustrates the historic population data based on the Town's LWSP.

Table 4 also summarizes the number of residential (non-irrigation) accounts and the calculation of people per account. The average number of people per residential dwelling in the Town's service area was estimated by dividing the population estimate by the number of residential housing units. The average of the data from 1997 to 2023 is 2.36 people per account. The Town's residential people per account is slightly lower than the national average of 2.6 as reported by Vickers (2001) and 2.62 reported by the U.S. Census Bureau (2021).

Table 4: Summary of Historic Population and Residential Accounts

Year	Population from Local Water Supply Plan	Annual Growth Rate (5-year Moving Average)	Annual Growth Rate	Population from Office of State Budget and Management [2]	Population from American Community Survey [3]	Number of Residential Accounts [4]	People per Account [5]
1997	6,249	----	5.5%	----	----	2,089	2.99
1998	7,066 [1]	----	13.1%	----	----	----	----
1999	7,883 [1]	----	11.6%	----	----	----	----
2000	8,701 [1]	----	10.4%	----	----	----	----
2001	9,518 [1]	----	9.4%	----	----	----	----
2002	10,335	10.6%	8.6%	----	----	4,454	2.32
2003	11,397 [1]	10.0%	10.3%	----	----	----	----
2004	12,460 [1]	9.6%	9.3%	----	----	----	----
2005	13,522 [1]	9.2%	8.5%	----	----	----	----
2006	14,584	8.9%	7.9%	----	----	6,201	2.35

Table 4: Summary of Historic Population and Residential Accounts

Year	Population from Local Water Supply Plan	Annual Growth Rate (5-year Moving Average)	Annual Growth Rate	Population from Office of State Budget and Management [2]	Population from American Community Survey [3]	Number of Residential Accounts [4]	People per Account [5]
2007	14,723 [1]	7.4%	0.95%	----	----	----	----
2008	14,861 [1]	5.5%	0.94%	----	----	----	----
2009	15,000	3.8%	0.93%	----	----	7,747	1.94
2010	17,937	6.1%	19.6%	18,109	16,152	7,800	2.30
2011	18,600	5.2%	3.7%	18,643	17,074	7,840	2.37
2012	19,674	6.2%	5.8%	19,386	18,143	8,341	2.36
2013	19,804	6.1%	0.66%	19,726	19,164	8,861	2.23
2014	21,653	7.8%	9.3%	21,693	20,246	9,907	2.19
2015	22,920	5.1%	5.9%	22,858	21,399	10,322	2.22
2016	26,105	7.1%	13.9%	24,365	22,722	10,763	2.43
2017	27,600	7.1%	5.7%	25,548	24,373	11,465	2.41
2018	29,450	8.3%	6.7%	26,924	25,932	11,979	2.46
2019	29,200	6.3%	-0.85%	----	----	12,480	2.34
2020	33,000	7.7%	13.0%	34,604	----	13,675	2.41
2021	34,152	5.6%	3.5%	----	----	14,419	2.37
2022	39,468	7.6%	15.6%	----	----	15,060	2.62
2023	43,481	10.6%	10.2%	----	----	19,396	2.24

[1] *Linear interpolation of population data.*
[2] *Population recorded using a fiscal year starting July 1.*
[3] *U.S. Census Bureau data as of April 2020.*
[4] *Town of Fuquay-Varina Local Water Supply Plans.*
[5] *Calculation based on Town of Fuquay-Varina Local Water Supply Plan population projections and number of residential accounts.*

5.2 Population Projections

Growth in Wake County and the Piedmont region has been significant due to several factors. The I-540 interchange has been in the planning process since the mid-1990s. The first stretch of I-540 opened in 1999 and the Triangle Expressway Southeast Extension (i.e., between the Town of Holly Springs and the Town of Garner) is under construction after approximately 15 years of delay. More significantly to the growth pressure is the recent economic development drive by the North Carolina Department of Commerce and the Economic Development Partnership of North Carolina (EDPNC) to attract industry to North Carolina. Founded as a non-profit in 2014, EDPNC is funded both by a contract with the North Carolina Department of Commerce and by private investment to provide economic development services. EDPNC, in partnership with the North Carolina Department of Commerce, has been highly successful in attracting new industry to the Piedmont region.

The Town of Fuquay-Varina is a secondary recipient of this growth. The Town has not gained new industry but is instead planning around the effects of residential and commercial growth to support surrounding communities' industrial growth. Furthermore, communities in the Triangle Region have been identified as best places in the United States to live and work, which has in part resulted in growth in the Piedmont region. Per the Town of Fuquay-Varina's Planning Department, annual population growth in the Town has been consistent over the last several years. In response to this growth, the Town has also seen a change in the mix of residential and commercial development over the last several years. The Town expects this change in land use to continue per the Town's Community Vision Land Use Plan.

The population projections documented in the Town of Fuquay Varina's LWSPs reflect the activity in the region given the uncertainties with the timing of NCDOT road projects and other economic development activities. The Town of Fuquay-Varina has adjusted population projections in the annual LWSPs as warranted by activity in the region. Table 5 provides a summary of the population projections as reported in the Town of Fuquay-Varina's LWSPs compared to the historic population. The following are observations with respect to the historic population compared to the population projections in the LWSPs:

- The 2010 population projection as reported in a 1989 Diehl and Phillips Comprehensive Water and Wastewater Facility study, the 2006 LWSP, and the 2009 LWSP was 19,184 people compared to the 2010 historic population of 17,937 people.
- The 2020 population projection as reported in the 2010 LWSP was 27,662 people compared to the historic 2020 population of 33,000 people.
- The 2020 population projection as reported in the 2016 LWSP was 31,105 people compared to the historic 2020 population of 33,000 people.
- The 2030 population projection as reported in the 2002 LWPS was 43,724 people as compared to a population projection of 51,530 people as reported in the 2023 LWSP.

Hazen and Sawyer updated the Town of Fuquay-Varina's population projections to support the proposed request for an interbasin transfer. The Town commissioned Hazen in early 2019 to begin the planning process. The population projections as reported in the Town of Fuquay-Varina's 2020 to 2023 LWSPs reflect the updated planning estimates for the Town's proposed interbasin transfer project.

ACS Block Group data was used to establish the growth areas in the municipal limits and extra-territorial jurisdiction (ETJ) (e.g., service area). The Wake County parcel data was linked to meter consumption (e.g., billing data) to filter existing accounts to residential homes and year built. The ACS Block Group data was also cross-referenced with Wake County tax parcel data to geospatially determine the number of filtered parcels and filtered parcels with accounts in each Block Group. The fraction of metered parcels was multiplied by the Block Group population to determine a served population. It was assumed that residential homes with metered connections (2019 consumption data) were connected by 2013 if built prior to 2013. An even distribution of persons per household was assumed in each Block Group. This analysis resulted in a 2018 served population of 27,700 people compared to the historic population estimate of 29,450 people, a reasonable 6 percent difference. The unserved population in the service area was determined to be 17,500 people. The unserved population is on private well systems.

The North Carolina Capital Areas Metropolitan Planning Organization (CAMPO) Traffic Analysis Zone (TAZ) data was used to estimate the build-out population in the Town's service area. The TAZ data was used to assess build-out population, provide an additional benchmark for the current population, and estimate the percent of current and future population served in the Cape Fear and the Neuse River basins. The most recent 2018 CAMPO data was used. The 2018 TAZ data starts with a baseline year of

2013 and projects population and employment out to 2045. The 2013 baseline year for TAZ was updated to 2018 using the ACS Block Group data. The dwelling units per acre was converted to population using the Triangle J Council of Governments (TJCOG) assumption of 2.9 persons per household for single family residences and 2.1 persons per household for multi-family residences. The calculations also assume that the Town will connect homes on private well systems (i.e., unserved population) at a rate of 1 percent per year.

Table 5: Population Projections as Reported in Town of Fuquay-Varina's Local Water Supply Plans Compared to Historic Population

Local Water Supply Plan Year	Historic Population	Population Projection As Reported for a Local Water Supply Planning Year						
		2010	2020	2030	2040	2050	2060	2070
1989 Study [1]	----	19,148	21,405	----	----	----	----	----
1997 LWSP	6,249	18,268	38,942	----	----	----	----	----
2002 LWSP	10,335	14,510	25,188	43,724	----	----	----	----
2006 LWSP	14,584	19,184	30,684	42,184	53,684	65,184	----	----
2009 LWSP	15,000	19,184	30,684	42,184	53,684	65,184	----	----
2010 LWSP	17,937	17,937	27,662	42,162	59,662	77,162	94,662	----
2011 LWSP	18,600	----	27,662	42,162	59,662	77,162	94,662	----
2012 LWSP	19,674	----	27,662	42,162	59,662	77,162	94,662	----
2013 LWSP	19,804	----	27,662	42,162	59,662	77,162	94,662	----
2014 LWSP	21,653	----	27,662	42,162	59,662	77,162	94,662	----
2015 LWSP	22,920	----	27,662	42,162	59,662	77,162	94,662	----
2016 LWSP	26,105	----	31,105	43,605	56,105	68,605	73,733	----
2017 LWSP	27,600	----	31,105	43,605	56,105	68,605	73,733	----
2018 LWSP	29,450	----	32,395	45,350	58,960	70,750	77,830	----
2019 LWSP	29,200	----	32,395	45,350	58,960	70,750	77,830	----
2020 LWSP [2]	33,000	----	33,000	51,530	70,290	89,050	108,000	126,000
2021 LWSP [2]	34,152	----	----	51,530	70,290	89,050	108,000	126,000
2022 LWSP [2]	39,468	----	----	51,530	70,290	89,050	108,000	126,000
2023 LWSP [2]	43,481	----	----	51,530	70,290	89,050	108,000	126,000

[1] *Diehl and Philips (1989).*

[2] *The Town of Fuquay-Varina's LWSP reflects IBT planning projections.*

Table 6 provides a summary of TAZ population projections from 2025 to 2045 and build-out in both the ETJ and served areas. The population projections within the ETJ include the served and unserved areas. The Town's near-term development data was compared to the 2025 TAZ projection data as a cross-check for reasonableness. The Town maintains proposed, approved, or under construction development data in GIS for single and multi-family lots. The Town's GIS development layer results in an additional 25,750 people that are estimated to be served by the Town in the next 5 to 7 years, which closely correlates to the anticipated 2025 TAZ population estimate. The build-out population is estimated to be approximately 135,000 people in the Neuse and Cape Fear River basins. The TAZ data does not provide an estimate of the timing of build-out population. The percent of population served in the Neuse and Cape Fear River basins at build-out is approximately 62 percent and 38 percent, respectively. The ratio of anticipated growth in the Cape Fear and Neuse River basins is fairly consistent throughout the planning period. Exhibit 4 provides an illustration of the TAZ dwelling unit data in the service area at build-out.

Table 6: Summary of TAZ Population Projections and Estimate of Build-out Population

Year	Population Projections in ETJ (Served and Unserved Population)			Population Projections in Served Area				
	Neuse	Cape Fear	Total	Neuse	Cape Fear	Total	% Served in Neuse	% Served in Cape Fear
2013	26,031	11,514	37,545	12,994	8,320	21,314	61.0%	39.0%
2014	27,414	12,686	40,100	13,867	9,347	23,214	59.7%	40.3%
2015	28,330	13,737	42,067	14,617	10,394	25,011	58.4%	41.6%
2016	28,957	13,160	42,117	15,245	9,959	25,204	60.5%	39.5%
2017	29,781	13,362	43,143	14,897	10,702	25,599	58.2%	41.8%
2018	31,193	13,930	45,123	17,157	10,496	27,653	62.0%	38.0%
2025 [1]	46,604	24,367	70,971	34,515	21,405	55,200	61.2%	38.8%
2035	63,624	34,935	98,559	52,603	32,234	83,400	61.3%	38.7%
2045	80,627	45,540	126,167	69,959	42,926	111,624	61.3%	38.7%
Build-out population [2, 3]	83,686	51,080	134,766	83,686	51,080	134,800	62.1%	37.9%

[1] The difference between the 2018 and the 2025 population is approximately equal to the Town's near-term active development.

[2] The timing of build-out population per TAZ is unknown.

[3] The build-out population is the same for the ETJ and served area, as it is assumed that all of the population would be served at build-out in either scenario.

Several projection methods were used to evaluate the Town's population out to 2055. The population projections were developed using several statistical techniques on the historic data set. The population data suggests that the historic growth follows an exponential pattern. A low-growth, best-fit growth, and high-growth population projections were developed to illustrate the range of possible population growth scenarios over the 30-year planning period. The statistical best-fit growth curve resulted in a 2055 population scenario of 360,000 people, which is double the TAZ build-out population estimate. Population projections were then prepared using an annual growth rate to match the average number of accounts per year since 2015. This method resulted in a population estimate of 160,000 people in 2055. A linear best fit method resulted in a 2055 served population estimate of 98,400 people. The linear best fit method is commensurate with the Town's expectations for growth based on the Community Vision Land Use Plan. Additionally, a portion of this future served population estimate includes population in the service area on private wells. The Town anticipates that 20 to 25 private wells per year will be converted to Town services over the planning period.

The selected population estimate using the linear fit method is summarized in Table 7. Figure 2 provides an illustration of the statistically developed population curves in addition to the TAZ population estimates. The 2055 population estimate using the linear fit method is 38 percent less than the build-out population of approximately 135,000.

Table 7: Summary of Population Projections in Town of Fuquay-Varina Service Area

Year	IBT Planning Population Projection [1]	IBT Planning Annual Percent Increase
2020	33,000	----
2025	42,150	4.7%
2030	51,530	3.8%
2035	60,910	3.2%
2040	70,290	2.7%
2045	79,670	2.4%
2050	89,050	2.2%
2055	98,430	1.9%

[1] *Population projection using linear best fit statistical method.*

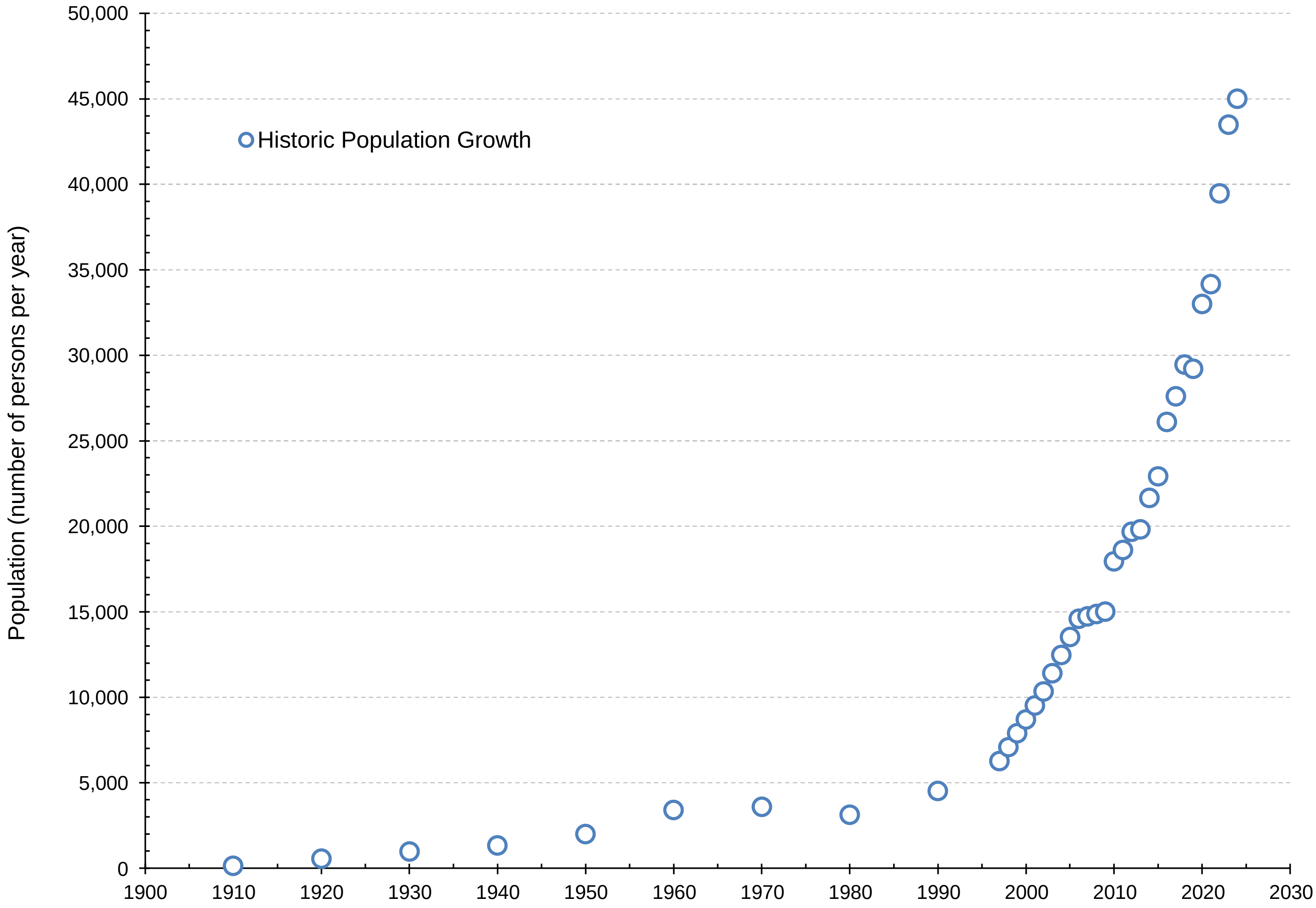


Figure 1: Historic Population for Town of Fuquay-Varina based on Local Water Supply Plans

Hazen

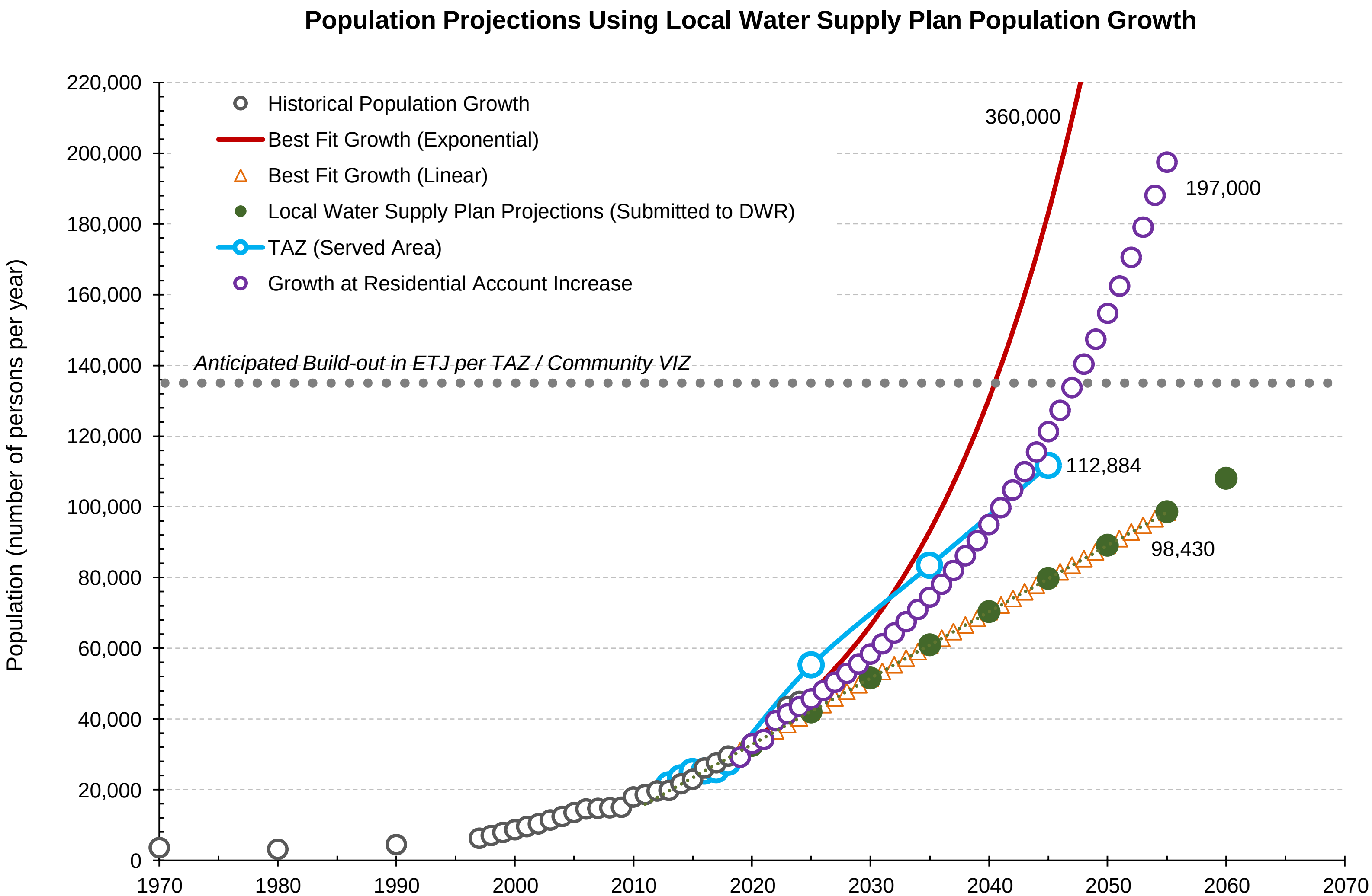


Figure 2: Town of Fuquay-Varina Population Projections

6. Water Demand Analysis

The Town's account data was evaluated to discern trends in water use across the Town's service area. Account data was obtained from the Town's LWSP data. The water use classes evaluated are those reported by the Town to DWR as part of the annual LWSP. The six classes (e.g., residential, commercial, industrial, institutional, system process, and unaccounted-for) may be conceptually divided into revenue water classes (e.g., residential, commercial, industrial, and institutional) and non-revenue classes (e.g., system process, and unaccounted-for).

Table 8 summarizes historic trends to include the number of accounts per use type, percent water use per account type (i.e., residential, commercial, industrial, institutional), percent of demand, and percent annual account increase. Residential accounts, as a percent of the total number of accounts, ranged from 89 to 95 percent. Residential use accounted for approximately two-thirds of the water use in the service area between 2019 and 2022. The service area has seen an average increase in the number of residential accounts at an average of 6.1 percent per year between 2013 and 2022. Commercial accounts have historically comprised approximately 8 percent of the total number of accounts and 16 percent of the total water demand. The growth in residential and commercial accounts illustrates the rapid rate of growth in the Town and is the primary driving force behind the Town's urgency to attain a new and reliable water supply.

6.1 Historic Per Capita Demand

Unit water demand estimates for the Town's service area were evaluated by water use class and then added together to provide an aggregate unit demand (i.e., water use across all water classes divided by population served or a per capita demand metric). Figure 3 graphically illustrates the revenue water classes over time on a per capita basis in gallons per capita per day. Table 9 summarizes the data in tabular format and includes the two non-revenue water classes.

The Town has experienced a general decline in overall per capita demand since 2002 consistent with regional and national trends. Over the latest 10-year period (2013 to 2022), the aggregate per capita usage in the Town's service area was 81.9 gpcd, which represents approximately a 20 to 25 percent reduction from the prior 10-year period between 2003 and 2012 when the aggregate per capita demand was approximately 105 gpcd. The Town is now more efficient (i.e., using less water on an aggregate per capita basis) than most regional peer utilities in the Cape Fear River basin (refer to Table 12).

Table 10 summarizes the total revenue water (billed to customers), the total water purchased, and non-revenue water per capita use metrics for each category. Table 10 also includes an estimate of the percentage of unaccounted-for-water (i.e., non-revenue water) as reported in the Town's LWSP. Unaccounted for water is the percentage of water not billed to customers and include water for firefighting, flushing, water leakage, or theft. The Town's percentage of unaccounted for water has declined from 15.7 percent in 2002 to 9.2 percent in 2022. The national average water loss is 16 percent (Wiant, 2017; EPA, 2013). The Town has not completed a formal water audit but has plans to commission an audit in fiscal year 2025/2026.

The decline in per capita demand in the Town's service area is consistent with declining per capita usage trends observed across other utilities in North Carolina and the U.S. In the mid-1990s, water demand trends began to exhibit patterns that were not typical of historic trends. This phenomenon is attributed primarily to the U.S. Energy Policy Act of 1992, which mandated maximum flow standards for many fixtures including toilets, faucets, and showerheads. Low-cost, high-efficiency plumbing fixtures and appliances became commercially available by 1994 when the Act came into effect and resulted in reduced residential, commercial, and institutional water consumption.

Hazen

Table 8: Summary of Historic Residential, Commercial, and Industrial Accounts

Year	Total Accounts	Residential				Commercial				Industrial				Institutional		
		Accounts	% of Accounts	% of Total Demand	% Annual Account Increase	Accounts	% of Accounts	% of Total Demand	% Annual Account Increase	Accounts	% of Accounts	% of Total Demand	% Annual Account Increase	Accounts	% of Accounts	% Annual Account Increase
2006	6,760	6,201	91.7%	52.5%	13.1%	501	7.4%	15.2%	7.7%	9	0.1%	2.0%	4.2%	49	0.7%	4.7%
2009	8,515	7,747	91.0%	87.3%	8.3%	702	8.2%	7.5%	13.4%	8	0.1%	3.2%	-3.7%	58	0.7%	6.1%
2010	8,524	7,800	91.5%	68.5%	0.7%	674	7.9%	13.2%	-4.0%	8	0.1%	1.0%	0.0%	42	0.5%	-27.6%
2011	8,646	7,840	90.7%	50.1%	0.5%	738	8.5%	8.4%	9.5%	12	0.1%	1.2%	50.0%	56	0.6%	33.3%
2012	9,130	8,341	91.4%	68.8%	6.4%	742	8.1%	16.9%	0.5%	7	0.1%	0.8%	-41.7%	40	0.4%	-28.6%
2013	9,922	8,861	89.3%	66.9%	6.2%	1,008	10.2%	15.5%	35.8%	9	0.1%	1.1%	28.6%	44	0.4%	10.0%
2014	10,794	9,907	91.8%	64.9%	11.8%	833	7.7%	16.0%	-17.4%	10	0.1%	3.4%	11.1%	44	0.4%	0.0%
2015	11,212	10,322	92.1%	69.0%	4.2%	836	7.5%	16.5%	0.4%	10	0.1%	1.2%	0.0%	44	0.4%	0.0%
2016	11,692	10,763	92.1%	66.1%	4.3%	875	7.5%	16.3%	4.7%	10	0.1%	1.4%	0.0%	44	0.4%	0.0%
2017	12,421	11,465	92.3%	67.8%	6.5%	904	7.3%	17.2%	3.3%	10	0.1%	1.2%	0.0%	42	0.3%	-4.5%
2018	12,933	11,979	92.6%	67.0%	4.5%	900	7.0%	17.1%	-0.4%	10	0.1%	1.1%	0.0%	44	0.3%	4.8%
2019	13,526	12,480	92.3%	65.7%	4.2%	985	7.3%	16.9%	9.4%	10	0.1%	3.9%	0.0%	51	0.4%	15.9%
2020	14,931	13,675	91.6%	68.1%	9.6%	1,195	8.0%	15.7%	21.3%	13	0.1%	1.0%	30.0%	48	0.3%	-5.9%
2021	15,697	14,419	91.9%	65.7%	5.4%	1,211	7.7%	14.6%	1.3%	17	0.1%	1.0%	30.8%	50	0.3%	4.2%
2022	15,909	15,060	94.7%	63.8%	4.4%	792	5.0%	14.7%	-34.6%	17	0.1%	9.4%	0.0%	40	0.3%	-20.0%
Average (2013 – 2022)			**92.1%**	**66.5%**	**6.1%**	**----**	**7.5%**	**16.1%**	**2.4%**	**----**	**0.1%**	**2.4%**	**10.1%**	**----**	**0.35%**	**0.45%**

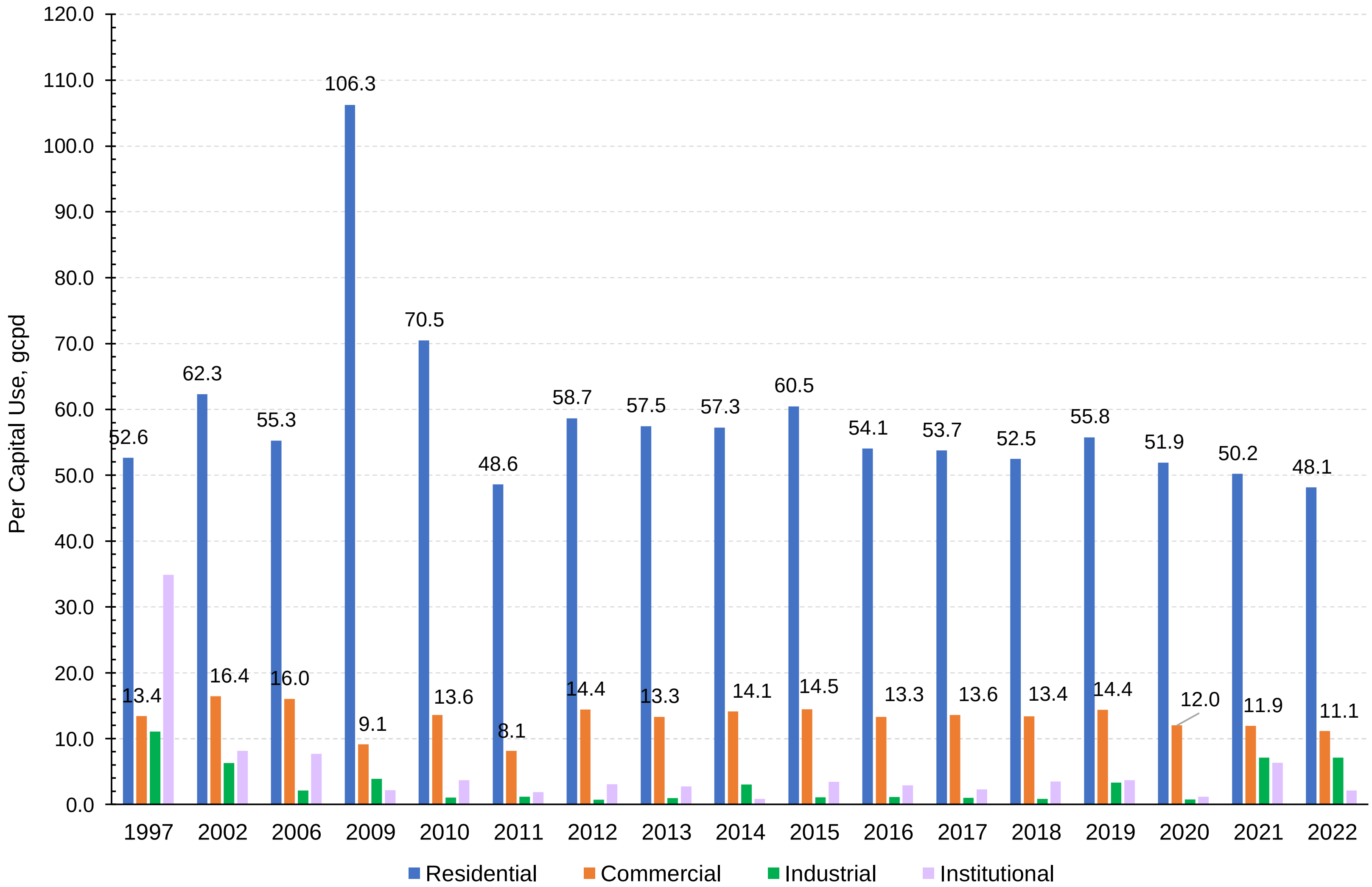


Figure 3: Historic Residential, Commercial, Industrial, and Institutional Per Capita Use

Table 9: Summary of Water Use by Class and Year

Year	Population	Residential		Commercial		Industrial		Institutional		Process		Unaccounted for Water	
		Water Demand, mgd	Per Capita Demand, gpcd	Water Demand, mgd	Per Capita Demand, gpcd	Water Demand, mgd	Per Capita Demand, gpcd	Water Demand, mgd	Per Capita Demand, gpcd	Water Demand, mgd	Per Capita Demand, gpcd	Water Demand, mgd	Per Capita Demand, gpcd
2006	14,584	0.806	55.3	0.234	16.0	0.031	2.1	0.112	7.7	0.001	0.1	0.352	24.1
2009	15,000	1.594	106.3	0.137	9.1	0.058	3.9	0.032	2.1	0.001	0.1	0.004	0.3
2010	17,937	1.264	70.5	0.244	13.6	0.019	1.1	0.066	3.7	0.010	0.6	0.243	13.5
2011	18,600	0.904	48.6	0.151	8.1	0.022	1.2	0.035	1.9	0.500	26.9	0.192	10.3
2012	19,674	1.154	58.7	0.284	14.4	0.014	0.7	0.060	3.0	0.010	0.5	0.155	7.9
2013	19,804	1.138	57.5	0.264	13.3	0.019	1.0	0.054	2.7	0.000	0.0	0.227	11.5
2014	21,653	1.240	57.3	0.306	14.1	0.065	3.0	0.018	0.8	0.000	0.0	0.283	13.1
2015	22,920	1.386	60.5	0.332	14.5	0.025	1.1	0.079	3.4	0.010	0.4	0.176	7.7
2016	26,105	1.411	54.1	0.348	13.3	0.029	1.1	0.076	2.9	0.010	0.4	0.262	10.0
2017	27,600	1.483	53.7	0.376	13.6	0.027	1.0	0.063	2.3	0.100	3.6	0.137	5.0
2018	29,450	1.545	52.5	0.395	13.4	0.025	0.8	0.102	3.5	0.100	3.4	0.139	4.7
2019	29,200	1.629	55.8	0.420	14.4	0.097	3.3	0.107	3.7	0.100	3.4	0.125	4.3
2020	33,000	1.713	51.9	0.396	12.0	0.025	0.8	0.039	1.2	0.100	3.0	0.244	7.4
2021	34,152	1.714	50.2	0.407	11.9	0.243	7.1	0.216	6.3	0.010	0.3	0.201	5.9
2022	39,468	1.900	48.1	0.439	11.1	0.280	7.1	0.084	2.1	0.030	0.8	0.244	6.2
Average (2013 – 2022)			**54.1**		**13.2**		**2.6**		**2.9**		**1.5**		**7.6**

Hazen

Table 10: Summary of Total Water Billed and Purchased Water Per Capita Demand

Year	Total Revenue Water, mgd [1]	Per Capita Water Demand (Revenue), gpcd [1]	Total Water Purchased, mgd [1]	Per Capita Water Demand (Purchased), gpcd [1]	Non-Revenue Water (Process and Unaccounted-for Water), % [1]	Non-Revenue Water (Process and Unaccounted-for Water), gpcd [1]
2006	1.183	81.1	1.536	105.3	23.0%	24.2
2009	1.821	121.4	1.826	121.7	0.3%	0.3
2010	1.593	88.8	1.846	102.9	13.7%	14.1
2011	1.112	59.8	1.804	97.0	38.4%	37.2
2012	1.512	76.9	1.677	85.3	9.9%	8.4
2013	1.475	74.5	1.702	85.9	13.3%	11.5
2014	1.629	75.2	1.912	88.3	14.8%	13.1
2015	1.822	79.5	2.008	87.6	9.3%	8.1
2016	1.864	71.4	2.136	81.8	12.7%	10.4
2017	1.949	70.6	2.186	79.2	10.8%	8.6
2018	2.067	70.2	2.306	78.3	10.4%	8.1
2019	2.253	77.2	2.478	84.9	9.1%	7.7
2020	2.173	65.8	2.517	76.3	13.7%	10.4
2021	2.580	75.5	2.791	81.7	7.6%	6.2
2022	2.703	68.5	2.977	75.4	9.2%	6.9
Average (2013 – 2022)	**2.05**	**72.8**	**2.30**	**81.9**	**11.1%**	**9.1**

[1] *Per Town of Fuquay-Varina Local Water Supply Plans.*

6.2 Residential Per Capita Demand Analysis – Home Age

Water conservation efforts in the region play a large role in the development of future per capita water demand projections with the increased efficiency of indoor plumbing fixtures and appliances (AWWA, 2011). As more homes are renovated or as new construction is built to newer building codes, water use on a per capita basis should decline. Over time, the volume of more efficient plumbing fixtures and appliances will have an impact on average day use and overall per capita demand. Water use per meter may also be dependent on the year in which the home was built. Typically, homes from the 1970s may not have undergone extensive renovations and may exhibit a higher residential meter demand (USGS, 2017). Homes from the 1950s and 1960s have a higher probability of renovation and therefore may exhibit a lower residential meter demand. Newer homes would be expected to exhibit lower residential meter demands due to the newer plumbing codes and more water efficient appliances. Typically, the difference between current and future per meter water use represents the anticipated decline in overall residential water demand.

Table 11 summarizes the single-family residential annual, summer, and winter water demand per meter by age of home. The single-family residential meter demand over the period of record ranges from 106 to 156 gallon per day (gpd) per meter based on 2019 billing records. Annual average water use prior to 1999 ranged from 111 gpd/meter to 129 gpd/meter. Annual average water use post 2000 ranged between 149 and 156 gpd/meter. The total annual average water use is 145 gpd/meter. The accounts without record information were not factored into the analysis. The summer and winter residential water demand per meter did not yield substantial differences in water use prior to 1999. Post-2000, approximately 14 to 22 gpd/meter more water is used in the summer months and 12 to 18 gpd/meter less water is used in the winter months.

The age of homes analysis was inconclusive as to how much per capita demand could be saved from home renovations and appliance updates. The majority of the growth in the Town is post-2000 construction, and therefore subject to newer building codes for increased efficiency. The homes constructed prior to 1989 comprise less than 20 percent of the total number of accounts.

The Town’s single family account use was also compared to a survey of annual water use per single family residential account by the Water Research Foundation (2016c). The survey consisted of 26 utilities, of which 23 utilities provided full data sets for analysis. A random sampling approach was used to select the households for the survey. The WRF research included an analysis of billed consumption. The average single family residential metered use per day was 241.1 gpd/meter compared to the Town’s average of 145 gpd/meter. The maximum and minimum account use from the Water Research Foundation Study was reported as 479.5 and 120.5 gpd/meter, respectively. The Town’s residential metered use is not excessive compared to the random sampling of surveyed utilities.

Table 11: Single-Family Residential Meter Demand by Age of Home Construction

Account Records for Year of Home Construction	Number of Single Family Accounts [1, 2]	Single-Family Residential Meter Use (gpd/meter) – Annual [3]	Single-Family Residential Meter Use (gpd/meter) – Summer [4]	Single-Family Residential Meter Use (gpd/meter) – Winter [5]
No Record	133	124	208	83
< 1950	293	118	126	113
Homes constructed between 1950 – 1959	293	106	111	101
Homes constructed between 1960 – 1969	208	117	122	114
Homes constructed between 1970 – 1979	97	111	111	112
Homes constructed between 1980 – 1989	372	122	124	121
Homes constructed between 1990 – 1999	1,322	129	136	123
Homes constructed between 2000 – 2009	3,668	156	170	144
Homes constructed between 2010 – 2019	4,350	149	169	128
Total	10,598 (Total)	145 (Average)	----	----

[1] Single-family residential meters per 2019 billing data. Data was edited to remove extreme high and low data, lots with no houses or under construction, and negative billing values.

[2] Excludes irrigation meters.

[3] Residential meter use is an average of the 2019 billing data.

[4] Summer months defined as April to September.

[5] Winter months defined as October to March.

6.3 Comparison of Cape Fear and Neuse River Basin Per Capita Use

Table 12 provides a summary of total per capita use for utilities in the Cape Fear and Neuse River basins based on approved 2022 LWSPs. The Town of Fuquay-Varina's total per capita use is generally less than other communities in the Cape Fear and Neuse River basins with a difference ranging from 3.2 gpcd more than Holly Springs to 79 gpcd less than Burlington. Out of the utilities compared, only the Town of Holly Springs demonstrated a total per capita use comparable to the Town of Fuquay-Varina. The 2022 per capita use for Raleigh Water and Cary-Apex was 90.4 and 95.3 gpcd, respectively. Other utilities in the state range from 72 to over 150 gpcd. The average domestic per capita use from a nationwide Water Research Foundation survey was 96 gpcd (2016c). Per a USGS study in 2017, domestic water use by state per a USGS analysis ranged from 35 to 184 gpcd, with the national average at 82 gpcd (USGS, 2017). The Town's per capita use is comparable to national per capital use trends and less than, or comparable to, regional per capita use trends.

Table 12: Summary of Total Per Capita Use Data for North Carolina Utilities in the Cape Fear and Neuse River Basins

Utility	River Basin [1]	Data of Approved Local Water Supply Plan	Residential Per Capital Use, gpcd [2, 3]	Total Per Capita Use, gpcd [2, 4]
Raleigh Water	Neuse	2022 LWSP	51.3	90.4
Cary-Apex	Neuse and Cape Fear	2022 LWSP	49.1	95.3
Holly Springs	Neuse and Cape Fear	2022 LWSP	45.5	72.2
Harnett County	Cape Fear	2022 LWSP	49.1	96.1
Johnston County	Neuse	2022 LWSP	53.5	90.0
City of Durham	Cape Fear	2022 LWSP	42.5	93.9
City of Sanford	Cape Fear	2022 LWSP	41.6	135.7
Fayetteville PWC	Cape Fear	2021 LSWP	53.2	125.1
City of Greensboro	Cape Fear	2022 LWSP	52.3	108.5
City of Burlington	Cape Fear	2022 LWSP	50.2	154.1
City of High Point	Cape Fear	2022 LWSP	48.9	114.6
Town of Fuquay-Varina	Neuse and Cape Fear	2022 LWSP	48.1	75.4
Cape Fear Utility Authority	Cape Fear	2022 LWSP	58.7	101.8

[1] Hydrologic river basin boundaries as defined in 1991 by Session Law 712 (General Statute § 143-215 22G).
[2] Data extracted from approved 2022 Local Water Supply Plans.
[3] The residential per capita use is the residential service area demand divided by the year-round service area population.
[4] The total per capita use is the total service area demand (i.e., all revenue and non-revenue water use classes) divided by the year-round service area population.

6.4 Future Per Capita Demand

Projecting future water use for the Town involves multiplying the expected population by an expected rate of water use. The Town's historic 10-year average unit demand across all water classes divided by population served (i.e., aggregate per capita demand) from 2013 through 2022 was 81.9 gpcd. The per capita use rate of approximately 82 gpcd is a starting point for determining an appropriate water utilization planning target for meeting the Town's expected growth. To assure a reliable supply over the next 30 years, the rate of use assumption for the Town was rounded up to 85 gpcd. The planning unit demand must account for the wider range of conditions that may occur over the 30-year IBT certificate period. These extenuating conditions may include periods of hot dry weather or more typical non-revenue water ratios as the Town's distribution system ages. Appendix A contains additional analyses of these factors.

6.5 Maximum Month and Maximum Day Peaking Factors

Maximum month and maximum day peaking factors were selected based on the Town's 2019 to 2022 water meter data. A maximum day peaking factor of 1.5 was selected based on the 2022 water meter data. A maximum month peaking factor of 1.18 was selected based on the 2019 to 2022 data. Table 13 provides a summary of the maximum month and day peaking factors for the Town.

Table 13: Summary of Maximum Month and Maximum Day Peaking Factors for Fuquay-Varina

Month	Fuquay-Varina, Maximum Month Peaking Factor				Fuquay-Varina, Maximum Day Peaking Factor			
	2019	2020	2021	2022	2019	2020	2021	2022
January	1.09	1.21	1.13	1.10	1.58	1.69	1.90	1.85
February	1.05	1.08	1.18	1.02	1.62	1.72	1.88	1.78
March	1.62	1.11	1.15	1.19	1.65	1.63	1.89	1.78
April	1.48	----	1.19	1.15	1.66	----	1.57	1.59
May	1.46	1.43	1.29	1.26	1.32	1.49	1.38	1.50
June	1.24	1.22	1.21	1.19	1.29	1.31	1.43	1.19
July	1.24	1.22	1.14	1.25	1.38	1.47	1.42	1.27
August	1.15	1.19	1.16	1.19	1.58	1.60	1.37	1.29
September	1.23	1.14	1.39	1.14	1.66	1.65	1.39	1.33
October	1.69	1.24	1.18	1.06	2.31	1.68	1.54	1.51
November	1.45	1.12	1.07	1.13	2.63	1.81	1.68	1.67
December	1.08	1.08	1.07	1.18	2.11	1.89	1.76	1.66
Average	1.31	1.18	1.18	1.16	1.73	1.63	1.60	1.54

6.6 Water Demand Projections

Table 14 provides a summary of the annual average, average day in a maximum month, and maximum day water demand. The annual average water demand projections assume 85 gpcd applied to the linear best fit population estimate over the planning period. Approximately 9.9 mgd of water will be needed by the Town in 2055 on a maximum month basis. Maximum month water demands were calculated to assess the average day water demand in a maximum month to meet the requirements of General Statute § 143 215.22L. Per General Statute § 143 215.22L, an interbasin transfer certificate is required if a daily average water demand of 2 mgd in a calendar month (i.e., maximum month) or 3 mgd in one day (i.e., maximum day) is exceeded.

Table 15 provides a summary of the average day in a maximum month water demand by river basin, water supply contract amounts with the associated expiration years, and the projected water supply shortfall. The water supply shortfall was calculated as the difference between the Town's current total contract amounts less the total average day water demand in a maximum month. Without provisions for additional water supply capacity, the Town is projected to have a water supply shortfall beginning in 2031. Additional water supply is needed to satisfy the projected water demand in the Town's service area.

Table 14: Summary of Annual Average, Maximum Month, and Maximum Day Water Demand Projections

Year	Population [1]	Annual Average Water Demand, mgd [2]	Average Water Demand Day in a Maximum Month, mgd [3]	Maximum Day Water Demand, mgd [4]
2025	42,150	3.6	4.2	5.4
2030	51,530	4.4	5.2	6.6
2035	60,910	5.2	6.1	7.8
2040	70,290	6.0	7.1	9.0
2045	79,670	6.8	8.0	10.2
2050	89,050	7.6	8.9	11.4
2055	98,430	8.4	9.9	12.6

[1] Population projections from linear best fit regression method used for the 2022 Local Water Supply Plan.

[2] Assumes a per capita use of 85 gpcd over the planning period.

[3] Maximum month peaking factor of 1.18. Maximum month water demands were calculated to assess the average day water demand in maximum month to meet the intent of General Statute § 143 215.22L.

[4] Maximum day peaking factor of 1.5.

Table 15: Summary of Average Day in the Maximum Month Water Demand, Wholesale Water Supply Contracts, and Projected Water Supply Deficit

Year	Average Day Water Demand in a Maximum Month			Current Water Supply Contract Amounts via Interlocal Agreements			Projected Water Supply Shortfall Indicated by Value in ( ), mgd [D + E + F - A]
	Total, mgd [A]	Neuse Basin, mgd [B]	Cape Fear Basin, mgd [C]	Raleigh Water (Neuse), mgd [D]	Johnston County (Neuse), mgd [E]	Harnett County (Cape Fear), mgd [F]	
2025	4.2	2.61	1.62	1.75	1.5	2	1.0 [2]
2030	5.2	3.19	1.98	1.75	1.5	2	0.08 [2]
2035	6.1	3.79	2.32	1.75	1.5	2	(0.86)
2036	6.3	3.90	2.39	0	1.5	2	(2.8)
2040	7.1	4.37	2.68	0	1.5	2	(3.6)
2041	7.2	4.49	2.75	0	1.5	2	(3.7)
2045	8.0	4.95	3.04	0	1.5	2	(4.5)
2049	8.7	5.42	3.32	0	1.5	2	(5.2)
2050	8.9	5.54	3.40	0	0	2	(6.9)
2055	9.9	6.15	3.73	0	0	2	(7.9)

[1] The projected water supply shortfall is the Town's total contract amount less the average day water demand in a maximum month.

[2] Amount does not include additional 2 mgd from Harnett County via the ILA signed in 2022.

7. Interbasin Transfer Projections

The interbasin transfer projections reflect the water demand in the Neuse less water supply from the Neuse River basin. Tables 16 and 17 provide a summary of average day in a maximum month and maximum day water demand projections, respectively. The basin distribution, water demand per basin, and anticipated water supply amounts are also included in Tables 16 and 17. The basin distribution percentages are supported by the TAZ population analysis, so a corresponding water demand per basin can be calculated. The water supply is delineated by river basin for both maximum month and maximum day. Per the Town of Fuquay-Varina's discussions with Raleigh Water and Johnston County staff, the Town anticipates water supply purchases from Raleigh Water and Johnston County will end in 2035 and 2049, respectively. Post 2049, all of the Town's water supply will originate from the Cape Fear River basin (2-03). The average day transfer in a maximum month in 2055 is anticipated to be 6.17 mgd. The maximum day transfer amount is anticipated to be 7.83 mgd. By 2055, approximately 13 mgd of water supply will be required to support peak day needs in the Town of Fuquay-Varina's service area.

7.1 Consumptive Water Loss

Consumptive water loss is defined as the amount of water withdrawn from a surface water without recycling of the water (i.e., a return) to the source or origin (Congressional Research Service, 2005). A few examples of consumptive loss activities include agricultural use, household use, lawn watering, household wastewater to a septic system, firefighting, and transmission main flushing. The water that is not returned to a centralized wastewater treatment plant, or "consumed," is the difference between the monthly average wastewater flow and the monthly average water use. Consumptive loss is typically applied as a percentage over the service area.

Table 18 provides a summary of the monthly consumptive loss percentages in the Town's service area from 2002 to 2023. The median consumptive loss over the period of record is approximately 17.5 percent (i.e., 17.5 percent of water supplied to the service area is not returned to a centralized wastewater treatment plant). There are 512 non-vacant parcels that are located in the Cape Fear hydrologic boundary. Water is supplied from the Cape Fear River and returned to the Cape Fear River via the North Harnett Regional WWTP. However, these 512 non-vacant parcels are legislatively located in the Neuse River basin per General Statute § 143-215.22L. Therefore, the only transfer for these parcels is the consumptive loss from these homes. The Town's medium consumptive loss percentage was applied to these non-vacant parcels and added into the interbasin transfer calculation.

Hazen

Table 16: Summary of Average Day in a Maximum Month Water Demand, Water Supply Contract Amounts, and Interbasin Transfer

Year	Total Projected Demand, Average Day in a Maximum Month, mgd	Basin Distribution [1]		Water Demand in Basin, mgd [2]		Water Supply Source By Seller, mgd				Total Water Supply in Basin, mgd		Interbasin Transfer, Cape Fear to Neuse, mgd [4, 5]
		Neuse	Cape Fear	Neuse	Cape Fear	Raleigh (Neuse) [3]	Johnston County (Neuse) [3]	Harnett County (Cape Fear) [3]	Sanford (Cape Fear)	Neuse	Cape Fear	
2023	3.5	62.0%	38.0%	2.18	1.33	1.75	1.5	2	0	3.25	2	0.00
2025	4.2	61.7%	38.3%	2.61	1.62	1.75	1.5	2	6	3.25	8	0.00
2030	5.2	61.7%	38.3%	3.19	1.98	1.75	1.5	2	6	3.25	8	0.00
2035	6.1	62.0%	38.0%	3.79	2.32	1.75	1.5	2	6	3.25	8	0.56
2036	6.3	62.0%	38.0%	3.90	2.39	0	1.5	2	6	1.5	8	2.42
2040	7.1	62.0%	38.0%	4.37	2.68	0	1.5	2	6	1.5	8	2.89
2041	7.2	62.0%	38.0%	4.49	2.75	0	1.5	2	6	1.5	8	3.01
2045	8.0	62.0%	38.0%	4.95	3.04	0	1.5	2	8	1.5	10	3.47
2049	8.7	62.0%	38.0%	5.42	3.32	0	1.5	2	8	1.5	10	3.94
2050	8.9	62.0%	38.0%	5.54	3.40	0	0	2	10	0	12	5.55
2055	9.9	62.3%	37.7%	6.15	3.73	0	0	2	11	0	13	6.17

[1] *Basin distribution based on TAZ build-out population analysis.*

[2] *Water demand in Town's service area.*

[3] *Water supply source currently in contract via temporary lease agreement (Interlocal Agreement).*

[4] *Water demand in Neuse less water supply from Neuse basin.*

[5] *A consumptive loss factor was applied to non-vacant parcels located in the Cape Fear River basin per hydrologic boundary line but are included in the Neuse River basin per the regulatory interbasin boundary line.*

Hazen

Table 17: Summary of Maximum Day Water Demand, Water Supply Contract Amounts, and Interbasin Transfer

Year	Total Projected Maximum Day Demand, mgd	Basin Distribution [1]		Water Demand in Basin, mgd [2]		Water Supply Source By Seller, mgd				Total Water Supply in Basin, mgd		Interbasin Transfer, Cape Fear to Neuse, mgd [4, 5]
		Neuse	Cape Fear	Neuse	Cape Fear	Raleigh (Neuse) [3]	Johnston County (Neuse) [3]	Harnett County (Cape Fear) [3]	Sanford (Cape Fear)	Neuse	Cape Fear	
2023	4.5	62.0%	38.0%	2.77	1.69	1.75	1.5	2	0	3.25	2	0.0
2025	5.4	61.7%	38.3%	3.32	2.06	1.75	1.5	2	6	3.25	8	0.08
2030	6.6	61.7%	38.3%	4.06	2.51	1.75	1.5	2	6	3.25	8	0.82
2035	7.8	62.0%	38.0%	4.82	2.95	1.75	1.5	2	6	3.25	8	1.58
2036	8.0	62.0%	38.0%	4.96	3.04	0	1.5	2	6	1.5	8	3.48
2040	9.0	62.0%	38.0%	5.56	3.41	0	1.5	2	6	1.5	8	4.07
2041	9.2	62.0%	38.0%	5.71	3.50	0	1.5	2	6	1.5	8	4.22
2045	10.2	62.0%	38.0%	6.30	3.86	0	1.5	2	8	1.5	10	4.81
2049	11.1	62.0%	38.0%	6.89	4.23	0	1.5	2	8	1.5	10	5.41
2050	11.4	62.0%	38.0%	7.04	4.32	0	0	2	10	0	12	7.05
2055	12.5	62.3%	37.7%	7.81	4.74	0	0	2	11	0	13	7.83

[1] *Basin distribution based on TAZ build-out population analysis.*

[2] *Water demand in Town's service area.*

[3] *Water supply source currently in contract via temporary lease agreement (Interlocal Agreement).*

[4] *Water demand in Neuse less water supply from Neuse basin.*

[5] *A consumptive loss factor was applied to non-vacant parcels located in the Cape Fear River basin per hydrologic boundary line but are included in the Neuse River basin per the regulatory interbasin boundary line.*

Table 18: Summary of Consumptive Water Loss Data

Month [1, 2, 3]	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009
Jan	----	----	----	----	3.4%	----	----	----	----	----	----	13.1%	----	----
Feb	----	----	----	----	8.0%	----	----	----	----	----	----	20.4%	----	17.5%
Mar	----	----	----	----	----	----	1.4%	--	--	1.9%	----	----	----	----
Apr	4.5%	10.6%	12.0%	----	----	3.6%	----	----	----	----	5.6%	13.4%	24.5%	19.6%
May	----	22.6%	10.1%	29.3%	13.6%	10.1%	1.2%	0.8%	7.6%	12.3%	17.7%	8.8%	4.8%	68.2%
Jun	23.2%	37.4%	14.3%	22.9%	16.4%	18.5%	29.4%	32.6%	35.9%	----	29.8%	19.4%	29.7%	45.6%
Jul	23.8%	11.5%	17.3%	27.1%	----	25.7%	28.1%	24.2%	35.0%	----	36.1%	44.0%	42.5%	28.2%
Aug	29.6%	20.8%	----	25.6%	----	21.0%	33.9%	35.1%	16.0%	15.2%	26.0%	32.2%	31.4%	36.7%
Sep	31.7%	----	----	33.5%	----	13.8%	20.5%	31.9%	3.7%	8.2%	24.0%	21.8%	5.1%	28.1%
Oct	10.6%	18.4%	2.6%	21.2%	----	13.4%	7.3%	4.6%	15.0%	17.5%	14.7%	30.5%	21.2%	31.7%
Nov	0.2%	9.5%	----	7.6%	----	2.5%	----	----	13.0%	16.1%	17.0%	8.2%	6.1%	4.6%
Dec	----	----	----	----	----	----	8.9%	----	----	----	12.8%	----	32.0%	0.2%
Median, 2002 – 2023					17.5%									

[1] Consumptive water loss is the percent of wastewater discharged to the amount of water supplied.

[2] Consumptive loss is calculated based on monthly average water use and discharged wastewater values.

[3] Values less than 0% were removed from the calculation, as these values are indicative of wet weather (i.e., more water discharged than supplied).

8. Summary

The Town intends to invest in water supply treatment capacity in partnership with the City of Sanford (e.g., TriRiver Water). The City of Sanford is planning an expansion of their water treatment facility to meet the City of Sanford's service area and partner's needs. The Town of Fuquay-Varina has recognized a need to secure a permanent water supply source in lieu of a continuation of ten to fifteen year temporary interlocal lease agreements with wholesale suppliers. The City of Sanford is looking for partners to invest in the facility at a time when such a partnership is advantageous to the Town of Fuquay-Varina. A purchase of water treatment plant capacity from a neighboring community will ensure that the Town of Fuquay-Varina will have a reliable and secure source of water well into the future.

9. References

American Water Works Association. 2011. Regional Water Use Trends in North America. Journal of American Water Works Association, 103(2) pp. 76 – 89.

Capital Area Metropolitan Area Planning Organization. 2018. 2045 Metropolitan Transportation Plan Traffic Analysis Zone Data.

Chang, H., Praskievicz, S., & Parandvash, H. 2014. Sensitivity of Urban Water Consumption to Weather and Climate Variability at Multiple Temporal Scales: The Case of Portland, Oregon. International Journal of Geospatial and Environmental Research,1(1), 7.

DeOreo, W. B., P. W. Mayer, L. Martien, M. Hayden, R. Davis, et al. 2011. Analysis of Water Use in New Single Family Homes. Aquacraft, Inc. Water Engineering and Management. Boulder, CO.

Diehl and Phillips, P.A. Consulting Engineers. 1989. Town of Fuquay-Varina Comprehensive Water and Wastewater Facility Study.

Dieter, C.A., Maupin, M.A., Caldwell, R.R., Harris, M.A., Ivahnenko, T.I., Lovelace, J.K., Barber, N.L., and Linsey, K.S., 2018, Estimated use of water in the United States in 2015: U.S. Geological Survey Circular 1441, 65 p., https://doi.org/10.3133/cir1441.

Fuquay-Varina, Town of and Harnett County. 2022. Bulk Water Supply Agreement.

Fuquay-Varina, Town of and City of Raleigh. 2021. Water Supply Agreement.

Fuquay-Varina, Town of. 2022. Letter of Intent – North Harnett Wastewater Treatment Plant Treatment Capacity. Letter to Harnett County.

Fuquay-Varina, Town of. 2022. 2040 Community Vision Land Use Plan.

Fuquay-Varina, Town of. 1997, 2002, 2006, 2009 – 2023. Local Water Supply Plans. Prepared for North Carolina Division of Water Resources.

Fuquay-Varina, Town of. Finance Department. Water Customer Account Data: 1997, 2002, 2006, 2009 – 2021.

Fuquay-Varina, Town of. Utility Billing Data: 2019.

Fuquay-Varina, Town of and City of Raleigh. 2004. Interlocal Agreement for Bulk Finished Water Supply.

Fuquay-Varina, Town of and Harnett County. 2023. Amendment to Interlocal Agreement for Wastewater Interceptor Line and Capacity.

Fuquay-Varina, Town of and Harnett County. 2000. Interlocal Agreement for Wastewater Interceptor Line and Capacity.

Fuquay-Varina, Town of and Harnett County. 1989. Interlocal Agreement for Bulk Finished Water Supply.

Fuquay-Varina, Town of and Johnston County. 1999. Interlocal Agreement for Bulk Finished Water Supply.

Karadirek, I.E, Kaya-Basar, E. and Tugba Akdenizc T. 2024. A Study on Pipe Failure Analysis in Water Distribution Systems using Logistic Regression. Water Supply, Vol 24 No 1 176 doi: 10.2166/ws.2023.335.

Li, Z.; Peng, S.; Zheng, G.; Chu, X.; Tian, Y. Prediction of Daily Water Consumption in Residential Areas Based on Meteorologic Conditions—Applying Gradient Boosting Regression Tree Algorithm. Water 2023, *15*, 3455. https://doi.org/10.3390/w15193455.

National Oceanic and Atmospheric Administration and American Water Works Association. 2021. Understanding Climate Normals. https://www.noaa.gov/explainers/understanding-climate-normals. Accessed 2025.

North Carolina Office of State Budget and Management. Accessed in 2020. Municipal and County Population Data.

United States Census Bureau. American Community Survey Data, Town of Fuquay-Varina Population Data 2010 to 2019.

United States Census Bureau. Quick Facts. https://www.census.gov/quickfacts/fact/table/US/HCN010212#:~:text=People%20%20%20%20Population%20%20%20,%20%2021.6%25%20%2041%20more%20rows%20. Accessed March 2021.

United States Environmental Protection Agency, Office of Water. 2013. EPA 816-F-13-002: Water Audits and Water Loss Control for Public Water Systems.

Vickers, Amy. 2001. Handbook of Water Use and Conservation: Homes, Landscapes, Businesses, Industries, Farms, First Edition.

United States Geological Survey. 2017. Estimated Use of Water in the United States in 2015. Circular 1441 (Supersedes USGS Open-File Report 2017-1131).

United States Geological Survey. 2007. Consumptive Water-Use Coefficients for the Great Lakes Basin and Climatically Similar Areas. Scientific Investigations Report 2007-5197.

Water Research Foundation. 2016a. Evaluation of Customer Information and Data Processing Needs for Water Demand Analysis, Planning, and Management. Web Report #4527.

Water Research Foundation. 2016b. Uncertainty in Long-Term Water Demand Forecasts: A Primer on Concepts and Review of Water Industry Practices. Project #4558.

Water Research Foundation. 2016c. Residential End Uses of Water, Version 2 (#4039b).

Wiant, C. 2017. Water Loss: Challenges, Costs, and Opportunities. Water Quality and Health Council.

WithersRavenel and Freese and Nichols. 2017. Water Capacity Study.

Womach, Jasper. 2005. Report for Congress: Agriculture: A Glossary of Terms, Programs, and Laws. Congressional Research Service.

Appendix A – Consideration of Future Unit Demands

Despite steady growth in total water use, the Town's water use intensity (per capita usage), like many communities across the region, has declined over the past two decades (Dieter, 2018). This is illustrated in Figure 3 and Table 10 in Section 6. These trends have been driven by several factors including regulation, evolving environmental awareness, and increased water prices. The Federal Energy Policy Act of 1992 played a large role in spurring the overall decline as it required U.S. markets to offer water efficient toilets, showerheads, and faucets and more recently extended to high-efficiency clothes washers and dishwashers. During the same period there has been widespread adoption of water-conserving habits (e.g. shorter showers and less frequent lawn watering) driven by public education campaigns, drought messaging, and a general rise in environmentally-minded values. Finally, water utilities have in many cases moved toward full-cost pricing, which has led to an increase in water rates that also encourage more efficient water usage. Nevertheless, these factors have likely achieved most of their potential for improving water efficiency and conservation. The evidence suggests the rate of decline in per capita water demands has been less in recent years and per capita water use is flattening.

The Town of Fuquay-Varina must provide a reliable and resilient water supply to its customers under all conditions. These conditions may include hotter, drier weather than observed over the 2013 to 2022 period and/or a modest increase in non-revenue water. Analyses of weather variability and non-revenue water are provided as supporting evidence for the selection of 85 gpcd as the rate of use for planning over the 30-year IBT certificate period.

Weather Variability

One limitation to using the 2013 to 2022 period for planning unit demand is that during this period the Town did not experience any particularly extreme combination of heat and dryness. Hot temperatures and dry weather tend to drive an increase in water demand. If the region's potential for these weather extremes are ignored, the Town risks underestimating the water need. Despite generally increasing temperatures relative to historical norms, there were not any extended periods of drought in the 10-year period from 2013 to 2022 comparable to those experienced during the late 1990s and early 2000s.

The Town's annual unit demand was correlated with temperature and precipitation to estimate unit demands if such conditions were to recur. The revenue water classes were evaluated in aggregate. Non-revenue water use classes (e.g., process water and unaccounted-for-water) were excluded from this particular analysis as these water use categories are less likely to be highly correlated with hot, dry weather. The revenue water categories are residential, commercial, industrial, and institutional as described in Section 6.1.

To estimate demand response with respect to annual weather variability, weather data for the region was collected over a 30-year period from 1994 to 2023. A 30-year period is long enough to smooth out short-term fluctuations and anomalies providing a stable and reliable average. This record length is recommended by the World Meteorological Organization (WMO) and the National Oceanic and Atmospheric Administration (NOAA). Both temperature and precipitation patterns influence water use and have long been known to have a significant influence on variability in outdoor water use (Chang, 2014). Data for the growing seasons from April through November of each year were obtained from nearby

National Weather Service Cooperative Observer Program (COOP) stations and Community Collaborative Rain, Hail, and Snow Network (CoCoRaHS) stations. The correlation between growing season temperature, rainfall and water use were then analyzed using regression analysis to discern how temperature and rainfall affect the Town's water use.

The regression models were developed using 2010 to 2023 revenue category unit demands to assess the range of influence weather has on the Town's water demand. The year 2010 was the last year with a more extreme combination of hot and dry weather in the record. Therefore, the regression model was "trained" using data back to 2010. However, unit usage has declined since 2010 independently of weather effects. To address this shift, the unit demands between 2010 and 2023 were "detrended" (i.e., a regression trend line through the detrended unit demands has a slope of zero) to remove the effects of other factors on water use. The detrended unit demands were pivoted (detrended) to have an average equivalent to the 2019 to 2023 period (i.e., the last 5 years in the record). The unadjusted and detrended unit demands for the revenue water categories are illustrated in Figure A-1. Both unadjusted and detrended unit demands have an average of 71.9 gpcd for the 2019 to 2023 period. The unit demand for 2011 was excluded from the analysis because the demand breakdown appears anomalous. The reported residential demand in 2011 was abnormally low whereas the non-revenue consumption was especially high (38 percent of total demand). The 2011 data suggests that there was an error in metering or tabulating total water use that year. Refer to Tables 9 and 10 to review the 2011 data anomaly.

Temperature alone proved to be weakly correlated with the Town's unit demand with an R-squared (R^2) value of 0.06. R^2 measures the proportion of the variance in the dependent variable (unit demand) that is explained by the model. This means that seasonal fluctuations in temperature only explain 6 percent of the year-to-year variation in demand over the 2010 to 2023 period (excluding 2011).

Aggregate precipitation over a full growing season was moderately correlated with the Town's annual unit demand, having an R^2 value of 0.24. However, aggregate precipitation over a growing season is not an ideal predictor of unit demand because the total seasonal precipitation may obscure the impact that dry periods during the growing season have on water demand. In other words, the temporal distribution of rainfall throughout the growing season is important, and in some cases more so, than the total amount of precipitation. To address this shortcoming, a water stress model was developed to capture the influence that dry periods have on water use.

Water Stress Model

The water stress model scored each day within a growing season (April through November) based on an algorithm using the precipitation records for that day and the prior 9 days (i.e., 10-days in total). Days with the greatest water stress received a score of 2. Days with moderate stress scored 1 and days with low or no water stress scored zero points.

The algorithm specifically works as follows:

1. Each day in the record receives a score of 0, 1, or 2 with higher numbers indicating greater stress.
2. The score for any day involves an analysis of precipitation on that day and over the prior 9 days.

3. To receive a score of 1 or 2, the sum of precipitation in first five days, or second five days must be less than 0.15-inches, which would cause some degree of water stress.
4. If the entire 10-day period meets the criteria in #3 and has a total 10-day precipitation less than 0.2-inches, it received a score of 2.
5. If the entire 10-day period meets the criteria in #3 and has a total 10-day precipitation less than 0.5-inches, it received a score of 1.
6. All other days received a score of 0.

Each growing season received a water stress score that was the sum of each day's score (0, 1, or 2). The water stress scores for each April through November season varied from 50 (2003 and 2020) to 214 (2007), with a mean of 112 and a standard deviation of 40.1. The annual water stress scores are summarized in Table A-1.

A regression analysis was then developed using the total water stress during the growing season and the Town's annual unit demand. Data for the years 2010 to 2023 were used to develop the regression model. For the regression analysis, the z-score of the season's water stress score was used rather than the water stress total itself. A z-score is a way to describe how unusual or typical a particular value is compared to the rest of the data. Specifically, the z-score indicates how many standard deviations the value is above or below the average (e.g., mean). For example, a z-score of +2 means the value is two standard deviations higher than average, while a z-score of -1 means it is one standard deviation lower than the average. The z-score helps identify whether a certain year's water use is likely to be higher or lower compared to long-term trends.

Hazen

Table A-1: Unit Demand and Weather Parameters

Year	Actual Unit Demand [1]	Detrended Unit Demand	April to November Average Daily High Temperature, °F	April to November Total Precipitation, inches	Annual Water Stress Score	Water Stress z-score
1994	----	----	78.95	30.7	124	0.307
1995	----	----	78.57	47.6	101	-0.267
1996	----	----	77.45	44.0	69	-1.065
1997	----	----	77.41	29.8	138	0.656
1998	----	----	80.61	24.5	155	1.080
1999	----	----	79.49	36.7	154	1.055
2000	----	----	78.76	32.4	125	0.332
2001	----	----	80.00	30.6	150	0.956
2002	----	----	80.20	29.7	176	1.604
2003	----	----	78.33	41.2	50	-1.540
2004	----	----	78.71	36.2	96	-0.392
2005	----	----	79.60	28.2	130	0.457
2006	----	----	78.57	42.6	63	-1.215
2007	----	----	80.99	26.3	214	2.553
2008	----	----	78.22	32.7	77	-0.866
2009	----	----	78.22	29.1	89	-0.566
2010	88.8	82.9	81.52	33.3	179	1.679
2011	59.8 [2]	56.1	80.38	25.8	78	-0.841
2012	76.9	72.6	78.26	26.2	109	-0.067
2013	74.5	70.8	76.87	41.3	90	-0.541
2014	75.2	71.9	77.88	39.0	92	-0.492
2015	79.5	76.5	79.18	35.9	105	-0.167
2016	71.4	69.1	79.75	31.4	127	0.382
2017	70.6	68.8	79.74	33.9	98	-0.342
2018	70.2	68.8	79.03	45.5	62	-1.240
2019	77.2	76.2	80.39	33.6	109	-0.067
2020	65.8	65.4	78.76	55.3	50	-1.540
2021	75.5	75.5	79.32	28.7	139	0.681
2022	68.5	68.9	79.98	33.4	77	-0.866
2023	72.2	73.2	78.76	37.8	125	0.332

[1] Unit demand for revenue categories only (residential, commercial, industrial, and institutional) and excludes process water and unaccounted-for-water.

[2] Revenue water is anomalously low whereas process water (e.g., a non-revenue category) was reported as 0.5 mgd, which is 5 to 50 times higher than other reporting years.

Table A-1 summarizes the key inputs for the analysis with the detrended unit demand and the z-score for water stress being the dependent and independent variables in the regression, respectively. The z-score is a statistical measure that indicates how many standard deviations a particular value in the dataset is from the mean. The z-score formula is:

Equation (1): $z = (x - \mu)/\sigma)$, where μ is the mean for the dataset and σ is the standard deviation

This model demonstrated an improved correlation with the Town's unit demand, having an R^2 value of 0.68. The quality of the model fit with the unit demand data is shown visually in Figure A-2. The coefficient for the water stress z-score was 4.49 gpcd per standard deviation and the intercept was 73.1 gpcd. The interpretation is that for each standard deviation increase in the dry score added up over the growing season, the Town's unit demand for revenue water classes would be expected to rise by 4.49 gpcd. The opposite is true for a reduction in water stress from the average. The model's formula for estimating the Town's unit demand in any year is given by Equation 2:

Equation (2): Revenue water unit demand (in gpcd) = 4.493 x [Water stress z-score] + 73.14

To evaluate the regression model further, and the utility of the water stress model, the coefficient's p-value is reported. A p-value helps determine whether a relationship seen in the data is likely to be real or just due to random chance. In the context of a linear regression, a low p-value (e.g., typically less than 0.05) means there's strong evidence that the variable being tested is actually related to the outcome and not just a coincidence. A high p-value suggests the relationship might not be meaningful. The p-value helps us decide which patterns in the data are likely to be statistically significant. The p-value for the water stress parameter for this model was 0.00048, indicating that this metric is statistically correlated with the Town's water use.

To test if the z-score coefficient was driven principally by the data early in the training period, a similar model was developed using only the 2018 to 2023 data. The retrained model excluded the 2010 data point (e.g., the extreme hot and dry year) but incurred fewer complications with changing water behavior (e.g., improving efficiency) over the longer 2010 to 2023 period. Despite excluding the 2010 data point, this model resulted in a very similar coefficient of 4.34 gpcd and intercept of 73.3 gpcd. The R^2 value of the water stress coefficient increased to 0.83 and the p-value of the coefficient remains a highly respectable 0.011. The increase in the R^2 is not surprising since there are fewer confounding factors over the shorter period.

Using Equation 2, the z-scores for water stress were put into the model for the entire 30-year period from 1994 to 2023, which forms the "climate normal." The result is illustrated in Figure A-3. This model suggests that over a similar 30-year weather period and with water use behavior that matches observations from 2019 through 2023, the Town could expect revenue water unit demands to range from a low of 66.2 gpcd to a high of 84.6 gpcd. The 84.6 gpcd for the revenue category is predicted during a repeat of 2007, which was a historically hot and dry year. When the 2019 to 2023 average annual non-revenue water categories of process water and unaccounted-for-water (i.e., 6.7 gpcd per Table 10) are added to the revenue water range suggested by the model, the model suggests Town may expect aggregate annual unit demands to vary from 72.9 gpcd to as much as 91.3 gpcd. This range serves as a guide for the purpose of planning to meet future needs.

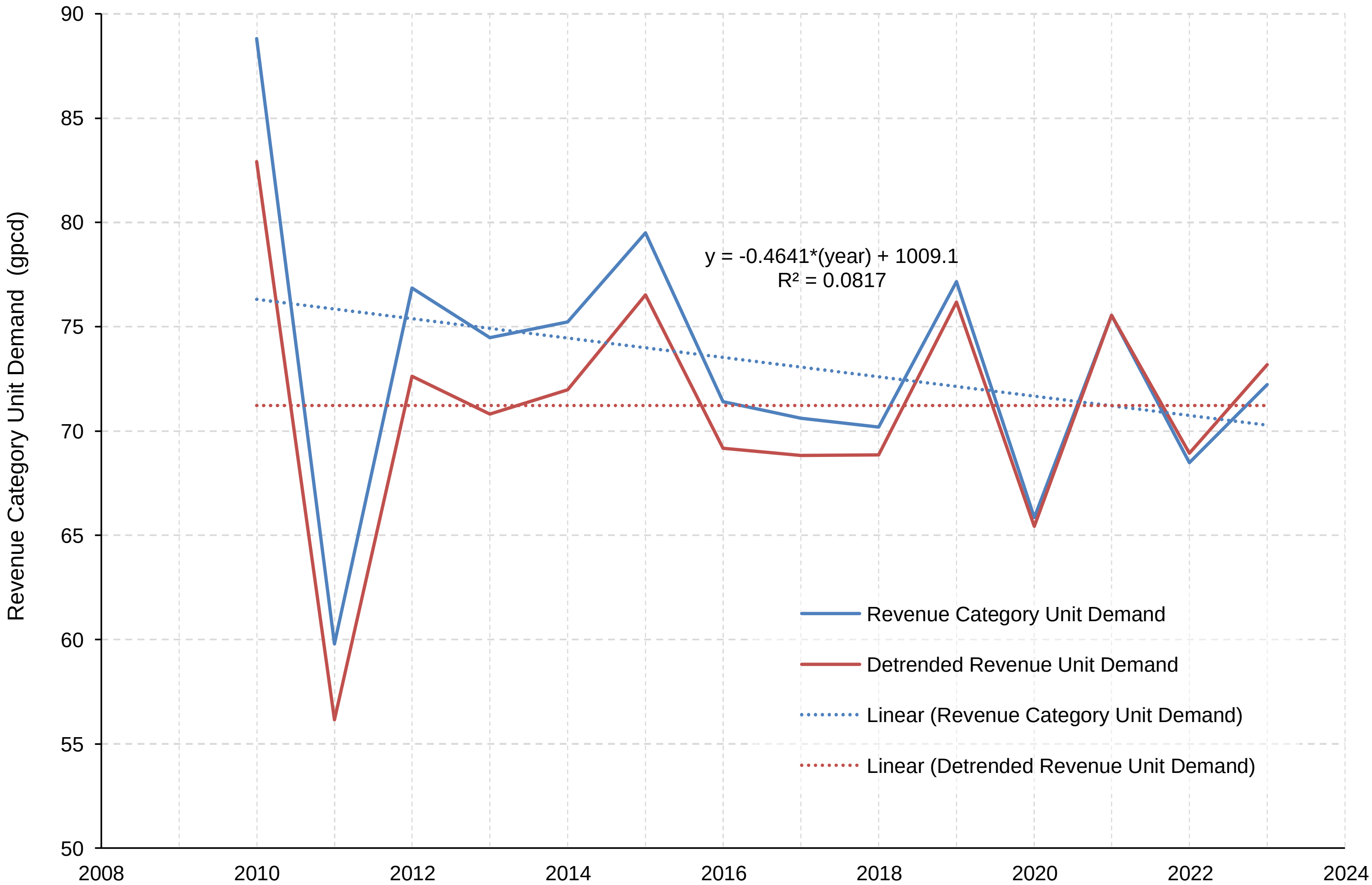


Figure A-1: Detrended Unit Water Demands

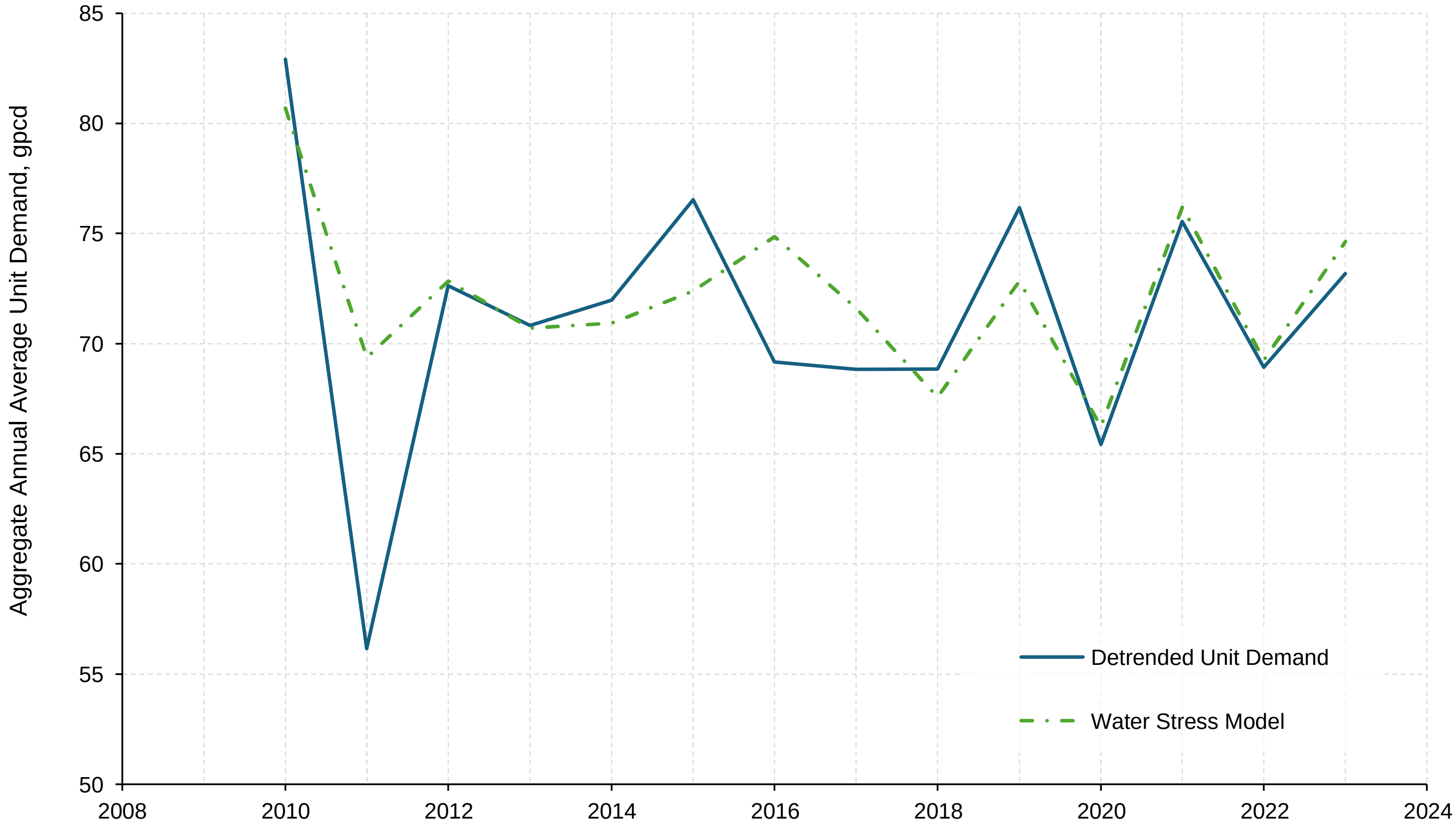


Figure A-2: Water Stress Model Prediction versus Detrended Revenue Category Unit Demand

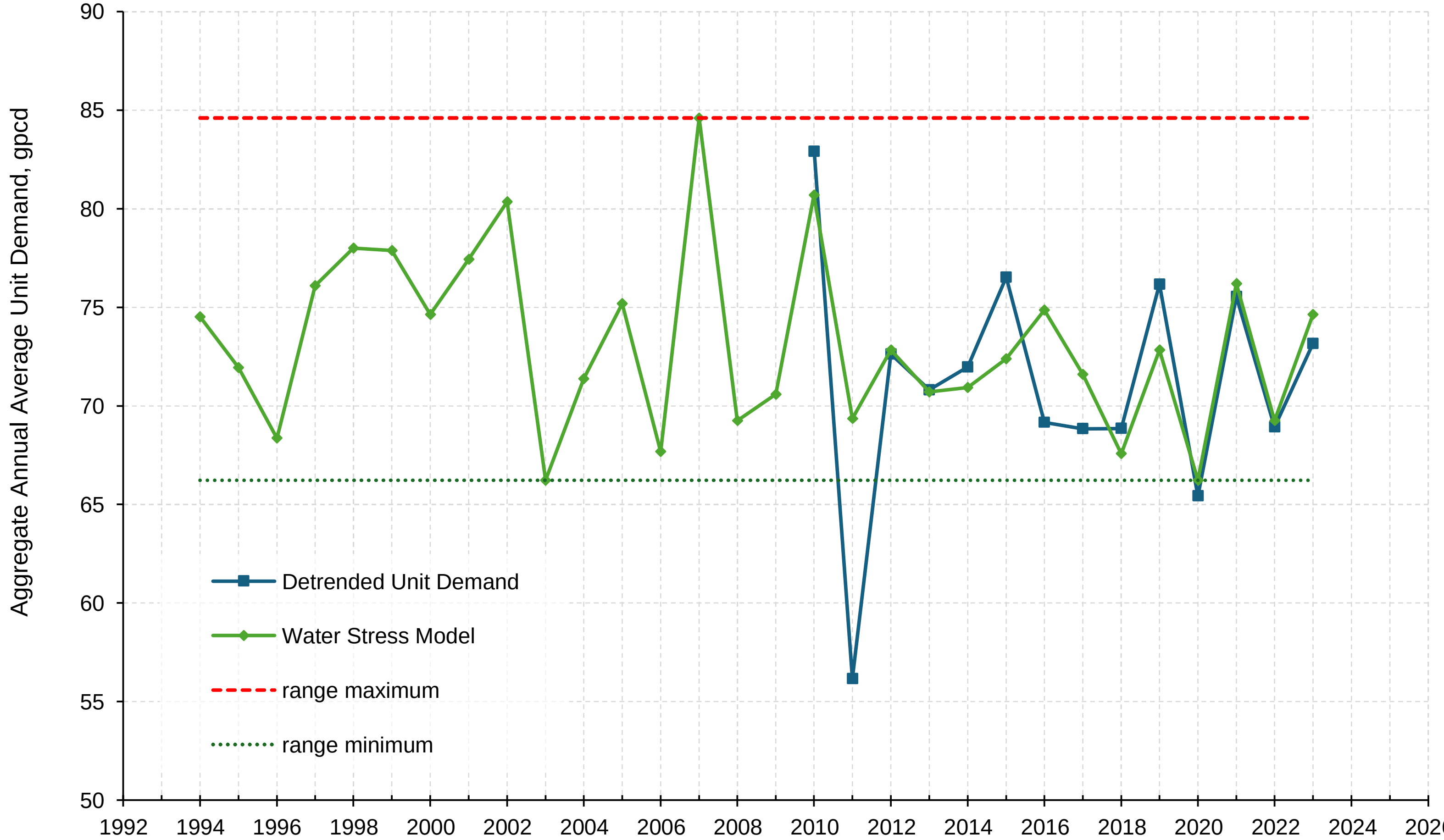


Figure A-3: Water Stress Model Predictions Extended Back to 1994

Precipitation Data

Daily precipitation records were sourced from the weather record repository at https://xmacis.rcc-acis.org/. No single nearby station contained a complete sequence from 1994 through 2023 without missing records. A complete record was synthesized from the data available from multiple stations. The following five station records were used:

1. Holly Springs 3.6 SSE
2. Holly Springs 2.0 ESE
3. Garner [Coop 313238; GARN7 NWS]
4. Sanford 8NE
5. Apex [Coop 310212; APXN7 NWS]

When multiple records were available, the precipitation estimate was based on the distance from the Town of Fuquay-Varina which is arranged in the aforementioned order. If neither Holly Springs stations had records and both the Garner and Sanford stations did have records, the average of the reported precipitation for the two stations was used.

Z-score

The z-score of the season's water stress score was used in the regression analysis rather than the water stress total. A z-score is a way to describe how unusual or typical a particular value is compared to the rest of the data. Specifically, the z-score represents how many standard deviations the value is above or below the average (mean). For example, a z-score of +2 means the value is two standard deviations higher than average, while a z-score of –1 means one standard deviation lower than average. The z-score helps identify whether a certain year's water use is likely to be higher or lower compared to long-term trends. The z-score formula is:

Equation (1): $z = (x - \mu)/\sigma$

where μ is the mean for the dataset

and σ is the standard deviation

The reason for use of the z-score in the regression analysis is that it makes the resulting formula more intuitive. Using Equation 2 as an example, the predictive formula for the Town's unit demand resulting from the regression analysis on the detrended 2010 to 2023 unit demands is:

Equation (2): Revenue water unit demand (in gpcd) = 4.493 x [Water stress z-score] + 73.14

So, in an average weather year where the z-score is zero, the Town's revenue unit demand is predicted to be 73.14 gpcd (i.e. the intercept represents and average year). If the non-revenue demand matches the most recent 5-year average then the total aggregate unit demand would be 79.8 gpcd. In a year where the z-score is +1, the revenue part of unit demand is predicted to be 77.63 gpcd (73.14 + 4.49) and the total unit demand would be 84.3 gpcd (i.e., assuming an average non-revenue component).

If the annual water stress score was used without converting it to a z-score first, the formula for revenue water unit demand would be as follows:

Equation (3): Revenue water unit demand (in gpcd) = 0.112119 x [Annual Water Stress Total] + 60.62

Equation 3 is somewhat less intuitive but gives the same predictive results and has the same R^2 value (0.68) and same p-value for the water stress variable (0.00048). In this case, the intercept (60.62 gpcd) describes the revenue water demand that would be predicted in a year when the water stress metric is zero, which is highly improbable. However, the annual water stress metric from Table A-1 may be used and the results are the same as for Equation 2 using the z-score of the water stress metric.

Mandatory Conservation

This analysis describes how the Town's unit demands were adjusted to anticipate more extreme weather years. Table A-2 summarizes model predicted revenue water use under typical weather conditions (i.e., the mean of the 30-year climate record from 1994 to 2023) as well as the high and low extremes predicted by the model. It is assumed that the non-revenue water would remain at the 5-year average, although it is anticipated that the non-revenue water value will also fluctuate.

Within the 30-year weather record for the regression modeling, the Town would have experienced the highest unit demand in 2007 (e.g., Figure A-3 and the water stress score summarized in Table A-1). From August to the end of 2007 (and into 2008) most public water supply systems in the Triangle area were under mandatory water use restrictions. For future planning, it was assumed the Town would implement the Water Shortage Response Plan (WSRP) during similar drought periods and mandate water use restrictions for customers. It is assumed that the Town could achieve an average 15 percent reduction in water demand from August through December during a repeat of the 2007 drought. This reduction is illustrated in Figure A-4 where mandatory restrictions start in August, much like they were in many Triangle communities in 2007. The annual average unit demand is reduced from a unit demand without water conservation at 91 gpcd to a unit use of 85 gpcd with water conservation.

Table A-2: Summary of Total Per Capita Use Demand Compared to Weather Regression Model Prediction

Parameter	Average Year Per Capita Water Use, gpcd	Wet year Per Capita Use Regression Model Prediction, gpcd	Dry year Per Capita Use Weather Regression Model Prediction, gpcd	Dry year Per Capita with Assumed Conservation
Revenue water [1]	73.1 [1]	66.2 [1]	84.6 [1]	78.4
Non-revenue water	6.7 [2]	6.7 [2]	6.7 [2]	6.7 [2]
Total per capita use	79.8	72.9	91.3	85.1

[1] Model prediction for revenue unit water use (e.g., residential, commercial, institutional, and industrial).
[2] Town average non-revenue water (e.g., process and unaccounted for water) between 2019 and 2023.

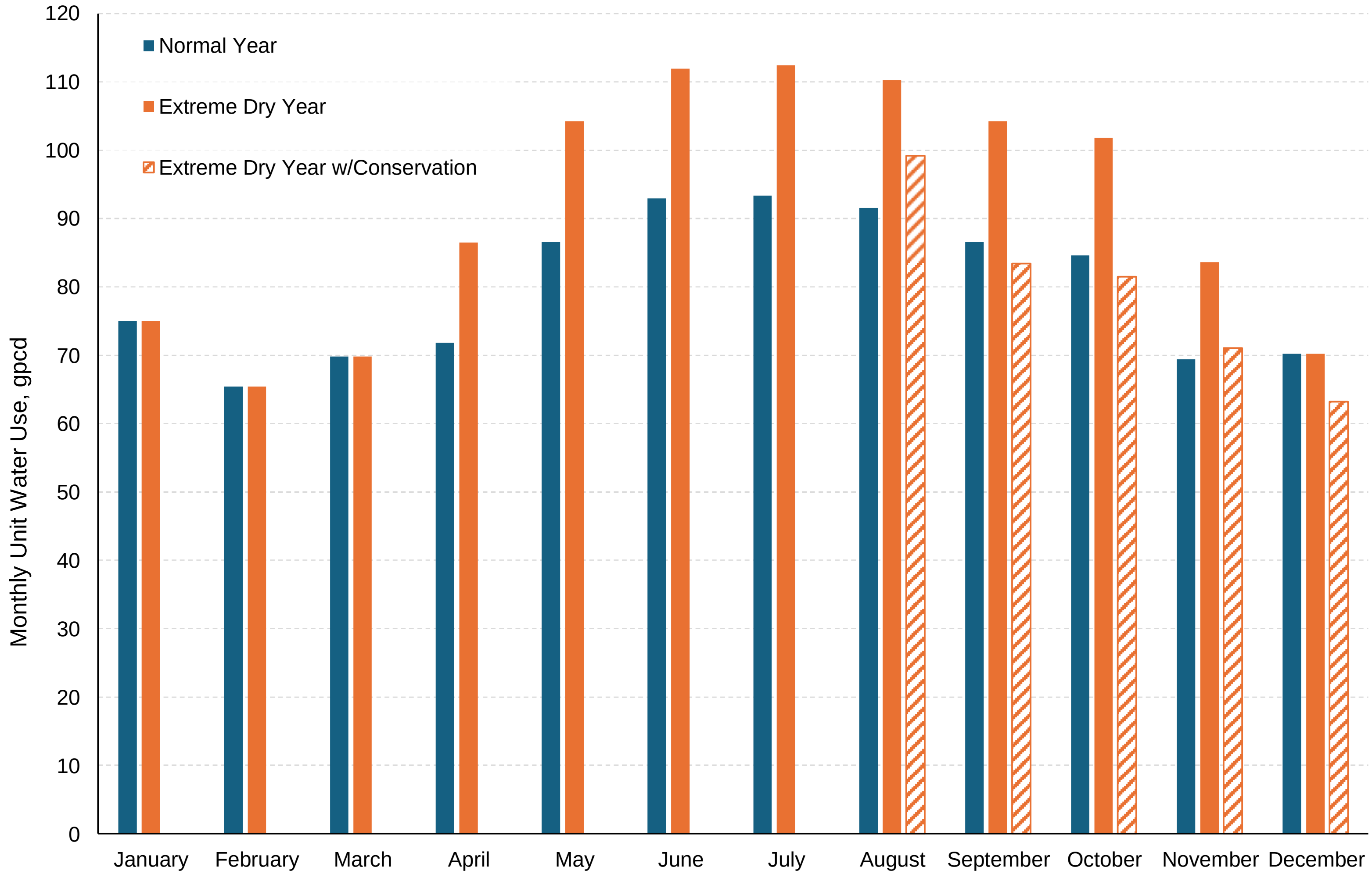


Figure A-4: Monthly unit demand under normal, extreme dry, and extreme dry w/ mandatory conservation conditions

Non-Revenue Water Analysis

Another potential reason the Town would have future water needs greater than observed during the 2013 to 2022 time period is water loss from the distribution network. Currently, the average pipe age in the distribution system is approximately 20 years per conversation with Town staff. A water distribution age of 20 years is relatively young by the standards of pipe infrastructure design lifetime. As a water network ages, it is anticipated that the amount of water loss in will increase. The Town’s infrastructure is young and growing rapidly, which contributes to a relatively low level of water loss.

One approach to demonstrate the Town’s current low level of water loss is through the non-revenue water categories water systems report to DWR as part of their annual local water supply plans. The non-revenue categories are process water and unaccounted-for-water. Since the process water category includes both losses at water treatment facilities as well as system flushing in the distribution system, the Town’s losses were compared only to other systems in the region without water plants. Systems with water plants would be expected to have additional losses from in-plant process water. The comparison was also narrowed further to systems that serve more than 5,000 persons as there are many smaller systems whose distribution networks and resources to maintain their systems may not be comparable to the Town’s. Finally, the losses were normalized on a per capita basis.

Figure A-5 illustrates the per capita sum of process water and unaccounted-for water for the period from 2014 to 2023. The data demonstrates that the Town’s water loss is consistently among the lowest across the Town’s peer group. The Town’s closest peer, the Town of Holly Springs, is similar in terms of number of connections, location, demographics. The Town of Holly Springs also has a low sum of process water and unaccounted-for water. Compared to the Town’s peers with older distribution systems, the Town of Fuquay-Varina’s sum of process water and unaccounted-for water is significantly lower.

Figure A-6 illustrates the Town’s data compared to a broader group of peer utilities without treatment plants but not limited by population served. The Town of Fuquay-Varina’s water loss is still low compared to this broader data set. As the Town’s water system ages, it is anticipated that the non-revenue water consumption will increase as the system ages and will not be as low as over the last 10-year period.

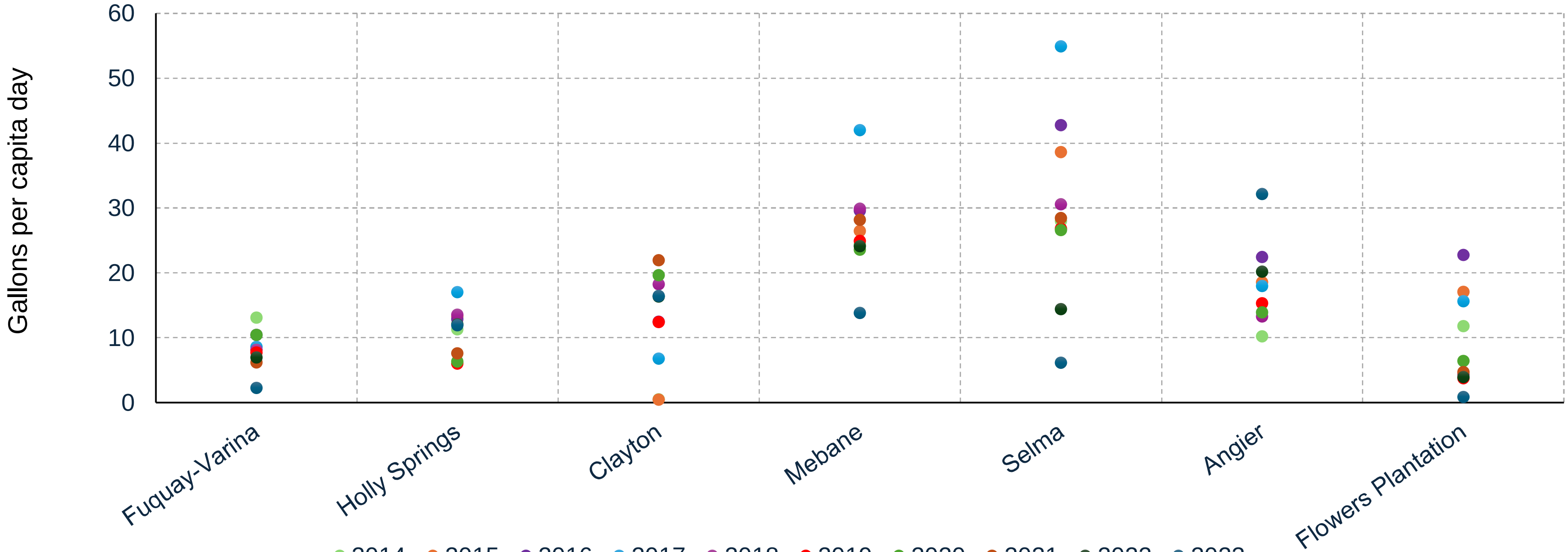


Figure A-5: Sum of Process and Unaccounted-for Water by Utility as Reported to DWR (2014 to 2023)

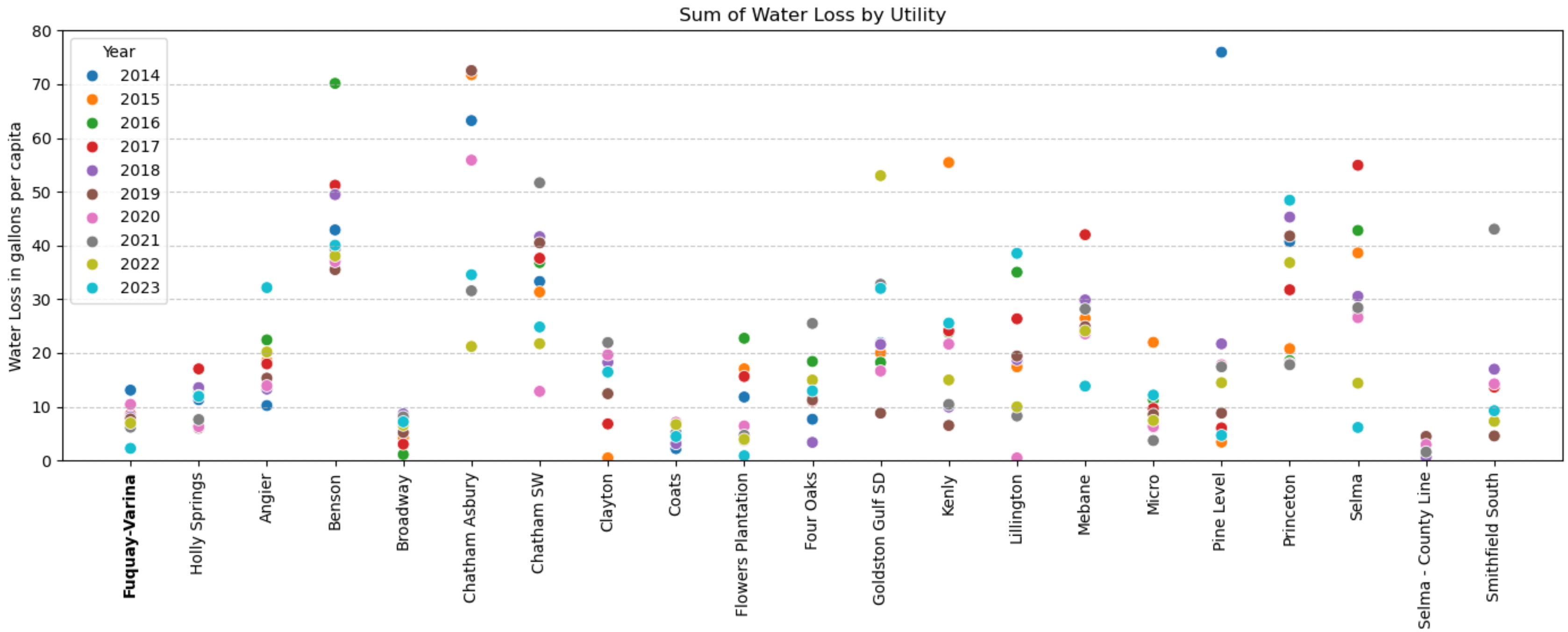
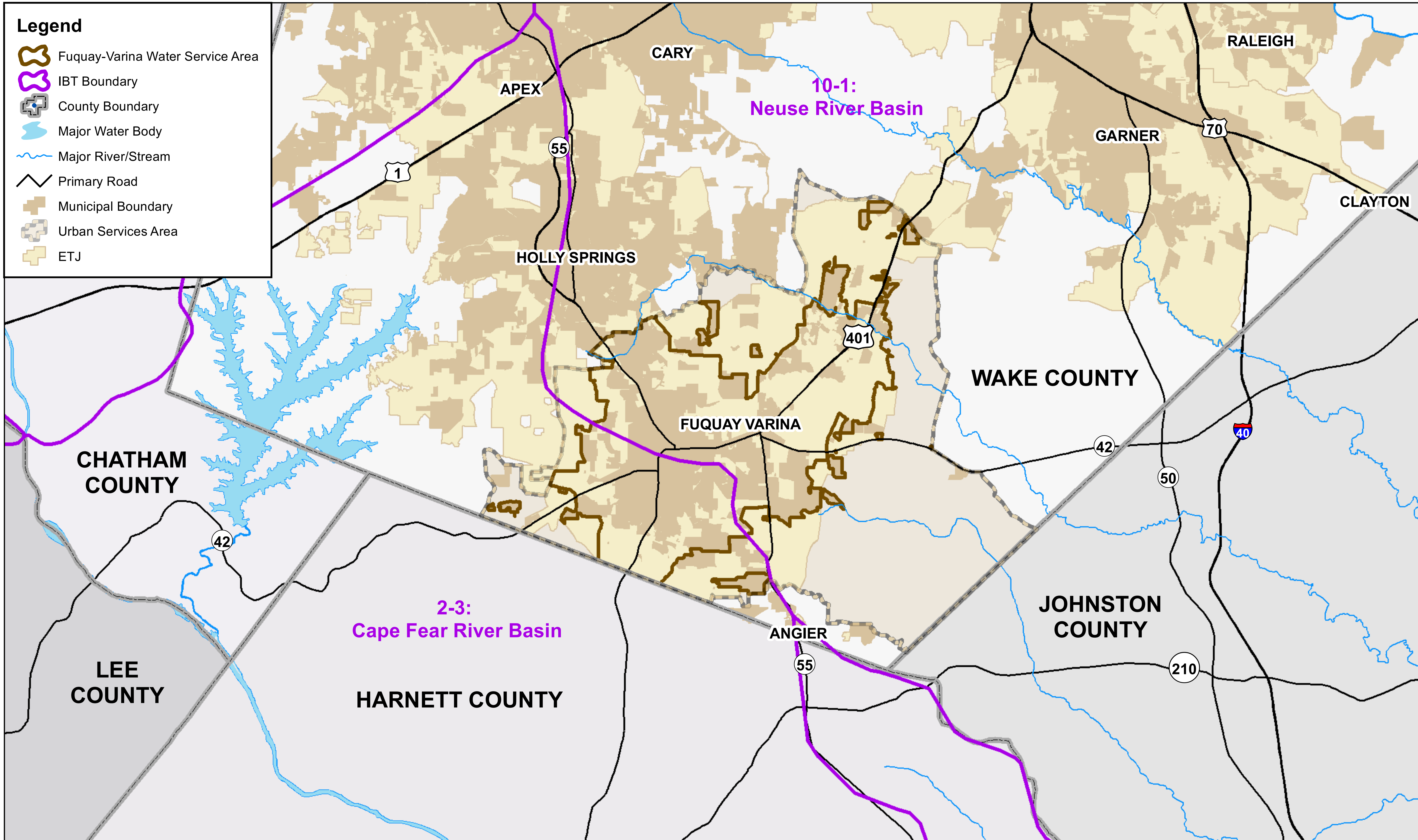


Figure A-6: Sum of Process and Unaccounted-for Water by Utility 2014 to 2023 (Broader Peer Comparison)

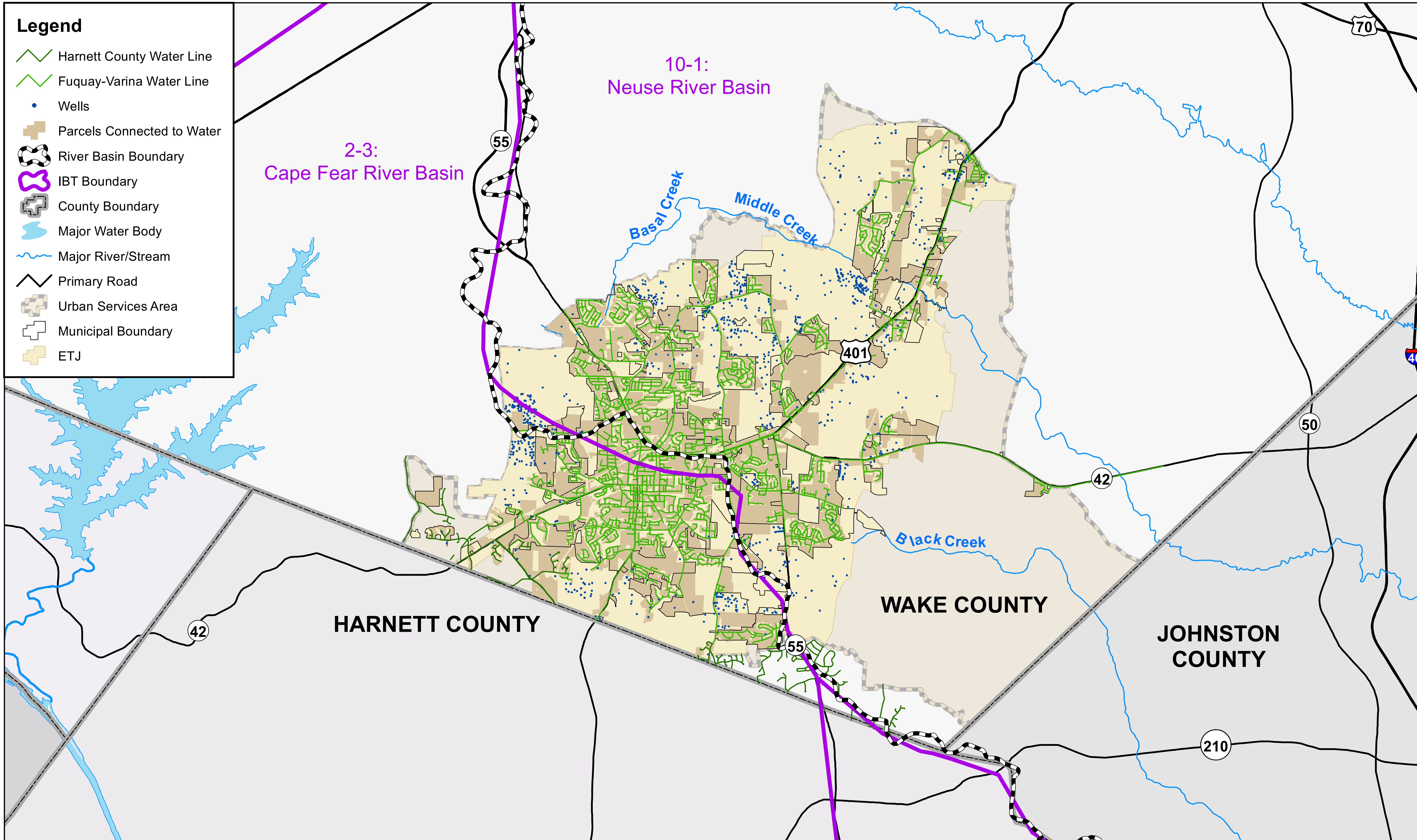


SCALE
1 inch = 2 miles
0 1 2
Miles

FUQUAY-VARINA
north carolina

Hazen

Exhibit 1: Town of Fuquay-Varina Service Area
Interbasin Transfer for Water Supply
from Cape Fear River to Neuse River



SCALE

1 inch = 1.5 miles

0 0.5 1 1.5 Miles

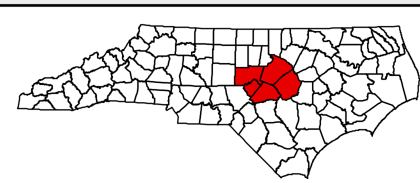
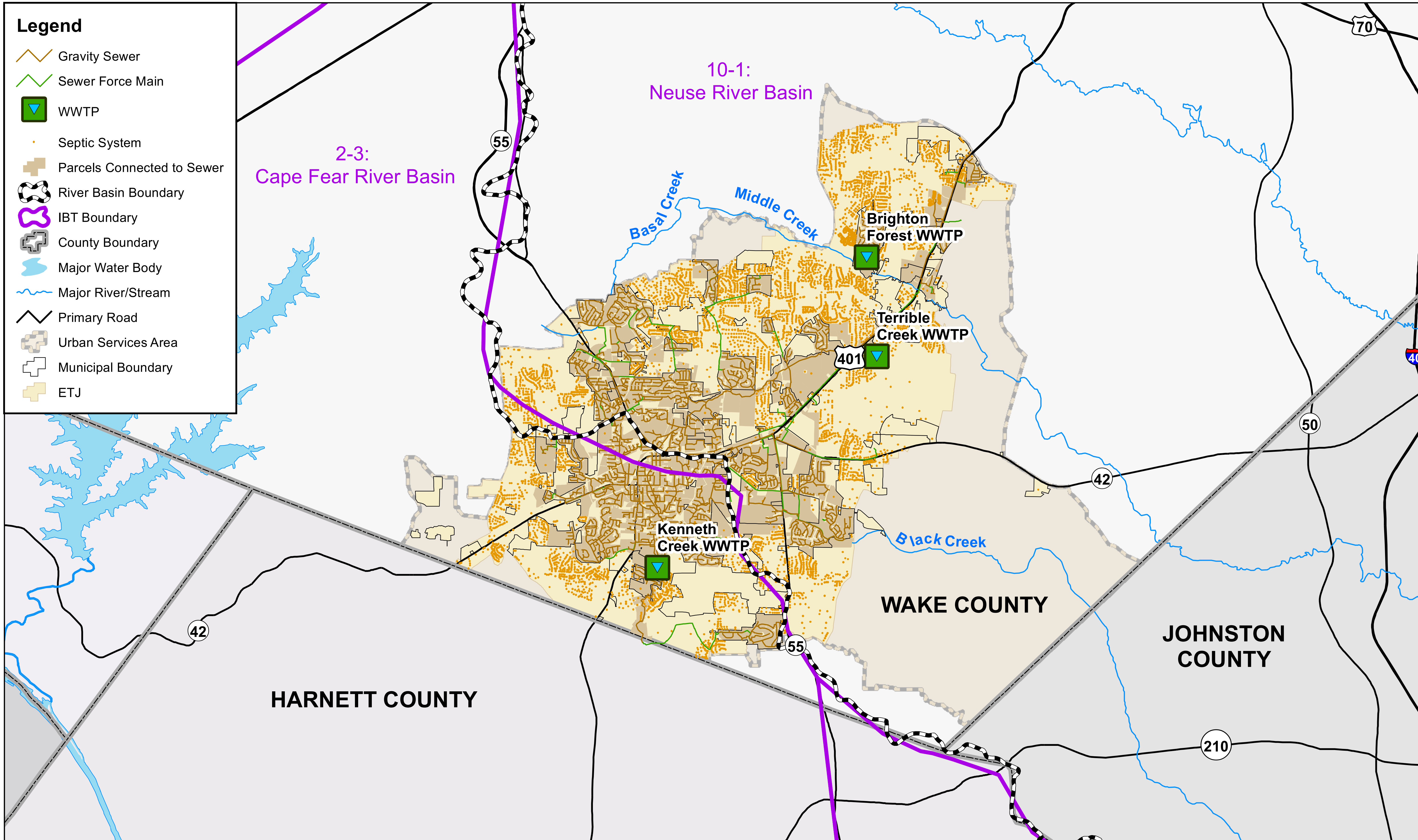


Exhibit 2: Water Infrastructure for the
Town of Fuquay-Varina
Interbasin Transfer for Water Supply
from Cape Fear River to Neuse River

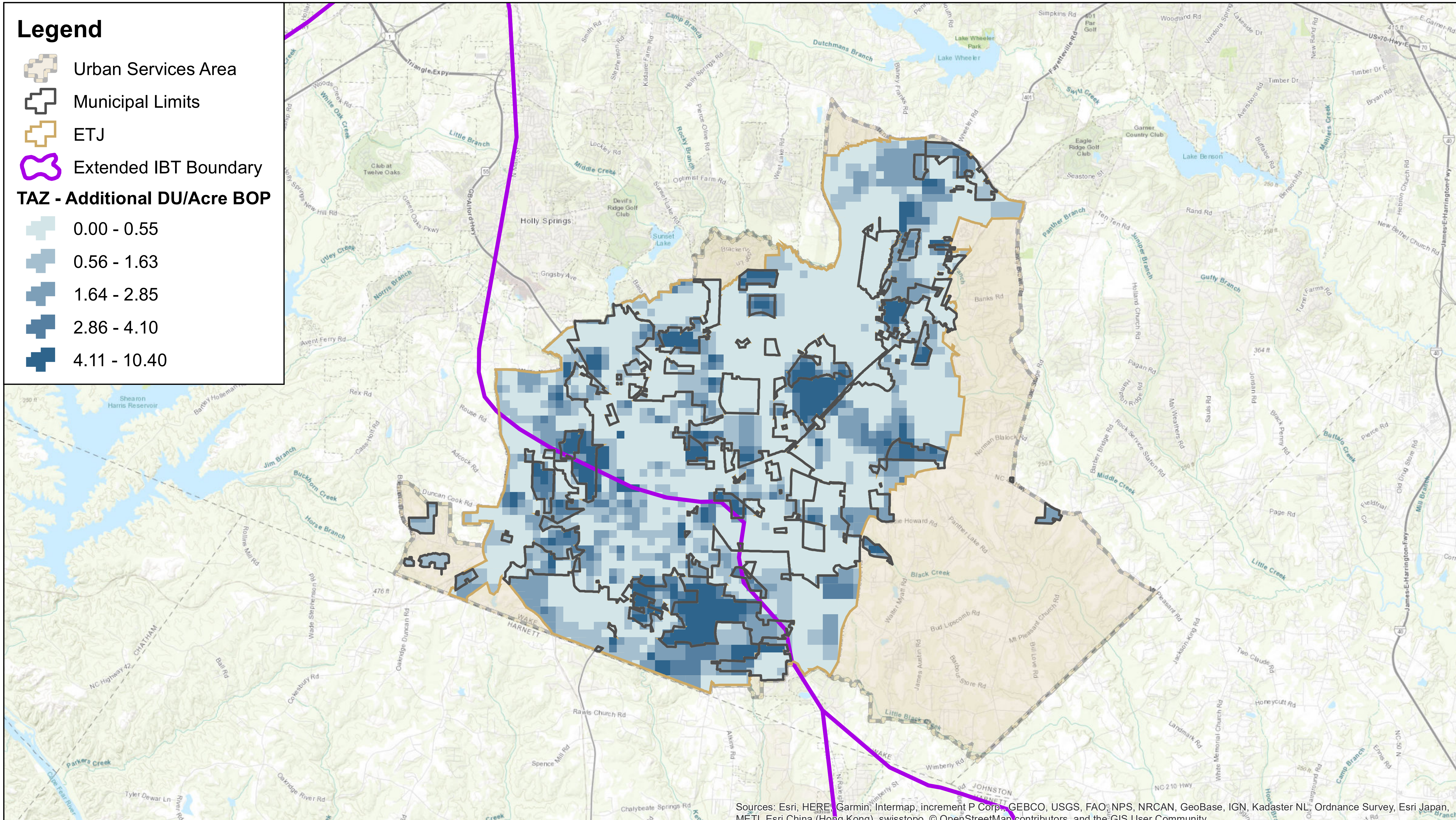


SCALE
1 inch = 1.5 miles
0 0.5 1 1.5 Miles

FUQUAY-VARINA north carolina

Hazen

Exhibit 3: Wastewater Infrastructure for the Town of Fuquay-Varina
Interbasin Transfer for Water Supply from Cape Fear River to Neuse River



N W E S

SCALE
1 inch = 1.5 miles
0 0.5 1 1.5 Miles

FUQUAY-VARINA north carolina

Hazen

Exhibit 4: TAZ Dwelling Unit Density at Build-Out
Interbasin Transfer for Water Supply
from Cape Fear River to Neuse River