Appendix B
Forecast of Water and Wastewater Demands

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R E V I S E D F I N A L R E P O R T

Long Range Water Resources Plan Update, Forecast of Water Demands and Wastewater Flows

Prepared for

Town of Cary

316 N. Academy Street
Cary, NC 27513

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CH2M HILL North Carolina, Inc.
111 Corning Street
Suite 116
Cary, NC 27518

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Acronyms and Abbreviations

BWOS	built without service
CH2M	CH2M HILL North Carolina, Inc.
COM	commercial
DU	dwelling unit
ft^2	square foot
GIS	geographic information system
GPCD	gallon(s) per capita per day
GPD	gallon(s) per day
IBT	interbasin transfer
ICI	industrial, commercial, and institutional
IND	industrial
INS	institutional
LRWRP	Long Range Water Resources Plan
MFR	multifamily residential
MGD	million gallons per day
NCWRF	North Cary Water Reclamation Facility
RDU	Raleigh-Durham International
REU	Residential End Uses of Water
RTP South	Wake County portion of Research Triangle Park
SCWRF	South Cary Water Reclamation Facility
SFR	single-family residential
Town	Town of Cary
WWRWRF	Western Wake Regional Water Reclamation Facility
WRF	Water Reclamation Facility
WTP	water treatment plant

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SECTION 1

Long Range Water Resources Plan History and Purpose

The Town of Cary (Town) has partnered with CH2M HILL North Carolina, Inc. (CH2M) to update the 2013 Long Range Water Resources Plan (LRWRP). The effort began with an analysis of customer water usage and water system patterns using the most recent 5 years of the Town's comprehensive collection of system data and customer billing information. The next step, completed in December 2017, was to develop an updated forecast of future water demand and wastewater flows to reassess the strategies in the Water Resources Portfolio provided in the 2013 LRWRP. Here, the forecast of water demands and wastewater flows is updated through 2065. New from 2013 is that reclaimed water projections are a part of the forecast.

The approach to this forecast is described and all input parameters and their sources are documented. Flows are presented in millions of gallons per day (MGD). This approach methodology included the development of a geographic information system (GIS)–based tool and an update to the Excel-based portion of the previous forecast. The Town's utility service area, as it was defined in 2016, including the Towns of Cary and Morrisville as well as the Raleigh-Durham International Airport (RDU) and Research Triangle Park (RTP) South, was used as the basis for this update. The following projections are included:

- Water demands, including raw water and finished water
- Wastewater flows
- Reclaimed water demands
- Interbasin transfer
- Required discharge

The Towns of Cary and Apex jointly own the Cary/Apex Water Treatment Facility (WTF), share wastewater treatment capacity at the Western Wake Regional Water Reclamation Facility (WWRWRF), and share an interbasin transfer (IBT) certificate. Hence, any consideration of future water, wastewater, and reclaimed water projections for the Town of Cary should also consider projections for the Town of Apex. Appendix A describes the methodology and forecast for the Town of Apex.

These projections provide a basis on which to evaluate the ability of the Town of Cary's water supply and infrastructure capacity to meet existing and future demands. The Town has invested in reclaimed water infrastructure and a water conservation program to aid in the offset of potable water demands. These programs are incorporated into this forecast. These projections will also be used to evaluate the potential of water resources portfolio alternatives to meet projected demands, as was conducted for the 2013 LRWRP.

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SECTION 2

LRWRP Update Projection Methodology

The Town's approach to the 2018 update of the LRWRP includes the use of a methodology similar to that of the 2013 LRWRP, alignment with the Cary 2040 Community Plan (*Imagine Cary*) (Town of Cary, 2017), and recent regional transportation planning efforts. A probabilistic modeling approach was used; Monte Carlo simulation supports a large number of simulations run in random quantities for uncertain variables and looks at the distribution of results to infer which values are most likely. This method provides the ability to incorporate uncertainty into the development of a water demand forecast, as well as understand the variability in the potential forecast outcomes. Each of the variables used in the forecast development is described, and their incorporation into the model simulation process shows the extreme possibilities along with possible outcomes for middle-of-the-road (or 50th percentile) scenarios.

The Town's water use analysis was updated in 2017 and is the basis for many of the water use statistics used in this forecast, including updated unit water demand factors (CH2M, 2017). Key years for the forecast are the following:

- 2016—baseline year
- 2025—selected to represent when current plans approved but not yet built will be online
- 2045—selected to align with regional planning efforts
- 2065—selected to represent reaching the Town's full capacity for development

In 2013, the demand projections included a major assumption that by 2040 the Towns would start to reach their full capacity for development, with full capacity reached between 2050 and 2060. This assumption was updated in 2018, with the new date of 2065 representing full capacity for development and use of a more linear growth curve than was predicted in 2013. When reviewing the demand projections from 2013 and 2018, average day finished water demand for the Towns (inclusive of Morrisville, RTP South, RDU Airport, and the service areas of Cary and Apex) at full capacity is just above 40 MGD. The expectation is just that this demand will be reached at a later timestep than was projected in 2013.

2.1 Aligning with Regional Planning Efforts

An overall objective of this update was to use recent regional planning information, including development projections through 2045 from the Triangle J Council of Governments (COG). The Triangle J COG, along with other regional planning organizations, worked to create a transportation model through 2045. The Town and others in the region provided land use and development data to the Triangle J COG to support their implementation of the CommunityViz 2.0 model (Triangle J COG, 2018). Appendix B includes an overview of the model and a map of the participating region. Also included in Appendix B is Triangle J COG's 2017 *Connect 2045 Place Type Summary for Raleigh, Cary, and Morrisville*.

The information provided to Triangle J COG was produced by the Town in 2015. The model's output for development, using an algorithm that worked around transportation corridors, and the Town's assessment of full capacity for development were used as the future land use inputs into our model.

The CommunityViz 2.0 model employed by Triangle J COG begins by predicting how "attractive" a given area is for new development. This attractiveness is referred to as "suitability." CommunityViz calculates a spatial distribution of suitability values based on features which would attract development such as locations of existing and future transportation corridors, anchor institutions, community centers, and availability of sewer services, as well as those features which would restrict or deter development such as stream buffers, conservation lands, or 100-year floodplains.

Triangle J COG received from municipalities within the Triangle J region the distribution of their parcels that have capacity for new development. Using the calculated suitability values, CommunityViz then predicts how much of that capacity can be expected to be developed by the year 2045 for a given area (Figure 2-1). Areas in red are those most suitable for development, while areas in blue are those least likely to develop. This amount of capacity expected to be developed by 2045 is referred to as an “allocation of capacity”; for this reason, the state of development in 2045 will frequently be referred to as “2045 Allocations.”

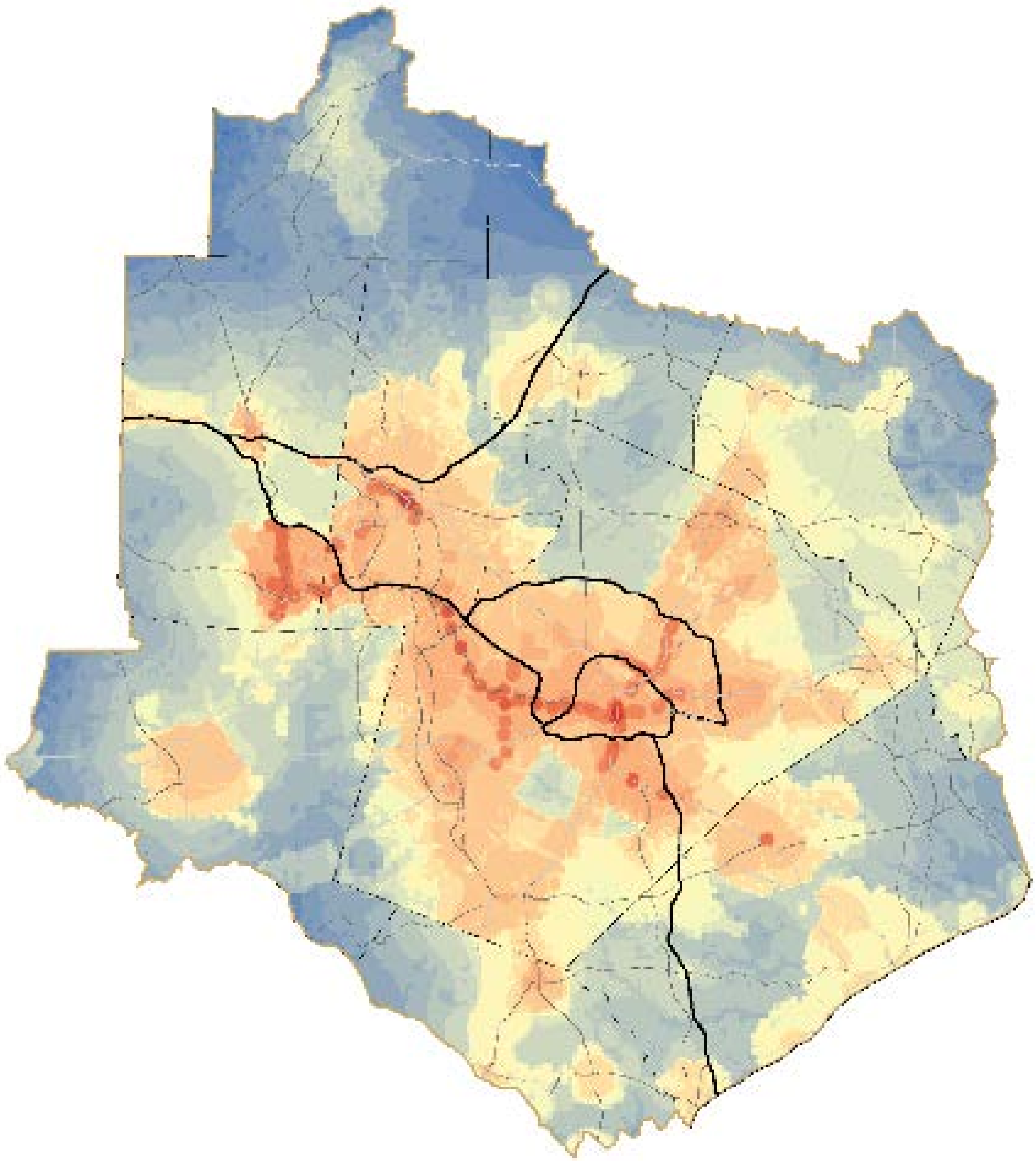

Figure 2-1. Suitability for Development

Source: Triangle J COG (2018)

The Town of Cary has opted to use this model’s output to reflect development status in 2045. The Town also selected the year 2065 to represent the Town’s full capacity for development. Therefore, while the allocations will be used to inform the projected water system demands in the year 2045, the full development capacities will be used to inform the projected water system demands in the year 2065.

2.2 Expected Development Patterns

Output from the CommunityViz model includes both population projections and development expectations. The Town's population in 2016 was 157,259. Growth is expected to continue, as shown in Table 2-1. Along with residential growth, the Town is also expected to see growth in the industrial, commercial, and institutional (ICI) sectors. A summary of projected ICI development is included in Table 2-2 (Triangle J COG, 2018). RDU Airport has not been included in this summary as the scale of it in the COM customer type skews the perception of trends in the other jurisdictions; it is expected to grow in both passenger count and building area during the planning period. According to Town land use records, approximately 16 percent of buildable vacant area remains. Additionally, some parcels are expected to redevelop, with a resulting increase in mixed use developments.

Table 2-1. Historical and Projected Population for the Town's Service Area
Includes the Towns of Cary and Morrisville

Town	2001	2007	2013	2015	2016	2065
Cary	99,798	122,643	144,982	153,867	157,259	210,772
Morrisville	8,973	15,393	21,696	23,682	24,456	31,782

Notes:
Historical population provided by Town of Cary as reported in CH2M, 2017
Population at full capacity is assumed for the purposes of this evaluation to occur in the year 2065
Population at full capacity is taken from the CommunityViz model as an additive value to the 2015 population (TJCOG, 2018)

Table 2-2. Projected ICI Development
Includes the Town of Cary, Town of Morrisville, and RTP South (RDU Airport excluded)

Customer Type	2016	2045	2065
COM (ft^2)	465,553,128	484,789,037	532,500,195
IND (ft^2)	12,296,782	15,135,601	15,145,907
INS (ft^2)	27,188,210	28,450,168	29,941,005

Notes:
ft^2 = square feet

Current square footage provided by Town of Cary as reported in CH2M, 2017
Full capacity for development is assumed for the purposes of this evaluation to occur in the year 2065

The Town is expecting to see an increase in mixed use development. The CommunityViz model output includes details on the components of expected mixed uses, such as a mix of multi-family and commercial land uses. For the purposes of forecasting, these components were used in the development of demand projections. Table 2-3 accounts for the components of mixed use development that were used in the forecast, which include SFR, MFR, and COM customer types. Note that mixed use was not a categorized customer type in 2016, therefore, current values are not provided. Adjustments from the 2013 LRWRP include moving townhomes and residential attached housing from SFR to MFR.

The total number of parcels included in the MIX customer type is 1,756. Of these, 91 percent of them are comprised of all three customer types, 5 percent are comprised of MFR and COM, while 4 percent are comprised of SFR and MFR. All MIX parcels include the MFR customer type, therefore, no parcels include only SFR and COM customer types.

Table 2-3. Mixed Use Development Components
Includes the Town of Cary, Town of Morrisville, and RTP South (RDU Airport not applicable)

Customer Type	2045	2065
SFR (DU)	4,266	4,365
MFR (DU)	3,612	7,735
COM (ft^2)	14,399,454	50,117,187

Notes:
Full capacity for development is assumed for the purposes of this evaluation to occur in the year 2065

2.3 Water Demand and Wastewater Flow Forecasting Tool

The forecasting tool developed for this update has two components: the LRWRP Calculation Tool, a GIS-based tool that uses spatial relationships to identify and group data required to calculate future demands, and the Excel Forecasting Tool, an Excel-based spreadsheet that references these data as well as water use statistics such as unit factors to develop the baseline forecast. As such, the type of development and the rate at which it occurs influence the forecast and it is not driven by population alone. The forecast tool also supports the spatial aggregation of data.

The primary purpose of the LRWRP Calculation Tool is to produce data summaries of the service area's existing meters' demand and future parcels' development in a format that can be accepted by the Excel Forecasting Tool. For this update, the Town's advanced meter infrastructure data for 2016 was used for the existing demands. For the future parcels' development, the LRWRP Calculation Tool again utilizes service area and sewer subbasin layers to group parcels which can accommodate future development. This provides the Excel Forecasting Tool with 2045 Allocations and 2065 Capacities, per subbasin, as expressed in number of dwelling units (DUs) for residential development and in square footage for commercial, industrial, and institutional development.

The Excel Forecasting Tool will import the two summarized tables assessing existing demand and future development. With this data, combined with inputs of Town-specific demographic and water system factors, allows the Excel Forecasting Tool to calculate future water demands and wastewater flows. Appendix B includes details of the development of these factors. The flow process diagram for these steps is shown in Figure 2-2.

The Excel Forecasting Tool is designed so that the Town can update it with current water demand and updated development capacity in future years. To do this, the year from which the LRWRP Calculation Tool is basing existing meters' demand can be input into the Excel Forecasting Tool as the "base year" in the Control Panel.

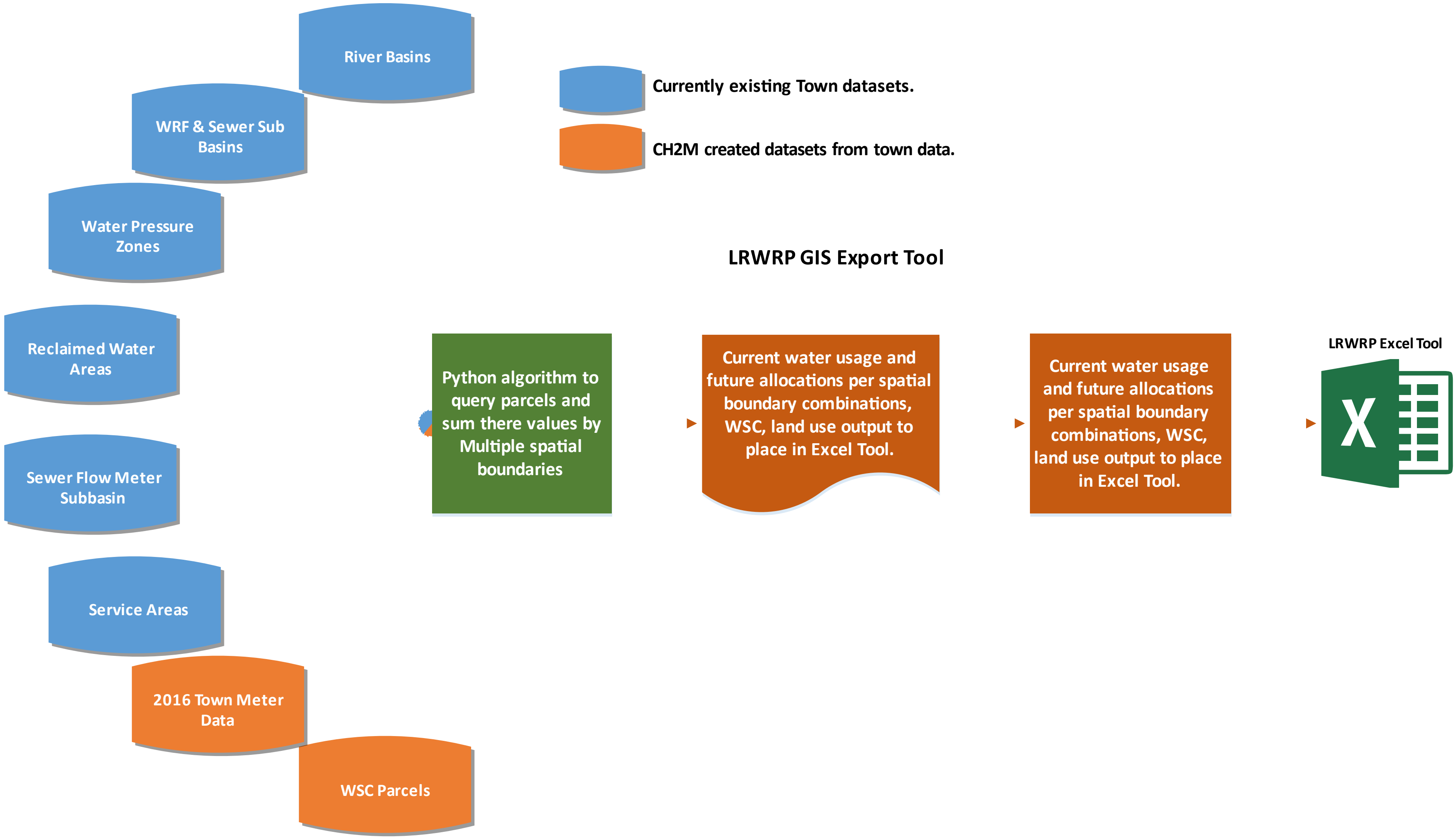

Figure 2-2. Diagram of the Water Demands and Wastewater Flows Forecasting Tool
2018 LRWRP GIS Export Tool

2.4 Water Demand Projections Methodology

Total water demand is tallied by first summarizing existing demand and assuming this demand continues through the planning period. The LRWRP Forecasting Tool then determines what percentage of the 2045 Allocations will be developed year-by-year and calculates the expected water demand from this future development by applying unit factors tailored to each general customer category. After applying vacancy rates and expected conservation rates, the existing meter and future parcel water demands by year are superimposed on one another to get the final water demand forecast. Future parcel water demands are calculated based on unit factors per water service customer type as presented in *Town of Cary Water Use Analysis* (CH2M, 2017) and summarized in Appendix C. Using spatial data in the GIS tool, the projections can be summarized by water pressure zone, river basin, and jurisdiction.

2.4.1 Calculating Existing Demands

For the existing meters' demand, the LRWRP Forecasting Tool uses spatial layers of the Town's service area and sewer subbasins to group existing meters into the following water service customer types:

- Single-family residential (SFR)
- Multi-family residential (MFR)
- Commercial (COM)
- Industrial (IND)
- Institutional (INS)

2.4.1.1 Approach for Existing Meters

Linking the meters to the Town's billing database provides a base year water demand per customer type within each sewer subbasin. This base year usage is carried forward into the future except in the case of low residential use meters. For residential meters, the LRWRP Forecasting Tool identifies meters with annual average potable water demand (not including any metered irrigation) of less than 50 gallons per day (GPD), or "low users," and a replacement methodology is then applied.

2.4.1.2 Approach for Low Use Meters

SFR and MFR meters with a base year annual average of less than 50 GPD (a value selected by the Town) are assumed to be due to residents who do not reside at their home for the entire year, or homes that have been left vacant between owners. While it is reasonable to assume existing customers will continue their usage patterns, some variation is expected in the future as homes are bought and sold. For this reason, the low use meters' water demand is replaced by the indoor-only SFR unit demand factor of 50 GPD.

This override does, however, increase the base year usage as compared to the historical data. As part of the quality assurance process and to accommodate this discontinuity, an "apparent" vacancy rate was back-calculated so that the base year water demand is accurate. This vacancy is then ramped up to the vacancy rate applied to future parcels over the first 5 years of the forecast. Data presented herein are actual 2016 usage values. A comparison of the model's predicted 2016 values and actual 2016 values, prepared as part of the quality assurance process, is presented in Appendix D.

2.4.2 Calculating Future Water Demands

The parcels identified by their water service connection are linked to 2045 Allocations and 2065 Capacities and are also grouped by water service customer category, water pressure zone, and sewer subbasin. The rate at which development occurs between the base year and 2045 is determined by a development rate table. Beyond 2045, the tool assumes a linear growth rate based on the 2045 and 2065 forecast data points, with the assumption that full capacity is reached in 2065. The calculated number of DUs for residential development and square footage for nonresidential development is then converted to a water demand using unit demand factors.

Demands were projected using a probabilistic modeling approach using the @Risk model. This section details the probabilistic distribution for each water service customer type's unit demand factor. Each of these variables is defined by three percentile values (5th, 50th, and 95th) and justification is given for these values here and in Appendix C. Tables include, in addition to these percentiles, the 25th and 75th percentile values resulting from model simulation to better describe the distribution. All variables in this section which are defined by historical usage are sourced from the *Town of Cary Water Use Analysis* (CH2M, 2017), unless otherwise noted.

2.4.2.1 Step 1: Unit Demand Factors and Development

Unit consumption factors were developed using data from 2013 through 2016 for each land use category: SFR, MFR, COM, IND, and INS. These factors are presented in the 2017 water use analysis (CH2M, 2017). Statistics were calculated separately for the Towns of Cary and Morrisville, as was done in the 2013 LRWRP (CH2M and Brown and Caldwell, 2013). Statistics for the Town of Cary include RTP South and RDU. Table 2-4 presents a summary comparison by land use category for both the 2013 LRWRP and the 2017 water use analysis. Overall, the water use per unit, both per capita and per square foot (ft^2), have declined except for IND.

Table 2-4. Unit Demand Factor Summary
Includes All Accounts from the Towns of Cary and Morrisville

	Cary		Morrisville	
Customer Type (Units)	**2013 LRWRP Forecast**	**2017 Water Use Analysis**	**2013 LRWRP Forecast**	**2017 Water Use Analysis**
SFR (GPCD)	76	58	76	58
MFR (GPCD)	52	40	64	40
COM (GPD/ft^2)	0.1	0.06	0.1	0.05
IND (GPD/ft^2)	0.1	0.09	0.1	0.09
INS (GPD/ft^2)	0.1	0.06	0.1	0.06

GPCD = gallons per capita per day

Single-Family Residential Demands

SFR demands were developed following the same methodology used in the 2013 LRWRP (CH2M and Brown and Caldwell, 2013). Water demands for SFR accounts are broken down into three separate types to aid in summarizing usage. These are indoor potable demand, metered outdoor demand (either potable irrigation meters or reclaimed irrigation meters), and unmetered outdoor demand (also referred to as "hidden irrigation"). While the indoor unit factors for Cary and Morrisville are the same, the persons-per-household average is slightly lower in Morrisville, as is irrigation usage. Therefore, median SFR usage in Morrisville is slightly less than in Cary. The following assumptions and values were used:

- Usage in existing homes will continue, with overrides for low usage as described previously
- Persons per household: Cary = 2.78; Morrisville = 2.70
- For DUs with reclaimed water usage for irrigation, reclaimed water demand values were used for outdoor water use

The SFR sub-unit factors are effectively combined into an overall SFR unit demand factor. This overall factor is not used directly in the forecast calculation but is included here to show the average resulting usage for SFR customers. It is defined by the following function:

$$\text{Overall SFR GPD/Unit} = a + (b \times c) + [d \times (1 - c)]$$

Where

a = indoor unit demand

b = separately metered irrigation unit demand

c = percent of new SFR accounts with a separate irrigation meter

d = unmetered “hidden” irrigation unit demand

Indoor Demand

The SFR indoor demand sub-unit factor and the variables input into the probabilistic forecast are listed in Table 2-5. These variables were selected using the following information:

- 5th percentile—35 GPCD is currently the most efficient indoor GPCD for a residential home, based on current technology.
- 50th percentile—equals the average GPCD for the population of SFR residences constructed after 2010 for the period from 2013 to 2016.
- 95th percentile—equals the highest annual average indoor demand for SFR residences with a single meter for the period from 2007 to 2016.

Table 2-5. Single-family Residential Indoor Sub-unit Demand Factors
For the Towns of Cary and Morrisville, Average Day Demands

SFR Indoor Demand	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile
GPCD	35	41.1	46.5	53	65
Cary (GPD/DU)	97	114.3	129	147.5	181
Morrisville (GPD/DU)	95	111	126	143.2	176

Metered Irrigation for Separately Metered Residences, Potable Water

SFR separately metered irrigation usage values are listed in Table 2-6. These variables were selected using the following information:

- 5th percentile—based on the irrigation demand for SFR residences with a separately metered irrigation meter constructed before 2010 for the period from 2013 to 2016.
- 50th percentile—equals the annual average GPD/DU for the population of SFR residences with a separately metered irrigation system for the period from 2013 to 2016.
- 95th percentile—equals the 75th percentile for separately metered irrigation for SFR residences constructed after 2010 for the period from 2013 to 2016.
- For other customer types, irrigation is built into the single unit factor.

Table 2-6. Single-Family Residential Separately Metered Irrigation Sub-unit Demand Factors
For the Towns of Cary and Morrisville, Average Day Demands

SFR Metered Irrigation	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile
Cary (GPD/DU)	31	99.0	154	216.4	321
Morrisville (GPD/DU)	29	92.0	143	201.1	299

Unmetered "Hidden" Irrigation

SFR customers without in-ground irrigation systems and separately metered irrigation still have some amount of outdoor water use. The methodology used to develop "hidden" irrigation demands is presented in the water use analysis technical memorandum (CH2M, 2017). The variables listed in Table 2-7 were selected using the following information:

- 5th percentile—minimum irrigation level = 0.
- 50th percentile—based on the annual average outdoor demand for SFR residences with a single meter constructed after 2010 for the time period from 2013 to 2016.
- 95th percentile— based on the annual average outdoor demand for SFR residences with a single meter constructed after 2005 for the time period from 2001-2009.

Table 2-7. Single-Family Residential Unmetered Irrigation Sub-unit Demand Factors
For the Towns of Cary and Morrisville, Average Day Demands

SFR Unmetered Irrigation	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile
Cary (GPD/DU)	0	3.9	8	13.7	26
Morrisville (GPD/DU)	0	3.4	7	12.2	24

Percent of Future SFR Accounts with Separate Irrigation Meters

Over the evaluation period from 2013 to 2016, the Town has seen a declining rate of installation of separate in-ground irrigation systems in residential developments. As of 2016, the installation rate for irrigation systems was 13 percent of new SFR construction. This is a decrease from the 35 percent used in the 2013 LRWRP. The variables listed in Table 2-8 were selected using the following information:

- 5th percentile—assumed minimum level of separately metered irrigation accounts.
- 50th percentile—equals the percent of SFR residence constructed after 2010 with separately metered irrigation accounts (as of 2016).
- 95th percentile—equals the percent of SFR residence constructed between 2001 and 2010 with separately metered irrigation accounts (CH2M, 2010).

Table 2-8. Percent of Separately Metered Single-Family Residential Accounts with New Construction
For the Towns of Cary and Morrisville

Percentage of SFR with Metered Irrigation	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile
Cary and Morrisville	5%	8.7%	13%	19.5%	35%

Resulting Overall SFR Unit Demand Factor

The SFR sub-unit factors are effectively combined in the model into an overall SFR unit demand factor, resulting in the probabilistic distribution of factors listed in Table 2-9. These values are a result of the modeling, not inputs into the model, because the sub-units described in this section are used and are provided for perspective only.

Table 2-9. Overall Single-Family Residential Unit Demand Factors Summary
For the Towns of Cary and Morrisville, Average Day Demands

SFR Overall	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile
Cary (GPCD)	43	51.0	58	67	83
Morrisville (GPCD)	42	50.4	58	66.2	82
Cary (GPD/DU)	119	141.7	162	186.3	231
Morrisville (GPD/DU)	114	136.1	155	178.7	221

Multi-family Residential Demands

Similar to SFR demands, the indoor unit factors for Cary and Morrisville are the same, while the persons per household value is slightly lower in Morrisville. In Cary, this value is 2.22, while in Morrisville this value is 2.18. Therefore, median MFR usage in Morrisville is slightly less than in Cary. The variables listed in Table 2-10 were selected using the following information:

- 5th percentile—35 GPCD is currently the most efficient indoor GPCD for a residential home, based on current technology.
- 50th percentile—equals the average 50th percentile GPCD for all MFR accounts for the 2013 to 2016 period.
- 95th percentile—equals the annual average demand for all MFR accounts for the 2001 to 2009 time period (CH2M, 2010).

Table 2-10. Multi-family Residential Unit Demand Factors
For the Towns of Cary and Morrisville, Average Day

MFR	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile
GPCD	35	37.3	40	44.3	55
Cary (GPD/Unit)	78	82.8	89	98.3	122
Morrisville (GPD/Unit)	76	81.3	87	96.5	120

Commercial Demands

A review of data from 2013 through 2016 was performed to select the median unit factors for COM accounts. For these accounts, the distribution of water use is important, as a few accounts use significant amounts of water. This was captured in the probabilistic approach, with the distribution of usage shown in Appendix C. The variables listed in Table 2-11 were selected using the following information:

- 5th percentile—assumed to be no less than half the median value for 2013–2016.
- 50th percentile—based on the average 50th percentile GPD/ft^2 for all COM accounts for the 2013–2016 period.

- 95th percentile—equals the average 90th percentile for the 2013–2016 period.

Table 2-11. Commercial Unit Demand Factors
For the Towns of Cary and Morrisville, average day

Commercial	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile
Cary (GPD/ft^2)	0.03	0.04	0.06	0.11	0.32
Morrisville (GPD/ft^2)	0.025	0.03	0.05	0.10	0.36

Industrial Demands

A review of data from 2013 through 2016 was performed to select the median unit factors for IND accounts. For these accounts, the distribution of water use is important, as a few accounts use significant amounts of water and the average account usage is therefore skewed. This is depicted in Appendix C. The variables listed in Table 2-12 were selected using the following information:

- 5th percentile—assumed to be no less than half the median value.
- 50th percentile—calculated based on Industrial customer demand per total square footage for the year 2016.
- 95th percentile—based on the annual average GPD/ft^2 for all Industrial accounts for the period from 2013 to 2016.

Table 2-12. Industrial Unit Demand Factors
For the Towns of Cary and Morrisville, Average Day

Industrial	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile
Cary (GPC/ft^2)	0.02	0.03	0.04	0.08	0.27
Morrisville (GPD/ft^2)	0.01	0.012	0.02	0.05	0.27

Institutional Demands

A review of data from 2013 through 2016 was performed to select the median unit factors for INS accounts. The variables listed in Table 2-13 were selected using the following information:

- 5th percentile—assumed to be no less than half the median value.
- 50th percentile—calculated based on Institutional customer demand per total square footage for the year 2016.
- 95th percentile—based on the annual average GPD/ft^2 for all Institutional accounts for the period from 2013 to 2016.

Table 2-13. Institutional Unit Demand Factors
For the Towns of Cary and Morrisville, Average Day

Institutional	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile
Cary (GPD/ft^2)	0.015	0.02	0.03	0.05	0.11
Morrisville (GPD/ft^2)	0.015	0.02	0.03	0.05	0.11

Reclaimed Water Demands

The Town requires separate meters for in-ground irrigation systems, and those within the Town's reclaimed water service areas are required to use reclaimed water to meet this demand. In addition, a portion of the Town's commercial, industrial, and institutional customers uses reclaimed water to meet cooling water demands.

Metered Irrigation for Separately Metered Residences, Reclaimed Water

A review of data from 2013 through 2016 shows that in general, the outdoor demand for irrigation systems for residential customers is independent of whether that customer uses potable or reclaimed water, even though there are fewer restrictions on reclaimed water use. Therefore, the residential reclaimed water unit factor demand employed in the simulation is the same as that used for separately metered potable irrigation systems. The variables listed in Table 2-14 were selected using the following information:

- 5th percentile—based on the irrigation demand for SFR residences with a separately metered irrigation meter constructed before 2010 for the period from 2013 to 2016.
- 50th percentile—equals the annual average GPD/DU for the population of SFR residences with a separately metered irrigation system for the period from 2013 to 2016.
- 95th percentile—equals the 75th percentile for separately metered irrigation for SFR residences constructed after 2010 for the period from 2013 to 2016.

Table 2-14. Single-Family Residential Separately Metered Reclaimed Water Irrigation Sub-unit Demand Factors
For the Towns of Cary and Morrisville, Average Day Demands

SFR Metered Reclaimed Water Irrigation	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile
Cary (GPD/DU)	31	99.0	154	216.4	321
Morrisville (GPD/DU)	29	92.0	143	201.1	299

Percent of Future SFR accounts with Separate Reclaimed Water Irrigation Meters

A review of data from 2013-2016 also shows that residential customers with access to reclaimed water tended to install irrigation systems at the same rate as customers without access to reclaimed water who irrigate with potable water. The variables listed in Table 2-15 were selected using the following information:

- 5th percentile—assumed minimum level of separately metered irrigation accounts.
- 50th percentile—equals the percent of SFR residence constructed after 2010 with separately metered irrigation accounts (as of 2016).
- 95th percentile—equals the percent of SFR residence constructed between 2001 and 2010 with separately metered irrigation accounts (CH2M, 2010).

Table 2-15. Percent of Separately Metered Single-family Residential Reclaimed Water Irrigation Accounts with New Construction
For the Towns of Cary and Morrisville

Percent of SFR with Metered Irrigation	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile
Cary and Morrisville	5%	8.7%	13%	19.5%	35%

Reclaimed Water Demand by Commercial, Industrial, and Institutional Customers

Due to limitations in historical reclaimed water demand records for ICI customers, there is not a single reclaimed water unit demand factor for these customers. In lieu of a unit demand factor, a multiplying factor which estimates reclaimed water demand based on potable water demand for ICI customers within reclaimed water service areas was determined based on a review of data from 2013 through 2016. For ICI customers within the Town of Cary service area, this factor is 0.227, and for ICI customers within the RTP South service area, it is 0.276.

Development Rates

Table 2-16 describes the percentage of the 2045 allocation by assigned current (2015) development status as discussed in the GIS technical memorandum. If the parcel is developing-permitted, it is assumed to be developed by 2025. If the parcel was developed in the 2045 Capacity Allocation, then it was assigned 100 percent. Any parcel not developed in the 2045 allocation was assumed to reach full capacity in 2065 and development was scaled linearly from 2045 to 2065.

Table 2-16. Development Rates by Assigned Parcel Development Status
Includes All Accounts from the Towns of Cary and Morrisville

Development Status	2016	2025	2030	2035	2040	2045
Vacant—Existing	0%	8%	30%	60%	80%	100%
Underdeveloped	0%	8%	35%	60%	80%	100%
Developing—Permitted	0%	100%	100%	100%	100%	100%
Developing	0%	60%	100%	100%	100%	100%
Existing—BWOS	0%	8%	35%	60%	80%	100%
Existing—New	0%	100%	100%	100%	100%	100%

BWOS: Built without service

These development rates were also included as a probabilistic variable. This variable was applied to all customer types and development statuses in rate table, across all forecast years as listed in Table 2-17.

Table 2-17. Development Variability
Includes All Accounts from the Towns of Cary and Morrisville

5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile
-30%	-12%	0%	12%	30%

2.4.2.2 Step 2: Water System Factors

In addition to customer demands, water usage includes non-revenue water and that used during the treatment process. Non-revenue water represents the portion of the water produced at the Cary/Apex WTF but not billed. Components of this factor include water lost to system leaks, hydrant flushing, metered flushing, and fire flows.

Non-revenue Water

Non-revenue water is a highly variable factor, reflecting day-to-day operations. A summary of historical non-revenue water is included as Table 3-12 in the 2017 Water Use Analysis (CH2M, 2017). A non-revenue water of 7 percent was used as the 50th percentile of the forecast variable based on Town data, with a low of 4.0 percent used as the 5th percentile and high of 10.3 percent used as the 95th percentile.

This value was used to support the calculation of total water distributed from total water demand. Table 2-18 shows the variability applied to this value in the probabilistic forecast.

Table 2-18. Non-revenue Water Percent Variation
For the Town of Cary

5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile
4.0%	5.8%	7.0%	8.2%	10.3%

Process Loss Factor

Using data from 2010 through 2016, the median process loss factor at the WTP is 1.17. Data to support this factor are included in Table 2-19. This value supports the calculation of raw water demand from the projection of total treated water distributed for both the annual average day forecast and the maximum day forecast.

Table 2-19. Cary/Apex WTF Process Water Usage
For the Town of Cary Only

Year	Cary's Raw Water from Jordan Lake (MGD)	WTP Finished Water (MGD)	WTP Process Water (MGD)	Process Loss Factor
2010	17.30	14.20	3.10	1.22
2011	16.90	14.50	2.40	1.17
2012	15.90	13.60	2.30	1.17
2013	15.30	13.40	1.90	1.14
2014	15.70	14.00	1.70	1.12
2015	17.40	14.80	2.60	1.18
2016	18.00	14.80	3.20	1.22

With this range of data, a variation approach was developed for the probabilistic forecast (Table 2-20).

Table 2-20. Process Loss Factor Variation Table
For the Cary/Apex WTF

5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile
1.09	1.14	1.17	1.21	1.30

2.4.2.3 Step 3: Calculating Maximum Day Water Demands

Maximum Day Peaking Factor

Maximum day increases in demand above annual average day demands are driven primarily by outdoor water use. Therefore, weather variability influences the maximum day water use. In 2018, it was recognized that the Town has seen in a decrease in outdoor water use and the installation of separately metered irrigation systems. Lot sizes are also decreasing, further reducing outdoor water demands. The maximum day peaking factor is used to calculate the maximum day forecast from the annual average day forecast.

In discussions with the Town, it was determined that the most appropriate timeframe to use was 2010–2017 (Table 2-21). The median peaking factor during this period is 1.53. This value was used in the 2018 forecast. The maximum day peaking factor variation evaluation is included in Appendix C, and probabilistic variables selected from this dataset are listed in Table 2-22.

Table 2-21. Maximum Day to Average Day Peaking Factors
For the Town of Cary Only

Year	Average Day Demands (MGD)	Maximum Day Demands (MGD)	Peaking Factor
2010	14.18	23.72	1.67
2011	14.56	23.22	1.59
2012	13.64	23.73	1.74
2013	13.46	19.28	1.43
2014	13.98	20.93	1.50
2015	14.76	21.63	1.47
2016	14.95	20.15	1.35
2017	15.60	23.30	1.50

Table 2-22. Maximum Day Peaking Factor Variation
For the Town of Cary Only, Using Data from 2010 to 2017

5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile
1.37	1.46	1.53	1.62	1.77

Maximum Month Average Day Peaking Factor

For the purposes of calculating interbasin transfer, a peaking factor from average day to maximum month average day water demands was calculated. This factor is built from finished water production at the WTP for the time period from 2010 through 2016, as shown in Table 2-23.

Table 2-23. Maximum Month Average Day Peaking Factor
Using Cary/Apex WTF Finished Water Data

Year	Water Production Maximum Month Average Day Factor
2010	1.27
2011	1.33
2012	1.26
2013	1.21
2014	1.23
2015	1.21
2016	1.18
Average	**1.24**

Water Conservation Factor Variation

Water conservation in the Town through both active and passive means is discussed in the water use analysis technical memorandum (CH2M, 2017). The Town expects that its water use behavior trends will continue to follow national trends, with per capita residential use declining over time. Actions such as home appliance replacement with newer models that are more water efficient is expected to continue. These reductions are also expected to be seen in the commercial and institutional water service customer categories. Therefore, a water conservation variable was added to the 2018 LRWRP Update. Expected reductions are listed in Table 2-24. These values were applied to all customer types except for IND. The same methodology was applied to the forecast for the Town of Apex (Appendix A).

Table 2-24. Water Conservation Factor Values
For all Customers Except IND

Percentile	2025	2030	2035	2040	2045	2065
5th	3%	6%	8%	10%	12%	16%
50th	1%	1%	2%	3%	4%	6%
95th	0%	1%	1%	2%	2%	4%

2.4.2.4 Step 4: Calculating Wholesale Customer Demands

Raleigh-Durham International Airport

The Town of Cary currently holds a 0.4-MGD contract to provide potable water to RDU Airport. RDU Airport drafted a Vision 2040 Master Plan in 2015 (Ricando & Associates, 2015), and water supply projections were included in the *Triangle Regional Water Supply Plan* (Triangle J COG, 2014). This airport was not split out as a line item in the Town’s Jordan Lake Round 4 application, which was developed prior to the airport’s 2015 master plan. The airport is expecting to grow by adding both more flights per day and by handling larger airplanes. Both factors will lead to higher daily passenger counts and higher corresponding water usage. Selected water demand projections are included in Table 2-25.

Table 2-25. RDU Airport Water Demand Forecast
Average Day Demand

Year	2016	2025	2045	2065
Demand (GPD)	300,000	317,800	400,000	482,000

Wake County Portion of RTP South

Potable water demands for the Wake County portion of RTP South are growing. Not only does the area have opportunity for development, but it also has the opportunity to add significant water users. This opportunity was incorporated into a raw water forecast as shown in Table 2-26 (NCDEQ, 2017). WTP process water and non-revenue water values were removed to arrive at the finished water demands listed in Table 2-26 and used in the forecast methodology. Information was taken from Round 4 of the Jordan Lake Allocation process (NCDEQ, 2017). These values do not include reclaimed water usage in RTP South.

Table 2-26. RTP South Water Demand Forecast
Average Day Demand

Year	2016	2025	2045	2065
Raw Water (GPD)	—	1,900,000	3,200,000	3,350,000
Finished Water (GPD)	496,000	1,500,000	2,600,000	2,750,000

2.5 Wastewater Flow Projections Methodology

The expected wastewater flow is built from the calculated water demands and flow data at the water reclamation facilities (WRFs). The LRWRP Forecasting Tool organizes the Existing Meters list and Future Parcels list by the WRF's basin in which they are located. Once the non-consumptive potable water demand (this excludes consumptive usage such as irrigation usage and non-revenue water) is calculated, these values are multiplied in the Excel Forecasting Tool by the percent return of their respective WRF to calculate wastewater flow as depicted in the following formula for each year of the planning period:

$$\text{Wastewater flow}_{\text{WRF, N}} = (\text{Water Demand}_{\text{WRF, N}} \times \%\ \text{Wastewater Return}_{\text{WRF}})$$

The "WRF" represents each treatment facility, and the "N" represents each year in the planning period for which projections were made. This average day wastewater flow is then multiplied by the respective maximum month peaking factor for each WRF to calculate maximum month average day wastewater flow.

The percent returns and maximum month peaking factors for each of the WRFs, shown in Table 2-27, were reported in the water use analysis technical memorandum (CH2M, 2017). The Town of Cary operates the North and South Cary WRFs and shares ownership of the WWRWRF with the Town of Apex. In 2013, the WWRWRF was not yet in operation.

Table 2-27. Water Reclamation Facility Percent Returns and Maximum Month Peaking Factors
For the Town of Cary Facilities

Water Reclamation Facility	Percent Return	Maximum Month Peaking Factor
North Cary WRF	122	1.10
South Cary WRF	132	1.17
Western Wake Regional WRF	103	1.14

The Town provided a diagram of sewer subbasins and flowmeter locations and how they flow to each WRF. This diagram, along with the sewer subbains GIS layer, was used to summarize projections. The diagram is included in Appendix E.

2.6 Interbasin Transfer Projections Methodology

The Towns of Cary and Apex hold an IBT certificate with the ability to transfer up to 33 MGD on a maximum month average day basis from the Haw River basin to the Neuse and Cape Fear River basins. The forecast methodology has a spatial component using meter locations, supporting the forecast of IBT by river basin. This methodology has been updated from that used in the 2013 LRWRP. The revised method focuses on the transfer of water across the basin boundary and is driven by water demands. This simplified approach is conservative as it does not account for water returned to the source basin or reclaimed water. Both values are currently minimal compared to the actual transfer. The revised methodology also assumes that the Apex WRF remains in operation, discharging to the Neuse River basin.

This projection uses the forecasted average day finished water demand delivered from the source basin to the receiving basin as well as a factor for nonrevenue water sent to the receiving basin and then multiplies the total by a maximum month average day factor according to the formula:

$$IBT_x \text{ to destination river basin} = [a_x + (a_x * b_x)] * c_x$$

Where

a_x = Average day finished water delivered to destination basin from source basin

b_x = Nonrevenue water factor (as a percentage)

c_x = Maximum month average day peaking factor

x = Given forecast year

2.7 Required Discharge Projections Methodology

As part of their IBT certificate, the Towns have a required discharge to the Cape Fear River basin. This metric is a calculation using average annual day finished water usage in the Neuse River basin and wastewater discharge to the Cape Fear River basin according to the formula:

$$\text{Required Discharge}_x = \text{Neuse Basin Demand (NBD)}_x - 9.7$$

Where

NBD = The 3-year running annual average daily amount for the 3 preceding years of all finished water supplied from sources within the Haw River and Cape Fear Basins, expressed in MGD, used by the Towns in the Neuse River Basin. Unbilled amounts of finished water use are to be quantified using procedures detailed in AWWA's M36 Water Audits and Loss Control Programs publication in effect as of 2017.

x = Given forecast year

This is currently achieved by the discharge of the WWRWRF but can also be met by other means. For the purposes of this evaluation, the projected average annual discharge from the WWRWRF was used in the calculation. For purposes of this calculation, the annual average daily amount of all such finished water for calendar year 2016 shall be 11.2 MGD. The Actual Discharge for 2016 shall be 4.9 MGD. Return wastewater discharges from the Cary/Apex WTF are not to be included in the calculation of Actual Discharge. The Required Discharge set for 2016 was 1.5 MGD and for 2017 was 1.7 MGD (Town of Cary, 2018).

2.8 Quality Assurance Process

With better data available now than there was for the 2013 evaluation, the probabilistic modeling approach and evaluation methodology was updated and improved from how it was conducted in the 2013 LRWRP (CH2M and Brown and Caldwell, 2013). The results were simulated for all years, 2016 through 2065, and the model output was checked against the most recent historical data, in this case 2016, to gage alignment before adjustments were made. This revised forecasting methodology is discussed further in the Revised Wastewater Flow Return Methodology Technical Memorandum included in Appendix D.

SECTION 3

Town of Cary Projections through 2065

The Town's future water demands were built from parcel-level planning information and water service customer types. Probabilistic forecasting results completed using Monte Carlo simulation via the @Risk model, an Excel-based tool, are summarized for the Town of Cary in this section. Tabular results through 2065 are presented for both the 50th and 75th percentile forecast values. Data presented for the start year of 2016 in all tables and figures are actual values as provided by the Town. The Town identified 2065 as the year in which it would likely reach its full capacity for development.

Projections for the combined service areas of the Towns of Cary and Apex are presented in Section 4. The Town of Apex's projections, based on input from Town of Apex staff and a different methodology than that used for the Town of Cary, are included in Appendix A.

3.1 Water Demand Projections

3.1.1 50th Percentile Water Demand Projections through 2065

The water demand forecast was first calibrated and built from the average annual finished water projections as land use planning information is the basis for the forecast. Therefore, these results are presented first. Annual average day finished water projections by customer type for the 50th percentile of the forecast are presented in Table 3-1. These data are also shown on Figure 3-1.

The two primary categories driving the water demand in the Town are SFR and COM customers. These two customer types are predicted to continue being the highest water users through the year 2065. Additionally, the Town is expecting a portion of its future development to include mixed uses as evident in Figure 3-1. SFR, MFR, and COM land uses comprise the demands listed under Mixed Use customer type. These components of the mixed use forecast are further described in Section 3.1.3.

Table 3-1. 50th Percentile Finished Water Demand Projections by Customer Type, 2016 to 2065, MGD, Annual Average Day

Includes the Town of Cary, Town of Morrisville, RTP South and RDU Airport

Customer Type	2016	2025	2030	2035	2040	2045	2065
Single-Family Residential	6.3	7.5	8.0	8.2	8.5	8.7	9.0
Multi-family Residential	2.8	3.2	3.2	3.2	3.1	3.1	3.3
Commercial	3.6	4.2	4.4	4.6	4.7	4.9	5.6
Industrial	0.3	0.9	1.0	1.2	1.4	1.6	1.6
Institutional	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Mixed Use	-	0.4	1.0	1.6	2.0	2.3	5.9
Sub-total Finished Water Demand	**13.3**	**16.5**	**17.9**	**19.1**	**20.0**	**20.9**	**25.7**
Non-revenue (Including Operational)	1.3	1.3	1.3	1.5	1.6	1.6	1.9
Total Annual Average Day Finished Water Demand	**14.6**	**17.8**	**19.2**	**20.6**	**21.6**	**22.5**	**27.6**

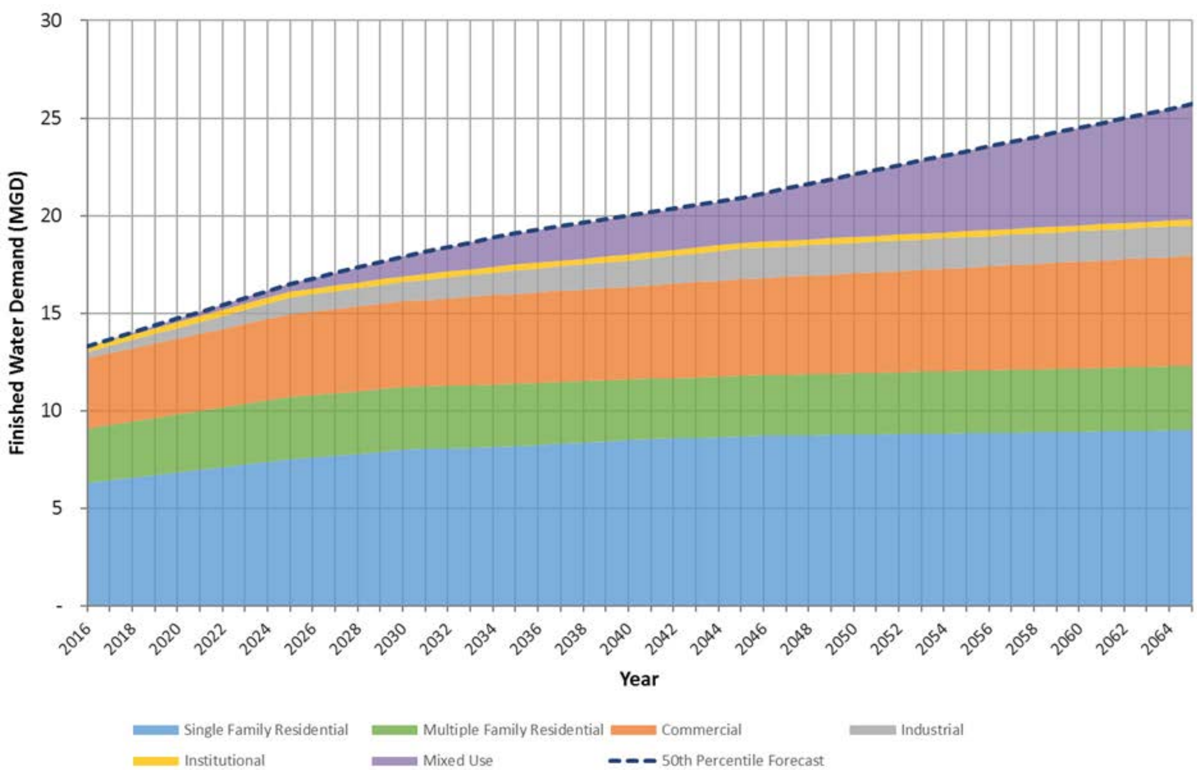

Figure 3-1. 50th Percentile Finished Water Demand Projections by Customer Type, Annual Average Day
Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

Table 3-2 summarizes the 50th percentile annual average day and maximum day finished and raw water demand projections by jurisdiction. Total water system demand is also shown to incorporate reclaimed water projections and provide a full picture of the Town's water uses and demands. Reclaimed water demands are further discussed in Section 3.2. The 50th percentile annual average day finished water demand projections are also presented by river basin in Table 3-3 and by pressure zone in Table 3-4.

Table 3-2. 50th Percentile Total Water Demand Projections by Jurisdiction, 2016 to 2065, MGD
Includes the Towns of Cary, Town of Morrisville, RTP South, and RDU Airport

	2016	2025	2030	2035	2040	2045	2065
Finished Water Demand by Jurisdiction							
Cary	10.7	12.6	13.5	14.2	14.7	15.3	19.1
Morrisville	1.8	2.1	2.3	2.5	2.6	2.7	3.4
RTP South	0.5	1.5	1.8	2.0	2.3	2.5	2.7
RDU	0.3	0.3	0.3	0.4	0.4	0.4	0.5
Non-revenue (Incl. Operational)	1.3	1.3	1.3	1.5	1.6	1.6	1.9
Total Annual Average Day Finished Water Demand	14.6	17.8	19.2	20.6	21.6	22.5	27.6
Maximum Day Finished Water Demand	20.2	27.2	29.5	31.6	33.1	34.6	42.1
Raw Water Demand							
WTP System Process Water	3.2	3.1	3.4	3.6	3.8	4.0	4.8
Annual Average Day Raw Water Demand	17.8	20.9	22.6	24.2	25.4	26.5	32.4
Maximum Day Raw Water Demand	24.4	32.1	34.7	37.2	39.0	40.8	49.7
Total Water Distributed							
Annual Average Day Reclaimed Water Demand	0.7	1.2	1.2	1.3	1.3	1.3	1.7
Annual Average Day Total Water Distributed	15.3	19.0	20.4	21.9	22.9	23.8	29.3
Maximum Day Reclaimed Water Demand	1.1	2.3	2.4	2.6	2.7	2.8	3.6
Maximum Day Total Water Distributed	21.3	29.5	31.9	34.2	35.8	37.4	45.7

Table 3-3. 50th Percentile Finished Water Demand Projections by River Basin, 2016 to 2065, MGD, Annual Average Day
Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

River Basin	2016	2025	2030	2035	2040	2045	2065
Neuse River	10.0	11.3	12.2	12.9	13.4	13.9	17.0
Haw River	3.3	5.2	5.7	6.2	6.6	7.0	8.7
Sub-total Finished Water Demand	**13.3**	**16.5**	**17.9**	**19.1**	**20.0**	**20.9**	**25.7**
Non-revenue (Incl. Operational)	1.3	1.3	1.3	1.5	1.6	1.6	1.9
Annual Average Day Finished Water Demand	**14.6**	**17.8**	**19.2**	**20.6**	**21.6**	**22.5**	**27.6**

Table 3-4. 50th Percentile Finished Water Demand Projections by Pressure Zone, 2016 to 2065, MGD, Annual Average Day
Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

Pressure Zone	2016	2025	2030	2035	2040	2045	2065
Central	9.1	10.9	11.7	12.3	12.8	13.2	16.3
Southern	0.5	0.6	0.7	0.8	0.8	0.9	0.9
Western	3.7	5.0	5.5	6.0	6.4	6.8	8.5
Sub-total Finished Water Demand	**13.3**	**16.5**	**17.9**	**19.1**	**20.0**	**20.9**	**25.7**
Non-revenue (Incl. Operational)	1.3	1.3	1.3	1.5	1.6	1.6	1.9
Annual Average Day Finished Water Demand	**14.6**	**17.8**	**19.2**	**20.6**	**21.6**	**22.5**	**27.6**

3.1.2 75th Percentile Water Demand Projections through 2065

The annual average day finished water demands for the 75th percentile forecast by water service customer type are summarized in Table 3-5.

Table 3-5. 75th Percentile Finished Water Demand Projections by Customer Type, 2016 to 2065, MGD, Annual Average Day
Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

Customer Type	2016	2025	2030	2035	2040	2045	2065
Single Family Residential	6.3	7.5	8.0	8.5	8.6	8.9	9.0
Multi-family Residential	2.8	3.2	3.2	3.2	3.2	3.2	3.3
Commercial	3.6	4.3	4.5	4.8	4.9	5.1	5.8
Industrial	0.3	0.9	1.1	1.2	1.5	1.6	1.7
Institutional	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Mixed Use	-	0.6	1.4	2.1	2.7	3.2	6.8
Sub-total Finished Water Demand	**13.3**	**16.8**	**18.5**	**20.1**	**21.2**	**22.3**	**26.9**
Non-revenue (Incl. Operational)	1.3	1.4	1.4	1.5	1.6	1.7	2.1
Annual Average Day Finished Water Demand	**14.6**	**18.2**	**19.9**	**21.6**	**22.8**	**24.0**	**29.0**

Table 3-6 summarizes the 75th percentile annual average day and maximum day finished and raw water demand projections by jurisdiction. Total water system demand is also shown to incorporate reclaimed water projections and provide a full picture of the Town's water uses and demands. Reclaimed water demands are further discussed in Section 3.2.

The 75th percentile water demand projections are presented by river basin in Table 3-7 and by pressure zone in Table 3-8. Detailed results by pressure zone are included in Appendix E.

Table 3-6. 75th Percentile Total Water Demand Projections by Jurisdiction, 2016 to 2065, MGD
Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

Jurisdiction	2016	2025	2030	2035	2040	2045	2065
Annual Average Day Finished Water Demand by Jurisdiction							
Cary	10.7	12.8	13.9	15.0	15.6	16.4	19.9
Morrisville	1.8	2.2	2.5	2.7	2.9	3.0	3.8
RTP South	0.5	1.5	1.8	2.0	2.3	2.5	2.7
RDU	0.3	0.3	0.3	0.4	0.4	0.4	0.5
Non-revenue (Incl. Operational)	1.3	1.4	1.4	1.5	1.6	1.7	2.1
Annual Average Day Finished Water Demand	14.6	18.2	19.9	21.6	22.8	24.0	29.0
Maximum Day Finished Water Demand	20.2	29.0	31.5	34.0	35.9	37.8	45.7
Raw Water Demand							
WTP System Process Water	3.2	3.6	3.9	4.1	4.3	4.5	5.5
Annual Average Day Raw Water Demand	17.8	21.8	23.8	25.7	27.1	28.5	34.5
Maximum Day Raw Water Demand	24.4	34.5	37.5	40.4	42.6	44.8	54.4
Total System Water Demand							
Annual Average Day Reclaimed Water Demand	0.7	1.2	1.3	1.3	1.4	1.5	1.8
Annual Average Total Water Distributed	15.3	19.4	21.2	22.9	24.2	25.5	30.8
Maximum Day Reclaimed Water Demand	1.1	2.4	2.6	2.8	2.9	3.1	3.9
Maximum Day Total Water Distributed	21.3	31.4	34.1	36.8	38.8	40.9	49.6

Table 3-7. 75th Percentile Finished Water Demand Projections by River Basin, 2016 to 2065, MGD, Annual Average Day
Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

River Basin	2016	2025	2030	2035	2040	2045	2065
Neuse River	10.0	11.5	12.6	13.6	14.3	14.9	17.8
Haw River	3.3	5.3	5.9	6.5	6.9	7.4	9.1
Sub-total Finished Water Demand	**13.3**	**16.8**	**18.5**	**20.1**	**21.2**	**22.3**	**26.9**
Non-revenue (Incl. Operational)	1.3	1.4	1.4	1.5	1.6	1.7	2.1
Annual Average Day Finished Water Demand	**14.6**	**18.2**	**19.9**	**21.6**	**22.8**	**24.0**	**29.0**

Table 3-8. 75th Percentile Finished Water Demand Projections by Pressure Zone, 2016 to 2065, MGD, Annual Average Day
Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

Pressure Zone	2016	2025	2030	2035	2040	2045	2065
Central	9.1	11.1	12.1	13.0	13.6	14.2	17.0
Southern	0.5	0.6	0.7	0.8	0.9	0.9	1.0
Western	3.7	5.1	5.7	6.3	6.7	7.2	8.9
Sub-total Finished Water Demand	**13.3**	**16.8**	**18.5**	**20.1**	**21.2**	**22.3**	**26.9**
Non-revenue (Incl. Operational)	1.3	1.4	1.4	1.5	1.6	1.7	2.1
Annual Average Day Finished Water Demand	**14.6**	**18.2**	**19.9**	**21.6**	**22.8**	**24.0**	**29.0**

Figures 3-2 and 3-3 display annual average day and maximum day finished water demand, respectively. Figures 3-4 and 3-5 display annual average day and maximum day raw water demand, respectively.

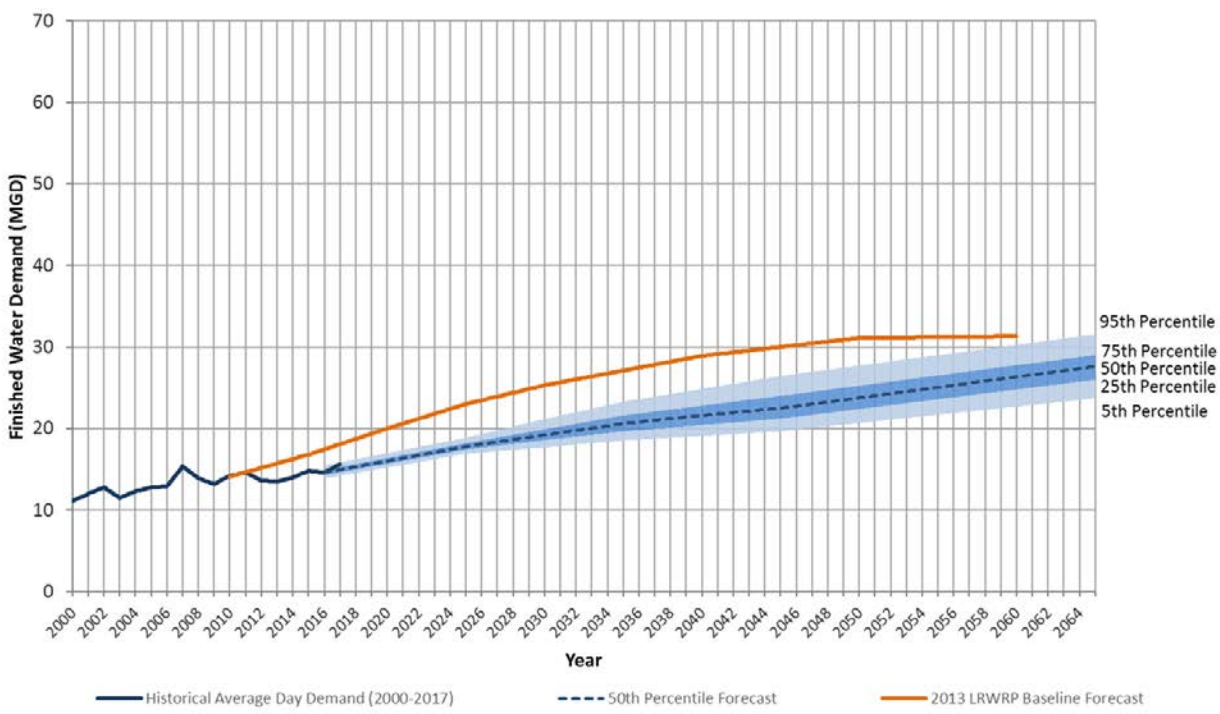

Figure 3-2. Annual Average Day Finished Water Demand Projections
Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

Figure 3-3. Maximum Day Finished Water Demand Projections
Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

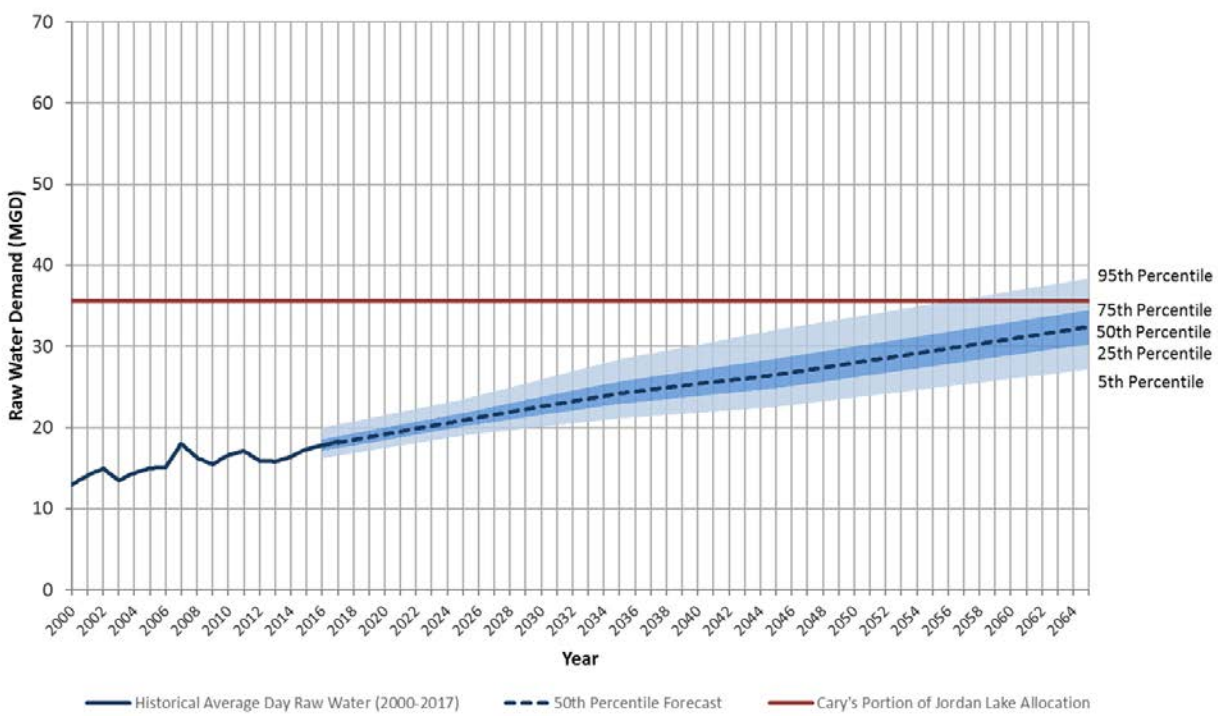

Figure 3-4. Annual Average Day Raw Water Demand Projections
Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

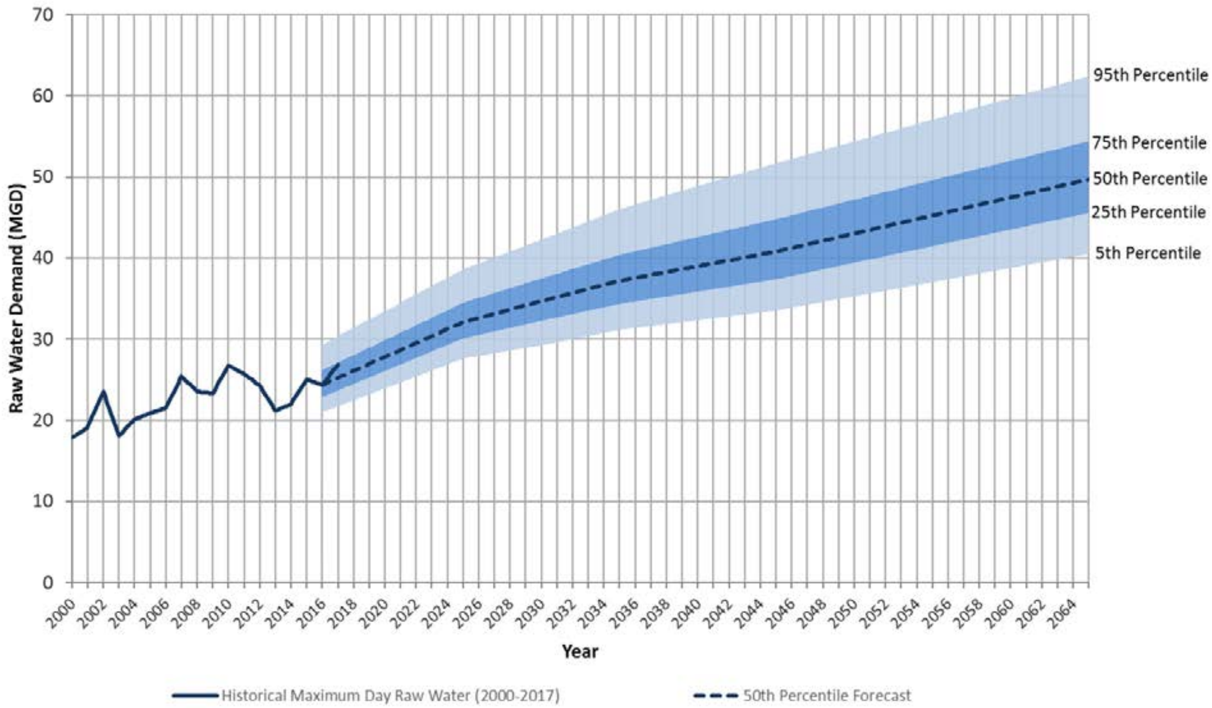

Figure 3-5. Maximum Day Raw Water Demand Projections
Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

3.1.3 Mixed Use Distribution

Mixed use developments, including projected combinations of SFR, MFR, and COM customer types, are predicted to increase into the year 2065. The largest uncertainty in the Town's forecast is with the mixed use customer type, as its combinations of SFR, MFR, and COM uses are predicted by the Town, and actual combinations and numbers of units may differ from current predictions as individual projects are planned and approved. Tables 3-9 and 3-10 present the annual average day mixed use finished water projections distribution for 50th and 75th percentile projections, respectively. These summarize how the demand from mixed use development is distributed in terms of the other customer types in the forecast. Mixed use was not a categorized customer type in 2016; therefore, current values are not provided.

Table 3-9. 50th Percentile Mixed Use Finished Water Demand Projections Distribution, 2016 to 2065, MGD, Annual Average Day

Includes the Town of Cary, Town of Morrisville, RTP South and RDU Airport

	2016	2025	2030	2035	2040	2045	2065
Mixed Use Finished Water Demand by Customer Type							
Mixed Use—SFR	-	0.2	0.4	0.6	0.8	0.9	1.0
Mixed Use—MFR	-	0.0	0.1	0.3	0.3	0.4	0.9
Mixed Use—COM	-	0.2	0.5	0.7	0.9	1.0	4.0
Total Mixed Use Finished Water Demand	-	0.4	1.0	1.6	2.0	2.3	5.9
Total Finished Water Demand							
Single-Family Residential	6.3	7.7	8.4	8.8	9.3	9.6	10.0
Multi-family Residential	2.8	3.2	3.3	3.5	3.4	3.5	4.2
Commercial	3.6	4.4	4.9	5.3	5.6	5.9	9.6
Industrial	0.3	0.9	1.0	1.2	1.4	1.6	1.6
Institutional	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Total Finished Water Demand (Not including Non-revenue Water)	13.3	16.5	17.9	19.1	20.0	20.9	25.7

Note: There are no industrial and institutional land uses expected within future mixed use development.

Table 3-10. 75th Percentile Mixed Use Finished Water Demand Projections Distribution, 2016 to 2065, MGD, Annual Average Day
Includes the Town of Cary, Town of Morrisville, RTP South and RDU Airport

	2016	2025	2030	2035	2040	2045	2065
Mixed Use Finished Water Demand by Customer Type							
Mixed Use—SFR	-	0.3	0.5	0.8	1.0	1.2	1.1
Mixed Use—MFR	-	0.1	0.2	0.3	0.4	0.5	1.0
Mixed Use—COM	-	0.2	0.7	1.0	1.3	1.5	4.7
Total Mixed Use Finished Water Demand	-	0.6	1.4	2.1	2.7	3.2	6.8
Total System Finished Water Demand							
Single-Family Residential	6.3	7.8	8.5	9.3	9.6	10.1	10.1
Multi-family Residential	2.8	3.3	3.4	3.5	3.6	3.7	4.3
Commercial	3.6	4.5	5.2	5.8	6.2	6.6	10.5
Industrial	0.3	0.9	1.1	1.2	1.5	1.6	1.7
Institutional	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Total Finished Water Demand (Not including Non-revenue Water)	13.3	16.8	18.5	20.1	21.2	22.3	26.9

Note: There are no industrial and institutional land uses expected within future mixed use development.

3.1.4 Irrigation Demands

The Town's irrigation demands have decreased since the 2013 LRWRP was completed (CH2M and Brown and Caldwell, 2013). For the years 2013 through 2016, there was relatively flat growth in separately metered irrigation accounts and an increase in irrigation account closures, a trend that is much different than what was observed from the data used in the 2010 Water Use Analysis (2001–2009 data set). In 2013, outdoor water demand assumptions were as follows:

- Outdoor unit demands for homes without an in-ground irrigation system = 16 percent of unit demand
- Irrigation unit demands for homes with an in-ground irrigation system = 54 percent of unit demand
- New homes that will have in-ground irrigation systems = 35 percent

These assumptions were revisited in the 2018 Water Use Analysis (CH2M, 2018). Since 2013, the Town has seen a decline in irrigation system installation. The installation rate is now 13 percent, and the same trend has been observed in the Town of Apex. Additionally, average new home lot sizes are smaller, which also leads to smaller per-household outdoor water demands in newer homes. This trend is expected to continue into the future, and the 2018 forecast methodology reflects this approach.

The portion of the Town's predicted annual average day future finished water demands attributable to SFR potable outdoor residential use, including both metered and estimated unmetered outdoor use, is presented in Table 3-11. As other land use types in the Town increase, SFR outdoor residential use becomes a smaller portion of the Town's total usage in 2065. In addition, it is expected that the Town's conservation programs are to stay in place, and this also contributes to an overall decline in outdoor usage as a portion of the total system demands.

Table 3-11. Single-Family Residential Outdoor Portion of Total Finished Water Demand, 2016 to 2065, Percent, Annual Average Day
Includes the Towns of Cary and Morrisville

Percentile	2016	2025	2030	2035	2040	2045	2065
50th	9.1%	7.7%	7.5%	7.4%	7.4%	7.3%	6.0%
75th	9.1%	7.7%	7.5%	7.5%	7.4%	7.4%	6.3%

3.2 Reclaimed Water Demand Projections

There are three reclaimed water service areas. The North service area is served by the North Cary WRF, the West service area is served by a connection with Durham County, and the South service area is served by South Cary WRF. A maximum day peaking factor of 2.5 is used throughout the forecast, with the exception of operational values which are not influenced by this. Usage at the NCWRF and SCWRF is not included. Tables 3-12 and 3-13 summarize the 75th percentile annual average day and maximum day reclaimed water demand, respectively. These projections assume that the reclaimed water system is expanded as described in the 2017 Reclaimed Water Master Plan Update Addendum (CDM Smith, 2017).

Table 3-12. 75th Percentile Total Reclaimed Water Demand Projections by Service Area, 2016 to 2065, MGD, Annual Average Day
Includes the Town of Cary, Town of Morrisville, and RTP South

Service Area	Use	2016	2025	2045	2065
North	Residential	0.05	0.09	0.18	0.25
	Cooling & ICI	0.11	0.12	0.17	0.19
	Operational	0.25	0.26	0.29	0.29
West	Residential	0.01	0.05	0.13	0.28
	Cooling & ICI	0.09	0.17	0.23	0.30
	Operational	0.01	0.02	0.04	0.07
South	Residential	0.01	0.02	0.03	0.04
	Cooling & ICI	0.09	0.09	0.14	0.15
	Operational	0.06	0.06	0.07	0.08
Total Reclaimed Water (Without Operational)		**0.36**	**0.54**	**0.88**	**1.21**
Total Reclaimed Water (Including Operational)		**0.68**	**0.88**	**1.28**	**1.65**

Table 3-13. 75th Percentile Total Reclaimed Water Demand Projections by Service Area, 2016 to 2065, MGD, Maximum Day
Includes the Town of Cary, Town of Morrisville, and RTP South

Service Area	Use	2016	2025	2045	2065
North	Residential	0.13	0.21	0.45	0.63
	Cooling & ICI	0.28	0.32	0.42	0.48
	Operational	0.25	0.26	0.29	0.29
West	Residential	0.02	0.14	0.32	0.69
	Cooling & ICI	0.22	0.42	0.57	0.75
	Operational	0.01	0.02	0.04	0.07
South	Residential	0.04	0.05	0.08	0.10
	Cooling & ICI	0.04	0.05	0.18	0.19
	Operational	0.06	0.06	0.07	0.08
Total Reclaimed Water (Without Operational)		**0.73**	**1.19**	**2.02**	**2.84**
Total Reclaimed Water (Including Operational)		**1.05**	**1.53**	**2.42**	**3.28**

3.3 Wastewater Demand Projections

Wastewater flow projections are calculated using the projected water demand and the historical percentage of wastewater returned from distributed finished water. The Town's currently permitted wastewater capacity is expected to be sufficient. The Town's flows to the WWRWRF facility are estimated using available meter data and its portion of capacity at the WWRWRF is used in this section.

3.3.1 50th Percentile Wastewater Demand Projections through 2065

The 50th percentile wastewater flow projections show that the Town may have sufficient wastewater treatment capacity through the planning period. Tables 3-14 and 3-15 summarize the 50th percentile annual average day and maximum month average day wastewater flow projections, respectively, by WRF.

Table 3-14. 50th Percentile Wastewater Flow Projections by Water Reclamation Facility, 2016 to 2065, MGD, Annual Average Day
Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

Jurisdiction	Permitted Capacity	2016	2025	2030	2035	2040	2045	2065
North Cary WRF	12.0	6.2	7.3	7.9	8.3	8.7	9.0	10.9
South Cary WRF	12.8	5.5	5.8	6.2	6.6	6.8	7.1	9.0
Western Wake Regional WRF	11.7	3.3	4.9	5.4	5.9	6.3	6.7	8.4
Total Flow	**38.0**	**15.0**	**18.0**	**19.5**	**20.8**	**21.8**	**22.8**	**28.3**

Note: Permitted wastewater capacity is a maximum month average day value.

Table 3-15. 50th Percentile Wastewater Flow Projections by Water Reclamation Facility, 2016 to 2065, MGD, Maximum Month Average Day
Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

Jurisdiction	Permitted Capacity	2016	2025	2030	2035	2040	2045	2065
North Cary WRF	12.0	7.3	8.1	8.6	9.2	9.5	9.9	12.0
South Cary WRF	12.8	6.5	6.7	7.2	7.7	8.0	8.3	10.5
Western Wake Regional WRF	11.7	3.8	5.6	6.2	6.7	7.2	7.6	9.6
Total Flow	**38.0**	**17.6**	**20.4**	**22.0**	**23.6**	**24.7**	**25.8**	**32.1**

3.3.2 75th Percentile Wastewater Demand Projections through 2065

The 75th percentile wastewater flow projections are calculated using the projected water demand and the historical percentage of wastewater returned from distributed finished water. Tables 3-16 and 3-17 summarize the 75th percentile annual average day and maximum month average day wastewater flow projections, respectively, by WRF.

Table 3-16. 75th Percentile Wastewater Flow Projections by Water Reclamation Facility, 2016 to 2065, MGD, Annual Average Day
Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

Jurisdiction	Permitted Capacity	2016	2025	2030	2035	2040	2045	2065
North Cary WRF	12.0	6.2	7.5	8.2	8.8	9.3	9.7	11.4
South Cary WRF	12.8	5.5	5.8	6.4	6.9	7.2	7.6	9.6
Western Wake Regional WRF	11.7	3.3	5.0	5.6	6.2	6.6	7.1	8.8
Total Flow	**38.0**	**15.0**	**18.3**	**20.2**	**21.9**	**23.1**	**24.4**	**29.8**

Note: Permitted wastewater capacity is a maximum month average day value.

Table 3-17. 75th Percentile Wastewater Flow Projections by Water Reclamation Facility, 2016 to 2065, MGD, Maximum Month Average Day
Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

Jurisdiction	Permitted Capacity	2016	2025	2030	2035	2040	2045	2065
North Cary WRF	12.0	7.3	8.3	9.0	9.7	10.2	10.6	12.5
South Cary WRF	12.8	6.5	6.8	7.5	8.1	8.5	8.9	11.3
Western Wake Regional WRF	11.7	3.8	5.7	6.4	7.0	7.5	8.1	10.0
Total Flow	**38.0**	**17.6**	**20.8**	**22.9**	**24.8**	**26.2**	**27.6**	**33.8**

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Combined Projections for Towns of Cary and Apex through 2065

Using the same probabilistic model approach, factors for the Towns of Cary and Apex were combined in the @Risk model to produce a combined projection forecast through 2065. The Town of Apex forecast and a description of the factors used in development are included in Appendix A. The methodology used for the Town of Apex was based on projected population growth, given that the primary land use in Apex is residential, and that is not expected to change during the planning period.

4.1 Water Demand Projections

The Cary/Apex WTF was expanded as part of the water resources strategy included in the 2013 LRWRP to a capacity of 56 MGD. The Town of Cary's portion of this capacity is 43.1 MGD and the Town of Apex owns 12.9 MGD. Projections included in this section indicate that additional capacity may be needed before the Town reaches its full capacity for development.

4.1.1 50th Percentile Water Demand Projections through 2065

Table 4-1 summarizes the 50th percentile annual average day and maximum day finished and raw water demand projections by jurisdiction. The 50th percentile annual average day finished water demand projections are presented by river basin in Table 4-2.

Table 4-1. 50th Percentile Total Water Demand Projections by Jurisdiction, 2016 to 2065, MGD
Includes the Towns of Cary, Morrisville, and Apex; RTP South; and RDU Airport

	2016	2025	2030	2035	2040	2045	2065
Finished Water Demand by Service Area							
Cary	13.3	16.5	17.9	19.1	20.0	20.9	25.7
Apex	3.1	4.9	5.9	6.8	7.7	8.5	8.8
Sub-total Billed Water Demand	16.4	21.4	23.8	25.9	27.7	29.4	34.5
Cary Non-revenue (Incl. Operational)	1.3	1.3	1.3	1.5	1.6	1.6	1.9
Apex Non-revenue (Incl. Operational)	0.5	0.6	0.8	0.9	1.0	1.1	1.2
Annual Average Day Finished Water Demand	**18.2**	**23.3**	**25.9**	**28.3**	**30.3**	**32.1**	**37.6**
Cary Maximum Day Finished Water	20.2	27.2	29.5	31.6	33.1	34.6	42.1
Apex Maximum Day Finished Water	5.2	8.8	10.6	12.2	13.8	15.3	15.9
Maximum Day Finished Water Demand	**25.4**	**36.0**	**40.1**	**43.8**	**46.9**	**49.9**	**58.0**
Raw Water Demand							
WTP System Annual Average Day Process Water	4.0	4.0	4.5	4.9	5.2	5.6	6.5
Annual Average Day Raw Water Demand	**22.2**	**27.3**	**30.4**	**33.2**	**35.5**	**37.7**	**44.1**
WTP System Maximum Day Process Water	4.7	6.7	7.4	8.3	8.9	9.6	11.1
Maximum Day Raw Water Demand	**30.1**	**42.7**	**47.5**	**52.1**	**55.8**	**59.5**	**69.1**

Table 4-2. 50th Percentile Finished Water Demand Projections by River Basin, 2016 to 2065, MGD, Annual Average Day

Includes the Towns of Cary, Morrisville, and Apex; RTP South; and RDU

River Basin	2016	2025	2030	2035	2040	2045	2065
Neuse River Basin							
Cary	10.0	11.3	12.2	12.9	13.4	13.9	17.0
Apex	1.0	1.3	1.5	1.6	1.6	1.7	1.7
Sub-total Neuse River	11.0	12.6	13.7	14.5	15.0	15.6	18.7
Haw River Basin							
Cary	3.3	5.2	5.7	6.2	6.6	7.0	8.7
Apex	1.9	3.3	3.9	4.3	4.8	5.2	5.4
Sub-total Haw River	5.2	8.5	9.6	10.5	11.4	12.2	14.1
Cape Fear River							
Apex	0.2	0.3	0.5	0.9	1.3	1.6	1.7
Sub-total Cape Fear River	0.2	0.3	0.5	0.9	1.3	1.6	1.7
Sub-total Billed Water Demand	**16.4**	**21.4**	**23.8**	**25.9**	**27.7**	**29.4**	**34.5**
Total Annual Average Day Finished Water Demand							
Cary Non-revenue (Incl. Operational)	1.3	1.3	1.3	1.5	1.6	1.6	1.9
Apex Non-revenue (Incl. Operational)	0.5	0.6	0.8	0.9	1.0	1.1	1.2
Annual Average Day Finished Water Demand	**18.2**	**23.3**	**25.9**	**28.3**	**30.3**	**32.1**	**37.6**

4.1.2 75th Percentile Water Demand Projections through 2065

Table 4-3 summarizes the 75th percentile annual average day and maximum day finished and raw water demand projections by jurisdiction. The 75th percentile annual average day finished water demand projections are presented by river basin in Table 4-4.

Table 4-3. 75th Percentile Total Water Demand Projections by Jurisdiction, 2016 to 2065, MGD
Includes the Towns of Cary, Morrisville, and Apex; RTP South; and RDU

	2016	**2025**	**2030**	**2035**	**2040**	**2045**	**2065**
Finished Water Demand by Service Area							
Cary	13.3	16.8	18.5	20.1	21.2	22.3	26.9
Apex	3.1	5.7	6.9	8.0	9.1	10.1	10.4
Sub-total Billed Water Demand	16.4	22.5	25.4	28.1	30.3	32.4	37.3
Cary Non-revenue (Incl. Operational)	1.3	1.4	1.4	1.5	1.6	1.7	2.1
Apex Non-revenue (Incl. Operational)	0.5	0.8	1.0	1.1	1.3	1.4	1.5
Annual Average Day Finished Water Demand	**18.2**	**24.7**	**27.8**	**30.7**	**33.2**	**35.5**	**40.9**
Cary Maximum Day Finished Water	20.2	29.0	31.5	34.0	35.9	37.8	45.7
Apex Maximum Day Finished Water	5.2	10.2	12.4	14.5	16.5	18.2	18.9
Maximum Day Finished Water Demand	**25.4**	**39.2**	**43.9**	**48.5**	**52.4**	**56.0**	**64.6**
Raw Water Demand							
WTP System Annual Average Day Process Water	4.0	5.0	5.6	6.2	6.6	7.0	8.1
Annual Average Day Raw Water Demand	**22.2**	**29.7**	**33.4**	**36.9**	**39.8**	**42.5**	**49.0**
WTP System Maximum Day Process Water	4.7	6.6	7.5	8.1	8.5	9.1	10.5
Maximum Day Raw Water Demand	**30.1**	**45.8**	**51.4**	**56.6**	**60.9**	**65.1**	**75.1**

Table 4-4. 75th Percentile Finished Water Demand Projections by River Basin, 2016 to 2065, MGD, Annual Average Day

Includes the Towns of Cary, Morrisville, and Apex; RTP South; and RDU

River Basin	2016	2025	2030	2035	2040	2045	2065
Neuse River Basin							
Cary	10.0	11.5	12.6	13.6	14.3	14.9	17.8
Apex	1.0	1.6	1.7	1.8	1.9	2.0	1.9
Sub-total Neuse River	11.0	13.1	14.3	15.4	16.2	16.9	19.7
Haw River Basin							
Cary	3.3	5.3	5.9	6.5	6.9	7.4	9.1
Apex	1.9	3.8	4.5	5.0	5.5	6.0	5.9
Sub-total Haw River	5.2	9.1	10.4	11.5	12.4	13.4	15.0
Cape Fear River Basin							
Apex	0.2	0.3	0.7	1.2	1.7	2.1	2.6
Sub-total Cape Fear River	0.2	0.3	0.7	1.2	1.7	2.1	2.6
Total Annual Average Day Finished Water Demand							
Sub-total Billed Water Demand	**16.4**	**22.5**	**25.4**	**28.1**	**30.3**	**32.4**	**37.3**
Cary Non-revenue (Incl. Operational)	1.3	1.4	1.4	1.5	1.6	1.7	2.1
Apex Non-revenue (Incl. Operational)	0.5	0.8	1.0	1.1	1.3	1.4	1.5
Annual Average Day Finished Water Demand	**18.2**	**24.7**	**27.8**	**30.7**	**33.2**	**35.5**	**40.9**

Figures 4-1 and 4-2 display annual average day and maximum day finished water demand, respectively. Figures 4-3 and 4-4 display annual average day and maximum day raw water demand, respectively.

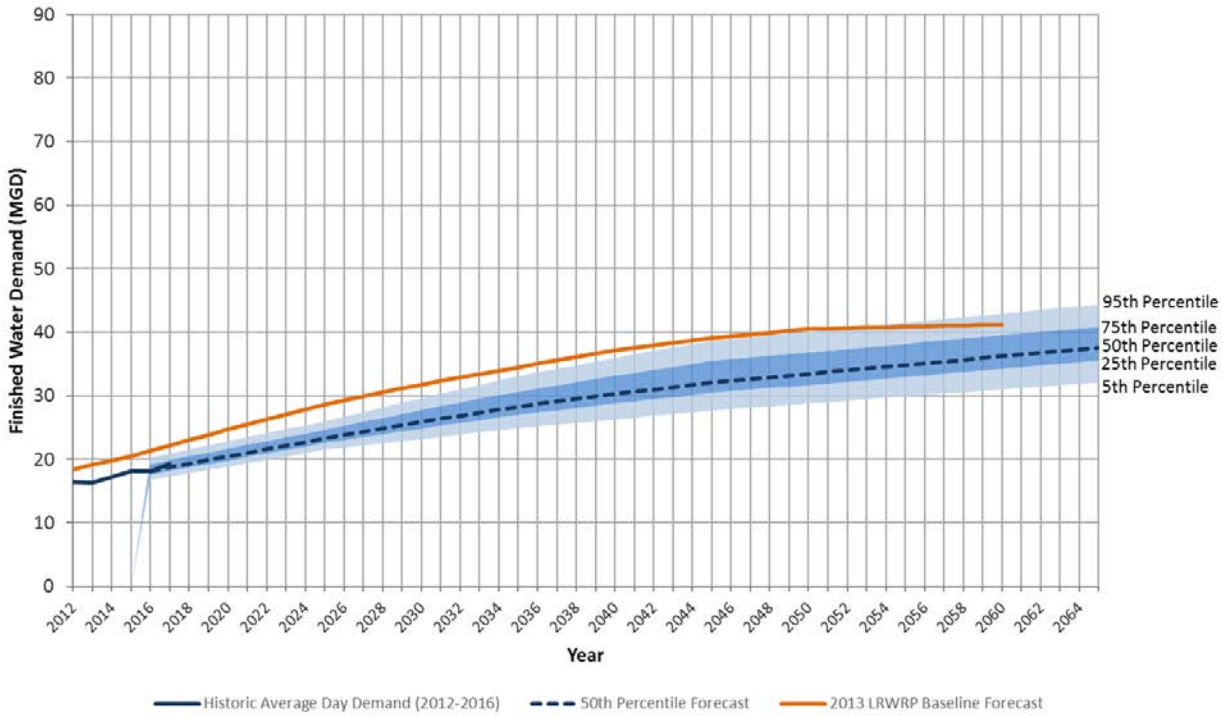

Figure 4-1. Annual Average Day Finished Water Demand Projections
Includes the Towns of Cary, Morrisville, and Apex; RTP South; and RDU

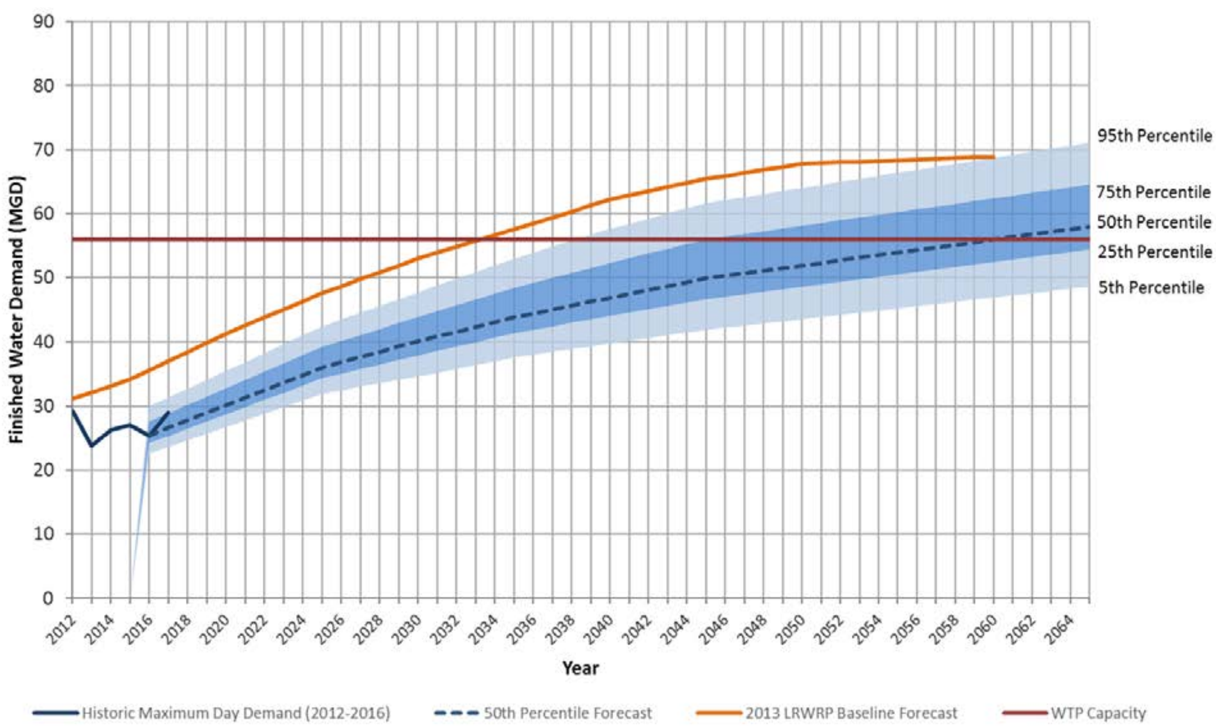

Figure 4-2. Maximum Day Finished Water Demand Projections
Includes the Towns of Cary, Morrisville, and Apex; RTP South; and RDU

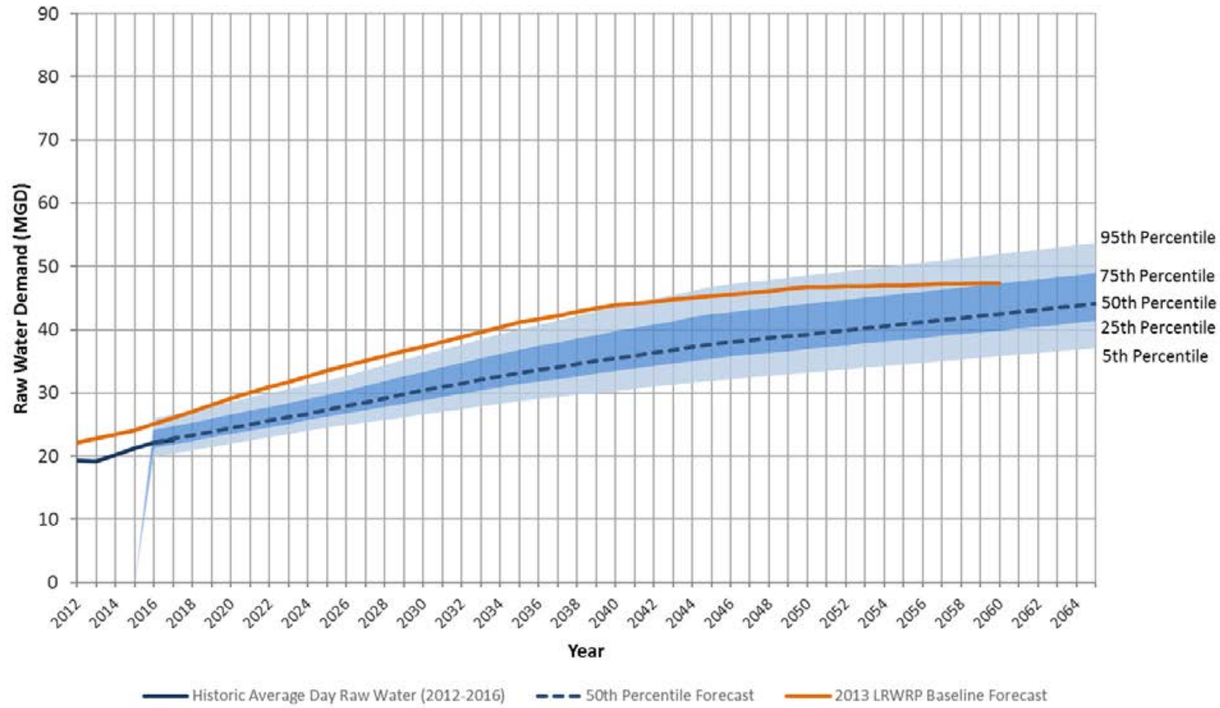

Figure 4-3. Annual Average Day Raw Water Demand Projections
Includes the Towns of Cary, Morrisville, and Apex; RTP South; and RDU

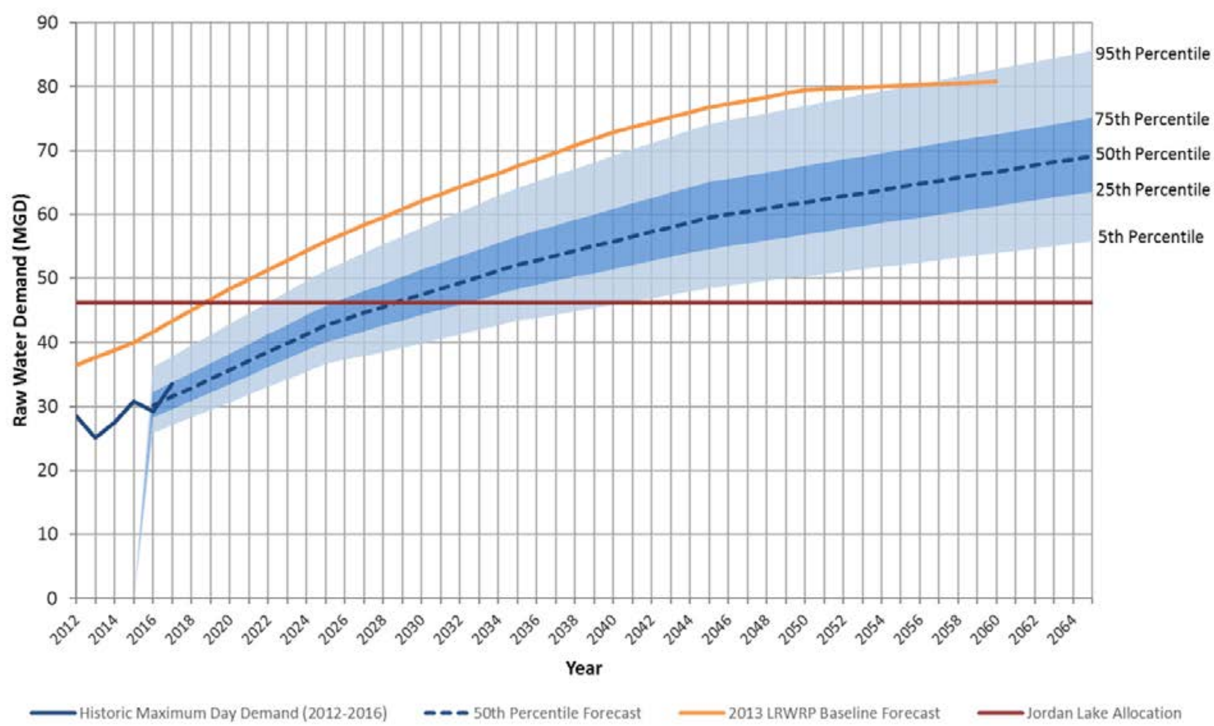

Figure 4-4. Maximum Day Raw Water Demand Projections
Includes the Towns of Cary, Morrisville, and Apex; RTP South; and RDU

4.2 Reclaimed Water Demand Projections through 2065

The Town of Apex does not currently have a reclaimed water program. It is assumed that a program will not begin with the timeframe of evaluation for this study. Therefore, reclaimed water projections presented for the Town of Cary's service area, in Section 3.2.1 for 50th percentile projections and Section 3.2.2 for 75th percentile projections, are the total reclaimed water projections for the combined towns' service areas.

4.3 Wastewater Demand Projections

Wastewater projections are presented along with each facility's currently permitted discharge amount, a maximum month average day value. The Town's NCWRF and SCWRF are expected to exceed 80 percent capacity during the planning period for both the 50th and 75th percentile projections. The NCWRF is also expected to exceed 90 percent capacity for both the 50th and 75th percentile projections, and the permitted capacity would be exceeded during the 75th percentile projections. The Apex WRF is expected to have sufficient capacity throughout the planning period. However, the expected growth in the Town of Apex's WWRWRF service area may lead to the need for additional capacity or an adjustment in the current capacity share agreement.

4.3.1 50th Percentile Wastewater Demand Projections through 2065

The wastewater flow projections are calculated using the projected finished water demand and the historical percentage of wastewater returned to each treatment facility. Tables 4-5 and 4-6 summarize the 50th percentile annual average day and maximum month average day wastewater flow projections, respectively, by WRF. Detailed tables summarizing projections by sewer subbasin are included in Appendix E.

Table 4-5. 50th Percentile Wastewater Flow Projections by Water Reclamation Facility, 2016 to 2065, MGD, Annual Average Day

Includes the Towns of Cary, Morrisville, and Apex; RTP South; and RDU

Jurisdiction	Permitted Discharge	2016	2025	2030	2035	2040	2045	2065
NCWRF	12.0	6.2	7.3	7.8	8.3	8.7	9.0	10.6
SCWRF	12.8	5.5	5.8	6.2	6.6	6.8	7.1	9.0
Apex WRF	3.6	0.8	1.0	1.1	1.1	1.2	1.2	1.2
WWRWRF Total	18.0	5.5	8.2	9.5	10.8	11.9	13.0	15.0
WWRWRF—Cary	11.7	3.3	4.9	5.4	5.9	6.3	6.7	8.4
WWRWRF—Apex	6.3	2.2	3.3	4.1	4.9	5.6	6.3	6.6
Total Flow	**47.9**	**18.0**	**22.3**	**24.6**	**26.8**	**28.6**	**30.3**	**35.8**

Note: Permitted discharge is a maximum month average day value.

Table 4-6. 50th Percentile Wastewater Flow Projections by Water Reclamation Facility, 2016 to 2065, MGD, Maximum Month Average Day

Includes the Towns of Cary, Morrisville, and Apex; RTP South; and RDU

Jurisdiction	Permitted Discharge	2016	2025	2030	2035	2040	2045	2065
NCWRF	12.0	7.3	8.0	8.6	9.2	9.5	9.9	11.7
SCWRF	12.8	6.5	6.7	7.2	7.7	8.0	8.3	10.5
Apex WRF	3.6	0.9	1.1	1.2	1.3	1.3	1.4	1.4
WWRWRF Total	18.0	6.3	9.4	10.9	12.3	13.6	14.8	17.1
WWRWRF—Cary	11.7	3.8	5.6	6.2	6.7	7.2	7.6	9.6
WWRWRF—Apex	6.3	2.5	3.8	4.7	5.6	6.4	7.2	7.5
Total Flow	**47.9**	**21.0**	**25.2**	**27.9**	**30.5**	**32.4**	**34.4**	**40.7**

4.3.2 75th Percentile Wastewater Demand Projections through 2065

The 75th percentile wastewater flow projections are calculated using the projected finished water demand and the historical percentage of wastewater returned to each treatment facility. Tables 4-7 and 4-8 summarize the 75th percentile annual average day and maximum month average day wastewater flow projections, respectively, by WRF.

Table 4-7. 75th Percentile Wastewater Flow Projections by Water Reclamation Facility, 2016 to 2065, MGD, Annual Average Day

Includes the Towns of Cary, Morrisville, and Apex; RTP South; and RDU

Jurisdiction	Permitted Discharge	2016	2025	2030	2035	2040	2045	2065
NCWRF	12.0	6.2	7.5	8.2	8.8	9.2	9.7	11.3
SCWRF	12.8	5.5	5.8	6.4	6.9	7.2	7.6	9.6
Apex WRF	3.6	0.8	1.2	1.3	1.4	1.4	1.5	1.5
WWRWRF Total	18.0	5.5	9.1	10.6	12.2	13.5	14.8	16.9
WWRWRF—Cary	11.7	3.3	5.0	5.6	6.2	6.6	7.1	8.8
WWRWRF—Apex	6.3	2.2	4.1	5.0	6.0	6.9	7.7	8.1
Total Flow	47.9	**18.0**	**23.6**	**26.5**	**29.3**	**31.3**	**33.6**	**39.3**

Note: Permitted discharge is a maximum month average day value.

Table 4-8. 75th Percentile Wastewater Flow Projections by Water Reclamation Facility, 2016 to 2065, MGD, Maximum Month Average Day

Includes the Towns of Cary, Morrisville, and Apex; RTP South; and RDU

Jurisdiction	Permitted Discharge	2016	2025	2030	2035	2040	2045	2065
NCWRF	12.0	7.3	8.2	9.0	9.7	10.2	10.6	12.4
SCWRF	12.8	6.5	6.8	7.5	8.1	8.5	8.9	11.3
Apex WRF	3.6	0.9	1.4	1.5	1.6	1.7	1.7	1.7
WWRWRF Total	18.0	6.3	10.4	12.2	13.9	15.4	17.0	19.3
WWRWRF—Cary	11.7	3.8	5.7	6.4	7.0	7.5	8.1	10.0
WWRWRF—Apex	6.3	2.5	4.7	5.8	6.9	7.9	8.9	9.3
Total Flow	**47.9**	**21.0**	**26.8**	**30.2**	**33.3**	**35.8**	**38.2**	**44.7**

4.4 Interbasin Transfer Projections

The Towns of Cary and Apex hold an IBT certificate with the ability to transfer up to 33 MGD on a maximum month average day basis from the Haw River basin to the Neuse and Cape Fear River basins. This total includes a 31 MGD transfer to the Neuse River basin and a 2 MGD transfer to the Cape Fear River basin.

Obtaining this increased IBT flexibility was one of the recommendations outlined in the 2013 LRWRP. This increase from the previous 24-MGD maximum day IBT amount provides the Towns with more flexibility as development and redevelopment occur throughout the Towns' service areas. Using the projections outlined in previous sections, IBT projections were made for the 25th, 50th, and 75th percentiles of the forecast. Total IBT and projected IBT by receiving basin are shown in Figures 4-5 through 4-7. This range of projections was used to demonstrate the potential variability in transfers, given the uncertainty of where and when development may occur.

IBT is driven by water demands. Conversions in water demands were made to predict transfers using the IBT statute's unit of compliance, the average day of a maximum month. Both finished water demands and nonrevenue water use are included in the projections. The maximum month transfer typically occurs in the summer, driven in part by outdoor water use. Transfers within the Town of Cary are expected to grow approximately 50 percent during the planning period, while transfers driven by Town of Apex water demands are expected to grow exponentially. The high rate of growth predicted in the Town of Apex, where more developable land is available, leads to more uncertainty around the forecasted transfer to the Cape Fear River. Growth there could lead to the need to revisit the Towns' transfer amount to the Cape Fear River.

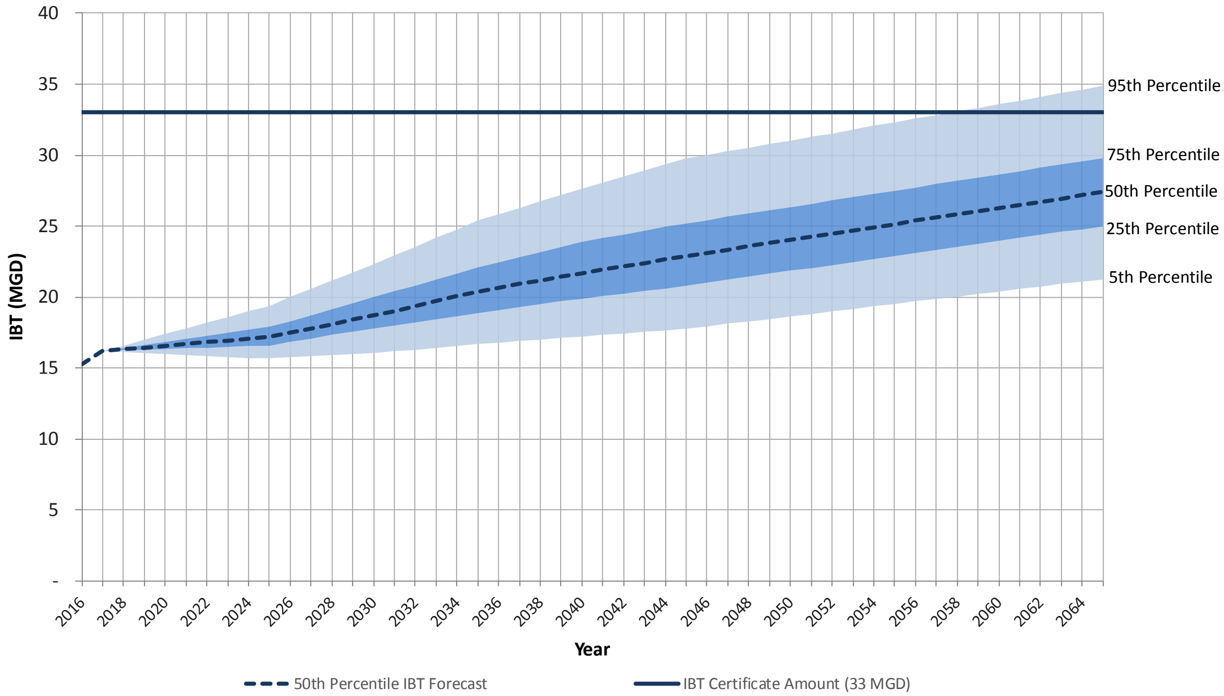

Figure 4-5. Total Interbasin Transfer Projections, Maximum Month Average Day
Includes the Towns of Cary, Morrisville, and Apex; RTP South; and RDU

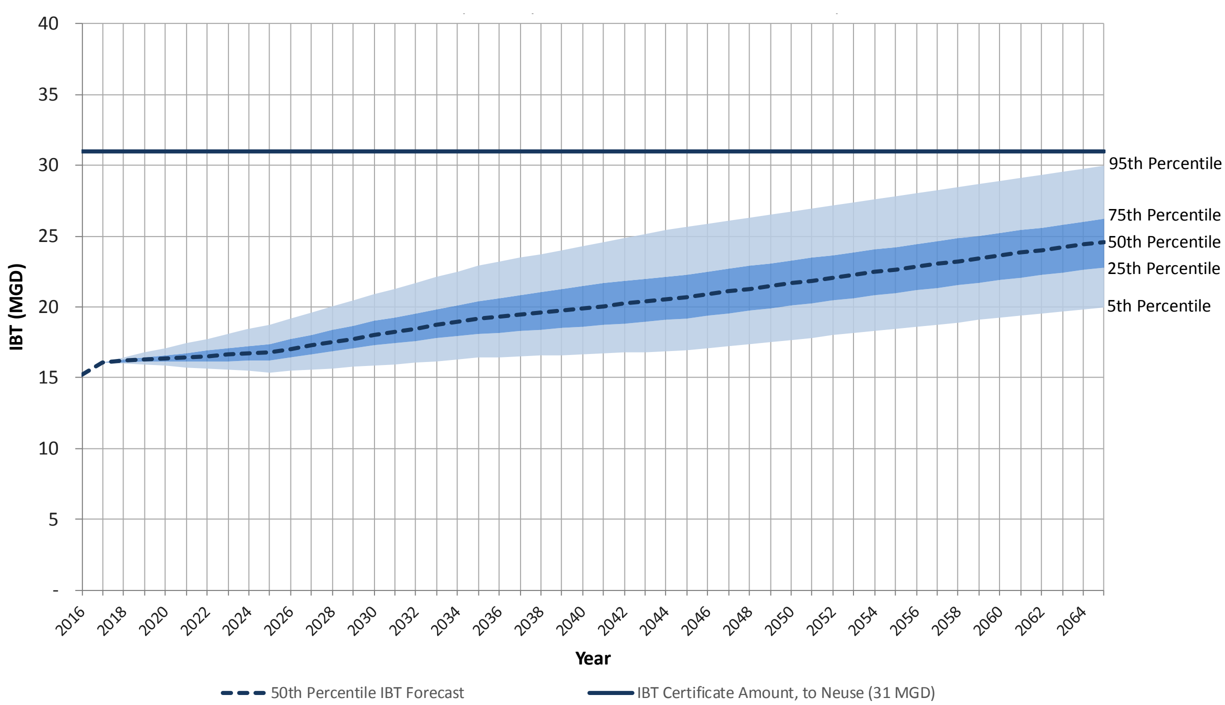

Figure 4-6. Interbasin Transfer to the Neuse River Basin Projections, Maximum Month Average Day
Includes the Towns of Cary, Morrisville, and Apex; RTP South; and RDU

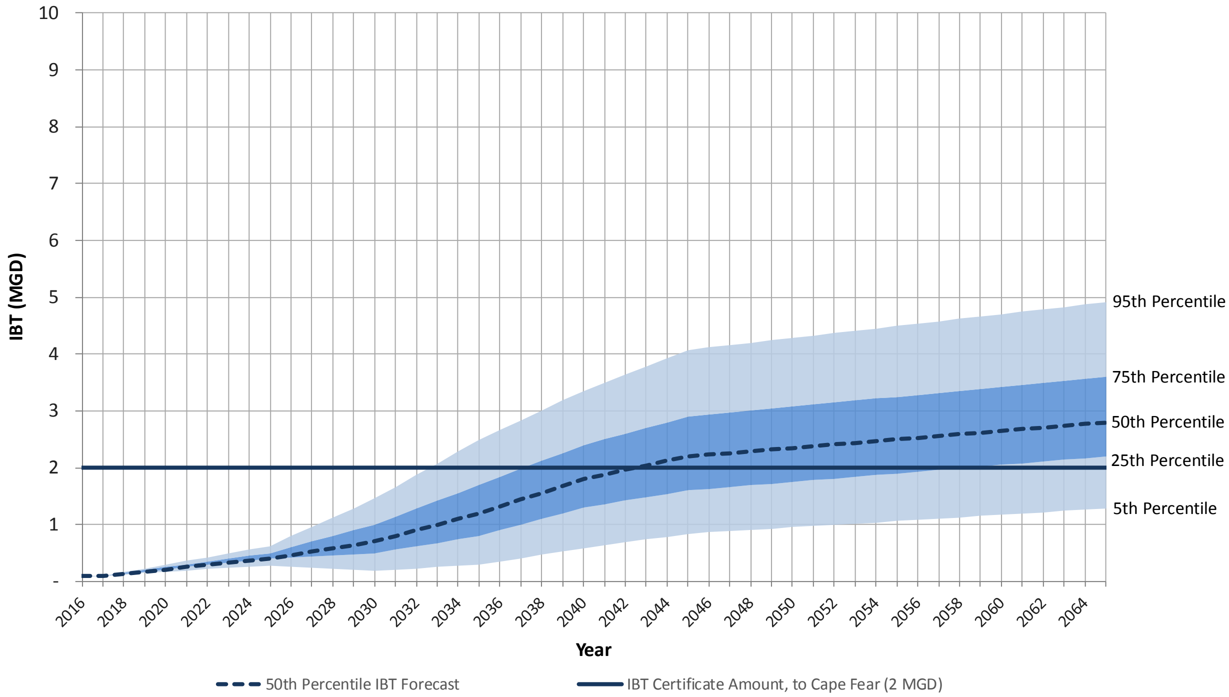

Figure 4-7. Interbasin Transfer to the Cape Fear River Basin Projections, Maximum Month Average Day

Includes the Towns of Cary, Morrisville, and Apex; RTP South; and RDU

4.4.1 25th Percentile Interbasin Transfer Projections through 2065

Table 4-9 summarizes the 25th percentile maximum month average day IBT projections for total IBT, transfer from the Haw to Neuse River basin and transfer from the Haw to Cape Fear River basin by jurisdiction, respectively. Calculated, not forecasted, values are included for 2016. The Towns currently do not calculate values by jurisdiction.

Table 4-9. 25th Percentile IBT Projections—Total by Jurisdiction and River Basin, 2016 to 2065, MGD, Maximum Month Average Day

Includes the Towns of Cary, Morrisville, and Apex; RTP South; and RDU

Jurisdiction	2016	2025	2030	2035	2040	2045	2065
Haw to Neuse River Basin							
Cary	—	14.8	15.7	16.4	16.9	17.4	21.0
Apex	—	1.4	1.6	1.7	1.7	1.8	1.8
Total IBT—Haw to Neuse	**15.2**	**16.2**	**17.3**	**18.1**	**18.6**	**19.2**	**22.8**
Haw to Cape Fear River Basin							
Cary	—	—	—	—	—	—	—
Apex	—	0.4	0.5	0.8	1.3	1.6	2.2
Total IBT—Haw to Cape Fear	**0.1**	**0.4**	**0.5**	**0.8**	**1.3**	**1.6**	**2.2**
Total IBT Forecast							
Cary	—	14.8	15.7	16.4	16.9	17.4	21.0
Apex	—	1.8	2.1	2.5	3.0	3.4	4.0
Total IBT from Haw	**15.3**	**16.6**	**17.8**	**18.9**	**19.9**	**20.8**	**25.0**

4.4.2 50th Percentile Interbasin Transfer Projections through 2065

Tables 4-10 and summarizes the 50th percentile maximum month average day IBT projections for the total IBT, transfer from the Haw to Neuse River basin, and transfer from the Haw to Cape Fear River basin by jurisdiction, respectively. Town calculated, not forecasted, values are included for 2016. The Towns currently do not calculate values by jurisdiction.

Table 4-10. 50th Percentile IBT Projections—Total by Jurisdiction and River Basin, 2016 to 2065, MGD, Maximum Month Average Day
Includes the Towns of Cary, Morrisville, and Apex; RTP South; and RDU

Jurisdiction	2016	2025	2030	2035	2040	2045	2065
Haw to Neuse River Basin							
Cary	—	15.1	16.2	17.3	17.9	18.6	22.6
Apex	—	1.7	1.8	1.9	2.0	2.1	2.0
Total IBT—Haw to Neuse	**15.2**	**16.8**	**18.0**	**19.2**	**19.9**	**20.7**	**24.6**
Haw to Cape Fear River Basin							
Cary	—	—	—	—	—	—	—
Apex	—	0.4	0.7	1.2	1.8	2.2	2.8
Total IBT—Haw to Cape Fear	**0.1**	**0.4**	**0.7**	**1.2**	**1.8**	**2.2**	**2.8**
Total IBT Forecast							
Cary	—	15.1	16.2	17.3	17.9	18.6	22.6
Apex	—	2.1	2.5	3.1	3.8	4.3	4.8
Total IBT from Haw	**15.3**	**17.2**	**18.7**	**20.4**	**21.7**	**22.9**	**27.4**

4.4.3 75th Percentile Interbasin Transfer Projections through 2065

Tables 4-11 summarizes the 75th percentile maximum month average day IBT projections the total IBT, transfer from the Haw to Neuse River basin, and transfer from the Haw to Cape Fear River basin by jurisdiction, respectively. Town calculated, not forecasted, values are included for 2016. The Towns currently do not calculate values by jurisdiction.

Table 4-11. 75th Percentile IBT Projections—Total by Jurisdiction and River Basin, 2016 to 2065, MGD, Maximum Month Average Day
Includes the Towns of Cary, Morrisville, and Apex; RTP South; and RDU

Jurisdiction	2016	2025	2030	2035	2040	2045	2065
Haw to Neuse River Basin							
Cary	—	15.5	16.9	18.1	19.1	19.8	23.8
Apex	—	1.9	2.1	2.3	2.4	2.5	2.4
Total IBT—Haw to Neuse	**15.2**	**17.4**	**19.0**	**20.4**	**21.5**	**22.3**	**26.2**
Haw to Cape Fear River Basin							
Cary	—	—	—	—	—	—	—
Apex	—	0.5	1.0	1.7	2.4	2.9	3.6
Total IBT—Haw to Cape Fear	**0.1**	**0.5**	**1.0**	**1.7**	**2.4**	**2.9**	**3.6**
Total IBT Forecast							
Cary	—	15.5	16.9	18.1	19.1	19.8	23.8
Apex	—	2.4	3.1	4.0	4.8	5.4	6.0
Total IBT from Haw	**15.3**	**17.9**	**20.0**	**22.1**	**23.9**	**25.2**	**29.8**

4.5 Required Discharge Projections

As part of their IBT certificate, the Towns have a required discharge to the Cape Fear River basin. This metric is a calculation using average annual day finished water usage in the Neuse River basin and wastewater discharge to the Cape Fear River basin. This is currently achieved by the discharge of the WWRWRF but can also be met by other means. For the purposes of this evaluation, the projected average annual discharge from the WWRWRF was used in the calculation. The Required Discharge set for 2016 was 1.5 MGD and for 2017 was 1.7 MGD (Town of Cary, 2018).

To capture the uncertainty associated with the location and rate of development and redevelopment, the 25th, 50th, and 75th percentiles of the forecast are included in Tables 4-12, 4-13, and 4-14, respectively. In all scenarios, the projected actual discharge from the WWRWRF is greater than the calculated required discharge. Therefore, the towns are expected to remain in compliance with this requirement.

Table 4-12. 25th Percentile Required Discharge Projections by Jurisdiction and Neuse River Basin, 2016 to 2065, MGD, Annual Average Day

Includes the Towns of Cary, Morrisville, and Apex; RTP South; and RDU

	2016	**2025**	**2030**	**2035**	**2040**	**2045**	**2065**
Neuse River Basin Finished Water Demands							
Cary	-	11.1	11.8	12.3	12.7	13.0	15.8
Apex	-	1.2	1.3	1.3	1.4	1.4	1.4
Non-revenue (Incl. Operational)	-	0.9	1.1	1.1	1.1	1.2	1.4
Total Neuse Finished Water Demand	**11.2**	**13.2**	**14.2**	**14.7**	**15.2**	**15.6**	**18.6**
Required Discharge to the Cape Fear River Basin							
Required Discharge	1.5	3.5	4.5	5.0	5.5	5.9	8.9
Actual Discharge to the Cape Fear River Basin							
WWRWRF Discharge—Cary	—	4.8	5.2	5.7	6.0	6.4	8.0
WWRWRF Discharge—Apex	—	2.7	3.3	3.9	4.5	5.0	5.2
Actual Discharge	**4.9**	**7.5**	**8.5**	**9.6**	**10.5**	**11.4**	**13.2**

Table 4-13. 50th Percentile Required Discharge Projections by Jurisdiction and Neuse River Basin, 2016 to 2065, MGD, Annual Average Day

Includes the Towns of Cary, Morrisville, and Apex; RTP South; and RDU

	2016	**2025**	**2030**	**2035**	**2040**	**2045**	**2065**
Neuse River Basin Finished Water Demands							
Cary	-	11.3	12.2	12.9	13.4	13.9	17.0
Apex	—	1.3	1.5	1.6	1.6	1.7	1.6
Non-revenue (Incl. operational)	-	1.1	1.1	1.2	1.3	1.3	1.5
Total Neuse Finished Water Demand	11.2	13.7	14.8	15.7	16.3	16.9	20.1
Required Discharge to the Cape Fear River Basin							
Required Discharge	1.5	4.0	5.1	6.0	6.6	7.2	10.4
Actual Discharge to the Cape Fear River Basin							
WWRWRF Discharge—Cary	-	4.9	5.4	5.9	6.3	6.7	8.4
WWRWRF Discharge—Apex	-	3.3	4.1	4.9	5.6	6.3	6.6
Actual Discharge	4.9	8.2	9.5	10.8	11.9	13.0	15.0

Table 4-14. 75th Percentile Required Discharge Projections by Jurisdiction and Neuse River Basin, 2016 to 2065, MGD, Annual Average Day

Includes the Towns of Cary, Morrisville, and Apex; RTP South; and RDU

	2016	2025	2030	2035	2040	2045	2065
Neuse River Basin Finished Water Demands							
Cary	-	11.5	12.6	13.6	14.3	14.9	17.8
Apex	—	1.6	1.7	1.8	1.9	2.0	1.9
Non-revenue (Incl. Operational)	-	1.2	1.2	1.3	1.3	1.4	1.7
Total Neuse Finished Water Demand	**11.2**	**14.3**	**15.5**	**16.7**	**17.5**	**18.3**	**21.4**
Required Discharge to the Cape Fear River Basin							
Required Discharge	1.5	4.6	5.8	7.0	7.8	8.6	11.7
Actual Required Discharge							
WWRWRF Discharge—Cary	-	5.0	5.6	6.2	6.6	7.1	8.8
WWRWRF Discharge—Apex	-	4.1	5.0	6.0	6.9	7.7	8.1
Actual Discharge	**4.9**	**9.1**	**10.6**	**12.2**	**13.5**	**14.8**	**16.9**

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Forecast Trends and Observations

5.1 Long-Range Planning Approach

The Town began the process of accounting for uncertainty in the process of estimating future water demands with the development of the 2013 LRWRP. This 2018 update followed the same approach, using probabilistic forecasting methodology built from the Town's expected land use projections and current water use patterns. These forecasts, as was documented in 2013, are only as accurate as the land use projections and historical demand and flow information from which they are derived. Moving forward, the Town intends to continue updating these forecasts at regular intervals so that demand trends and updated land use and development projections are incorporated. This supports the Town's approach to long-range planning for infrastructure needs and supports guiding assumptions used in the Town's detailed water, wastewater, and reclaimed water master plans.

This approach is increasingly important, as regional cooperation continues to play a role in water supply allocation and through agreements such as the one the Town holds with the Town of Apex. The Towns of Cary and Apex play an active role in the Jordan Lake Partnership and achieved an increase in water supply allocation during the Jordan Lake Round 4 Allocation process. In addition, the Towns achieved an increase in their IBT certificate.

In reviewing the historical water use in the period from 2010 to 2016, the Town has observed that water use has not grown at the rate predicted and has grown at different rates throughout the service areas. The Town made assumptions for the 2013 LRWRP that have been updated in 2018 based on more detailed advanced meter infrastructure water meter data (not available for the development of the 2013 LRWRP) and recently updated parcel-based land use projections. In developing these water demand projections and for those developed in the future, the following sources, among others, are available:

- Town of Cary Planning Department future land use plans, including assumptions related to capacity for development on parcels and opportunities for mixed use and redevelopment
- Town of Cary Engineering Department input on information related to submitted or approved site plans
- Water billing records, used in the development of unit water consumption factors for demand projections

Each of these data sources is regularly updated by its sponsoring departments as new data are compiled or conditions for development change. In specific locations, development may occur more or less quickly than currently projected or in a pattern different than that in the future land use plan. The actual future year water demands for the service area may differ substantially from the projections presented in this report if conditions upon which these projections are based change. Water use trends will continue to be monitored for changes; trends in water conservation, household appliance efficiency, and other factors, including variability in weather patterns, will influence unit consumption rates. The Town should monitor these water use trends to determine whether (and when) to adjust the demand projections.

5.2 Addressing Future Uncertainty

To account for uncertainty and to support planning efforts to maintain a reliable water supply and infrastructure capacity for water and wastewater treatment, it is recommended that the Town use the 75th percentile of the probabilistic forecast for planning purposes. This approach will be carried forward into the Water Resources Portfolio evaluation as the next step in the development of the 2018 LRWRP Update.

5.2.1 Town of Apex Land Use Planning

The Town of Apex is currently experiencing a high rate of growth. The high number of housing units approved by the Town but not yet built is captured in the forecast and predicted to be constructed by 2025. In addition, the Town is currently in the process of updating its land use plan. This level of detailed planning was not available for use in this 2018 LRWRP, and as a result the Town of Apex's future projections have a higher degree of uncertainty. The Towns should continue to monitor this rapid pace of growth and incorporate updated land use planning information into the next LRWRP update. The Town of Apex's portions of capacity in shared infrastructure between the towns may need updated as a result of this population growth. In addition to timing of growth, the location of growth should also be monitored. The Town's IBT to the Cape Fear River basin should be monitored closely.

The probabilistic forecast methodology and results presented herein show a relatively narrow cone of uncertainty, or in other words a smaller variation across the probabilistic distribution of future water demands than produced with the 2013 LRWRP. As a community approaches buildout, it is natural for this uncertainty to decrease, as there is less vacant area to develop. The town estimates that approximately 16 percent of its land remains vacant and developable, reducing uncertainty at a system-wide scale. At this point, focus begins shifting from new development of vacant areas to redevelopment of target areas, and uncertainty associated with the timing of redevelopment grows. Therefore, although reduced, the potential for population growth and changes in customer water use patterns should continue to be monitored.

5.2.2 Town of Cary Land Use Planning and Considerations for Redevelopment

5.2.2.1 Water Conservation and Efficiency

The town has an active water conservation program that promotes efficiency and valuation of water resources. This program, including ordinances to limit outdoor irrigation to 3 days per week and the establishment of a reclaimed water program, has had positive and lasting impacts on water consumption. In addition, continued improvements in water efficiency of household appliances and industrial processes has contributed to decreases in water consumption. These active and passive water conservation programs have been incorporated into the 2018 LRWRP Update. The continued benefits of these programs on customer use should be monitored for effectiveness.

5.2.2.2 Redevelopment

With less than 20 percent of the Town's land vacant, redevelopment and mixed use development will be a driving factor in the Town's future water use demands. The Cary 2040 Community Plan, adopted January 24, 2017, focuses on encouragement of redevelopment and infill efforts. Over the next 20 years, growth will shift from primarily new developments built on vacant land to revitalizing aging or poorly performing areas to mixed use centers (Town of Cary, 2017).

Both the pace and composition of mixed use developments are difficult to predict, as these factors can vary greatly from project to project. The probabilistic forecasting methodology presented in this report is used to project large-scale water demand for making capital improvement recommendations for interlocal agreements and major infrastructure decisions and timing. This approach does not focus on small-scale evaluations, such as determining the impact an individual project will have on a specific area of the system. A deterministic forecasting methodology based on customer type is more appropriate to project increased water demand from redevelopment.

The following two redevelopment scenarios illustrate how changes in customer type to mixed use may impact future water demand. The unit factor for each customer type predicted for mixed use developments was used to calculate future water demand in Tables 5-1 and 5-3. For the deterministic forecasting methodology, the median (50th percentile) unit factors and the assumptions used to determine them are included in Appendix C.

Village Square Commercial Center

One potential area for redevelopment is Village Square, located along Walnut Street between SE Maynard Road and Ryan Road. A hypothetical redevelopment scenario was evaluated in which the customer type was changed from single-family residential and commercial to multi-family residential with additional commercial square footage. The redevelopment scenario also includes property owned by the Town along SE Maynard Road between Village Square and East Cary Middle School, as well as four single-family residences on Mayodan Drive and five single-family residences on Ryan Road. The redevelopment scenario encompasses approximately 27 acres within the area shown on Figure 5-1 and includes the following:

- Demolition of the existing shopping center
- Construction of mixed use buildings to include:
  - 200,000 ft^2 of retail space
  - 200,000 ft^2 of commercial/office space
  - 400 multi-family residences
  - Parking decks
- Construction of 35 townhomes on Mayodan Drive and Ryan Road
- Construction of surfaced parking, internal roads, and stormwater infrastructure

Table 5-1 summarizes the potential for future water demand for the Village Square redevelopment scenario based on the number of units by customer type and their respective unit factors. Table 5-2 compares the 2016 existing demand of the project area to the future demand, showing an increase from 10,060 GPD to 62,715 GPD. This equates to a usage change ratio of 6.2.

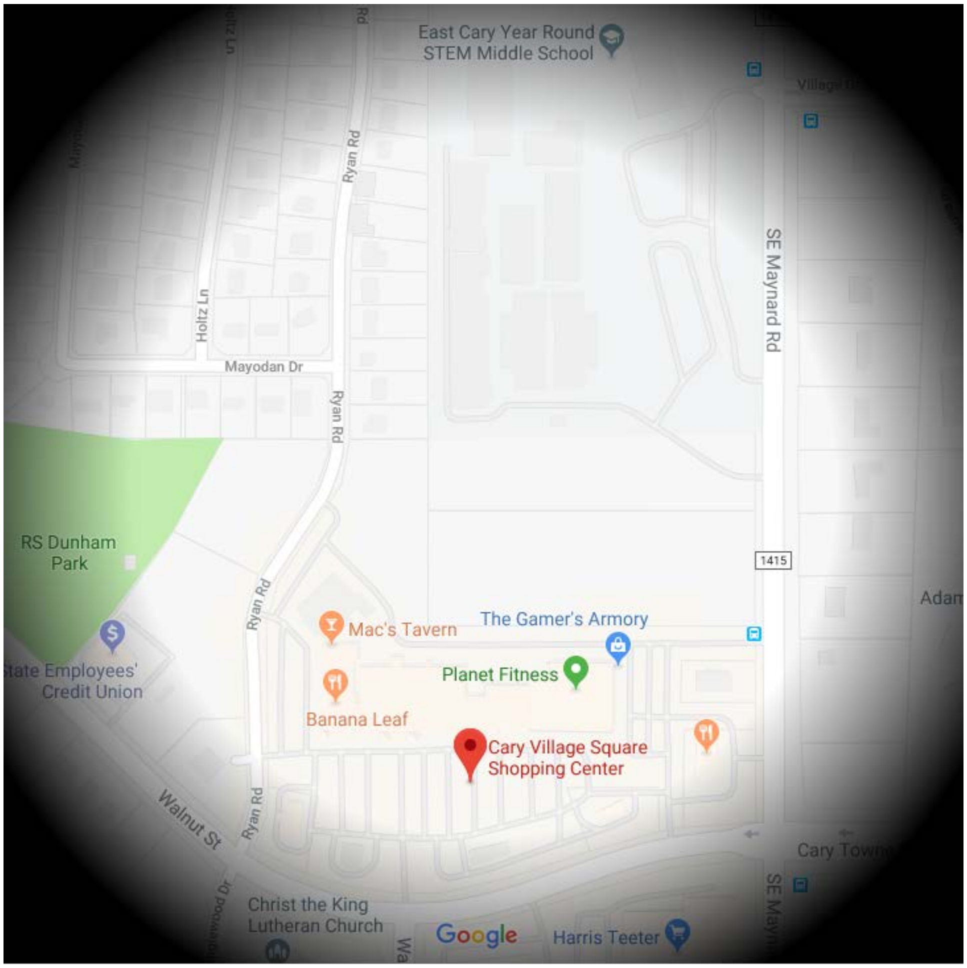

Figure 5-1. Village Square Redevelopment Project Area
Current site of Cary Village Square Shopping Center

Table 5-1. Village Square Redevelopment Potential Future Demand
Median (50th percentile) unit factors by customer type

Customer Type	Units	Unit Factor	Water Demand (GPD)
SFR (unit)	—	155	—
MFR (unit)	435	89	38,715
COM (ft^2)	400,000	0.06	24,000
IND (ft^2)	—	0.04	—
INS (ft^2)	—	0.03	—
Total	**—**	**—**	**62,715**

Table 5-2. Village Square Redevelopment Water Demand Summary
Usage change based on unit demand

Customer Type (Units)	2016 Existing		Future	
	Units	**Demand (GPD)**	**Units**	**Demand (GPD)**
SFR (count)	9	—	—	—
MFR (count)	—	—	435	38,715
COM (ft²)	146,500	—	400,000	24,000
IND (ft²)		—	—	—
INS (ft²)	—	—	—	—
Total	**—**	**10,060**	**—**	**62,715**
Usage Change Ratio		**6.2**		

Sorrell Street Townhomes

Sorrell Street redevelopment is an approved project which will convert single-family residences and vacant land to multi-family residences. Approved developments were assumed to be complete in the 2025 timestep of the projections. The property includes five parcels centered at 510 Sorrell Street. Single-family residences are located on two of the lots, while the remaining three lots are vacant and wooded. The redevelopment scenario includes construction of 58 townhomes, surfaced parking, and stormwater infrastructure. Around 2 acres will remain wooded. The total project area encompasses approximately 8 acres within the area shown on Figure 5-2.

Table 5-3 summarizes the potential future water demand for the Sorrell Street redevelopment scenario based on the units by customer type and their respective unit factors. Table 5-4 compares the 2016 existing demand of the project area to the future demand, showing an increase from 279 GPD to 5,162 GPD. This equates to a usage change ratio of 18.5.

Figure 5-2. Sorrell Street Redevelopment Project Area
Current site of single-family residences and vacant lots

Table 5-3. Sorrell Street Redevelopment Potential Future Demand
Median (50th percentile) unit factors by customer type

Customer Type	Units	Unit Factor	Water Demand (GPD)
SFR (unit)	—	155	—
MFR (unit)	58	89	5,162
COM (ft^2)	—	0.06	—
IND (ft^2)	—	0.04	—
INS (ft^2)	—	0.03	—
Total	**—**	**—**	**5,162**

Table 5-4. Sorrell Street Redevelopment Water Demand Summary
Usage change based on unit demand.

Customer Type (Units)	2016 Existing		Future	
	Units	**Demand (GPD)**	**Units**	**Demand (GPD)**
SFR (count)	2	279	—	—
MFR (count)	—	—	58	5,162
COM (ft^2)	—	—	—	—
IND (ft^2)	—	—	—	—
INS (ft^2)	—	—	—	—
Total	**—**	**279**	**—**	**5,162**
Usage Change Ratio	**18.5**			

These examples show how unique change is to each redevelopment project, as the usage change ratio for these two examples ranges from 6.2 to 18.5. This is directly related to the large-scale mixed use customer type portion of the forecast as presented in Section 3.1.3. The combinations of customer subtypes are predicted by the Town and actual combinations and numbers of units may differ from current predictions. Therefore, this accounts for the largest uncertainty in the forecast.

The Town's shift in strategy is not only driven by reduced amounts of vacant land, but also changing demographics as the Town is seeing an increase in young professionals, singles, couples without children, seniors, and empty-nesters. The Cary 2040 Community Plan emphasizes downtown, targeted locations (Eastern Cary Gateway, Downtown, Historic Carpenter, Green Level, Chatham County–Town of Cary Joint Planning Area), underperforming land and building assets, as well as vacant areas served by existing infrastructure. To support this, policies are proposed to provide the greatest variety of housing options in Commercial Mixed Use Centers and Employment Mixed Use Centers, as well as facilitating the redevelopment and revitalization of Downtown and the Town's aging or poorly performing commercial centers (Town of Cary, 2017).

With the Cary 2040 Community Plan's focus on redevelopment and infill, evaluations at this smaller scale will be important to determine potential impacts throughout the Town's system. The Cary Community Plan encourages development of new tools to guide design of redevelopment and infill projects, and the GIS tool developed as part of this project is one way the Town has a means to do this.

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Appendix A

Town of Apex Forecast

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TECHNICAL MEMORANDUM

Long Range Water Resources Plan Update: Town of Apex Projections

PREPARED FOR:	Town of Apex
DATE:	July 2018
PROJECT NUMBER:	418666

The Town of Cary has partnered with CH2M HILL North Carolina, Inc. (CH2M) to update the 2013 Long Range Water Resources Plan (LRWRP). The effort began with an analysis of customer water usage and water system patterns using the most recent 5 years of its comprehensive collection of system data and customer billing information. The Towns of Cary and Apex jointly own the Cary/Apex Water Treatment Plant (WTP), share wastewater treatment capacity at the Western Wake Regional Water Reclamation Facility (WWRWRF), and share an interbasin transfer (IBT) certificate. Hence, any consideration of future water and wastewater projections for the Town of Cary should also consider projections for the Town of Apex. This technical memorandum describes the methodology and presents the forecast for the Town of Apex through 2065.

The Town of Apex's (Town) utility service area, as it was defined in 2016, and data provided by the Town through a series of meetings in early 2018 and data provided in April of 2018 were used as the basis for this update (Town of Apex, 2018a and 2018b). The following projections are included:

- Water demands including raw water and finished water
- Wastewater flows

These projections provide a basis on which to evaluate the ability of the Towns' water supply and infrastructure capacity to meet existing and future demands. These programs are incorporated into this forecast. These projections, along with the Towns' combined forecasts for IBT and required discharge, will also be used to evaluate the potential of water resources portfolio alternatives to meet projected demands, as was conducted for the 2013 LRWRP.

Forecasting Approach

A probabilistic modeling approach was used - Monte Carlo simulation supports a large number of simulations run in random quantities for uncertain variables and looking at the distribution of results to infer which values are most likely. This method provides the ability to incorporate uncertainty into the development of a water demand forecast, as well as understand the variability in the potential forecast outcomes. Each of the variables used in the forecast development is described, and their incorporation into the model simulation process shows the extreme possibilities along with possible outcomes for middle-of-the-road (or 50^{th} percentile) scenarios.

The Town of Apex elected to use a population-based probabilistic forecast for projections through 2065. To align with the Town of Cary's forecast, key years are 2025, 2045, and 2065. The Town of Apex is currently seeing a significant rate of residential growth, with over 8,000 approved housing units to be built in the near future (pers. comm., Matt Echols, 2018a). Therefore, the Town of Apex's projections do not align well with the results of the regional planning information newly available from the Triangle J Council of Government (Triangle J COG) which was the basis for the 2045 timestep in the Town of Cary's forecast (Triangle J COG, 2018). The Town is also predicting that the growth rate will be steepest from now until 2025, slow slightly to 2045, and then begin to level off between 2045 and 2065.

Data show that the Town has had a steady to slightly declining per capita use rate and it is expected that the Town will remain primarily a residential community with commercial and institutional growth supporting the residential population. Therefore, this approach driven by population and per capita usage rate is appropriate for the Town of Apex.

Forecasting Methodology

An Excel Forecasting Tool using the @Risk model to run Monte Carlo simulations was used, incorporating water use statistics such as unit factors to develop the probabilistic forecast. A series of variables were included. These variables are described in Attachment A and include:

- Population variation by river basin
- Unit factor for total billed gallons per capita per day (GPCD)
- Non-revenue water
- Maximum day peaking factor – water
- Process loss factor – water
- Water conservation rate
- Wastewater percent return
- Maximum month average day peaking factor – wastewater

Data provided by the Town of Apex on April 5, 2018 and used to support these variables is included as Attachment B (Town of Apex, 2018a).

Forecasting Results

The Town's forecasts for average day and maximum day finished water demands are shown in Figures 1 and 2, respectively. These charts include the baseline forecast from 2013 for the Town of Apex, depicted in orange for reference and comparison purposes. Results for the 50th percentile of the probabilistic forecast for water are presented in Table 1. Results for the 75th percentile forecast are in Table 2.

Corresponding wastewater projections for the 50th and 75th percentile forecasts are listed in Tables 3 and 4, respectively. Results presented for the WWRWRF are for the Town of Apex's flow projections only. The Town of Cary also owns a portion of the facility, which discharges to the Cape Fear River. The Middle Creek WRF discharges to the Neuse River basin. Corresponding results for the 75th percentile forecast are in Tables 3 and 4.

These results were then combined with the Town of Cary's forecast to create a total forecast for raw and finished water demands, wastewater flows, interbasin transfer, and required discharge. These results are included in the *2018 Long Range Water Resources Plan Update Forecast of Water Demands and Wastewater Flows Technical Memorandum* prepared for the Town of Cary (CH2M, 2018).

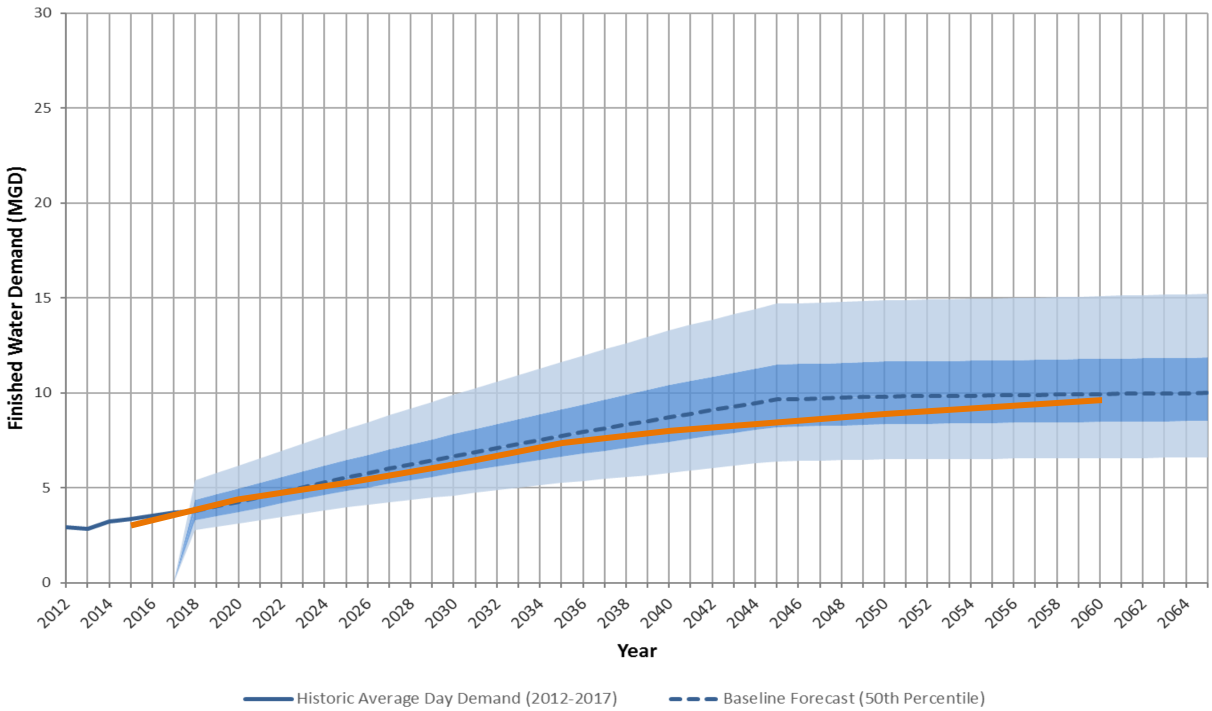

Figure 1. Average Day Finished Water Demand Forecast

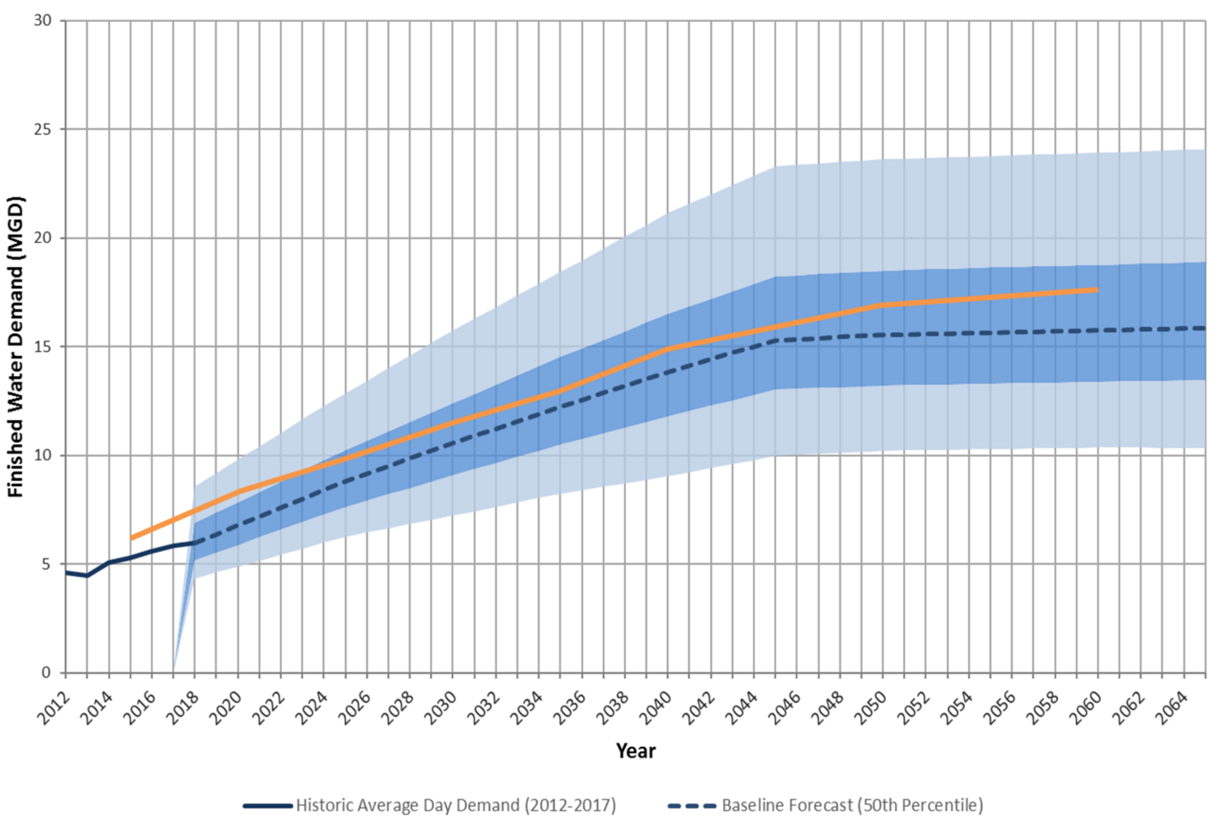

Figure 2. Maximum Day Finished Water Demand Forecast

Table 1. Town of Apex Water Demand Forecast, 50th percentile

Includes the Town of Apex only, million gallons per day (MGD)

Annual Average Billed Water	**2018**	**2025**	**2045**	**2065**
Neuse River	1.0	1.3	1.7	1.6
Cape Fear River	0.2	0.3	1.6	2.0
Haw River	2.0	3.2	5.3	5.2
Sub-Total Billed Water	3.3	4.9	8.5	8.8

Annual Average Finished Water	**2018**	**2025**	**2045**	**2065**
Neuse River	1.2	1.5	1.9	1.9
Cape Fear River	0.3	0.3	1.8	2.3
Haw River	2.3	3.7	6.0	5.9
Sub-Total Finished Water Demand	3.8	5.6	9.7	10.0
WTP System Process Water	0.7	1.0	1.7	1.8
Annual Average Day Raw Water Demand	**4.4**	**6.5**	**11.4**	**11.8**

Maximum Day Billed Water	**2018**	**2025**	**2045**	**2065**
Neuse River	1.6	2.1	2.7	2.6
Cape Fear River	0.4	0.5	2.5	3.2
Haw River	3.2	5.2	8.3	8.2
Sub-Total Billed Water	5.2	7.8	13.5	14.0

Maximum Day Finished Water	**2018**	**2025**	**2045**	**2065**
Neuse River	1.9	2.4	3.0	2.9
Cape Fear River	0.4	0.5	2.8	3.6
Haw River	3.7	5.9	9.5	9.3
Sub-Total Finished Water Demand	6.0	8.8	15.3	15.9
WTP System Process Water	1.0	1.5	2.8	3.0
Maximum Day Raw Water Demand	**6.9**	**10.3**	**18.1**	**18.8**

Table 2. Town of Apex Water Demand Forecast, 75th percentile

Includes the Town of Apex only, MGD

Annual Average Billed Water	**2018**	**2025**	**2045**	**2065**
Neuse River	1.2	1.6	2.0	1.9
Cape Fear River	0.3	0.3	2.1	2.6
Haw River	2.4	3.8	6.1	6.0
Sub-Total Billed Water	**3.8**	**5.7**	**10.1**	**10.4**

Annual Average Finished Water	**2018**	**2025**	**2045**	**2065**
Neuse River	1.4	1.8	2.2	2.2
Cape Fear River	0.3	0.4	2.4	2.9
Haw River	2.7	4.3	7.0	6.8
Sub-Total Finished Water Demand	4.3	6.5	11.5	11.9
WTP System Process Water	0.8	1.2	2.2	2.2
Annual Average Day Raw Water Demand	**5.1**	**7.6**	**13.7**	**14.1**

Maximum Day Billed Water	**2018**	**2025**	**2045**	**2065**
Neuse River	1.9	2.5	3.1	3.1
Cape Fear River	0.4	0.6	3.3	4.1
Haw River	3.7	6.0	9.7	9.6
Sub-Total Billed Water	**6.1**	**9.0**	**16.0**	**16.5**

Maximum Day Finished Water	**2018**	**2025**	**2045**	**2065**
Neuse River	2.2	2.8	3.6	3.5
Cape Fear River	0.5	0.6	3.7	4.6
Haw River	4.3	6.8	11.0	10.8
Sub-Total Finished Water Demand	6.9	10.2	18.2	18.9
WTP System Process Water	1.2	1.9	3.4	3.5
Maximum Day Raw Water Demand	**8.1**	**12.1**	**21.6**	**22.4**

Table 3. Town of Apex Projected Wastewater Flows, 50th percentile

Includes the Town of Apex only, MGD

Average Daily Flows	**2018**	**2025**	**2045**	**2065**
WWRWRF	2.2	3.3	6.3	6.6
Middle Creek	0.8	1.0	1.2	1.2
Total Flow	**2.9**	**4.3**	**7.5**	**7.8**

Maximum Month Average Day Flows	**2018**	**2025**	**2045**	**2065**
WWRWRF	2.5	3.8	7.2	7.5
Middle Creek	0.9	1.1	1.4	1.4
Total Flow	**3.3**	**4.9**	**8.6**	**8.9**

Table 4. Town of Apex Projected Wastewater Flows, 75th percentile

Includes the Town of Apex only, MGD

Average Daily Flows	**2018**	**2025**	**2045**	**2065**
WWRWRF	2.6	4.1	7.7	8.1
Middle Creek	0.9	1.2	1.5	1.5
Total Flow	**3.6**	**5.3**	**9.2**	**9.5**

Maximum Month Average Day Flows	**2018**	**2025**	**2045**	**2065**
WWRWRF	3.0	4.7	8.9	9.3
Middle Creek	1.1	1.4	1.7	1.7
Total Flow	**4.1**	**6.1**	**10.6**	**11.0**

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Attachment A

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ch2m

Updated May 1, 2018

Subject: LRWRP Forecast, Probabilistic Variables for Town of Apex Uncertainty Model

This list details the probabilistic functions used to define the input variables for the Town of Apex's long range water demands uncertainty model. The majority use historic data to determine the shape and scale of the distribution. Data used to develop these probabilistic functions was provided by the Town of Apex on April 5, 2018.

<u>Population Variation</u>

Normal Distribution:

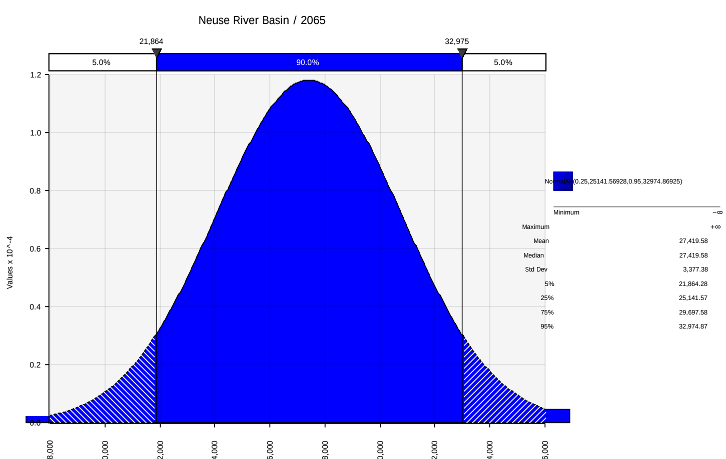
25th Percentile = Low-Growth Projection, 95th percentile = High-Growth Projection

Town of Apex staff prepared population projections for high-growth and low-growth scenarios. The high-growth scenario assumes that all currently-approved development will be built-out by 2025, and new development will continue at the current pace. Because the current pace of development is unprecedented and not likely to be exceeded, the high-growth projection is input as the 95th percentile. The low-growth scenario assumes all currently-approved development will be built-out by 2029, and new development will continue at a slower pace. While the projections for the low-growth scenario are lower than what the town anticipates, it is recognized that market changes could occur that would dramatically slow development and result in an even lower population growth. Thus, the low-growth projection is input as the 25th percentile.

Each river basin has its own distribution. These distributions are then force-correlated to total 100% so that total population is accurate. 2065 Distributions by river basin are shown below as examples. Each year calculated has different distribution based on population tables.

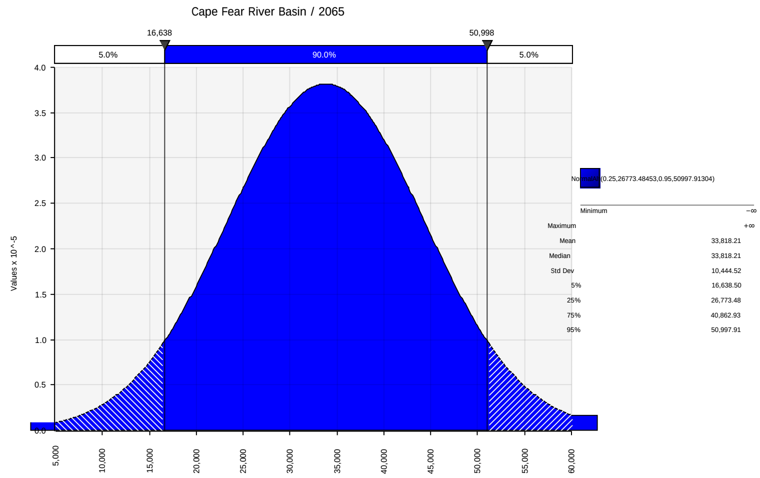
Neuse River Basin Population, 2065

5th percentile	25th percentile	50th percentile	75th percentile	95th percentile
21,864	25,141	27,419	29,697	32,974



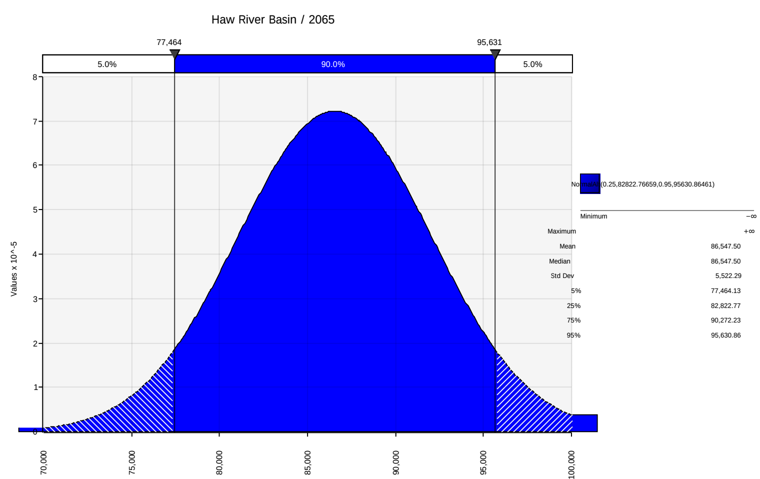
Cape Fear River Basin Population, 2065

5th percentile	25th percentile	50th percentile	75th percentile	95th percentile
16,638	26,773	33,818	40,862	50,997



Haw River Basin Population, 2065

5th percentile	25th percentile	50th percentile	75th percentile	95th percentile
77,464	82,272	86,547	90,272	95,630



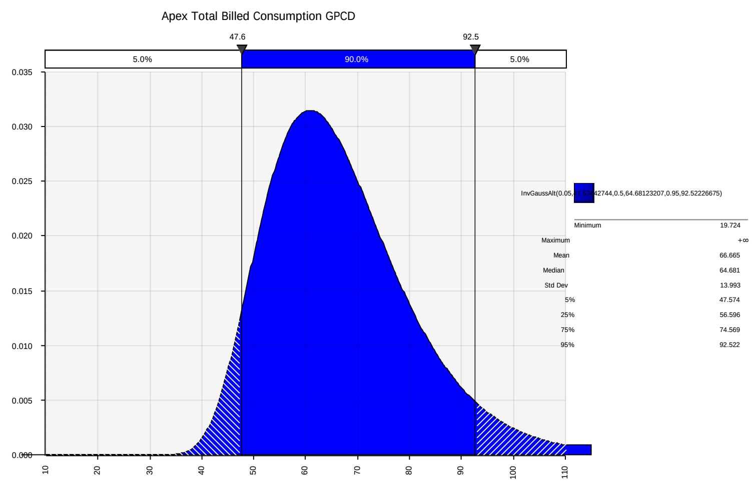
Total Billed Gallons Per Capita per Day (GPCD) (unit demand factor)

Inverse Gaussian Distribution

Median value based on historic Apex data (2012-2017).
5th and 95th percentile inputs scale with Cary SFR Unit Demand Factor inputs.

This variable is inclusive of all customer categories in the Town.

5th percentile	25th percentile	50th percentile	75th percentile	95th percentile
47.6	56.6	64.7	74.6	92.5

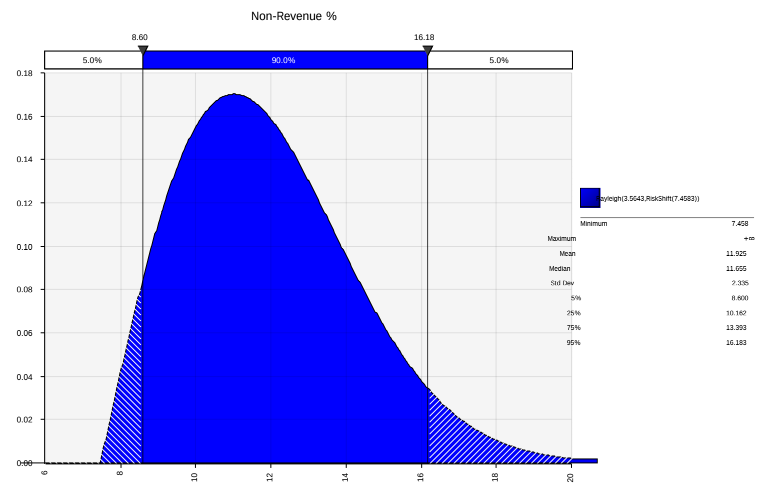


Non-Revenue Water Percent Variation

Rayleigh Distribution

Used to calculate total water distributed from total water demand.
Developed from data for years 2012-2017.

5th percentile	25th percentile	50th percentile	75th percentile	95th percentile
8.6%	10.2%	11.7%	13.4%	16.2%

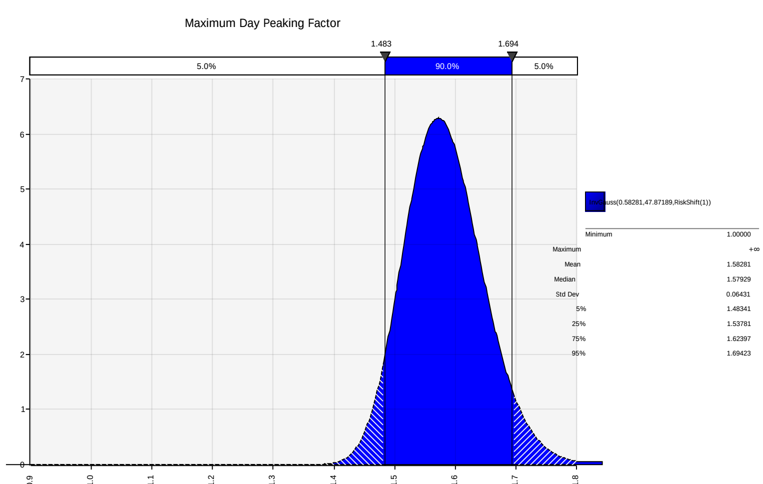


Max Day Peaking Factor Variation

Inverse Gaussian Distribution

Used to calculate Max Day forecast line from simulated Annual Average forecast line.
Selected using data from 2013 – 2017, a range identified by the Town as the most representative.

5th percentile	25th percentile	50th percentile	75th percentile	95th percentile
1.48	1.53	1.58	1.62	1.69

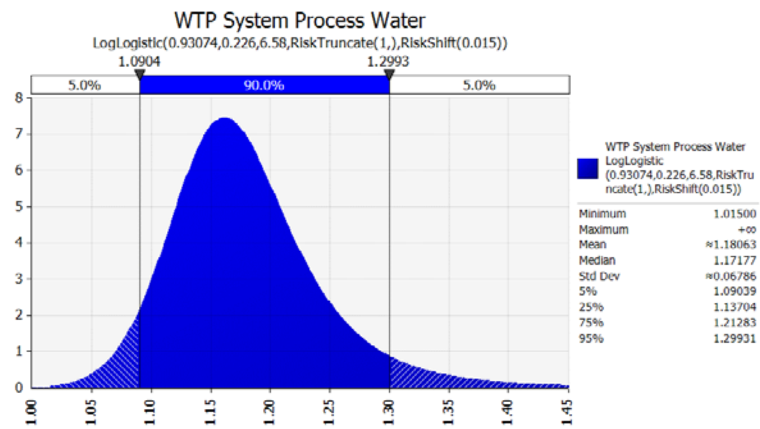


Process Loss Factor Variation (same as Cary forecast)

Log-logistic Distribution

Used to calculated Raw Water demand from total water distributed, for Annual Average Forecast and Max Day Forecast.
Selected from data for years 2010-2016.

5th percentile	25th percentile	50th percentile	75th percentile	95th percentile
1.09	1.14	1.17	1.21	1.30



Conservation Rate Variation
Log-Normal Distributions

Applied to all Customer Types except for Industrial

Developed using information provided by Amy Vickers & Associates under Task 9

Percentile	**2025**	**2030**	**2035**	**2040**	**2045**	**2065**
5th	3%	6%	8%	10%	12%	16%
50th	1%	1%	2%	3%	4%	6%
95th	0%	1%	1%	2%	2%	4%

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Attachment B

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Town of Apex Population Forecast Estimates by River Basin, 2018-2065

Year	Neuse River Basin	Cape Fear River Basin	Haw River Basin	Total Population
2018	16,110	3,520	31,750	**51,390**
2025	21,460	4,900	52,650	**79,010**
2030	23,950	10,170	63,020	**97,140**
2035	25,670	17,490	71,930	**115,080**
2040	27,460	24,580	80,690	**132,740**
2045	29,000	30,680	88,700	**148,380**
2050	29,060	32,890	89,230	**151,170**
2055	29,060	34,890	89,230	**153,170**
2060	29,060	36,890	89,230	**155,170**
2065	29,060	38,890	89,230	**157,170**

High-Growth Projection

Year	Neuse River Basin	Cape Fear River Basin	Haw River Basin	Total Population
2018	16,112	3,524	31,753	**51,390**
2025	22,538	5,495	56,837	**84,870**
2030	25,377	14,512	67,389	**107,278**
2035	27,900	25,105	76,768	**129,774**
2040	30,739	34,123	87,320	**152,182**
2045	32,975	41,718	95,631	**170,324**
2050	32,975	44,038	95,631	**172,644**
2055	32,975	46,358	95,631	**174,964**
2060	32,975	48,678	95,631	**177,284**
2065	32,975	50,998	95,631	**179,604**

Low-Growth Projection

Year	Neuse River Basin	Cape Fear River Basin	Haw River Basin	Total Population
2018	16,112	3,524	31,753	**51,390**
2025	20,382	4,300	48,470	**73,152**
2030	22,515	5,833	58,649	**86,998**
2035	23,432	9,877	67,087	**100,396**
2040	24,189	15,044	74,056	**113,290**
2045	25,026	19,650	81,760	**126,436**
2050	25,142	21,733	82,823	**129,698**
2055	25,142	23,413	82,823	**131,378**
2060	25,142	25,093	82,823	**133,058**
2065	25,142	26,773	82,823	**134,738**

Town of Apex Non-Revenue Water

Metric	2012	2013	2014	2015	2016	2017	Average
Population	39,413	40,769	42,920	45,317	47,165	49,541	
Total Water Supply (MGD)	2.91	2.84	3.20	3.34	3.52	3.70	
Total Billed Consumption (MGD)	2.63	2.60	2.75	2.93	3.05	3.18	
Non-Revenue Water (MGD)	0.28	0.24	0.45	0.41	0.47	0.52	
Non-Revenue Water (%)	9.72	8.43	14.15	12.32	13.43	13.96	12.00
Billed Consumption Per-Capita (GPD)	66.7	63.8	64.1	64.7	64.7	64.2	64.68
Total Finished Water Demand Per-Capita (GPD)	73.9	69.6	74.6	73.7	74.7	74.61	73.54

Town of Apex Water Peaking Factor

Year	Year Total	Year Daily Avg.	Daily max	Peaking Factor
2005	1018.726	2.791	4.926	1.76
2006	1003.142	2.748	4.699	1.71
2007	1113.246	3.050	5.148	1.69
2008	994.2505	2.717	5.219	1.92
2009	1068.138	2.926	5.100	1.74
2010	1076.658	2.950	5.240	1.78
2011	1047.382	2.870	4.943	1.72
2012	1066.241	2.913	5.525	1.90
2013	1036.378	2.839	4.524	1.59
2014	1169.227	3.203	5.354	1.67
2015	1219.686	3.342	5.398	1.62
2016	1289.461	3.523	5.231	1.48
2017	1349.061	3.696	5.726	1.55

Average Peaking Factor (2005-2017)	1.70
Average Peaking Factor (2013-2017)	1.58

Percentage of the Town of Apex Wastewater Service Area split by River Basin and WRF Service Area

WRF Service Area	River Basin	Percent of Land Area Served by Given WRF
Middle Creek WRF	Cape Fear	1%
	Haw	0%
	Neuse	82%
Western Wake WRF	Cape Fear	99%
	Haw	100%
	Neuse	18%

Town of Apex Service Area Maximum Month to Annual Average Peaking Factor Ratio

Year	Annual Average Wastewater Flow (MGD)	Maximum Month Wastewater Flow (MGD)
2011	0.00	0.00
2012	0.00	0.00
2013	0.00	0.00
2014	0.00	0.00
2015	0.00	0.00
2016	0.00	0.00
2017	0.00	0.00
7- Year Average Peaking Factor (2011-2017)		
5-Year Average Peaking Factor (2013-2017)		

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Appendix B

Triangle J Council of Governments CommunityViz Model Background

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Triangle CommunityViz 2.0 Technical Overview (January 30, 2018)

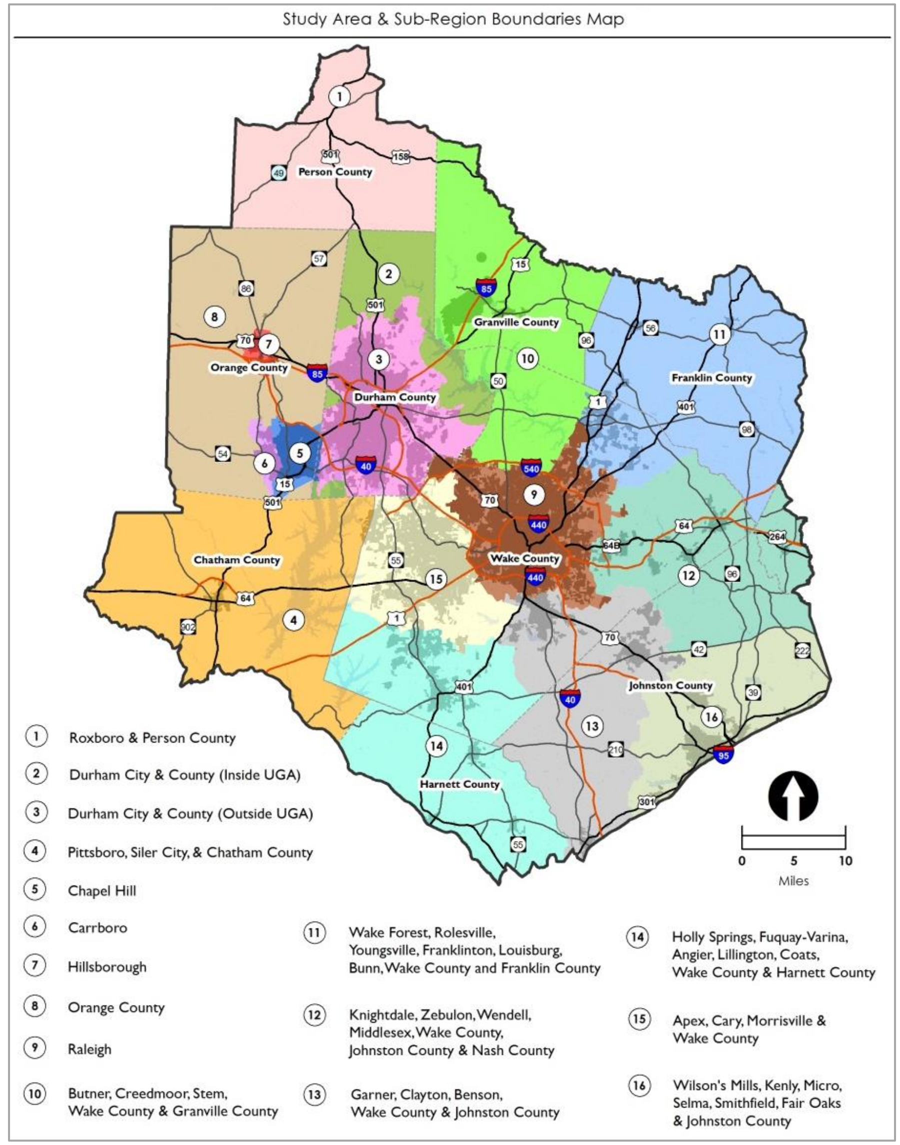
Pages 1 and 2 present a TCV2 overview
Pages 3 and 4 summarize place types and development status
Page 5 gives contact information

What CommunityViz Is

CommunityViz is a tool that projects where future growth will occur based on current development and assumptions about what makes some locations more attractive than others. It can be used for a small area or an entire region. In the Research Triangle Region, an initial forecast of future growth to the Year 2040 was used to allocate growth for the region's 2040 Metropolitan Transportation Plan. The model was refined to create Version 2.0 (TCV2), which was used for the 2045 Metropolitan Transportation Plan.

The area covered by this forecast is shown to the right. It is the "modeled area" of the region's transportation model, which converts the CommunityViz forecasts into projections of future travel on area roadways and transit routes. It consists of ~3,400 square miles covering all or parts of 10 counties.

The region is divided into 16 sub-regions (map at right) for better reporting of results and more efficient software processing. CommunityViz uses data from individual land parcels and assigns it to over 100,000 grid cells for analysis. These grid cell data are then translated into the 2,857 "traffic analysis zones" (TAZs) used in Version 6 of the Triangle Regional Travel Demand Model.

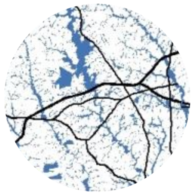


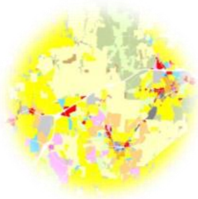
What CommunityViz Needs From Local Planners

CommunityViz needs five basic things, summarized on the following pages:

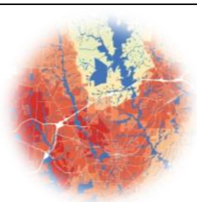
1. The location of <u>features that constrain development</u>, such as water bodies, wetlands and stream buffers,
2. The <u>type of place</u> each parcel is ***today*** and ***will become*** (and the intensity of each place type for each jurisdiction),
3. The current <u>development status</u> of each parcel relative to its future use,
4. The factors that will determine how attractive each parcel is for development, termed <u>land suitability</u> (decided regionally); and
5. The <u>types and amounts of growth</u> that will be allocated, termed "growth targets" (decided regionally).

CommunityViz Major Elements

<table>
<tr><td></td><td>Development Constraints – Constraints were reviewed and updated, but do not chan

Development constraints are special conditions that restrict the amount of development a parcel or grid cell can receive, even if the underlying parcel or grid cell might be undeveloped and zoned for development. The development constraint used in this version of CommunityViz is a Resource Conservation designation, which consists of water bodies, stream buffers, wetlands and permanent conservation areas where development is precluded.</td></tr>
<tr><td></td><td>Place Types

Each parcel of land is assigned one of 37 different CommunityViz place types spanning a range of residential, commercial, industrial and mixed-use development possibilities. Each place type in each jurisdiction is assigned a density or intensity measure designed to reflect the average value for that jurisdiction. Densities and intensities may be further modified by special conditions such as watershed protection or historic preservation designations. Residential place types include the % of land that is single family vs. multifamily. For mixed use place types, the designation includes the % of land that is residential and % of residential land that is multi-family. Place type may be one thing today and another in the future.</td></tr>
<tr><td></td><td>Development Status

Parcels of land receive one of 5 development status assignments (excluding water, open space & agricultural designations):
• developed: already built and can not accept additional growth
• committed or asserted: new growth manually assigned based on buildings under construction and anchor institution plans
• undeveloped: can accept new growth up to the capacity of the place type
• under-developed: can add development to what is already there (each parcel with this status will include a user-designated percentage of the parcel capacity that is <u>already</u> developed and can not accept more growth)
• re-developable: can accept new growth up to the capacity of the place type, but what is there now will be subtracted.</td></tr>
<tr><td></td><td>Land Suitability

Land suitability is a measure of how “attractive” a parcel or grid cell is for new growth, relative to all the other parcels or grid cells in the county. TCV2.0 uses 14 different suitability factors, although some may not apply to a particular scenario (e.g. high frequency transit stations in a scenario without such service). A full list of factors, and the weights assigned to each factor in each scenario for TCV2.0, is available.</td></tr>
<tr><td></td><td>Growth Allocation &Growth Targets

The final step is to assign new growth to parcels or grid cells based on their relative suitability. Growth is based on control totals that are developed for each county, and for each of the 7 categories of growth that are forecast: single-family residential units, multi-family residential units and 5 categories of jobs: Office, Industrial, Retail, Service-high visitor rate, Service-low visitor rate. The updated CommunityViz software includes a more refined version of the growth allocation method, called Allocator5.</td></tr>
</table>

Triangle CommuntyViz Development Pattern & Place Type Wheel

Existing parcels of land can be assigned one of 37 place types, shown on the wheel at left.

In general, particular place types describe a development pattern: rural, suburban or city & town, with industrial and special place types possible as part of any development pattern.

In practice, the link between place type and development pattern is not so neat, but considering the development patterns of an area can help in deciding how to assign place types to parcels.

Different communities will define categories differently; the mechanics of CommunityViz allow for finer distinctions based on the development intensities input for each category in each jurisdiction.

Development Status

Every parcel is assigned a development status from 8 possible choices, shown in the table below. The default value, which is pre-populated in the data set, is the status from the CommunityViz 1.0 data set used in the 2040 Metropolitan Transportation Plan (MTP).

Five of these choices are designed to help people understand how development on the parcel today relates to the type of place the parcel is planned to be under an associated scenario (e.g., the "default" 2045 MTP scenario, which is based on the 2040 adopted MTP scenario).

Two of the choices – "water" and "open space" – are designed to avoid confusion when selecting a development status, since a parcel consisting of water or protected open space would logically be thought of as undeveloped, but for the purposes of allocating growth, it needs to be treated as if it is fully developed, i.e., it can accommodate no additional development.

The final choice – "agriculture" is used to allow a calculation of how much agricultural land is converted to development under a growth allocation.

Development Status	What it means	How CommunityViz will actually treat it	What other information is needed?
Developed	Development on the parcel will be the same in 2045 as it is in 2015	As fully developed – no additional growth	
Undeveloped	The parcel will develop based on the CV2 algorithm	As able to add 100% of the place type capacity	
Under-developed (also used for redevel-opable parcels in CV1)	The parcel will develop based on the CV2 algorithm	As able to add only the % of the place type capacity that is not already on the site	The % of the site capacity already taken up by existing development that will stay (pull down menu)
Redevelopable (new for CV2)	The parcel will develop based on the CV2 algorithm	As able to add 100% of the place type capacity, but the existing development will be subtracted	Dwellings & non-residential square footage that exist and will be removed
Committed or Asserted	Development of the parcel will be asserted prior to the CV2 model run	As fully developed – no additional growth. The committed development is manually added.	Dwellings & non-residential square footage that will be on the site
Water	Development on the parcel will be the same in 2045 as it is in 2015	As fully developed – no additional growth	
Open Space	Development on the parcel will be the same in 2045 as it is in 2015	As fully developed – no additional growth	
Agriculture	The parcel will develop based on the CV2 algorithm	As able to accommodate 100% of the place type capacity	Any easements or other protections that would preclude development

For parcels designated under-developed, re-developable or committed, it is important for the local planners to understand the additional information that is needed to accurately reflect future growth on those parcels, including how TCV2 allocates new growth by area (acreage).

Guidance & Assistance

Need help? Unsure of something? Want some guidance on a particular place type or how to handle an unusual situation? Please don't hesitate to contact Triangle J COG staff.

For guidance on the ***CommunityViz software***, (Version 5, including Allocator5), contact:

Ben Bearden bearden@tjcog.org 919-558-2701

For guidance on ***what*** a particular place type or development status means, contact:

John Hodges-Copple johnhc@tjcog.org 919-558-9320

For guidance on ***how*** to enter or edit place type or development status information into TCV2, contact:

Ben Bearden bearden@tjcog.org 919-558-2701

For assistance on ***the definitions and sources*** for development constraints in TCV2, contact:

Ben Bearden bearden@tjcog.org 919-558-2701

For assistance on ***place type development factors*** ("look-up tables") such as residential density for individual jurisdictions in TCV2, contact:

Aspen Romeyn aromeyn@tjcog.org 919-558-9319

For assistance on ***development*** associated with anchor institutions, Large Scale Developments, and committed or asserted development in TCV2, contact:

Matt Day mday@tjcog.org 919-558-9397

For guidance on ***future scenarios, suitability factors and growth targets***, and associated housing type distributions, and job and population ratios, contact:

John Hodges-Copple johnhc@tjcog.org 919-558-9320

Additional information is available to provide greater detail; the most recent versions, along with much other information, are posted on the project website at: http://www.tjcog.org/future-growth-scenarios-imagine-2040-connect-222045.aspx under the Connect 2045 headings.

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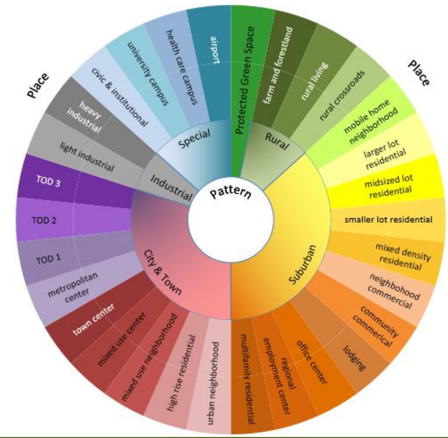
Connect 2045 Place Type Summary | Raleigh, Cary, Morrisville

Place types are used in the CommunityViz model to represent development patterns. The place type lookup tables allow each jurisdiction to set FAR, density, and other development intensities at values that match their community. This place type summary provides a quick overview of each place type and the FAR, density, and land use type percentages that Raleigh, Cary, and Morrisville currently have in the Connect 2045 Community Plans scenario. These values can be adjusted or the place types can be changed for specific parcels to reflect the desired type and intensity of development in the AIM High scenario. In addition, new place types can be added to accommodate types of development not captured in the existing place type categories.



General place type information was compiled from the *Imagine 2040 – Place Type Summary*, the *Imagine 2040 – Summary Document - Complete*, and the *Durham-Orange County Corridor Alternatives Analysis, Volume 4: TOD Assessment Report* and updated to match the Connect 2045 place types.

FF | Farm and Forestland

Description

Working farms are actively being used for agriculture or forestry activities, including cultivated farmland, timber harvest, livestock, or woodlands. Secondary land uses may include a single-family detached home, warehouse, storage, or light industrial facilities associated with farm activities.

Example

Lookup Table	Raleigh	Cary	Morrisville
FAR	0.10	0.10	0.10
Density	0.1 du/ac.	0.01 du/ac.	0.01 du/ac.
Non-Residential	50%	50%	50%
Residential	50%	50%	50%
Single-Family	100%	100%	100%
Multifamily	0%	0%	0%

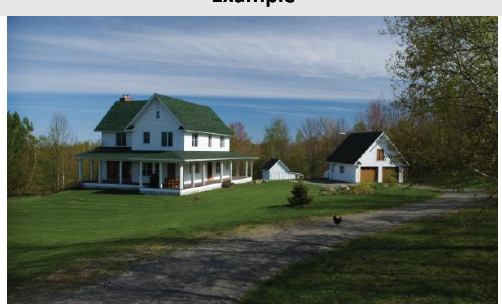
RL | Rural Living

Description

Rural living areas are characterized by large lots, abundant open space, pastoral views, and a high degree of separation between buildings.

- Primary land uses include single-family homes, mobile homes, and hobby farms.
- Secondary land uses may include churches and natural areas.

Example



Lookup Table	Raleigh	Cary	Morrisville
FAR	0.00	0.00	0.00
Density	0.72 du/ac.	0.52 du/ac.	0.52 du/ac.
Non-Residential	0%	0%	0%
Residential	100%	100%	100%
Single-Family	100%	100%	100%
Multifamily	0%	0%	0%

RCR | Rural Cross Roads

Description	Example	Lookup Table	Raleigh	Cary	Morrisville
Rural cross roads represent the small nodes of commercial activity along rural highways. Small-scale businesses, such as gas stations, convenience stores, or restaurants, service some daily needs of the surrounding rural population. - Primary land uses include gas stations, restaurants, convenience stores. - Secondary land uses may include fire stations, post offices, general government centers.		FAR	0.20	0.15	0.15
		Density	0.0 du/ac.	0.0 du/ac.	0.0 du/ac.
		Non-Residential	100%	100%	100%
		Residential	0%	0%	0%
		Single-Family	0%	0%	0%
		Multifamily	0%	0%	0%

MHP | Mobile Home Neighborhood

Description	Example	Lookup Table	Raleigh	Cary	Morrisville
Mobile home parks are characterized by single-wide and double-wide mobile homes on individual lots, which may be clustered in an area owned and managed by a single entity. - Primary land uses include single and double-wide mobile homes. - Secondary land uses may include a community center or a pool and its amenities.		FAR	0.00	0.00	0.00
		Density	2.36 du/ac.	4.11 du/ac.	4.11 du/ac.
		Non-Residential	0%	0%	0%
		Residential	100%	100%	100%
		Single-Family	100%	100%	100%
		Multifamily	0%	0%	0%

LLRN | Larger-Lot Residential

Description	Example	Lookup Table	Raleigh	Cary	Morrisville
Large-lot residential neighborhoods are generally formed as subdivisions and consist almost entirely of single-family detached homes. Buildings are oriented interior to the site and are typically buffered from surrounding development by transitional uses, topography, or vegetative areas. - Primary land uses include single-family homes. - Secondary land uses may include churches, schools, community centers, pools and amenities, natural areas.		FAR	0.00	0.00	0.00
		Density	0.55 du/ac.	0.45 du/ac.	0.45 du/ac.
		Non-Residential	0%	0%	0%
		Residential	100%	100%	100%
		Single-Family	100%	100%	100%
		Multifamily	0%	0%	0%

MLRN | Midsized-Lot Residential

Description

Midsized-lot residential neighborhoods are found in close proximity to traditional urban centers and provide the rooftops necessary to support nearby commercial and employment areas.

- Primary land uses include single-family homes.
- Secondary land uses may include duplexes, mobile homes, churches, schools, community centers, parks or playgrounds, natural areas.

Example

Lookup Table	Raleigh	Cary	Morrisville
FAR	0.00	0.00	0.00
Density	3.5 du/ac.	2.5 du/ac.	2.5 du/ac.
Non-Residential	0%	0%	0%
Residential	100%	100%	100%
Single-Family	100%	100%	100%
Multifamily	0%	0%	0%

SLRN | Smaller-Lot Residential

Description

Smaller-lot residential neighborhoods are generally formed as subdivisions or communities with a relatively uniform housing type and density. They are often found in close proximity to commercial and suburban office centers.

- Primary land uses single-family homes, townhomes, and duplexes.
- Secondary land uses may include churches, schools, community centers, pools and amenities, natural areas.

Example

Lookup Table	Raleigh	Cary	Morrisville
FAR	0.00	0.00	0.00
Density	4.5 du/ac.	3 du/ac.	3 du/ac.
Non-Residential	0%	0%	0%
Residential	100%	100%	100%
Single-Family	100%	100%	100%
Multifamily	0%	0%	0%

MRN | Mixed-Density Residential

Description

Mixed-density residential neighborhoods are characterized by a variety of housing types and residential densities organized in a cohesive, well-connected community.

- Primary land uses include single-family homes, townhomes, condominiums, apartments, and duplexes.
- Secondary land uses may include churches, schools, community centers, pool and amenities, natural areas.

Example

Lookup Table	Raleigh	Cary	Morrisville
FAR	0.25	0.25	0.75
Density	9.27 du/ac.	5.08 du/ac.	5.08 du/ac.
Non-Residential	0%	0%	0%
Residential	100%	100%	100%
Single-Family	70%	70%	70%
Multifamily	30%	30%	30%

NCC | Neighborhood-scale Commercial Center

Description	Example	Lookup Table	Raleigh	Cary	Morrisville
Neighborhood-scale commercial centers provide goods and services to surrounding neighborhoods. Their proximity to neighborhoods requires that operations be low-intensity, unobtrusive, and at a scale and design compatible with nearby residential development. They include safe and convenient pedestrian and bicycle access, and some may include upper story residential. - Primary land uses include restaurants, small supermarkets, convenience stores, dry cleaners, banks, barber shops, and community-serving retail. - Secondary land uses may include farmers markets and pocket parks.		FAR	0.13	0.13	0.13
		Density	15 du/ac.	8 du/ac.	8 du/ac.
		Non-Residential	100%	100%	100%
		Residential	0%	0%	0%
		Single-Family	0%	0%	0%
		Multifamily	0%	0%	0%

CCC | Community-scale Commercial Center

Description	Example	Lookup Table	Raleigh	Cary	Morrisville
Community-scale commercial centers serve the daily needs of surrounding residential neighborhoods. They typically locate near high-volume roads and key intersections, and are designed to be accessible primarily by automobile. Buildings are often set back from the road behind large surface parking lots. - Primary land uses include restaurants, multi-tenant & big box commercial, banks, hotels, and offices. - Secondary land uses may include churches, fire stations, and police stations.		FAR	0.23	0.16	0.16
		Density	0 du/ac.	0 du/ac.	0 du/ac.
		Non-Residential	100%	100%	100%
		Residential	0%	0%	0%
		Single-Family	0%	0%	0%
		Multifamily	0%	0%	0%

L | Lodging

Description	Example	Lookup Table	Raleigh	Cary	Morrisville
Lodging provides short-term lodging to the general public. The buildings are generally oriented interior to the site, surrounded by surface parking, located near high-volume roads and key intersections, and are accessible primarily by automobile. - Primary land uses include hotels and motels. - Secondary land uses may include both sit-down and fast-food restaurants, fitness clubs, retail, and gas stations.		FAR	0.45	0.16	0.37
		Density	0 du/ac.	0 du/ac.	0 du/ac.
		Non-Residential	100%	100%	100%
		Residential	0%	0%	0%
		Single-Family	0%	0%	0%
		Multifamily	0%	0%	0%

OC | Office Center

Description	Example	Lookup Table	Raleigh	Cary	Morrisville
Office centers include both large-scale isolated buildings with numerous employees as well as areas containing multiple businesses that support and serve one another. They are often located in close proximity to major highways or thoroughfares. - Primary land uses include multi-tenant professional offices, medical offices, and call centers. - Secondary land uses may include banks, copy and printing services, restaurants, and flex spaces.		FAR	0.23	0.10	0.30
		Density	0 du/ac.	0 du/ac.	0 du/ac.
		Non-Residential	100%	100%	100%
		Residential	0%	0%	0%
		Single-Family	0%	0%	0%
		Multifamily	0%	0%	0%

REC | Regional Employment Center

Description	Example	Lookup Table	Raleigh	Cary	Morrisville
A regional employment center draws people from throughout the region (and beyond) for employment activities and tend to locate near major transportation corridors, often at the intersection of two major highways or an interstate exit. - Primary land uses include professional offices, corporate campuses, research and development, and government buildings. - Secondary land uses may include retail and restaurants.		FAR	0.17	0.08	0.08
		Density	0 du/ac.	0 du/ac.	0 du/ac.
		Non-Residential	100%	100%	100%
		Residential	0%	0%	0%
		Single-Family	0%	0%	0%
		Multifamily	0%	0%	0%

MFRN | Multifamily Residential Development

Description	Example	Lookup Table	Raleigh	Cary	Morrisville
Multi-family residential neighborhoods are generally formed as complexes or communities, with a relatively uniform housing type and density throughout. They support the highest residential density in the suburban landscape. - Primary land uses include apartments, townhomes, condominiums, and senior housing. - Secondary land uses may include churches, community centers, a pool and amenities, natural areas.		FAR	0.00	0.00	0.22
		Density	24 du/ac.	12.5 du/ac.	7.51 du/ac.
		Non-Residential	0%	0%	0%
		Residential	100%	100%	100%
		Single-Family	0%	0%	0%
		Multifamily	100%	100%	100%

UN | Urban Neighborhood

Description	Example	Lookup Table	Raleigh	Cary	Morrisville
Urban neighborhoods are relatively compact and built to a design and scale that encourages active living with a complete and comprehensive network of walkable streets. - Primary land uses single-family homes, duplexes, townhomes, apartments, and condominiums. - Secondary land uses may include churches, schools, and pocket parks.		FAR	0.00	0.00	0.25
		Density	7.45 du/ac.	3.04 du/ac.	3.04 du/ac.
		Non-Residential	0%	0%	0%
		Residential	100%	100%	100%
		Single-Family	80%	80%	80%
		Multifamily	20%	20%	20%

HRR | High-rise Residential

Description	Example	Lookup Table	Raleigh	Cary	Morrisville
High-rise residential areas support the highest residential densities in the region outside of metropolitan centers. They generally include one building with apartments or condominiums that can easily be seen for some distance from the site. - Primary land uses apartments and condominiums. - Secondary land uses may include senior housing, ground floor retail, and pocket parks.		FAR	0.00	0.00	0.00
		Density	100 du/ac.	100 du/ac.	100 du/ac.
		Non-Residential	0%	0%	0%
		Residential	100%	100%	100%
		Single-Family	0%	0%	0%
		Multifamily	100%	100%	100%

MUN | Mixed-Use Neighborhood

Description	Example	Lookup Table	Raleigh	Cary	Morrisville
A mixed-use neighborhood enables residents to live, shop, work, and play in one community. They include a mix of housing types integrated with goods and services and support multiple transportation modes. - Primary land uses include single-family homes, condominiums, apartments, townhomes, retail, restaurants, offices, and government buildings. - Secondary land uses may include churches, schools, pocket parks, community parks, and natural areas.		FAR	1.25	1.25	1.25
		Density	8 du/ac.	4.79 du/ac.	4.79 du/ac.
		Non-Residential	60%	60%	60%
		Residential	40%	40%	40%
		Single-Family	70%	70%	70%
		Multifamily	30%	30%	30%

MUC | Mixed-Use Center

Description	Example	Lookup Table	Raleigh	Cary	Morrisville
Mixed-use centers serve broader community, economic, and entertainment activities. Buildings in the core may stand three or more stories, and residential units or office space may be found above storefronts. They include small blocks with pedestrian-friendly streets. - Primary land uses include retail, offices, restaurants, residential, plazas, and movie theaters. - Secondary land uses may include farmers' markets, pocket parks, day cares, and dry cleaners.		FAR	1.50	1.50	1.50
		Density	45 du/ac.	2.04 du/ac.	2.04 du/ac.
		Non-Residential	65%	65%	65%
		Residential	35%	35%	35%
		Single-Family	0%	0%	0%
		Multifamily	100%	100%	100%

TC | Town Center

Description	Example	Lookup Table	Raleigh	Cary	Morrisville
Town centers are locally-serving areas of economic, entertainment, and community activity. They generally have small blocks with pedestrian-friendly streets and buildings two-or-more stories tall. Town centers often represent the traditional downtown or courthouse area of historic towns. - Primary land uses include townhomes, apartments, senior housing, restaurants, commercial, offices, post offices, and community facilities. - Secondary land uses may include day cares, farmers' markets, and pocket parks.		FAR	1.00	0.24	0.24
		Density	10 du/ac.	10 du/ac.	10 du/ac.
		Non-Residential	50%	50%	50%
		Residential	50%	50%	50%
		Single-Family	20%	20%	20%
		Multifamily	80%	80%	80%

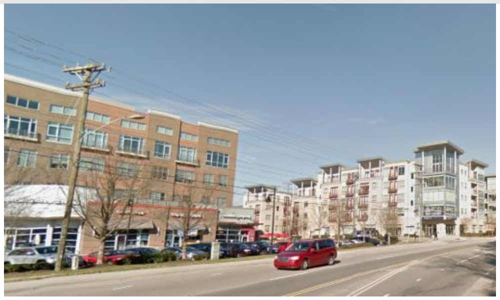
MC | Metropolitan Center

Description	Example	Lookup Table	Raleigh	Cary	Morrisville
Metropolitan centers are the focal points of the region, acting as a hub of employment, entertainment, civic, and cultural activities, with a mix of housing types and common open space. They typically have very tall buildings and a compact development pattern that supports multiple transportation modes. - Primary land uses include residential, restaurants, retail, offices, , museums, libraries, conference centers, transportation hubs, and government buildings. - Secondary land uses may include churches, schools, public plazas, pocket parks, and parking decks.		FAR	6.00	6.00	6.00
		Density	145 du/ac.	140 du/ac.	140 du/ac.
		Non-Residential	75%	75%	75%
		Residential	25%	25%	25%
		Single-Family	10%	10%	10%
		Multifamily	90%	90%	90%

TOD-I | Transit-Oriented Development, Type I – Urban Center

Description	Example	Lookup Table	Raleigh	Cary	Morrisville
- The TOD-I Urban Center place type is typically a regional-oriented destination center, generally defined by a diverse mix of land uses supporting a concentration of civic, cultural, and entertainment uses combined with active public open spaces framed with high densities of commercial and residential development.		FAR	4.00	4.00	4.00
		Density	120 du/ac.	120 du/ac.	120 du/ac.
		Non-Residential	20%	20%	20%
		Residential	80%	80%	80%
		Single-Family	0%	0%	0%
		Multifamily	100%	100%	100%

TOD-II | Transit-Oriented Development, Type II – Urban Neighborhood

Description	Example	Lookup Table	Raleigh	Cary	Morrisville
The TOD-II Urban Neighborhood is typically a local-oriented neighborhood center, generally defined by a diverse mix of land uses supporting a concentration of residential uses as well as local commercial and community facilities.		FAR	2.00	2.00	2.00
		Density	50 du/ac.	45 du/ac.	45 du/ac.
		Non-Residential	50%	50%	50%
		Residential	50%	50%	50%
		Single-Family	0%	0%	0%
		Multifamily	100%	100%	100%

TOD-III | Transit-Oriented Development, Type III – Suburban Neighborhood

Description

The TOD-III Suburban Center place type is typically a local/regional-oriented commercial and employment center, generally defined by a diverse mix of land uses with concentrations of local and regional commercial, employment, and community facilities.

Example

Lookup Table	Raleigh	Cary	Morrisville
FAR	1.50	1.50	1.50
Density	15 du/ac.	15 du/ac.	15 du/ac.
Non-Residential	50%	50%	50%
Residential	50%	50%	50%
Single-Family	80%	8%	8%
Multifamily	20%	20%	20%

LIC | Light Industrial Center

Description

Light industrial centers generally support manufacturing and production uses and are found in close proximity to major transportation corridors. Clusters of uses that support or serve one another are often encouraged to locate in the same light industrial center.

- Primary land uses include light manufacturing and assembly, processing facilities, laboratory, warehouse, and distribution.
- Secondary land uses may include small-scale commercial uses and natural areas.

Example

Lookup Table	Raleigh	Cary	Morrisville
FAR	0.18	0.18	0.18
Density	0 du/ac.	0 du/ac.	0 du/ac.
Non-Residential	100%	100%	100%
Residential	0%	0%	0%
Single-Family	0%	0%	0%
Multifamily	0%	0%	0%

HIC | Heavy Industrial

Description

Heavy industrial centers support large-scale production and manufacturing uses, and are found in close proximity to major transportation corridors. Activities are not confined entirely to buildings; conveyer belts, holding tanks, smoke stacks, or outdoor storage all may be present in a heavy industrial center.

- Primary land uses include factories, heavy assembly plants, regional warehouses, regional distribution and trucking centers, and landfills.
- Secondary land uses may include small-scale commercial uses and natural areas.

Example

Lookup Table	Raleigh	Cary	Morrisville
FAR	0.08	0.13	0.13
Density	0 du/ac.	0 du/ac.	0 du/ac.
Non-Residential	100%	100%	100%
Residential	0%	0%	0%
Single-Family	0%	0%	0%
Multifamily	0%	0%	0%

CIV | Civic and Institutional

Description

Civic and institutional facilities typically include a building or complex of buildings that serve a public purpose, including a library, school, public works complex, or town hall.

- Primary land uses include government buildings, libraries, schools, and prisons.
- Secondary land uses may include public works buildings, churches, community centers, and water or wastewater treatment plants.

Example

Lookup Table	Raleigh	Cary	Morrisville
FAR	0.17	0.07	0.07
Density	0 du/ac.	0 du/ac.	0 du/ac.
Non-Residential	100%	100%	100%
Residential	0%	0%	0%
Single-Family	0%	0%	0%
Multifamily	0%	0%	0%

HCC | Health Care Campus

Description

A health care campus is relatively large in scale, and may include a hospital, teaching facilities, research and rehabilitation centers, and medical offices. They typically have large buildings connected via walkways, structured parking, or an internal street network.

- Primary land uses include primary care buildings, emergency services, and research centers.
- Secondary land uses may include teaching facilities, private medical office buildings, parking decks or surface parking lots.

Example

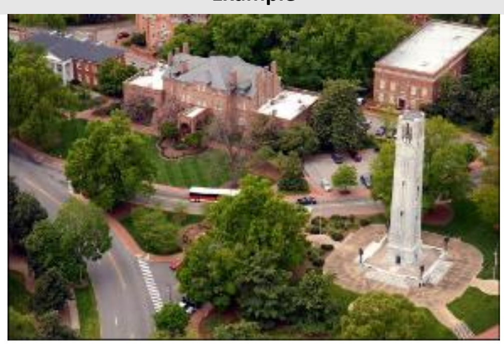
Lookup Table	Raleigh	Cary	Morrisville
FAR	0.27	0.09	0.09
Density	0 du/ac.	0 du/ac.	0 du/ac.
Non-Residential	100%	100%	100%
Residential	0%	0%	0%
Single-Family	0%	0%	0%
Multifamily	0%	0%	0%

UC | University Campus

Description

A university campus includes all of the academic buildings, residence halls, athletic facilities, or other ancillary needs to support an institution for higher education. Buildings are oftend oriented around a highly-walkable network of internal streets and pedestrian pathways which support several modes of transportation.

Example



Lookup Table	Raleigh	Cary	Morrisville
FAR	0.17 (NCSU 0.35)	2.50	2.50
Density	50 du/ac. (NCSU 18)	50 du/ac.	50 du/ac.
Non-Residential	75%	75%	75%
Residential	25%	25%	25%

- Primary land uses include academic buildings, athletic buildings, resident halls, recreation center, and open spaces.
- Secondary land uses may include private research and development buildings, supporting retail and restaurants, residential neighborhood, parking decks, and surface parking lots.

Single-Family	0%	0%	0%
Multifamily	100%	100%	100%

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Appendix C

Probabilistic Demand Forecast – Input Variables

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Appendix C1

Unit Demand Factors

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New Single Family Residential (SFR) Account Unit Demand Assumptions

a **Indoor Unit Demand per Capita (GPCD)**

	Median (50th Perc.)	5th Percentile	95th Percentile	Resulting Average
Cary & Morrsiville	46.5	35	65	48
(GPD/Unit)				
Cary	129	97	181	133
Morrisville	126	95	176	129

Unit Factor Assumption Basis:

Persons Per Household — Cary PPH: 2.78; Morrisville PPH: 2.70

Median (50th)	Equals the average GPCD for the population of SFR residences constructed after 2010 for the 2013 to 2016 time period.
5th	35 GPCD is currently the most efficient indoor GPCD for a residential home, based on current technology.
95th	Equals the highest annual average indoor demand for SFR residences with a single meter for the 2007 to 2016 time period.

b **Metered Irrigation Demand for Separately Metered Residences (GPD/Unit)**

	Median (50th Perc.)	5th Percentile	95th Percentile	Resulting Average
Cary	154	31	321	162
Morrisville	143	29	299	151

Unit Factor Assumption Basis:

Median (50th)	Equals the annual average GPC/Unit for the population of SFR residences with a separately metered irrigation systems for the 2013 to 2016 time period.
5th	Based on the irrigation demand for SFR residences with separately metered IR constructed before 2010 for the 2013 to 2016 time period.
95th	Equals the 75th percentile for separately metered irrigation for SFR residences constructed after 2010 for the 2013 to 2016 time period.

c **% of New SFR accounts with a Separate Irrigation Meter**

	Median (50th Perc.)	5th Percentile	95th Percentile	Resulting Average
Cary & Morrsiville	13%	5%	35%	16%

Unit Factor Assumption Basis:

Median (50th)	Equals the percent of SFR residence constructed after 2010 with separately metered irrigation accounts (as of 2016).
5th	Assumed minimum level of separately metered irrigation accounts
95th	Equals the percent of SFR residence constructed between 2001 and 2010 with separately metered irrigation accounts. (Source: 2010 Water Use Analysis)

d **Outdoor/Irrigation Demand for Single Meter Residences (GPD/Unit)**

	Median (50th Perc.)	5th Percentile	95th Percentile	Resulting Average
Cary	8	0	26	10
Morrisville	7	0	24	9

Unit Factor Assumption Basis:

Median (50th)	Based on the annual average outdoor demand for SFR residences w/ a single meter constructed after 2010 for the time period from 2013-2016
5th	Minimum irrigation level = 0
95th	Based on the annual average outdoor demand for SFR residences w/ a single meter constructed after 2005 for the time period from 2001-2009 (Source: 2010 Water Use Analysis)

SFR Total Unit Demand (GPD/Unit)

Calculated as: New SFR GPC/Unit = a + (b*c) + [d * (1-c)]

a = Indoor Unit Demand

b = Separately Metered Irrigation Unit Demand

c = % of New SFR accounts with a Seprate Irrigation Meter

d = Outdoor/Irrigation Demand

Note:

This "New SFR GPD/Unit" is to be used for future SFR without access to Reclaimed Water.

For those with Reclaimed Water service, the "Indoor Unit Demand GPD/Unit" will be used.

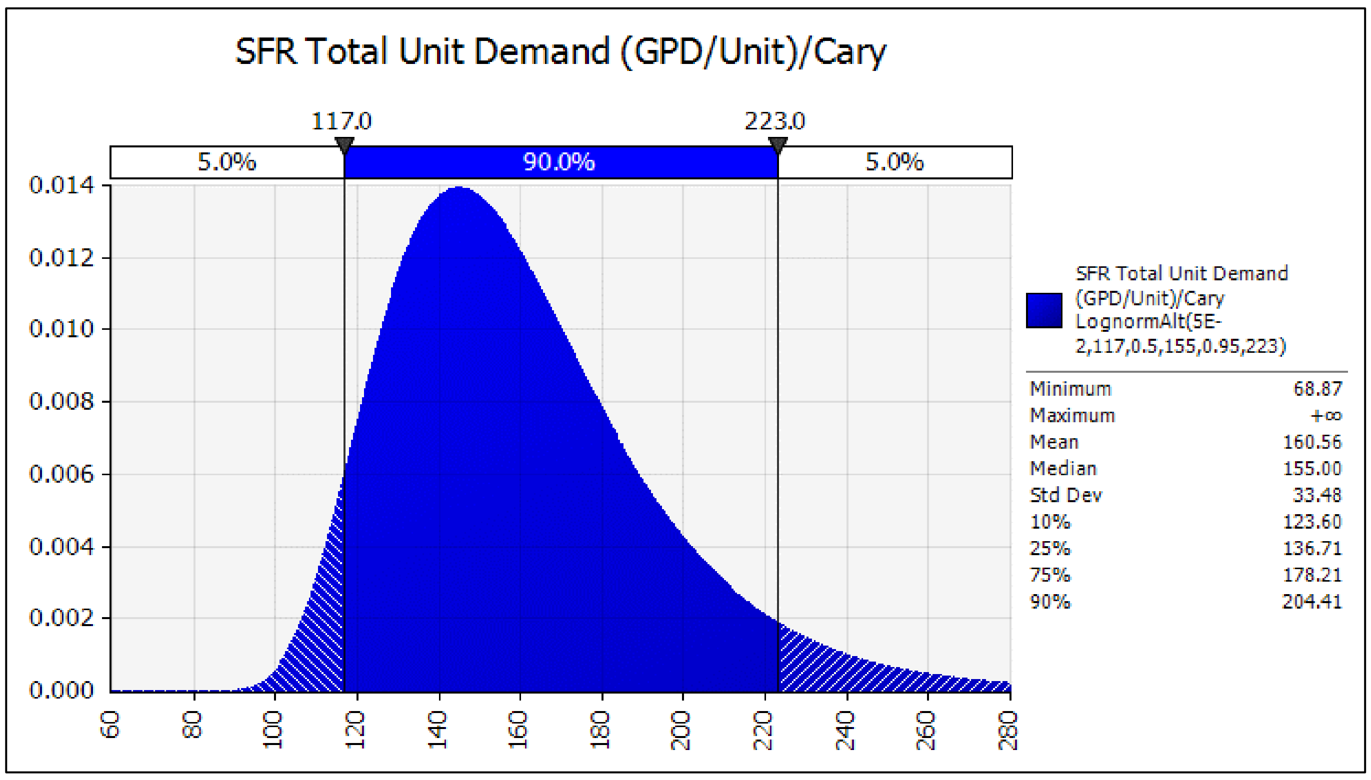
	Median (50th Perc.)	5th Percentile	95th Percentile	Resulting Average
Cary	155	117	223	161
Morrisville	149	113	214	154

Unit Factor Assumption Basis:

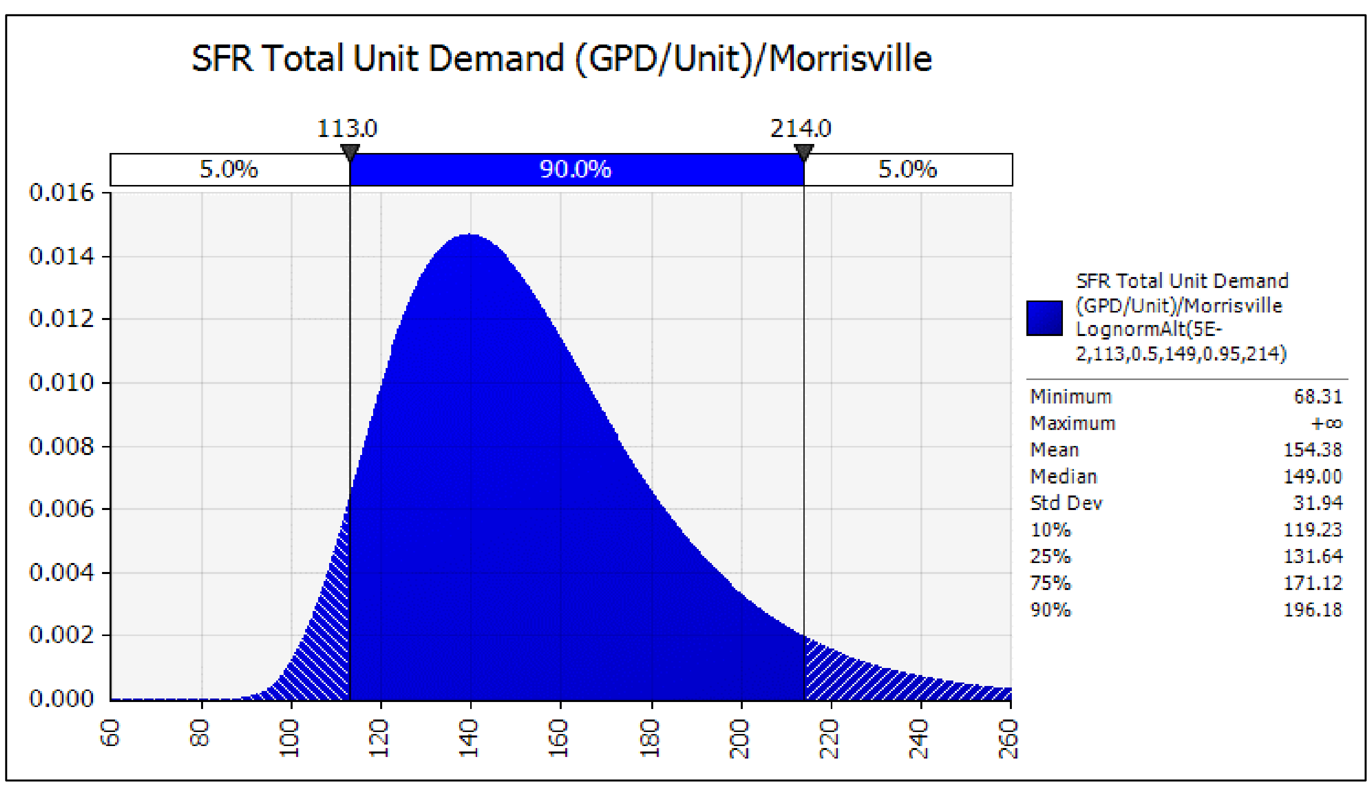
The percentile values for SFR Total Unit Demand are calculated based on a convergent simulation of the above probablistic funtion.

Probability Density Functions assuming Log-Normal Distributions (in GPD/Unit)

Cary



Morrisville



New Multi-Family Residential (MFR) Account Unit Demand Assumptions

MFR Unit Demand per Capita (GPCD)

	Median (50th Perc.)	5th Percentile	95th Percentile	Resulting Average
Cary & Morrsiville	40	35	55	42
(GPD/Unit)				
Cary	89	78	122	93
Morrisville	87	76	120	91

Unit Factor Assumption Basis:

Persons Per Household	Cary PPH:	2.22
	Morrisville PPH:	2.18

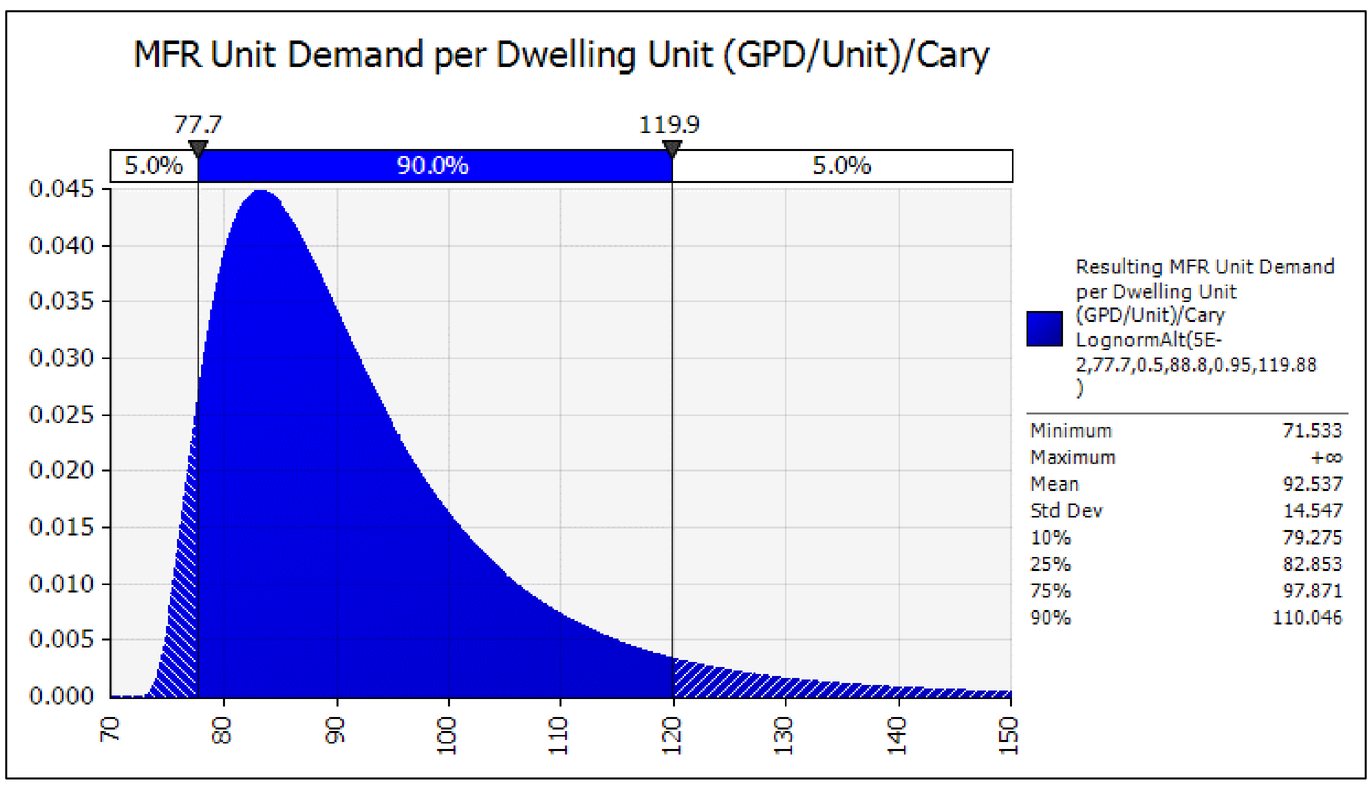
Median (50th) 40 GPCD is the average 50th percentile GPCD for all MFR accounts for the 2013 to 2016 period.

5th 35 GPCD is currently the most efficient indoor GPCD for a residential home, based on current technology.

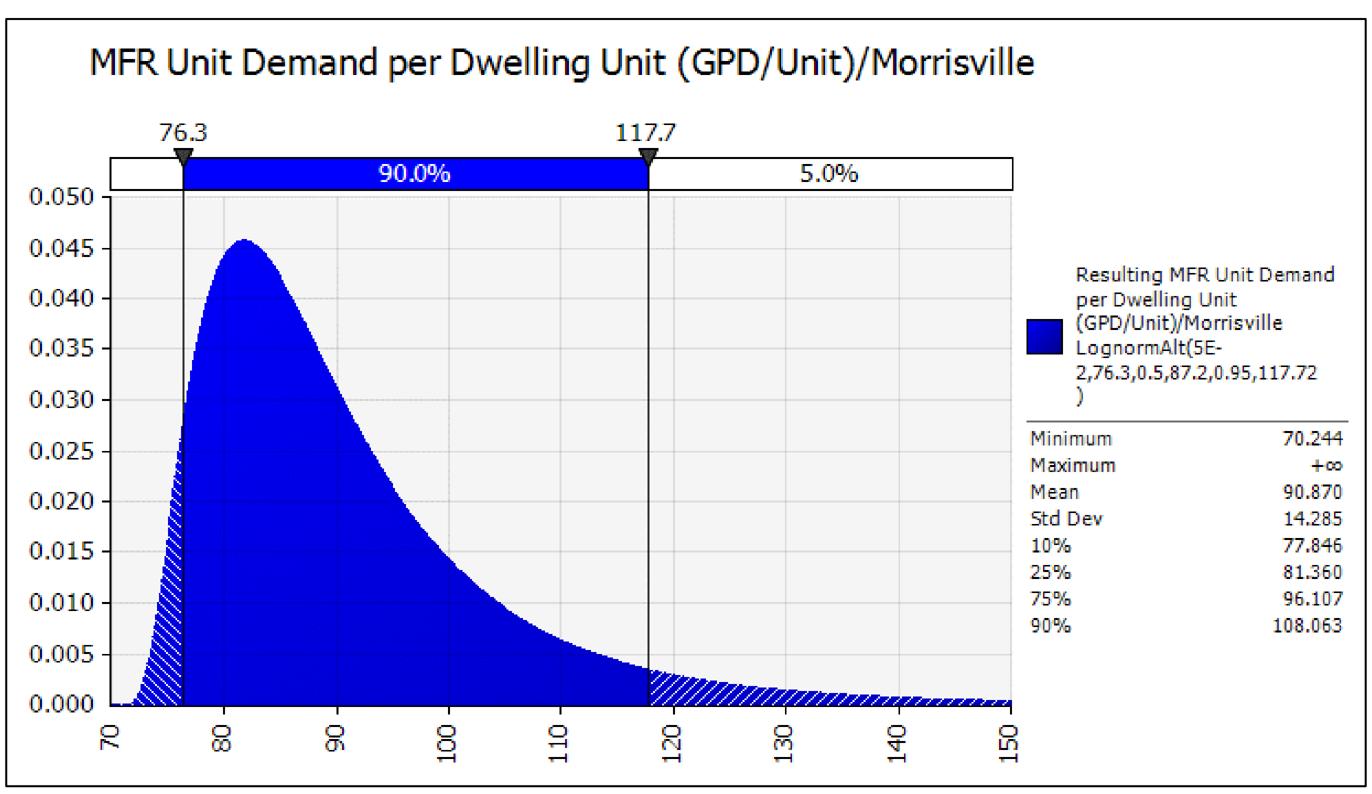
95th 55 GPCD is the annual average demand for all MFR accounts for the 2001 to 2009 time period.

Probability Density Functions assuming Log-Normal Distributions (in GPD/Unit)

Cary



Morrisville



New Commercial (COM) Account Unit Demand Assumptions

COM Unit Demand (GPD/Square Foot)

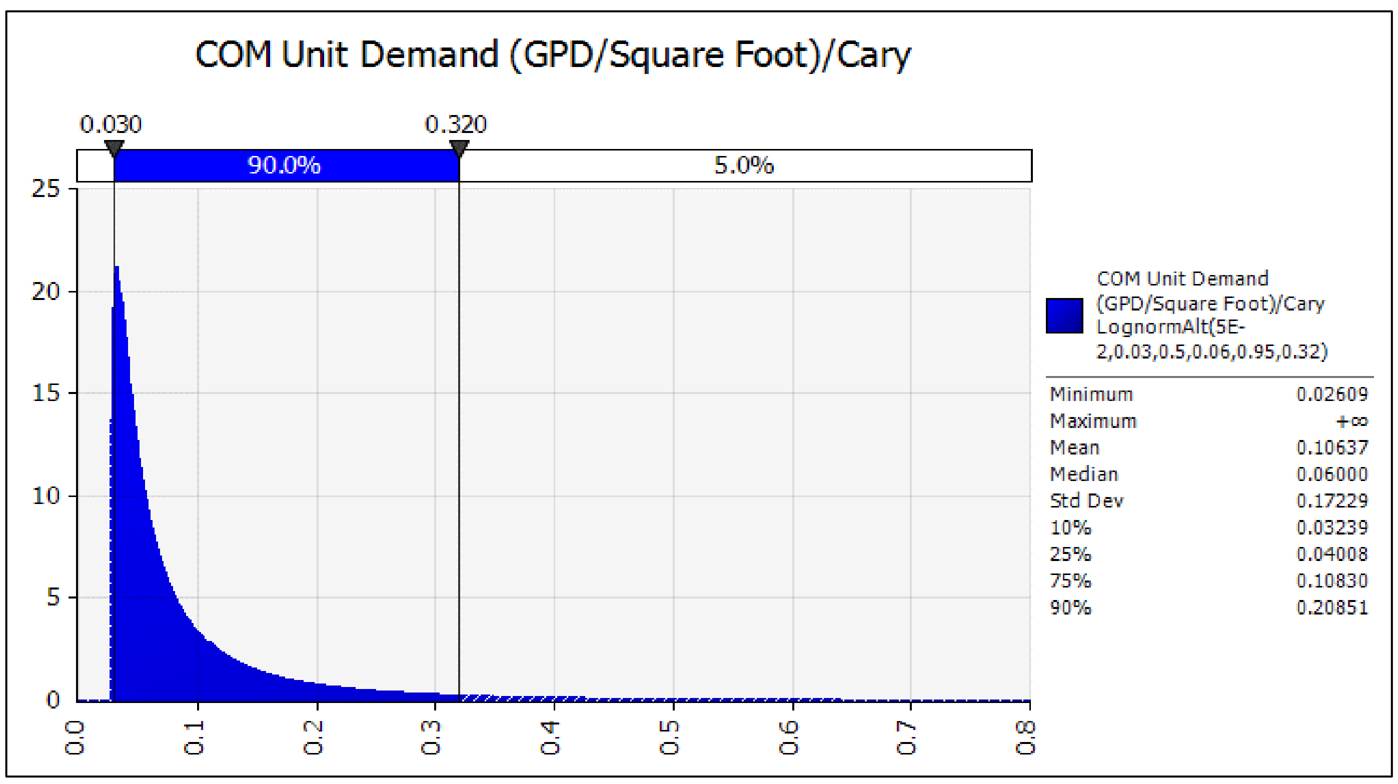
	Median (50th Perc.)	5th Percentile	95th Percentile	Resulting Average
Cary	0.06	0.03	0.32	0.11
Morrisville	0.05	0.025	0.36	0.11

Unit Factor Assumption Basis:

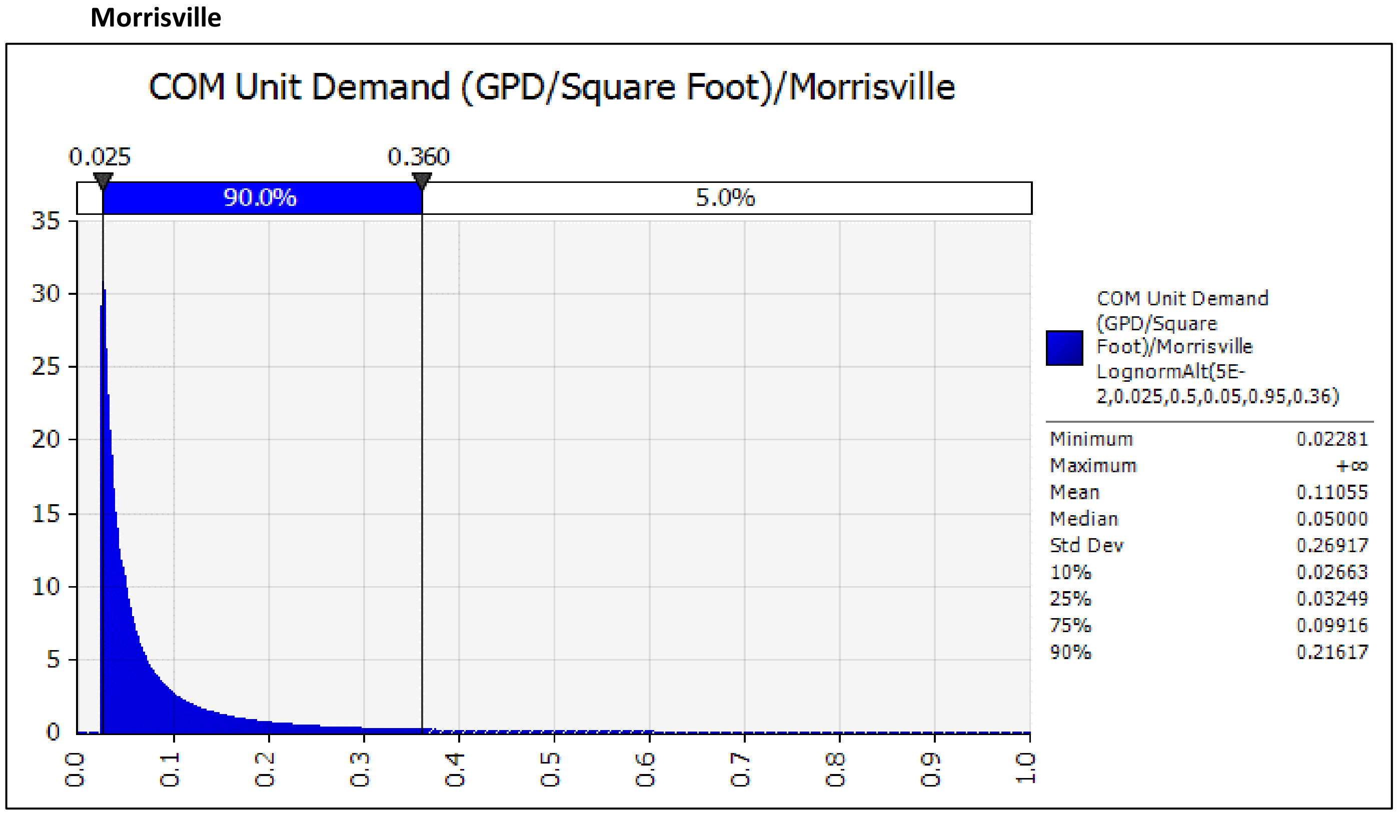
Median (50th)	Based on the average 50th percentile GPD/Square Foot for all COM accounts for 2013 to 2016 period.
5th	Assumed to be no less than half the median value for 2013-2016.
95th	Equals the average 90th percentile for the 2013 to 2016 period.

Probability Density Functions assuming Log-Normal Distributions (in GPD/SqFt)

Cary



Morrisville



New Industrial (IND) Account Unit Demand Assumptions

IND Unit Demand (GPD/Square Foot)

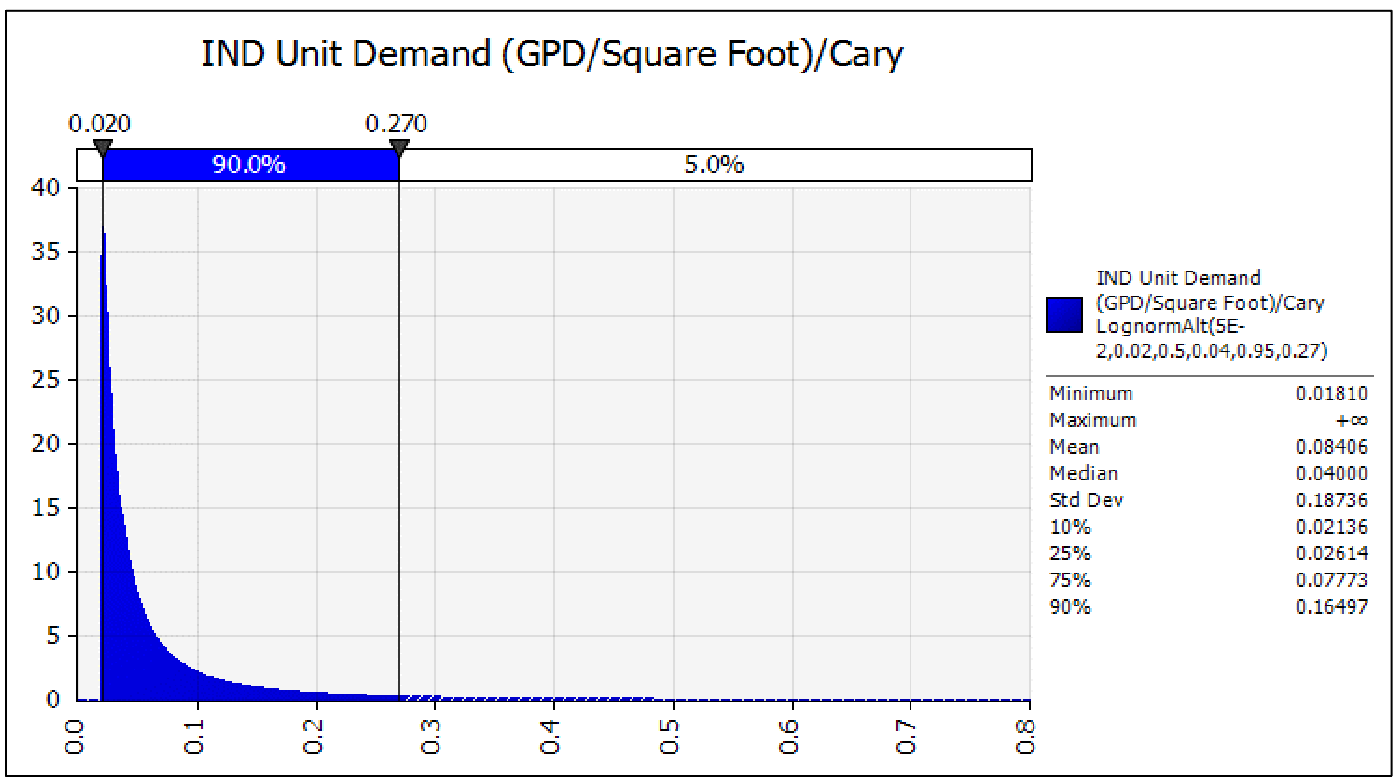
	Median (50th Perc.)	5th Percentile	95th Percentile	Resulting Average
Cary	0.04	0.02	0.27	0.08
Morrisville	0.02	0.01	0.27	0.08

Unit Factor Assumption Basis:

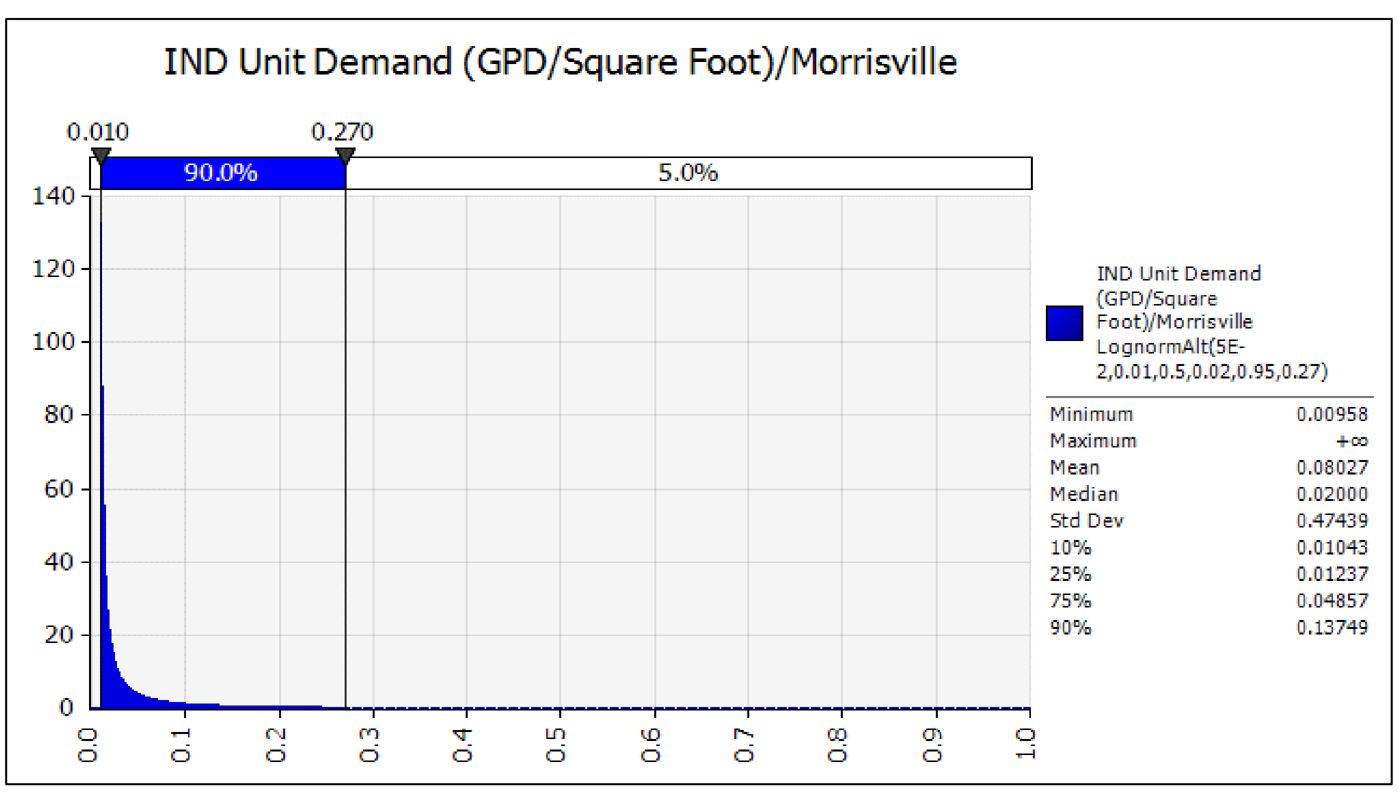
Median (50th)	Calculated based on IND demand per total square footage for the year 2016.
5th	Assumed to be no less than half the median value.
95th	Based on the annual average GPD/Square Foot for all IND accounts for the 2013 to 2016 time period.

Probability Density Functions assuming Log-Normal Distributions (in GPD/SqFt)

Cary



Morrisville



New Institutional (INS) Account Unit Demand Assumptions

INS Unit Demand (GPD/Square Foot)

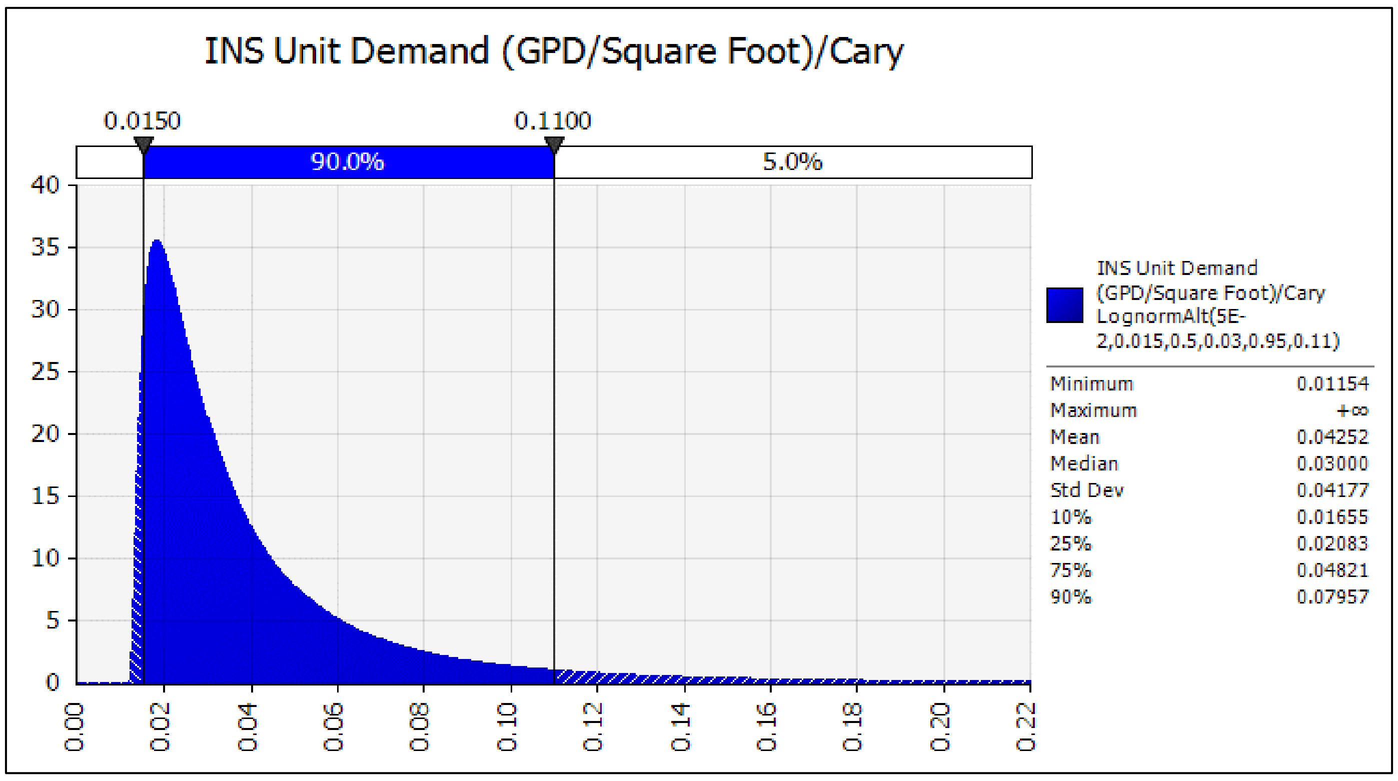
	Median (50th Perc.)	5th Percentile	95th Percentile	Resulting Average
Cary	0.03	0.015	0.11	0.04
Morrisville	0.03	0.015	0.11	0.04

Unit Factor Assumption Basis:

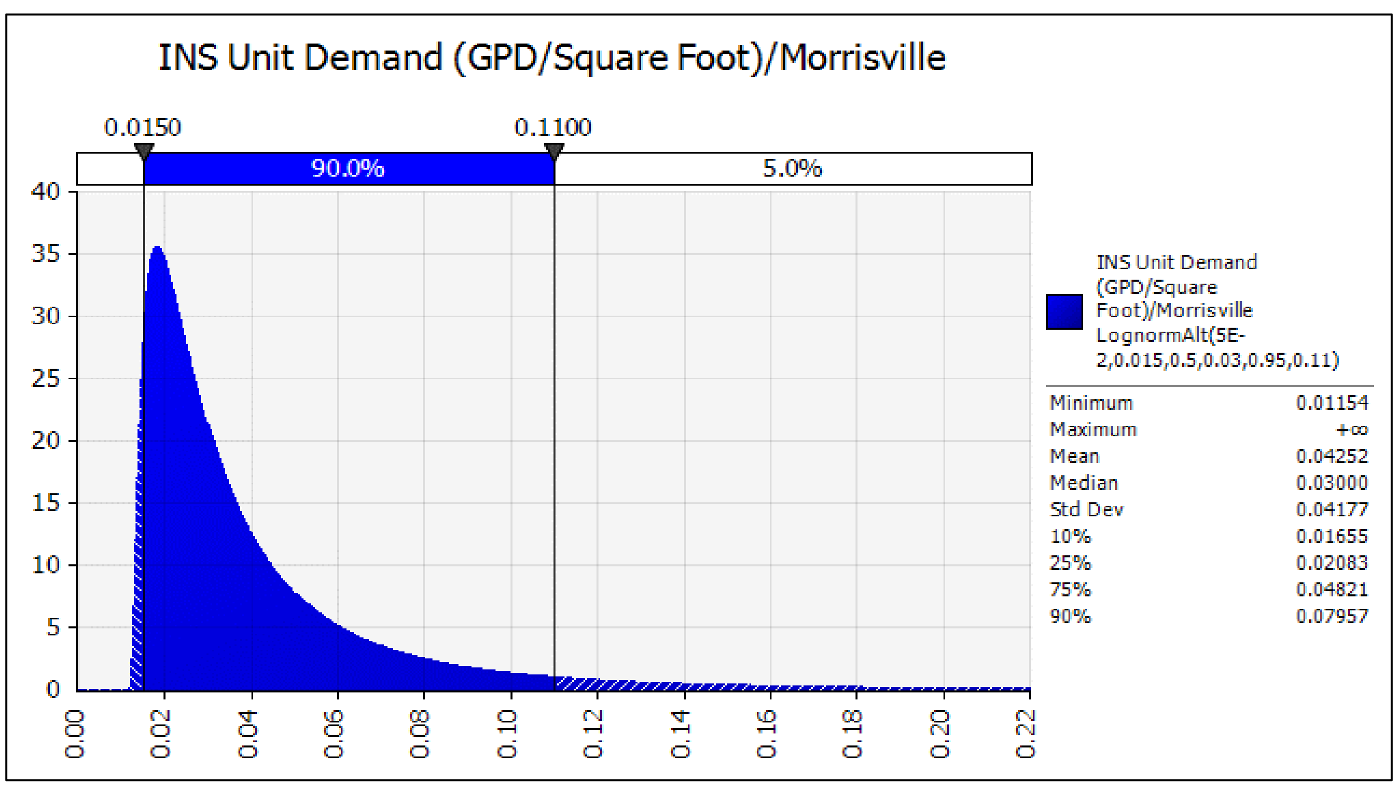
Median (50th)	Calculated based on INS demand per total square footage for the year 2016.
5th	Assumed to be no less than half the median value.
95th	Based on the annual average GPD/Square Foot for all INS accounts for the 2013 to 2016 time period.

Probability Density Functions assuming Log-Normal Distributions (in GPD/SqFt)

Cary



Morrisville



Appendix C2
Probabilistic Variables for Town of Cary

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April 30, 2018

Subject: LRWRP Forecast, Probabilistic Variables for Town of Cary Uncertainty Model

This list details the probabilistic functions (not including Unit Demand Factors) used to define the input variables for the Town of Cary's long range water demands uncertainty model. The majority use historic data to determine the shape and scale of the distribution. This list will become an attachment to the technical memorandum documenting the forecast.

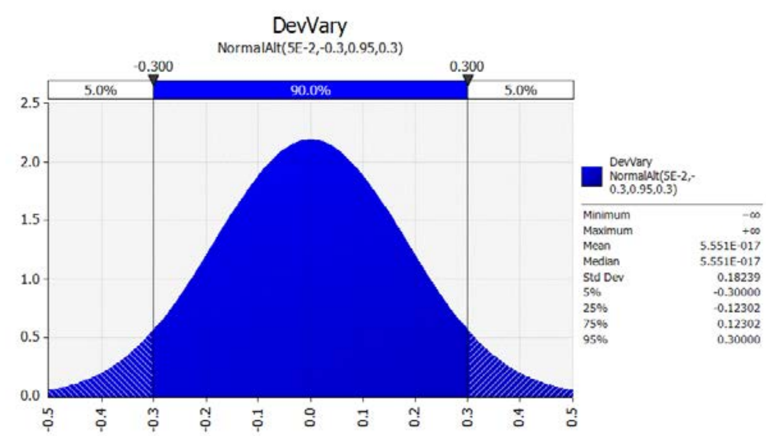
Development Rate Variation

Normal Distribution

Applied to all customer types and development statuses in rate table, across all forecast years

At year 2065, 95th percentile drops to 12%.

5th percentile	25th percentile	50th percentile	75th percentile	95th percentile
-30%	-12%	0%	12%	30%

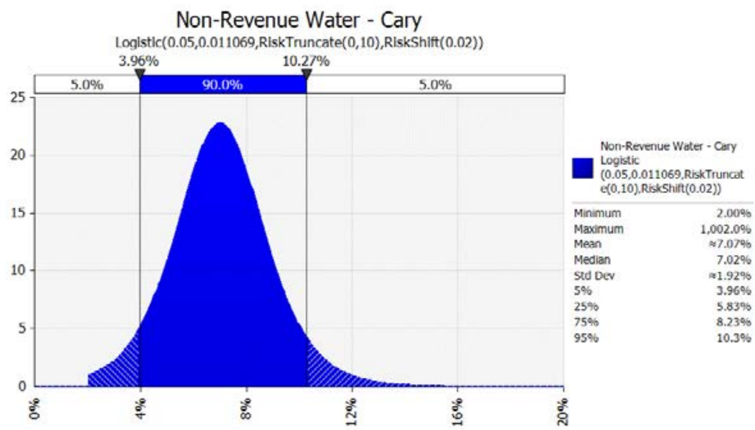


Non-Revenue Water Percent Variation

Logistic Distribution

Used to calculate total water distributed from total water demand
Developed from data for years

5th percentile	25th percentile	50th percentile	75th percentile	95th percentile
4.0%	5.8%	7.0%	8.2%	10.3%

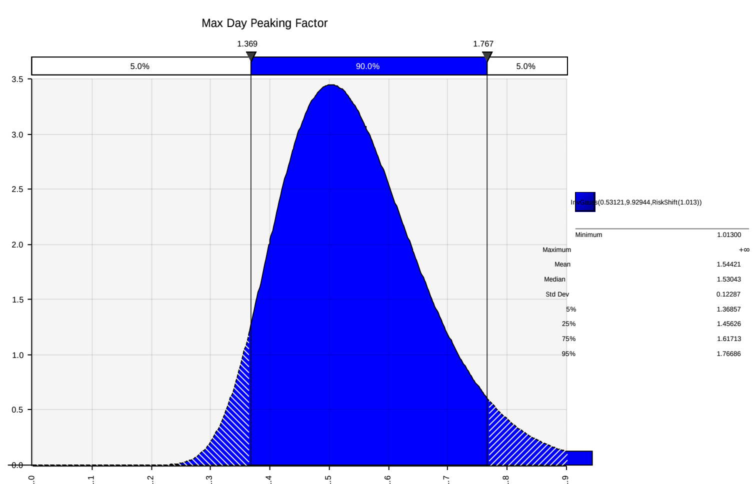


Max Day Peaking Factor Variation

Inverse Gaussian Distribution

Used to calculate Max Day forecast line from simulated Annual Average forecast line
Selected using data from 2010 – 2017

5th percentile	25th percentile	50th percentile	75th percentile	95th percentile
1.37	1.46	1.53	1.62	1.77



Average Peaking Factor Options

	2013-2016	2013-2017	2009-2017	2010-2017
Peaking Factor	1.43	1.45	1.53	1.53

Town of Cary Peaking Factors

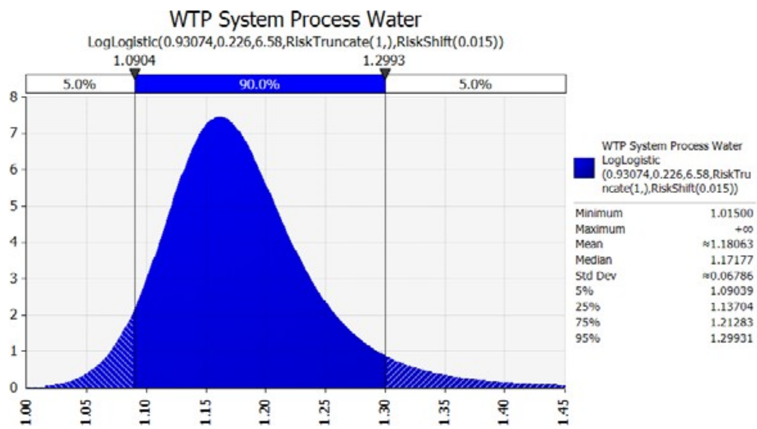
Year	Average Day – Cary Only (MGD)	Maximum Day – Cary Only (MGD)	Peaking Factor
2007	15.35	23.21	1.51
2008	13.88	21.07	1.52
2009	13.15	20.32	1.55
2010	14.18	23.72	1.67
2011	14.56	23.22	1.59
2012	13.64	23.73	1.74
2013	13.46	19.28	1.43
2014	13.98	20.93	1.50
2015	14.76	21.63	1.47
2016	14.95	20.15	1.35
2017	15.60	23.30	1.50

Process Loss Factor Variation

Log-logistic Distribution

Used to calculated Raw Water demand from total water distributed, for Annual Average Forecast and Max Day Forecast
Selected from data for years 2010-2016

5th percentile	25th percentile	50th percentile	75th percentile	95th percentile
1.09	1.14	1.17	1.21	1.30



Town of Cary Process Water Usage

Year	Cary's Raw Water from Jordan Lake (MGD)	WTP Finished Water (MGD)	WTP Process Water (MGD)	Process Loss Factor
2010	17.30	14.20	3.10	1.22
2011	16.90	14.50	2.40	1.17
2012	15.90	13.60	2.30	1.17
2013	15.30	13.40	1.90	1.14
2014	15.70	14.00	1.70	1.12
2015	17.40	14.80	2.60	1.18
2016	18.00	14.80	3.20	1.22
2017	24.05	19.70		1.19

Total Process Water Usage

Year	WTP Process Water (MGD)	Ratio of Raw Water to Finished Water
2014	2.11	1.12
2015	3.36	1.18
2016	3.95	1.22
2017	3.92	1.19

As provided by Sarah Braman, emailed dated

Conservation Rate Variation

Log-Normal Distributions

Applied to all Customer Types except for Industrial

Developed using information provided by Amy Vickers & Associates under Task 9

Percentile	2025	2030	2035	2040	2045	2065
5^{th}	3%	6%	8%	10%	12%	16%
50^{th}	1%	1%	2%	3%	4%	6%
95^{th}	0%	1%	1%	2%	2%	4%

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Appendix D

Forecasting Methodology Quality Assurance

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Long Range Water Resources Plan Update: Forecasting Methodology Quality Assurance

PREPARED FOR: Town of Cary

DATE: October 2018

PROJECT NUMBER: 692605

The Town of Cary has partnered with CH2M HILL North Carolina, Inc. (CH2M) to update the 2013 Long Range Water Resources Plan (LRWRP). The effort includes projecting demands using a probabilistic modeling approach. The evaluation methodology was updated from how it was done in the 2013 LRWRP (CH2M and Brown and Caldwell, 2013). With automated meter infrastructure available beginning in 2013, the evaluation methodology was improved and supported more detailed analysis of sectors of water use including separately metered irrigation. This technical memorandum describes the calibration measures applied for the water demand forecast and revised methodology for the wastewater flow portion of the forecast for the Town of Cary through 2065.

Water Demand Forecasting

Methodology

The forecasting methodology is discussed in the *2018 Long Range Water Resources Plan Update Forecast of Water Demands and Wastewater Flows Technical Memorandum* prepared for the Town of Cary (CH2M, 2018). The results are simulated for all years, 2016 through 2065, then the model output is calibrated to annual average day (AAD) historical demands from the most recent historical data, in this case 2016. The forecast methodology includes the use of a "low use override" and brings those accounts with water use below 50 gallons per day (gpd) up to 50 gpd. This allows for the occupancy rates to be the same across existing parcels and future parcels as the forecast projects into the future. Without conducting the low-use override, the existing parcels would not change from what their occupancy rate was in 2016.This step conservatively accounts for the potential for occupancy changes and water use behavior changes throughout the planning period, but does initially produce modeled results for 2016 that are higher than 2016 actual water demands.

The next step in the forecast is to adjust the 2016 year via application of an occupancy rate to better calibrate the model (in 2016 only) to align with 2016 actual water demands. This is needed to support the calibration of other projections built from the average annual day finished water forecast. Adjustments were made by applying an "apparent occupancy" to the start year, 2016, in lieu of using the occupancy factors established for the rest of the forecast. The apparent occupancy initially used was a single factor that was applied to all customers. This focused on aligning the forecast to the 2016 water treatment plant (WTP) production.

Calibration Results

A comparison of modeling results to Town of Cary 2016 actual annual average day (AAD) values by jurisdiction is presented in Table D-1. Precision is represented by percent difference. These results are within an acceptable margin of accuracy and still slightly overpredict actual demands for the Town of Cary's jurisdiction. Given that this model will be used for future infrastructure planning purposes, it is best practice to conservatively slightly overpredict results rather than under predict.

Table D-1. Water Demand Comparison by Jurisdiction, 2016, MGD, Annual Average Day
Includes the Towns of Cary, Town of Morrisville, RTP South, and RDU Airport

Jurisdiction	Actual	Modeled	Percent Difference
Cary	10.7	11.2	4.6%
Morrisville	1.8	1.8	0.0%
RTP South	0.5	0.5	0.0%
RDU	0.3	0.3	0.0%
Sub-total Finished Water Demand	**13.3**	**13.8**	**3.7%**

Once the 2016 AAD values were calibrated, the other forecast values were generated using the probabilistic model including application of factors selected with the Town of Cary to best represent historical data and future patterns for demands. First, water system factors such as non-revenue water and process loss were applied and a water conservation factor was applied to all customer types except industrial. Then, peaking factors were applied to calculate maximum day water demand. Table D-2 presents the total water demand comparison for 2016.

Table D-2. Total Water Demand Comparison, 2016, MGD
Includes the Towns of Cary, Town of Morrisville, RTP South, and RDU Airport

Jurisdiction	Actual	Modeled	Percent Difference
Finished Water Demand			
Non-revenue (Incl. Operational)	1.3	1.0	-26.1%
Annual Average Day Finished Water Demand	14.6	14.8	1.4%
Maximum Day Finished Water Demand	20.2	22.8	12.1%
Raw Water Demand			
WTP System Process Water	3.2	2.6	-20.7%
Annual Average Day Raw Water Demand	17.8	17.4	2.3%
Maximum Day Raw Water Demand	24.4	26.8	9.4%

Wastewater Flow Projections

Revised Methodology

Wastewater flows were calculated by applying percent returns for each facility to the water demands. Since Cary has multiple water reclamation facility (WRF) service areas, the approach of using a single factor for the apparent occupancy across all service areas was not ideal, and the model output did not calibrate. For example, all three service areas would be adjusted to achieve the WTP production, but the South Cary WRF could have more low-use overrides than the North Cary WRF and Western Wake Regional WRF service areas.

This methodology has been revised to where three respective apparent occupancies are applied to the individual WRF service areas, and a better value was achieved. Therefore, instead of calibrating these to the overall 2016 WTP production value, they are calibrated to their respective 2016 WRF flows.

As a result of this revision, when checking against the 2016 WTP production value, the results are not in line with the historical data. This highlights that percent returns were calculated by comparing flows measured at the WRF to all potable flow, including irrigation in the 2013 forecast. However, due to improved data, the 2016 forecast is calculating wastewater using potable flow, excluding irrigation.

To balance historic WTP demand, WRF flows, and percent returns, the apparent occupancies by WRF service area are determined based on the selected return factors and start year, 2016, WRF flows. The the 2016 WTP production value is checked, and based on this process the following section presents the revised return factors and results.

Wastewater Flow Results

The Town of Cary operates the North and South Cary WRFs and shares ownership of the WWRWRF with the Town of Apex. The individual percent return value used to calculate the wastewater flow is 122 percent for North Cary WRF, 132 percent for South Cary WRF, and 103 percent for Western Wake Regional WRF. A comparison of modeling results for the revised methodology to 2016 actual values by jurisdiction is presented in Table D-3 for annual average day values and Table D-4 for maximum month average day values.

Table D-3. Wastewater Flow Comparison by Water Reclamation Facility, 2016, MGD, Annual Average Day
Includes the Towns of Cary, Town of Morrisville, RTP South, and RDU Airport

Jurisdiction	Actual	Modeled	Percent Difference
North Cary WRF	6.2	6.2	0.0%
South Cary WRF	5.5	5.5	0.0%
Western Wake Regional WRF	3.3	3.3	0.0%
Total Flow	**15.0**	**15.0**	**0.0%**

Table D-4. Wastewater Flow Comparison by Water Reclamation Facility, 2016, MGD, Maximum Month Average Day
Includes the Towns of Cary, Town of Morrisville, RTP South, and RDU Airport

Jurisdiction	Actual	Modeled	Percent Difference
North Cary WRF	7.3	6.9	5.6%
South Cary WRF	6.5	6.4	1.6%
Western Wake Regional WRF	3.8	3.8	0.0%
Total Flow	**17.6**	**17.1**	**2.9%**

Conclusion

The Town's forecasts were updated following the change in methodology and return factors. Each set of modeled results was populated through separate model simulations. The forecast completed using these approaches calibrates to the actual values within the expected tolerances. These forecast results are included in the *2018 Long Range Water Resources Plan Update Forecast of Water Demands and Wastewater Flows Technical Memorandum* prepared for the Town of Cary (CH2M, 2018).

Appendix E

Detailed Forecast Results

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Appendix E1

Water Demand Forecast by Pressure Zones

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Table E1-1. 50th Percentile Finished Water Demand Projections by Pressure Zone, 2016 to 2065, MGD, Annual Average Day

Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

Pressure Zone	**2016**	**2025**	**2030**	**2035**	**2040**	**2045**	**2065**
Central	9.1	10.9	11.7	12.3	12.8	13.2	16.3
Southern	0.5	0.6	0.7	0.8	0.8	0.9	0.9
Western	3.7	5.0	5.5	6.0	6.4	6.8	8.5
Sub-total Finished Water Demand	**13.3**	**16.5**	**17.9**	**19.1**	**20.0**	**20.9**	**25.7**
Non-revenue (Incl. Operational)	1.3	1.3	1.3	1.5	1.6	1.6	1.9
Annual Average Day Finished Water Demand	**14.6**	**17.8**	**19.2**	**20.6**	**21.6**	**22.5**	**27.6**

Table E1-2. 75th Percentile Finished Water Demand Projections by Pressure Zone, 2016 to 2065, MGD, Annual Average Day

Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

Pressure Zone	**2016**	**2025**	**2030**	**2035**	**2040**	**2045**	**2065**
Central	9.1	11.1	12.1	13.0	13.6	14.2	17.0
Southern	0.5	0.6	0.7	0.8	0.9	0.9	1.0
Western	3.7	5.1	5.7	6.3	6.7	7.2	8.9
Sub-total Finished Water Demand	**13.3**	**16.8**	**18.5**	**20.1**	**21.2**	**22.3**	**26.9**
Non-revenue (Incl. Operational)	1.3	1.4	1.4	1.5	1.6	1.7	2.1
Annual Average Day Finished Water Demand	**14.6**	**18.2**	**19.9**	**21.6**	**22.8**	**24.0**	**29.0**

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Appendix E2

Wastewater Flows Forecast by Sewer Subbasins

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Table E2-1. Wastewater Flow Monitor Location Percent Returns and Max Month Peaking Factors for 2016

Site No.	Flow Monitor Location	2016 Percent Return (%)	2016 Max Month Peaking Factor
North Cary Water Reclamation Facility Sewer Basin			
1	Black Creek	93	1.08
3	Crabtree Creek	110	1.24
8	Carpenter	114	1.15
11	Upper Preston	134	1.15
12	Black Creek	153	1.17
13	Jenks Carpenter	153	1.13
16	Crabtree Creek	89	1.14
22	Indian Creek	118	1.11
23	York Interceptor	107	1.08
24	Aviation Parkway	301	1.16
25	Brier Creek	149	1.11
27	Harrison Oaks	166	1.14
28	Medfield Road	216	1.18
South Cary Water Reclamation Facility Sewer Basin			
2	Lynn's Branch	110	1.20
4	Walnut Creek	172	1.29
5	MacDonald Woods	195	1.21
6	Upper Swift Creek	173	1.15
7	Upper Swift Creek	129	1.23
9	Lower Wyndfall	103	1.07
10	Long Branch	145	1.21
15	Camp Branch	160	1.08
17	Speight Branch	62	1.19
31	Lower Swift Creek	129	1.11
32	Lower Swift Creek	13	1.09
33	Lochmere	147	1.19
Western Wake Regional Water Reclamation Facility			
14	Panther Creek	167	1.29
18	Kit Creek	107	1.04
26	White Oak	140	1.18
29	Nancy Branch	141	1.03
30	Green Level	41	1.03
54	West Reedy Branch	91	1.07

Notes:
Max = maximum
No. = number

Table E2-2. 50th Percentile Wastewater Demand Projections by Sewer Subbasin, 2016 to 2065, MGD, Annual Average Day

Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

Sewer Subbasin	2016	2025	2030	2035	2040	2045	2065
C1	-	0.00	0.00	0.00	0.00	0.00	0.00
C2	0.01	0.02	0.02	0.02	0.02	0.02	0.02
C3	-	0.00	0.00	0.01	0.01	0.01	0.03
C4	-	0.00	0.00	0.01	0.01	0.01	0.03
C5	-	0.00	0.00	0.00	0.00	0.00	0.01
C6	-	0.00	0.00	0.00	0.00	0.00	0.01
C7	-	0.00	0.00	0.00	0.00	0.00	0.00
C8	-	0.01	0.02	0.02	0.02	0.02	0.04
M1	0.02	0.03	0.04	0.05	0.06	0.07	0.11
M10	0.02	0.02	0.02	0.02	0.03	0.03	0.05
M11	0.00	0.02	0.02	0.02	0.02	0.02	0.02
M12	0.07	0.09	0.12	0.15	0.17	0.19	0.28
M13	0.12	0.14	0.14	0.14	0.14	0.14	0.20
M14	0.14	0.31	0.34	0.35	0.35	0.36	0.55
M15	0.08	0.08	0.08	0.08	0.09	0.09	0.16
M16	0.01	0.01	0.01	0.01	0.01	0.01	0.02
M17	0.01	0.01	0.01	0.01	0.01	0.01	0.01
M18	0.02	0.02	0.02	0.02	0.03	0.03	0.03
M19	0.08	0.08	0.08	0.08	0.09	0.09	0.09
M2	0.08	0.08	0.08	0.08	0.09	0.09	0.09
M20	0.08	0.09	0.10	0.11	0.11	0.12	0.13
M20A	0.14	0.16	0.17	0.19	0.20	0.21	0.21
M20B	-	0.00	0.00	0.01	0.01	0.01	0.03
M21	0.17	0.18	0.18	0.19	0.19	0.19	0.19
M21A	0.05	0.05	0.06	0.06	0.06	0.06	0.07
M3	0.11	0.12	0.12	0.12	0.12	0.12	0.11
M4	0.16	0.19	0.20	0.21	0.22	0.24	0.40
M5	0.18	0.19	0.19	0.19	0.19	0.19	0.20
M6	0.09	0.09	0.10	0.10	0.10	0.10	0.10
M6A	0.10	0.10	0.11	0.11	0.11	0.11	0.14
M7	0.02	0.03	0.03	0.03	0.03	0.03	0.03
M8	0.01	0.02	0.02	0.02	0.02	0.02	0.02
M9	0.07	0.10	0.17	0.24	0.29	0.34	0.43

Table E2-2. 50th Percentile Wastewater Demand Projections by Sewer Subbasin, 2016 to 2065, MGD, Annual Average Day

Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

Sewer Subbasin	2016	2025	2030	2035	2040	2045	2065
N1	0.02	0.03	0.05	0.07	0.10	0.11	0.12
N10	0.13	0.14	0.14	0.14	0.14	0.14	0.14
N11	0.16	0.20	0.23	0.24	0.25	0.26	0.28
N12	0.84	0.92	0.94	0.94	0.95	0.95	1.02
N13	0.27	0.30	0.31	0.31	0.31	0.31	0.33
N13A	0.08	0.08	0.08	0.08	0.09	0.09	0.09
N13B	0.28	0.34	0.35	0.35	0.35	0.34	0.36
N14	0.08	0.09	0.11	0.11	0.11	0.11	0.17
N15	0.48	0.52	0.56	0.58	0.61	0.62	0.72
N16	0.09	0.09	0.10	0.10	0.10	0.10	0.11
N17	0.37	0.40	0.42	0.44	0.48	0.50	0.65
N18	0.04	0.04	0.04	0.04	0.04	0.04	0.06
N2	0.01	0.01	0.02	0.02	0.02	0.02	0.03
N3	0.67	0.74	0.77	0.78	0.80	0.81	0.91
N3A	0.28	0.29	0.31	0.31	0.31	0.31	0.33
N4	0.10	0.12	0.13	0.15	0.16	0.17	0.25
N4A	0.02	0.02	0.02	0.02	0.02	0.02	0.02
N4B	0.05	0.05	0.05	0.05	0.05	0.05	0.06
N5	0.00	0.04	0.10	0.15	0.17	0.20	0.24
N5A	0.02	0.02	0.02	0.02	0.02	0.02	0.02
N5B	0.01	0.01	0.01	0.01	0.01	0.01	0.01
N5C	0.26	0.36	0.41	0.48	0.51	0.56	0.72
N6	0.03	0.03	0.05	0.06	0.07	0.09	0.12
N6A	0.06	0.06	0.07	0.07	0.07	0.07	0.08
N6B	0.06	0.06	0.07	0.07	0.09	0.09	0.10
N7	0.00	0.00	0.00	0.00	0.00	0.00	0.01
N8	0.29	0.37	0.38	0.38	0.38	0.40	0.44
N9	0.15	0.18	0.22	0.27	0.31	0.34	0.43
RTP	0.40	1.30	1.52	1.76	2.00	2.23	2.48
S1	0.30	0.33	0.39	0.46	0.50	0.56	0.65
S10	0.18	0.21	0.23	0.25	0.26	0.27	0.41
S11	0.19	0.22	0.23	0.24	0.23	0.23	0.27
S11A	0.13	0.14	0.14	0.14	0.14	0.14	0.15

Table E2-2. 50th Percentile Wastewater Demand Projections by Sewer Subbasin, 2016 to 2065, MGD, Annual Average Day

Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

Sewer Subbasin	2016	2025	2030	2035	2040	2045	2065
S11B	0.13	0.14	0.14	0.15	0.15	0.15	0.18
S11C	0.01	0.02	0.02	0.02	0.01	0.01	0.01
S12	0.10	0.10	0.10	0.11	0.11	0.11	0.11
S12A	0.01	0.01	0.01	0.01	0.01	0.01	0.01
S12B	0.06	0.06	0.06	0.06	0.06	0.07	0.07
S12C	0.01	0.01	0.01	0.01	0.01	0.01	0.01
S13	0.25	0.26	0.29	0.29	0.30	0.31	0.35
S14	0.27	0.28	0.28	0.29	0.29	0.29	0.33
S15	0.59	0.60	0.62	0.64	0.64	0.66	0.73
S16	0.14	0.15	0.15	0.15	0.15	0.15	0.16
S17	0.20	0.21	0.21	0.20	0.20	0.21	0.22
S18	0.19	0.20	0.20	0.20	0.19	0.20	0.21
S19	0.18	0.19	0.19	0.19	0.18	0.18	0.23
S2	0.29	0.32	0.38	0.45	0.50	0.55	1.10
S20	0.15	0.15	0.15	0.15	0.15	0.16	0.17
S20A	0.00	0.00	0.00	0.00	0.00	0.00	0.01
S21	0.08	0.07	0.09	0.11	0.12	0.12	0.13
S22	0.05	0.05	0.06	0.06	0.06	0.08	0.07
S23	0.11	0.14	0.19	0.27	0.32	0.37	0.42
S24	0.01	0.02	0.03	0.03	0.04	0.04	0.05
S25	0.10	0.11	0.13	0.15	0.17	0.20	0.23
S26	0.13	0.13	0.13	0.13	0.13	0.13	0.14
S3	0.20	0.21	0.22	0.23	0.24	0.24	0.32
S4	0.10	0.11	0.12	0.13	0.14	0.14	0.32
S4A	0.06	0.06	0.07	0.09	0.09	0.10	0.15
S5	0.51	0.52	0.53	0.54	0.54	0.54	0.65
S6	0.19	0.20	0.20	0.20	0.20	0.21	0.23
S7	0.01	0.02	0.02	0.02	0.03	0.03	0.05
S8	0.26	0.26	0.28	0.29	0.29	0.30	0.44
S8A	-	0.00	0.00	0.00	0.00	0.00	0.00
S9	0.26	0.28	0.29	0.29	0.30	0.30	0.41
S9A	0.02	0.02	0.02	0.02	0.02	0.02	0.02
W1	0.05	0.05	0.06	0.06	0.06	0.06	0.07

Table E2-2. 50th Percentile Wastewater Demand Projections by Sewer Subbasin, 2016 to 2065, MGD, Annual Average Day

Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

Sewer Subbasin	2016	2025	2030	2035	2040	2045	2065
W10	-	0.00	0.01	0.01	0.02	0.02	0.03
W10A	0.08	0.12	0.13	0.14	0.15	0.16	0.17
W11	-	0.01	0.02	0.02	0.03	0.04	0.04
W12	-	0.00	0.00	0.00	0.00	0.00	0.01
W13	0.02	0.03	0.04	0.05	0.06	0.07	0.07
W13A	0.03	0.04	0.04	0.04	0.04	0.04	0.04
W13B	0.01	0.01	0.01	0.01	0.01	0.01	0.01
W1A	0.02	0.02	0.02	0.02	0.02	0.02	0.04
W2A	0.07	0.08	0.09	0.09	0.09	0.10	0.21
W2B	0.04	0.05	0.05	0.05	0.05	0.05	0.06
W2C	0.04	0.09	0.12	0.15	0.16	0.17	0.32
W3	0.26	0.41	0.42	0.44	0.46	0.47	0.68
W3A	0.11	0.14	0.15	0.15	0.16	0.16	0.25
W4	0.43	0.55	0.61	0.66	0.68	0.71	0.82
W5	0.03	0.04	0.05	0.05	0.05	0.05	0.05
W5A	0.39	0.43	0.43	0.44	0.44	0.44	0.46
W5B	0.09	0.11	0.11	0.12	0.12	0.12	0.13
W6B	-	0.00	0.01	0.01	0.01	0.02	0.02
W6C	-	0.00	0.01	0.01	0.01	0.01	0.01
W7	0.03	0.04	0.06	0.07	0.09	0.10	0.32
W7A	0.24	0.28	0.29	0.31	0.31	0.31	0.34
W8	0.01	0.04	0.06	0.09	0.11	0.13	0.42
W8A	0.50	0.56	0.57	0.57	0.58	0.58	0.60
Total Wastewater Flow	**15.0**	**18.0**	**19.5**	**20.8**	**21.8**	**22.8**	**28.3**

NOTE: 0.00 indicates a non-zero but very small value and a hyphen ("-") indicates a zero value.

Table E2-3. 50th Percentile Wastewater Demand Projections by Sewer Subbasin, 2016 to 2065, MGD, Maximum Month Average Day

Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

Sewer Subbasin	2016	2025	2030	2035	2040	2045	2065
C1	-	0.00	0.00	0.00	0.00	0.00	0.00
C2	0.01	0.02	0.02	0.02	0.02	0.02	0.02
C3	-	0.00	0.01	0.01	0.01	0.02	0.03
C4	-	0.00	0.00	0.01	0.01	0.01	0.04
C5	-	0.00	0.00	0.00	0.00	0.01	0.01
C6	-	0.00	0.00	0.00	0.00	0.00	0.01
C7	-	0.00	0.00	0.00	0.00	0.00	0.00
C8	-	0.01	0.02	0.02	0.02	0.02	0.04
M1	0.03	0.03	0.04	0.06	0.07	0.08	0.13
M10	0.02	0.02	0.03	0.03	0.03	0.04	0.04
M11	0.00	0.02	0.03	0.03	0.03	0.03	0.03
M12	0.08	0.10	0.13	0.16	0.20	0.22	0.32
M13	0.13	0.14	0.14	0.14	0.14	0.16	0.22
M14	0.16	0.34	0.36	0.38	0.38	0.39	0.58
M15	0.09	0.09	0.09	0.09	0.09	0.09	0.18
M16	0.01	0.01	0.01	0.01	0.01	0.01	0.03
M17	0.01	0.01	0.01	0.01	0.01	0.01	0.01
M18	0.03	0.03	0.03	0.03	0.03	0.03	0.03
M19	0.10	0.10	0.10	0.10	0.10	0.10	0.11
M2	0.09	0.10	0.10	0.10	0.10	0.10	0.11
M20	0.08	0.09	0.10	0.11	0.12	0.12	0.13
M20A	0.15	0.17	0.18	0.19	0.20	0.20	0.22
M20B	-	0.00	0.00	0.01	0.01	0.01	0.03
M21	0.18	0.19	0.19	0.19	0.19	0.19	0.20
M21A	0.06	0.06	0.06	0.06	0.06	0.06	0.07
M3	0.12	0.12	0.12	0.12	0.12	0.12	0.12
M4	0.18	0.20	0.22	0.24	0.25	0.26	0.44
M5	0.20	0.19	0.19	0.20	0.20	0.20	0.21
M6	0.10	0.10	0.10	0.10	0.10	0.10	0.11
M6A	0.11	0.11	0.11	0.11	0.11	0.12	0.14
M7	0.03	0.03	0.03	0.03	0.03	0.03	0.03
M8	0.01	0.02	0.02	0.02	0.02	0.02	0.02
M9	0.08	0.11	0.17	0.25	0.30	0.35	0.45

Table E2-3. 50th Percentile Wastewater Demand Projections by Sewer Subbasin, 2016 to 2065, MGD, Maximum Month Average Day

Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

Sewer Subbasin	2016	2025	2030	2035	2040	2045	2065
N1	0.02	0.03	0.06	0.08	0.09	0.11	0.13
N10	0.14	0.15	0.15	0.14	0.14	0.14	0.15
N11	0.18	0.22	0.25	0.27	0.28	0.28	0.32
N12	1.01	1.04	1.03	1.06	1.06	1.05	1.14
N13	0.32	0.34	0.33	0.34	0.34	0.34	0.36
N13A	0.09	0.10	0.10	0.09	0.09	0.09	0.10
N13B	0.32	0.37	0.37	0.38	0.38	0.38	0.39
N14	0.09	0.10	0.11	0.11	0.11	0.11	0.19
N15	0.56	0.59	0.62	0.65	0.67	0.69	0.79
N16	0.10	0.10	0.10	0.10	0.10	0.10	0.12
N17	0.42	0.42	0.45	0.48	0.50	0.54	0.69
N18	0.04	0.04	0.05	0.05	0.05	0.05	0.07
N2	0.01	0.01	0.02	0.02	0.02	0.02	0.03
N3	0.82	0.85	0.86	0.90	0.90	0.92	1.03
N3A	0.31	0.32	0.31	0.32	0.32	0.32	0.35
N4	0.11	0.12	0.14	0.15	0.17	0.19	0.27
N4A	0.02	0.02	0.02	0.02	0.02	0.02	0.02
N4B	0.05	0.06	0.06	0.06	0.06	0.06	0.07
N5	0.00	0.04	0.10	0.15	0.20	0.23	0.26
N5A	0.02	0.03	0.03	0.02	0.02	0.02	0.02
N5B	0.01	0.01	0.01	0.01	0.01	0.01	0.01
N5C	0.31	0.40	0.46	0.53	0.56	0.61	0.79
N6	0.03	0.04	0.05	0.07	0.08	0.09	0.13
N6A	0.07	0.07	0.08	0.08	0.08	0.09	0.09
N6B	0.07	0.08	0.08	0.09	0.09	0.09	0.12
N7	0.00	0.00	0.00	0.00	0.00	0.00	0.01
N8	0.37	0.44	0.45	0.46	0.46	0.47	0.54
N9	0.17	0.19	0.24	0.30	0.34	0.37	0.48
RTP	0.45	1.46	1.73	1.98	2.26	2.51	2.83
S1	0.38	0.41	0.50	0.59	0.65	0.71	0.82
S10	0.21	0.25	0.27	0.29	0.32	0.33	0.49
S11	0.22	0.26	0.26	0.26	0.26	0.26	0.31
S11A	0.14	0.14	0.15	0.15	0.15	0.15	0.16

Table E2-3. 50th Percentile Wastewater Demand Projections by Sewer Subbasin, 2016 to 2065, MGD, Maximum Month Average Day

Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

Sewer Subbasin	2016	2025	2030	2035	2040	2045	2065
S11B	0.14	0.14	0.15	0.16	0.16	0.17	0.19
S11C	0.02	0.02	0.02	0.02	0.02	0.02	0.02
S12	0.11	0.11	0.11	0.12	0.12	0.13	0.12
S12A	0.01	0.01	0.01	0.01	0.01	0.01	0.01
S12B	0.07	0.07	0.07	0.07	0.07	0.07	0.08
S12C	0.01	0.01	0.01	0.01	0.01	0.01	0.01
S13	0.30	0.32	0.33	0.35	0.36	0.37	0.42
S14	0.33	0.33	0.34	0.35	0.35	0.36	0.39
S15	0.73	0.72	0.75	0.77	0.78	0.79	0.86
S16	0.16	0.16	0.17	0.17	0.17	0.17	0.19
S17	0.24	0.24	0.23	0.23	0.23	0.23	0.24
S18	0.22	0.23	0.23	0.22	0.22	0.22	0.23
S19	0.20	0.20	0.21	0.21	0.21	0.21	0.25
S2	0.37	0.40	0.49	0.58	0.63	0.70	1.37
S20	0.17	0.16	0.17	0.18	0.18	0.18	0.19
S20A	0.00	0.00	0.00	0.00	0.00	0.00	0.01
S21	0.07	0.08	0.09	0.12	0.12	0.13	0.13
S22	0.05	0.06	0.06	0.07	0.07	0.07	0.08
S23	0.12	0.14	0.21	0.28	0.34	0.39	0.43
S24	0.01	0.02	0.03	0.03	0.04	0.04	0.04
S25	0.11	0.11	0.15	0.18	0.20	0.22	0.25
S26	0.15	0.14	0.15	0.15	0.15	0.15	0.16
S3	0.25	0.25	0.26	0.26	0.28	0.27	0.38
S4	0.12	0.12	0.14	0.15	0.16	0.17	0.38
S4A	0.07	0.08	0.09	0.09	0.11	0.12	0.18
S5	0.61	0.61	0.62	0.64	0.63	0.63	0.76
S6	0.24	0.24	0.24	0.24	0.24	0.24	0.27
S7	0.01	0.02	0.02	0.03	0.03	0.04	0.06
S8	0.31	0.31	0.32	0.34	0.35	0.35	0.51
S8A	-	0.00	0.00	0.00	0.00	0.00	0.00
S9	0.31	0.32	0.33	0.35	0.35	0.35	0.49
S9A	0.02	0.02	0.02	0.02	0.02	0.02	0.02
W1	0.05	0.05	0.05	0.05	0.06	0.06	0.07

Table E2-3. 50th Percentile Wastewater Demand Projections by Sewer Subbasin, 2016 to 2065, MGD, Maximum Month Average Day

Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

Sewer Subbasin	2016	2025	2030	2035	2040	2045	2065
W10	-	0.00	0.01	0.02	0.02	0.03	0.04
W10A	0.10	0.14	0.16	0.17	0.19	0.19	0.22
W11	-	0.01	0.02	0.02	0.03	0.04	0.05
W12	-	0.00	0.00	0.00	0.00	0.00	0.01
W13	0.02	0.03	0.04	0.05	0.06	0.06	0.07
W13A	0.04	0.05	0.05	0.05	0.06	0.06	0.05
W13B	0.01	0.01	0.01	0.01	0.01	0.01	0.01
W1A	0.02	0.02	0.02	0.02	0.02	0.02	0.04
W2A	0.07	0.09	0.09	0.09	0.10	0.10	0.21
W2B	0.04	0.05	0.05	0.05	0.05	0.05	0.06
W2C	0.04	0.10	0.13	0.15	0.17	0.18	0.33
W3	0.27	0.41	0.44	0.45	0.46	0.47	0.70
W3A	0.11	0.14	0.15	0.16	0.16	0.17	0.25
W4	0.55	0.71	0.78	0.83	0.88	0.92	1.06
W5	0.03	0.04	0.05	0.05	0.05	0.05	0.05
W5A	0.49	0.55	0.55	0.56	0.57	0.56	0.60
W5B	0.13	0.14	0.15	0.15	0.15	0.16	0.16
W6B	-	0.00	0.01	0.01	0.01	0.02	0.02
W6C	-	0.00	0.01	0.01	0.01	0.01	0.01
W7	0.03	0.05	0.06	0.09	0.10	0.12	0.38
W7A	0.28	0.33	0.35	0.35	0.36	0.36	0.40
W8	0.02	0.04	0.07	0.11	0.13	0.16	0.49
W8A	0.59	0.66	0.66	0.67	0.68	0.67	0.71
Total Wastewater Flow	**17.6**	**20.4**	**22.0**	**23.6**	**24.7**	**25.8**	**32.1**

NOTE: 0.00 indicates a non-zero but very small value and a hyphen ("-") indicates a zero value.

Table E2-4. 75th Percentile Wastewater Demand Projections by Sewer Subbasin, 2016 to 2065, MGD, Annual Average Day

Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

Sewer Subbasin	2016	2025	2030	2035	2040	2045	2065
C1	-	0.00	0.00	0.00	0.00	0.00	0.00
C2	0.01	0.02	0.02	0.02	0.02	0.02	0.02
C3	-	0.00	0.00	0.01	0.01	0.01	0.03
C4	-	0.00	0.00	0.01	0.01	0.01	0.03
C5	-	0.00	0.00	0.00	0.00	0.00	0.01
C6	-	0.00	0.00	0.00	0.00	0.00	0.01
C7	-	0.00	0.00	0.00	0.00	0.00	0.00
C8	-	0.01	0.02	0.02	0.02	0.02	0.04
M1	0.02	0.03	0.04	0.06	0.07	0.08	0.12
M10	0.02	0.02	0.02	0.02	0.03	0.03	0.05
M11	0.00	0.02	0.02	0.02	0.02	0.02	0.02
M12	0.07	0.1	0.12	0.16	0.18	0.21	0.3
M13	0.12	0.14	0.14	0.15	0.15	0.15	0.21
M14	0.14	0.32	0.35	0.37	0.38	0.39	0.57
M15	0.08	0.09	0.09	0.09	0.09	0.09	0.17
M16	0.01	0.01	0.01	0.01	0.01	0.01	0.02
M17	0.01	0.01	0.01	0.01	0.01	0.01	0.01
M18	0.02	0.02	0.02	0.02	0.03	0.03	0.04
M19	0.08	0.09	0.09	0.09	0.09	0.09	0.1
M2	0.08	0.09	0.09	0.09	0.09	0.09	0.1
M20	0.08	0.09	0.1	0.12	0.12	0.13	0.13
M20A	0.14	0.17	0.18	0.19	0.21	0.22	0.22
M20B	-	0.00	0	0.01	0.01	0.01	0.03
M21	0.17	0.19	0.19	0.19	0.20	0.20	0.20
M21A	0.05	0.06	0.06	0.06	0.06	0.06	0.07
M3	0.11	0.12	0.12	0.12	0.13	0.13	0.12
M4	0.16	0.19	0.21	0.22	0.24	0.25	0.42
M5	0.18	0.19	0.20	0.20	0.21	0.21	0.21
M6	0.09	0.10	0.10	0.10	0.10	0.10	0.11
M6A	0.10	0.11	0.11	0.11	0.11	0.12	0.14
M7	0.02	0.03	0.03	0.03	0.03	0.03	0.04
M8	0.01	0.02	0.02	0.02	0.02	0.02	0.02

Table E2-4. 75th Percentile Wastewater Demand Projections by Sewer Subbasin, 2016 to 2065, MGD, Annual Average Day

Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

Sewer Subbasin	2016	2025	2030	2035	2040	2045	2065
M9	0.07	0.11	0.18	0.26	0.31	0.37	0.45
N1	0.02	0.03	0.06	0.08	0.10	0.12	0.13
N10	0.13	0.14	0.14	0.15	0.15	0.15	0.14
N11	0.16	0.20	0.24	0.26	0.26	0.28	0.30
N12	0.84	0.95	0.98	1.00	1.02	1.03	1.07
N13	0.27	0.31	0.32	0.33	0.33	0.33	0.34
N13A	0.08	0.09	0.09	0.09	0.09	0.09	0.10
N13B	0.28	0.34	0.36	0.37	0.38	0.37	0.38
N14	0.08	0.10	0.11	0.11	0.11	0.12	0.18
N15	0.48	0.54	0.58	0.62	0.65	0.67	0.75
N16	0.09	0.10	0.10	0.10	0.10	0.10	0.12
N17	0.37	0.41	0.44	0.47	0.51	0.54	0.68
N18	0.04	0.04	0.04	0.04	0.05	0.05	0.06
N2	0.01	0.01	0.02	0.02	0.02	0.02	0.04
N3	0.67	0.77	0.80	0.83	0.86	0.88	0.95
N3A	0.28	0.30	0.32	0.33	0.33	0.33	0.34
N4	0.10	0.12	0.13	0.16	0.17	0.18	0.26
N4A	0.02	0.02	0.02	0.02	0.02	0.02	0.02
N4B	0.05	0.05	0.06	0.06	0.06	0.06	0.06
N5	0.00	0.04	0.10	0.16	0.18	0.22	0.25
N5A	0.02	0.02	0.02	0.02	0.02	0.02	0.02
N5B	0.01	0.01	0.01	0.01	0.01	0.01	0.01
N5C	0.26	0.37	0.43	0.50	0.55	0.60	0.75
N6	0.03	0.03	0.06	0.07	0.08	0.09	0.13
N6A	0.06	0.06	0.08	0.08	0.08	0.08	0.08
N6B	0.06	0.06	0.08	0.08	0.09	0.09	0.11
N7	0.00	0.00	0.00	0.00	0.00	0.00	0.01
N8	0.29	0.38	0.40	0.40	0.41	0.43	0.46
N9	0.15	0.18	0.23	0.29	0.33	0.37	0.45
RTP	0.40	1.33	1.58	1.85	2.09	2.37	2.60
S1	0.30	0.33	0.41	0.48	0.53	0.60	0.69
S10	0.18	0.21	0.24	0.26	0.27	0.29	0.44
S11	0.19	0.22	0.24	0.25	0.24	0.24	0.29

Table E2-4. 75th Percentile Wastewater Demand Projections by Sewer Subbasin, 2016 to 2065, MGD, Annual Average Day

Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

Sewer Subbasin	2016	2025	2030	2035	2040	2045	2065
S11A	0.13	0.14	0.14	0.15	0.15	0.15	0.16
S11B	0.13	0.14	0.14	0.16	0.16	0.16	0.19
S11C	0.01	0.02	0.02	0.02	0.01	0.01	0.01
S12	0.10	0.10	0.10	0.11	0.11	0.12	0.12
S12A	0.01	0.01	0.01	0.01	0.01	0.01	0.01
S12B	0.06	0.06	0.07	0.07	0.07	0.07	0.07
S12C	0.01	0.01	0.01	0.01	0.01	0.01	0.01
S13	0.25	0.26	0.30	0.30	0.32	0.34	0.38
S14	0.27	0.28	0.29	0.30	0.31	0.31	0.35
S15	0.59	0.60	0.64	0.67	0.68	0.71	0.78
S16	0.14	0.15	0.15	0.16	0.16	0.16	0.17
S17	0.20	0.21	0.22	0.21	0.22	0.22	0.23
S18	0.19	0.20	0.21	0.21	0.20	0.21	0.22
S19	0.18	0.19	0.20	0.20	0.19	0.20	0.24
S2	0.29	0.32	0.40	0.47	0.53	0.59	1.17
S20	0.15	0.15	0.15	0.16	0.16	0.17	0.18
S20A	0.00	0.00	0.00	0.00	0.00	0.00	0.01
S21	0.08	0.07	0.09	0.11	0.13	0.13	0.13
S22	0.05	0.05	0.07	0.07	0.07	0.08	0.07
S23	0.11	0.14	0.20	0.28	0.34	0.39	0.45
S24	0.01	0.02	0.03	0.03	0.05	0.05	0.05
S25	0.10	0.11	0.13	0.16	0.18	0.21	0.24
S26	0.13	0.13	0.13	0.14	0.14	0.14	0.15
S3	0.20	0.21	0.23	0.24	0.25	0.26	0.34
S4	0.10	0.11	0.12	0.14	0.15	0.15	0.34
S4A	0.06	0.06	0.08	0.09	0.09	0.10	0.16
S5	0.51	0.52	0.55	0.56	0.57	0.58	0.69
S6	0.19	0.20	0.21	0.21	0.22	0.22	0.24
S7	0.01	0.02	0.02	0.02	0.03	0.03	0.05
S8	0.26	0.26	0.29	0.30	0.31	0.32	0.47
S8A	-	0.00	0.00	0.00	0.00	0.00	0.00
S9	0.26	0.28	0.30	0.30	0.32	0.32	0.44
S9A	0.02	0.02	0.02	0.02	0.02	0.02	0.02

Table E2-4. 75th Percentile Wastewater Demand Projections by Sewer Subbasin, 2016 to 2065, MGD, Annual Average Day

Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

Sewer Subbasin	2016	2025	2030	2035	2040	2045	2065
W1	0.05	0.06	0.06	0.06	0.06	0.06	0.07
W10	-	0.00	0.01	0.01	0.02	0.02	0.03
W10A	0.08	0.12	0.13	0.15	0.16	0.17	0.18
W11	-	0.01	0.02	0.02	0.03	0.04	0.04
W12	-	0.00	0.00	0.00	0.00	0.00	0.01
W13	0.02	0.03	0.04	0.05	0.06	0.07	0.07
W13A	0.03	0.04	0.04	0.04	0.04	0.04	0.04
W13B	0.01	0.01	0.01	0.01	0.01	0.01	0.01
W1A	0.02	0.02	0.02	0.02	0.02	0.02	0.04
W2A	0.07	0.08	0.10	0.10	0.10	0.11	0.22
W2B	0.04	0.05	0.05	0.05	0.05	0.05	0.06
W2C	0.04	0.09	0.12	0.16	0.17	0.18	0.33
W3	0.26	0.42	0.44	0.47	0.48	0.50	0.71
W3A	0.11	0.14	0.15	0.16	0.17	0.17	0.26
W4	0.43	0.57	0.63	0.69	0.71	0.76	0.86
W5	0.03	0.04	0.05	0.05	0.05	0.05	0.05
W5A	0.39	0.44	0.45	0.46	0.46	0.47	0.48
W5B	0.09	0.11	0.11	0.13	0.13	0.13	0.13
W6B	-	0.00	0.01	0.01	0.01	0.02	0.02
W6C	-	0.00	0.01	0.01	0.01	0.01	0.01
W7	0.03	0.04	0.06	0.08	0.10	0.11	0.34
W7A	0.24	0.29	0.30	0.32	0.32	0.33	0.36
W8	0.01	0.04	0.07	0.10	0.12	0.14	0.44
W8A	0.50	0.58	0.59	0.60	0.61	0.62	0.63
Total Wastewater Flow	**15.0**	**18.3**	**20.2**	**21.9**	**23.1**	**24.4**	**29.8**

NOTE: 0.00 indicates a non-zero but very small value and a hyphen (“-“) indicates a zero value.

Table E2-5. 75th Percentile Wastewater Demand Projections by Sewer Subbasin, 2016 to 2065, MGD, Maximum Month Average Day

Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

Sewer Subbasin	2016	2025	2030	2035	2040	2045	2065
C1	-	0.00	0.00	0.00	0.00	0.00	0.00
C2	0.01	0.02	0.02	0.02	0.02	0.02	0.02
C3	-	0.00	0.01	0.01	0.01	0.02	0.03
C4	-	0.00	0.00	0.01	0.01	0.01	0.04
C5	-	0.00	0.00	0.00	0.00	0.01	0.01
C6	-	0.00	0.00	0.00	0.00	0.00	0.01
C7	-	0.00	0.00	0.00	0.00	0.00	0.00
C8	-	0.01	0.02	0.02	0.02	0.02	0.04
M1	0.03	0.03	0.04	0.07	0.08	0.09	0.14
M10	0.02	0.02	0.03	0.03	0.03	0.04	0.05
M11	0.00	0.02	0.03	0.03	0.03	0.03	0.03
M12	0.08	0.10	0.14	0.17	0.21	0.23	0.33
M13	0.13	0.15	0.15	0.15	0.15	0.17	0.23
M14	0.16	0.35	0.38	0.40	0.41	0.42	0.61
M15	0.09	0.09	0.10	0.10	0.10	0.10	0.18
M16	0.01	0.01	0.01	0.01	0.01	0.01	0.03
M17	0.01	0.01	0.01	0.01	0.01	0.01	0.01
M18	0.03	0.03	0.03	0.03	0.03	0.03	0.03
M19	0.10	0.10	0.11	0.11	0.11	0.11	0.11
M2	0.09	0.10	0.11	0.11	0.11	0.11	0.11
M20	0.08	0.09	0.10	0.11	0.13	0.13	0.13
M20A	0.15	0.17	0.19	0.20	0.21	0.22	0.23
M20B	-	0.00	0.00	0.01	0.01	0.01	0.03
M21	0.18	0.19	0.20	0.20	0.20	0.20	0.21
M21A	0.06	0.06	0.07	0.07	0.07	0.06	0.07
M3	0.12	0.13	0.13	0.13	0.13	0.13	0.13
M4	0.18	0.21	0.23	0.25	0.26	0.28	0.46
M5	0.20	0.20	0.20	0.21	0.21	0.21	0.22
M6	0.10	0.10	0.11	0.11	0.11	0.11	0.11
M6A	0.11	0.12	0.12	0.12	0.12	0.13	0.15
M7	0.03	0.03	0.03	0.03	0.03	0.03	0.03
M8	0.01	0.02	0.02	0.02	0.02	0.02	0.02

Table E2-5. 75th Percentile Wastewater Demand Projections by Sewer Subbasin, 2016 to 2065, MGD, Maximum Month Average Day

Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

Sewer Subbasin	2016	2025	2030	2035	2040	2045	2065
M9	0.08	0.12	0.18	0.26	0.32	0.38	0.47
N1	0.02	0.03	0.06	0.09	0.10	0.12	0.14
N10	0.14	0.16	0.16	0.15	0.15	0.15	0.16
N11	0.18	0.23	0.26	0.28	0.30	0.30	0.33
N12	1.01	1.07	1.08	1.12	1.14	1.13	1.19
N13	0.32	0.35	0.35	0.36	0.36	0.37	0.38
N13A	0.09	0.10	0.11	0.10	0.10	0.10	0.10
N13B	0.32	0.38	0.39	0.40	0.41	0.41	0.41
N14	0.09	0.10	0.12	0.12	0.12	0.12	0.19
N15	0.56	0.61	0.65	0.68	0.72	0.74	0.82
N16	0.10	0.10	0.11	0.11	0.11	0.11	0.13
N17	0.42	0.43	0.47	0.51	0.54	0.58	0.72
N18	0.04	0.04	0.05	0.05	0.06	0.06	0.07
N2	0.01	0.01	0.02	0.02	0.02	0.02	0.03
N3	0.82	0.87	0.90	0.95	0.97	0.98	1.07
N3A	0.31	0.32	0.33	0.34	0.34	0.34	0.37
N4	0.11	0.13	0.15	0.16	0.19	0.20	0.29
N4A	0.02	0.02	0.02	0.02	0.02	0.02	0.02
N4B	0.05	0.06	0.06	0.07	0.07	0.07	0.07
N5	0.00	0.04	0.11	0.16	0.21	0.24	0.27
N5A	0.02	0.03	0.03	0.02	0.02	0.02	0.02
N5B	0.01	0.01	0.01	0.01	0.01	0.01	0.01
N5C	0.31	0.41	0.48	0.55	0.61	0.65	0.82
N6	0.03	0.04	0.05	0.08	0.09	0.10	0.14
N6A	0.07	0.07	0.08	0.09	0.09	0.10	0.09
N6B	0.07	0.08	0.08	0.10	0.10	0.10	0.13
N7	0.00	0.00	0.00	0.00	0.00	0.00	0.01
N8	0.37	0.45	0.47	0.49	0.50	0.50	0.56
N9	0.17	0.20	0.25	0.32	0.36	0.40	0.50
RTP	0.45	1.49	1.78	2.07	2.36	2.67	2.95
S1	0.38	0.42	0.52	0.62	0.69	0.76	0.88
S10	0.21	0.25	0.28	0.31	0.34	0.35	0.52
S11	0.22	0.26	0.27	0.28	0.28	0.28	0.33

Table E2-5. 75th Percentile Wastewater Demand Projections by Sewer Subbasin, 2016 to 2065, MGD, Maximum Month Average Day

Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

Sewer Subbasin	2016	2025	2030	2035	2040	2045	2065
S11A	0.14	0.15	0.15	0.16	0.16	0.16	0.17
S11B	0.14	0.15	0.15	0.17	0.17	0.18	0.20
S11C	0.02	0.02	0.02	0.02	0.02	0.02	0.02
S12	0.11	0.11	0.12	0.12	0.12	0.14	0.13
S12A	0.01	0.01	0.01	0.01	0.01	0.01	0.01
S12B	0.07	0.07	0.08	0.08	0.08	0.08	0.08
S12C	0.01	0.01	0.01	0.01	0.01	0.01	0.01
S13	0.30	0.32	0.35	0.37	0.38	0.40	0.45
S14	0.33	0.33	0.36	0.37	0.37	0.39	0.42
S15	0.73	0.73	0.78	0.81	0.83	0.85	0.93
S16	0.16	0.17	0.17	0.18	0.18	0.18	0.20
S17	0.24	0.24	0.24	0.24	0.25	0.25	0.26
S18	0.22	0.23	0.24	0.23	0.24	0.24	0.25
S19	0.20	0.21	0.22	0.22	0.22	0.23	0.27
S2	0.37	0.40	0.51	0.61	0.67	0.75	1.48
S20	0.17	0.17	0.17	0.19	0.19	0.19	0.20
S20A	0.00	0.00	0.00	0.00	0.00	0.00	0.01
S21	0.07	0.08	0.10	0.12	0.12	0.14	0.14
S22	0.05	0.06	0.07	0.08	0.08	0.08	0.08
S23	0.12	0.15	0.22	0.30	0.36	0.42	0.46
S24	0.01	0.02	0.03	0.03	0.04	0.05	0.05
S25	0.11	0.11	0.15	0.19	0.21	0.24	0.27
S26	0.15	0.15	0.15	0.16	0.16	0.16	0.17
S3	0.25	0.25	0.27	0.28	0.29	0.29	0.41
S4	0.12	0.12	0.14	0.16	0.17	0.18	0.41
S4A	0.07	0.08	0.10	0.10	0.11	0.12	0.19
S5	0.61	0.62	0.65	0.68	0.67	0.68	0.82
S6	0.24	0.24	0.25	0.25	0.26	0.26	0.29
S7	0.01	0.02	0.02	0.03	0.03	0.05	0.06
S8	0.31	0.31	0.34	0.35	0.37	0.37	0.55
S8A	-	0.00	0.00	0.00	0.00	0.00	0.00
S9	0.31	0.32	0.35	0.37	0.37	0.37	0.52
S9A	0.02	0.02	0.02	0.02	0.02	0.02	0.02

Table E2-5. 75th Percentile Wastewater Demand Projections by Sewer Subbasin, 2016 to 2065, MGD, Maximum Month Average Day

Includes the Town of Cary, Town of Morrisville, RTP South, and RDU Airport

Sewer Subbasin	2016	2025	2030	2035	2040	2045	2065
W1	0.05	0.06	0.06	0.06	0.06	0.06	0.07
W10	-	0.00	0.01	0.02	0.02	0.03	0.04
W10A	0.10	0.15	0.17	0.18	0.19	0.21	0.23
W11	-	0.01	0.02	0.02	0.03	0.04	0.05
W12	-	0.00	0.00	0.00	0.00	0.00	0.01
W13	0.02	0.03	0.04	0.05	0.06	0.07	0.07
W13A	0.04	0.05	0.05	0.06	0.06	0.06	0.05
W13B	0.01	0.01	0.01	0.01	0.01	0.01	0.01
W1A	0.02	0.02	0.02	0.02	0.02	0.02	0.04
W2A	0.07	0.09	0.09	0.10	0.11	0.11	0.22
W2B	0.04	0.05	0.05	0.05	0.05	0.05	0.06
W2C	0.04	0.10	0.13	0.15	0.17	0.19	0.34
W3	0.27	0.42	0.45	0.47	0.48	0.50	0.73
W3A	0.11	0.14	0.15	0.16	0.16	0.18	0.26
W4	0.55	0.73	0.81	0.87	0.92	0.98	1.10
W5	0.03	0.04	0.05	0.05	0.05	0.05	0.05
W5A	0.49	0.56	0.57	0.58	0.59	0.60	0.63
W5B	0.13	0.14	0.15	0.15	0.15	0.17	0.16
W6B	-	0.00	0.01	0.01	0.01	0.02	0.02
W6C	-	0.00	0.01	0.01	0.01	0.01	0.01
W7	0.03	0.05	0.07	0.10	0.11	0.13	0.40
W7A	0.28	0.34	0.36	0.36	0.38	0.38	0.42
W8	0.02	0.04	0.08	0.11	0.14	0.17	0.51
W8A	0.59	0.67	0.69	0.70	0.70	0.71	0.74
Total Wastewater Flow	**17.6**	**20.8**	**22.9**	**24.8**	**26.2**	**27.6**	**33.8**

NOTE: 0.00 indicates a non-zero but very small value and a hyphen ("-") indicates a zero value.

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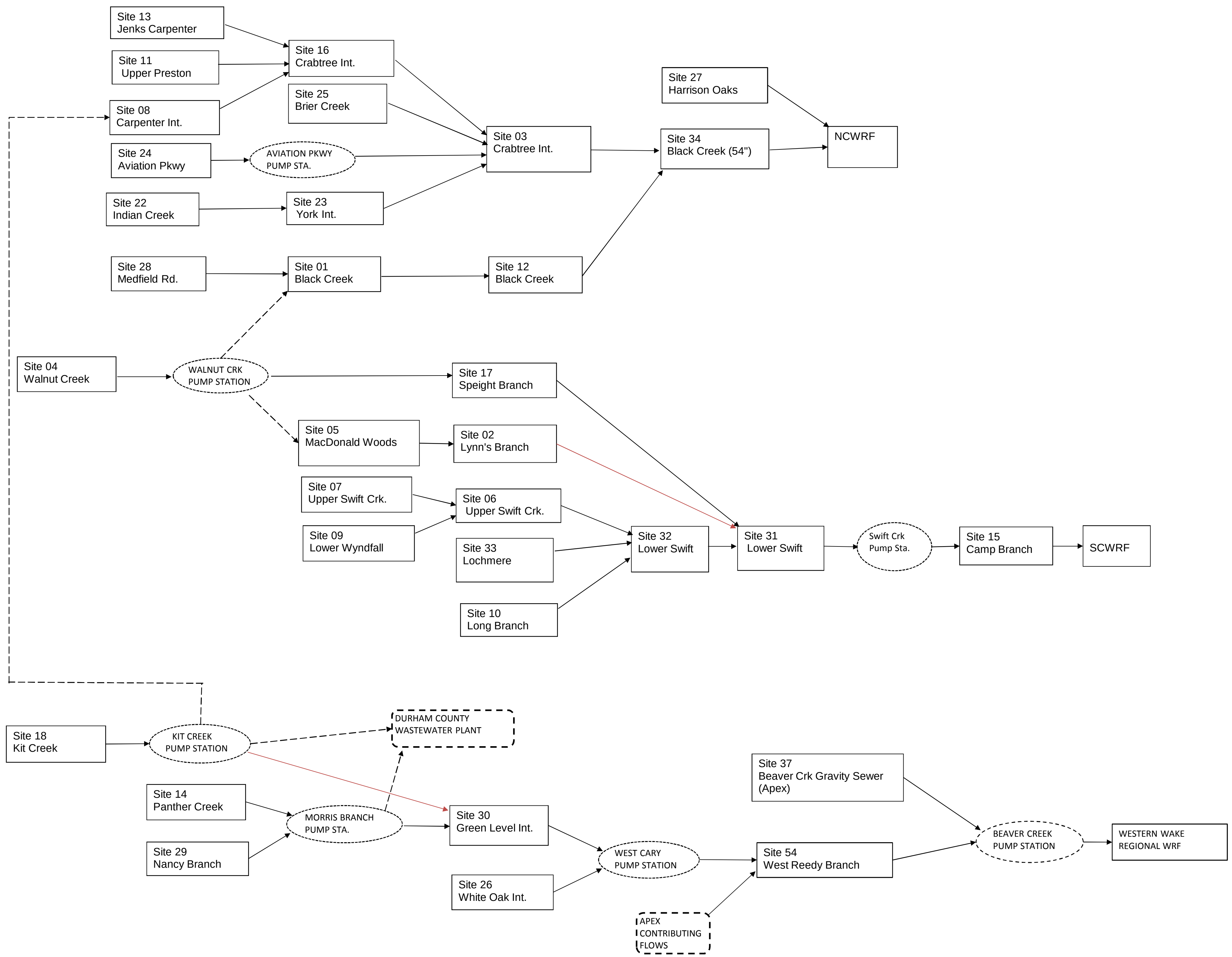
Figure E2-1. Town of Cary Wastewater Flow Monitoring

Schematic *Last updated 26-Feb-18*



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