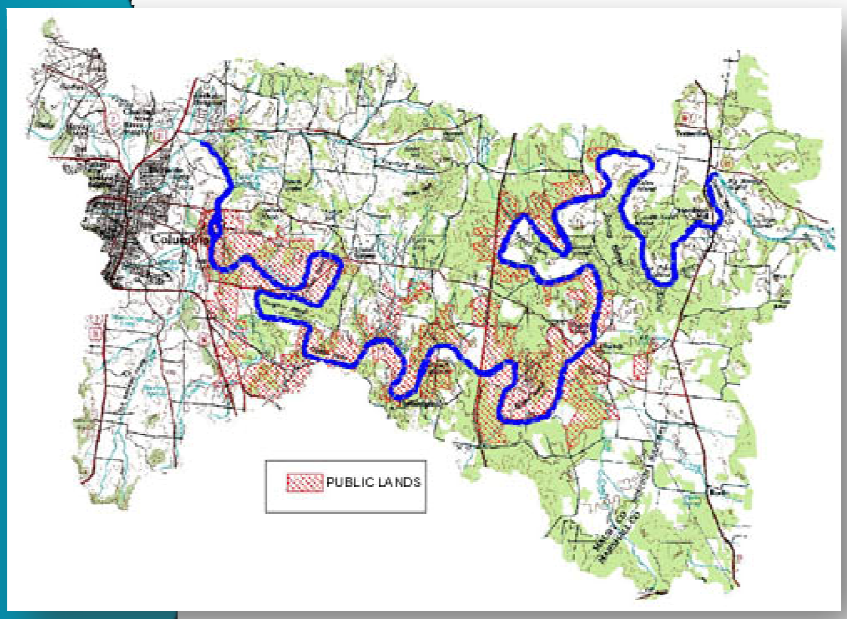
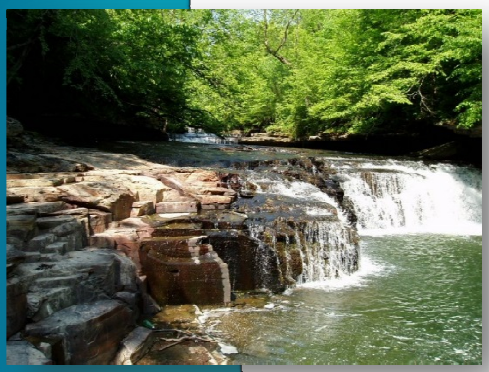
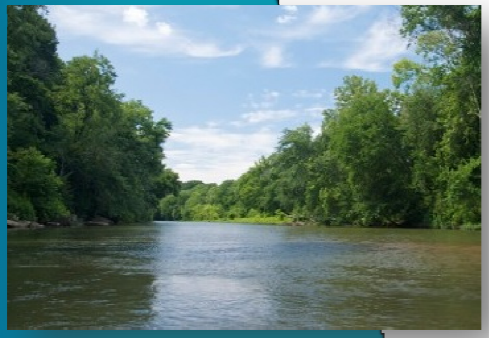


Tennessee Duck River Development Agency

FINAL Regional Water Data Collection and Demand Projection Analysis

September 29, 2016





MADDAUS WATER MANAGEMENT INC.

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LIST OF ACRONYMS

AB	Assembly Bill
ACS	American Community Survey
AF	acre-foot/acre-feet
AFY	acre-foot/acre-feet per year
AMI	Automated Meter Infrastructure
AWWA	American Water Works Association
AWWARF	American Water Works Association Research Foundation
BCUD	Bedford County Utility District
BLS	Bureau of Labor Statistics
BMP	Best Management Practice
CBER-UT	University of Tennessee's Center of Business and Economics Research
CEC	California Energy Commission
CII	Commercial, Industrial, and Institutional
CPI	Consumer Price Index
CPWS	Columbia Power and Water Systems
CUWCC	California Urban Water Conservation Council
DMP	Drought Management Plan
DRA	Duck River Development Agency
DRATAC	Tennessee Duck River Development Agency Technical Advisory Committee
DSS	Decision Support System
EPA	Environmental Protection Agency
FY	Fiscal Year
gpd	gallons per day
gpf	gallons per flush
gpm	gallons per minute
HE	High Efficiency
HEU	High Efficiency Urinal
ILI	Infrastructure Leakage Index
IRR	Irrigation
LWW	Lewisburg Water and Wastewater
MF	multifamily
MG	million gallons
MGD	million gallons per day
MMDD	Master Measure Design Database
MWM	Maddaus Water Management, Inc.
MWSD	Manchester Water and Sewer Department
ND	new development
NRW	non-revenue water
O&M	operations and maintenance
OBG	O'Brien and Gere
PV	present value
PWSS	Public Water System Statistics
SF	single family
SHWS	Spring Hill Water System
SMSWP	Sonoma-Marin Saving Water Partnership
SPWSS	Shelbyville Power, Water, and Sewerage System
TAC	Tennessee Advisory Commission
TUB	Tullahoma Utilities Board
UHET	Ultra-High Efficiency Toilet
ULFT	Ultra-Low Flow Toilet
WF	Water Factor
WSP	Water Supply Plan

EXECUTIVE SUMMARY

The purpose of the Executive Summary is to briefly describe the findings from the Tennessee Duck River Development Agency's (Duck River or DRA) Regional Water Data Collection and Demand Projection Analysis Report (Report). A more detailed discussion of the evaluation process and assumptions used to develop this Report and ideas for future implementation are included in the main body of the report.

Overview

Growing concerns regarding the reliability of increasing demand for quality water due to regional growth, uncertain climate change impacts, and new regulatory requirements are all driving the need for increased water-use efficiency in all water-use sectors. These long-term trends will continue to challenge the efforts of Tennessee water agencies to supply increasing water demands. The purpose of the Demand Projection Analysis Report is to update the projected demands for the seven Water Systems represented by the DRA, including Bedford County Utility District (BCUD), Columbia Power and Water Systems (CPWS), Lewisburg Water and Wastewater (LWW), Manchester Water and Sewer Department (MWSD), Shelbyville Power, Water, and Sewerage System (SPWSS), Spring Hill Water System (SHWS), and Tullahoma Utilities Board (TUB).

For the water demand projections (2015 through 2050) in this study, Maddaus Water Management Inc.'s Demand Side Management Least Cost Planning Decision Support System (DSS) Model was used to forecast water demand for each Water System. The initial phase of this effort included a data collection process using a Data Collection File (Data Workbook) that each Water System completed and/or verified.

Demographic Data and Historical Water Demand

Each Water System's future population and employment projection rates were incorporated into each DSS Model to project future water demand through the year 2050. Population projections were obtained from the June 2009 joint publication of the *Population Projections for the State of Tennessee, 2010-2030* by the Tennessee Advisory Commission (TAC) on Intergovernmental Relations and the University of Tennessee's Center of Business and Economics Research (CBER-UT). Employment projection rates were based on historical County employment rates from 2010-2015 and applied as relevant to each Water System. The actual number of jobs was neither provided nor determined for the Water Systems; rather 2010-2015 average employment growth was applied to each Water System's commercial and industrial account growth through year 2050.

The historical water use patterns were analyzed based on water production and consumption data provided by each Duck River Water System. When available, 15 years of monthly water consumption and production were analyzed (years 2000 to 2015) and for most Water Systems a baseline range of 2010-2015 was used to derive an average per type of account per day water use.

A different approach for developing water demands was used by DRA's engineering consultants O'Brien and Gere (OBG) in their 2011 regional water supply planning study and more specifically in their 2013 Regional Drought Management Plan. The OBG water demand projections were developed in year 2009 and used year 2000 data as a baseline to establish a gross per capita demand which was held constant through the planning period. In summary, the projected 2050 water demand for the seven water systems based on MWM and OBG analyses was approximately 41 MGD and 48

MGD, respectively. A comparison of the water demands published in the Maddaus Water Management's report (2016) to the water demands published in the OBG 2013 analysis is presented in Appendix D.

Demand Projections

Each Water System's water demand is forecasted through 2050 using the DSS Model. The demand analysis process includes forecasting future water demand (2015-2050) by customer category based upon forecasted increases in population and employment. Average water use per customer category account is based on an analysis of historical data between 2000 and 2015 historical range (or a shorter period if a Water System's historical data was incomplete). To forecast water demands, the DSS Model relies on demographic and employment projections, combined with the effects of natural fixture replacement due to the implementation of plumbing codes. Natural fixture replacement due to the implementation of plumbing codes is part of passive conservation savings. Passive conservation refers to water savings resulting from actions and activities that do not depend on direct financial assistance or educational programs from Water Systems. Information and assumptions about plumbing codes and appliance standards can be found in Appendix A. Projected water demands for each Water System can be found in Appendix B.

The following tables and figure present each Water System's average day water demands with and without plumbing code savings. By 2050, water demands are projected to increase 73% without the plumbing code and 52% with the code. The plumbing codes are projected to save an overall 5 MGD or over 12% without the codes by 2050. Savings of this magnitude could produce large benefits in terms of deferred capital and operation expenditures.

Table ES-1. Average Day Water Demands WITHOUT Plumbing Code Savings (MGD)

Water System	2015	2020	2025	2030	2035	2040	2045	2050
Coffee County								
Tullahoma Utilities Board	3.08	3.39	3.73	4.12	4.55	5.03	5.57	6.18
Manchester Water and Sewer Department	2.46	2.68	2.90	3.15	3.43	3.73	4.07	4.45
Bedford County								
Shelbyville Power, Water, and Sewerage System	3.85	4.18	4.52	4.89	5.19	5.51	5.85	6.22
Bedford County Utility District	1.80	1.94	2.07	2.21	2.31	2.40	2.50	2.60
Marshall County								
Lewisburg Water and Wastewater	2.47	2.64	2.90	3.17	3.40	3.64	3.90	4.20
Maury/Southern Williamson County								
Spring Hill Water System	2.66	3.03	3.41	3.84	4.08	4.31	4.55	4.79
Columbia Power and Water Systems	7.54	8.22	8.91	9.63	10.35	11.10	11.88	12.74
Total DRA Demand WITHOUT Plumbing Code Savings	**23.86**	**26.08**	**28.44**	**31.01**	**33.31**	**35.72**	**38.32**	**41.18**

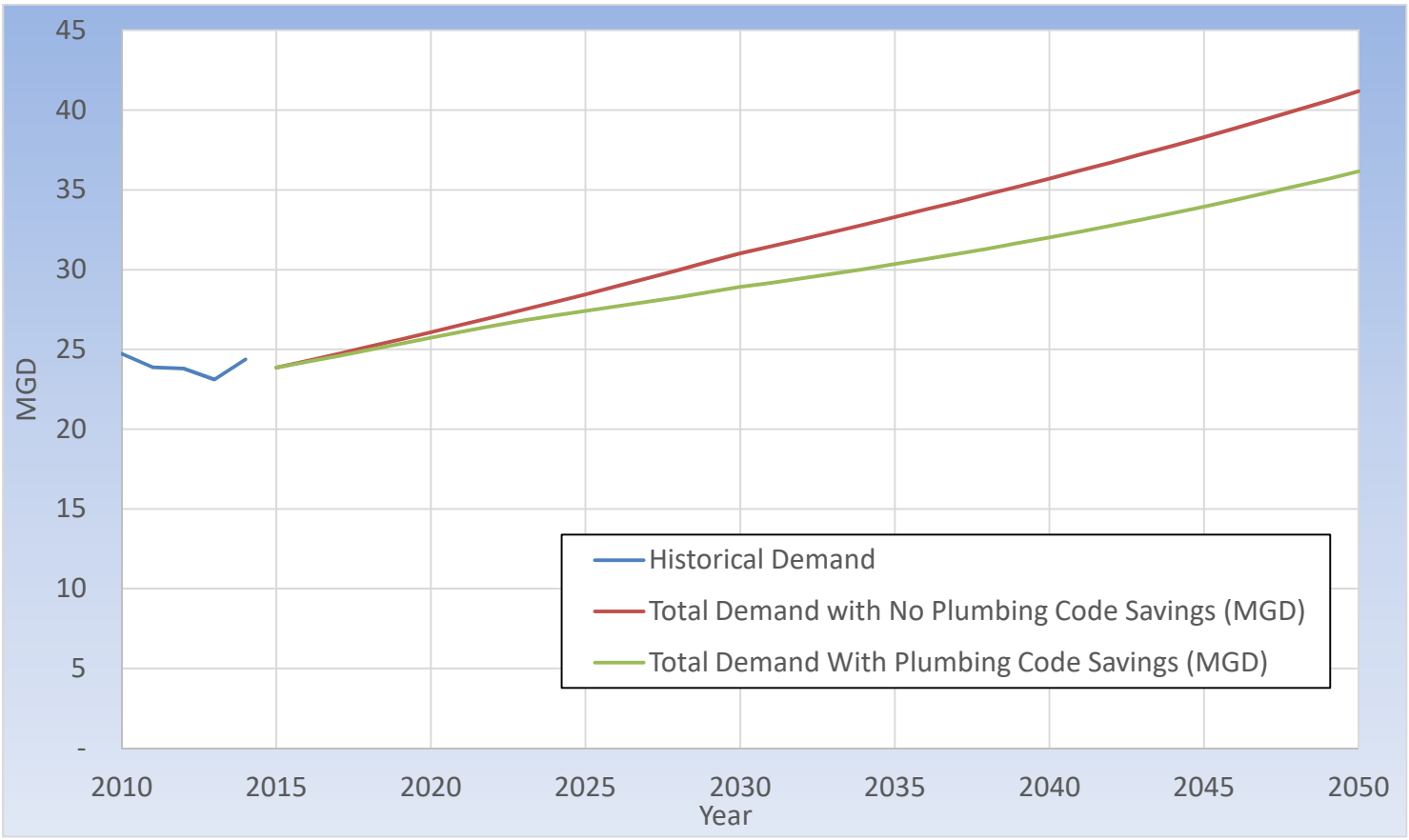
Note: Demands based on surface water supply deliveries from public water systems. Demands do not include historical, current, or future private well use by customers. Demands do not include conversion of existing private well-users to the public water system.

Table ES-2. Average Day Water Demands WITH Plumbing Code Savings (MGD)

Water System	2015	2020	2025	2030	2035	2040	2045	2050
Coffee County								
TUB	3.08	3.33	3.57	3.82	4.12	4.49	4.92	5.43
Manchester Water and Sewer Department	2.46	2.64	2.81	2.98	3.18	3.41	3.68	3.99
Bedford County								
Shelbyville Power, Water, and Sewerage System	3.85	4.13	4.39	4.60	4.80	5.02	5.28	5.57
Bedford County Utility District	1.80	1.91	1.98	1.99	1.99	2.01	2.03	2.07
Marshall County								
Lewisburg Water and Wastewater	2.47	2.59	2.76	2.93	3.06	3.21	3.39	3.61
Maury/Southern Williamson County								
Spring Hill Water System	2.66	3.01	3.30	3.56	3.68	3.82	3.97	4.14
Columbia Power and Water Systems	7.54	8.12	8.60	9.04	9.52	10.07	10.67	11.35
Total DRA Demand WITH Plumbing Code Savings	**23.86**	**25.73**	**27.41**	**28.92**	**30.35**	**32.03**	**33.94**	**36.16**

Note: Demands based on surface water supply deliveries from public water systems. Demands do not include historical, current, or future private well use by customers. Demands do not include conversion of existing private well-users to the public water system.

Figure ES-1. Regional Average Day Water Demands (MGD)



Note: Total Demand accounts for the total projected water demand in a service area Water System regardless of source. Source can be from surface water or groundwater.

Conclusions

The service areas for the Tennessee Duck River Development Agency's seven Water Systems have a relatively high portion of residential water use and moderate total forecasted growth. Consequently, residential indoor plumbing codes are projected to produce significant water savings. Since the service areas do not use a significant amount of water outdoors and are not as heavy in manufacturing, the water-reduction potential for outdoor water-use efficiency measures and the commercial sector is lower than that of indoor water use. The amount of new growth forecasted for some of the service areas is high, indicating that measures directed at new development have the potential to produce large savings. It is recommended that a water-use efficiency analysis be conducted for the region, particularly to address the high non-revenue water use in many of the Water Systems. Water loss management is critical, as is identifying and tracking any deliberate and necessary non-revenue water uses. See Section 6 Conclusions/Next Steps for additional detail on actions that the Water Systems can take.

1. INTRODUCTION

This section describes the purpose and scope of the Regional Water Data Collection and Demand Projection Analysis Report (Report), provides an overview of the Tennessee Duck River Development Agency Water Systems, presents background information on the demand modeling approach, and provides a project history of the steps used to complete the Report.

1.1 Project Background and Purpose

The DRA recognizes that water-use efficiency is a necessary part of any overall water supply strategy. Significant water savings is potentially achievable by providing customers with the tools and education they need to use water efficiently.

This report is part of a two-phased project (Project) with the ultimate goal being to develop a regional water-use efficiency program. This first phase includes the collection and analysis of key water use data to create the demand projections needed to prepare a regional water-use efficiency program in a subsequent project phase. DRA's objective in this first phase is to collect and analyze historical water use and other data from the Tennessee Duck River Development Agency Technical Advisory Committee (DRATAC) using a consistent approach. The purpose of the DRATAC, which is made up of the seven Water Systems, is to provide advice and guidance to the DRA concerning water projects and other activities it may pursue to fulfill its mission.

Key components of the DRA two-phased Project include:

- Coordination and buy-in from DRA and DRATAC;
- Working with DRA, who is leading the Project and directing specific activities;
- Conducting two workshops with DRA staff to first explain the type of data needed and the program analysis and verification and second to present the results in the form of a water use profile for each Water System;
- Data compilation in Excel workbooks, one per Water System and one for the region;
- Analysis of data in Decision Support System (DSS) Models for demand forecasts to the year 2050;
- Conducting workshops with DRA staff to discuss preliminary and final demand projections; and
- Documentation of the work in a report.

1.2 Overview of Duck River Agency's Water Systems

The Tennessee General Assembly created the DRA in 1965 as a comprehensive regional development agency. Its broad powers include the "control and development of the water resources" of those portions of the Duck River Watershed in Bedford, Coffee, Hickman, Marshall, and Maury Counties. Any county or municipality in the Duck River Basin, any governmental entity from which flows any tributary stream of the river, or any county adjoining the river basin may become a sponsoring and participating entity. In 1998, the DRA Board of Directors adopted the following mission statement:

> "To develop, protect, and sustain a clean and dependable water resource for all citizens of the Duck River region."

The DRA represents seven water utilities that serve approximately 250,000 people as well as industries that include car manufacturers, food processing plants, and other businesses utilizing water for production. In addition to these uses, the

river provides a wide range of other values, including recreation, an excellent fishery, and one of the most biologically-rich freshwater habitats in North America.

The DRA represents the following seven water utilities:

- Bedford County Utility District (BCUD)
- Columbia Power and Water Systems (CPWS)
- Lewisburg Water and Wastewater (LWW)
- Manchester Water and Sewer Department (MWSD)
- Shelbyville Power, Water, and Sewerage System (SPWSS)
- Spring Hill Water System (SHWS)
- Tullahoma Utilities Board (TUB)

Figure 1-1 shows the location of the Duck River watershed as well as the areas studied for the 2011 Comprehensive Regional Water Supply Plan developed by OBG for the DRA.

The drought of 2007 highlighted the issue that in extended dry weather conditions the citizens of the Duck River Region primarily depend on the water stored in Normandy Reservoir to meet multiple uses, including drinking water, wastewater dilution, recreation, and natural resource protection. The dramatic decrease in rainfall, combined with the multiple uses of the reservoir and the river, caused record low-water levels in Normandy Reservoir that resulted in temporary operational changes in downstream water releases to protect all water uses. Weather patterns and growth projections were drivers in development of a comprehensive regional water supply plan for the Duck River Region.

This region typically experiences 50 inches of rain per year allowing for an abundance of water in the river from this amount of precipitation. If the watershed only receives 30-40 inches of rain per year, then the Water Systems experience issues similar to those exhibited during the 2007-2008 drought. In year 2015, the total average daily water use from the Duck River for the seven DRA Water Systems was approximately 24 MGD.

1.3 Modeling Demands using the DSS Model

Maddaus Water Management Inc.'s Demand Side Management Least Cost Planning Decision Support System Model (DSS Model) can be used to prepare long-range, water demand and water-use efficiency water savings projections. First developed in 1999 and continuously updated, the DSS Model is an end-use model that breaks down total water production (i.e., water demand in the service area) into specific water end uses (e.g., toilets, faucets, irrigation, etc.). This "bottom-up" approach allows for detailed criteria to be considered when estimating future demands, such as the effects of natural fixture replacement, plumbing codes, and water-use efficiency efforts. The purpose of using end-use data is to enable a more accurate assessment of the impact of plumbing codes and water efficiency programs on demand and to provide a rigorous and defensible modeling approach necessary for projects subject to regulatory or environmental review.

Figure 1-1. Duck River Watershed and Water Supply Plan Study Areas



Source: O'Brien & Gere Engineers, Inc. *Duck River Comprehensive Regional Water Supply Plan*, Prepared for Tennessee Duck River Development Agency (March 25, 2011).

The DSS Model can be used to prepare short- and long-range, detailed water demand projections and water-use efficiency savings projections to enable a more accurate assessment of the impact of water-use efficiency programs on water demand. The DSS Model can use one of the following:

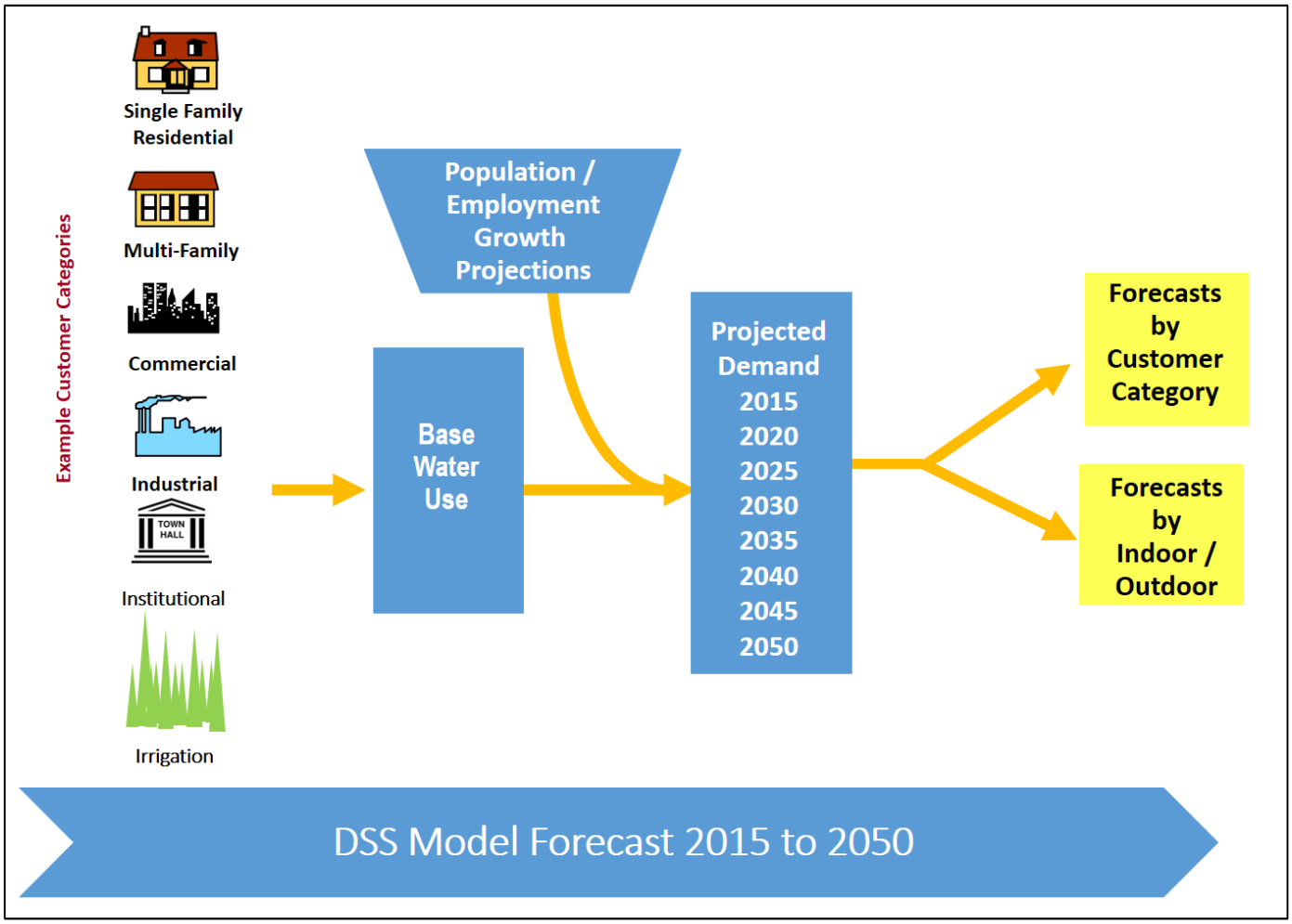
- A statistical approach to forecast demands (e.g., an econometric model)
- A forecasted increase in population and employment
- Predicted future demands
- A demand projection which is input into the model from an outside source

For Duck River Agency's Water Systems, the water demand projection was based on a forecasted increase in population and employment. Forecasted population was developed by the University of Tennessee Center of Business and Economics Research (CBER-UT) through year 2030 and was used in this project. More background information about the DSS Model can be found in Appendix A.

For the water demand projections (2015 through 2050), the DSS Model was used to forecast water demand for each Water System. The DSS Model also includes a water-use efficiency component that quantifies savings from passive water-use efficiency (e.g., plumbing codes) and active water-use efficiency programs. Quantification of savings potential from active water-use efficiency programs was not conducted in this phase of the Project.

This Report presents the DSS Model's demand estimates taking into account savings only from passive water-use efficiency. Passive water-use efficiency or "passive conservation" refers to water savings resulting from customer actions and activities that do not depend on direct assistance from Water System water-use efficiency programs. This includes water savings resulting from 1) the natural replacement of existing plumbing fixtures with water-efficient models required under current plumbing code standards, and 2) the installation of water-efficient fixtures in new buildings and retrofits as required under federal building code standards.

Figure 1-2. DSS Model Flow Diagram



As shown in the Figure 1-2, the first step in forecasting water demands using the DSS Model is to gather customer category billing data from each Water System. The next step is to check the model by comparing water use data with available demographic data to characterize water usage for each customer category (single family, multifamily, commercial, industrial, and institutional) in terms of number of users per account and per capita water use. During the DSS Model calibration process, data was further analyzed to approximate the indoor/outdoor split by customer category. The indoor/outdoor water usage was also further divided into typical end uses for each customer category. Published data on average per capita indoor water use and average per capita end use was combined with the number of water users to verify that the volume of water allocated to specific end uses in each customer category is consistent with social norms from end-use studies on water use behavior (e.g., flushes per person per day).

1.4 Report Development

Working with the DRA staff, the Report was prepared by Maddaus Water Management, Inc. (MWM). The Report development included review of past documentation and previously performed data analyses. The Duck River Water Systems provided data per a list of MWM-requested parameters. The information requested and received includes the following:

- Prior year production data on a monthly or quarterly basis for the different sources of water
- Prior year water use data on a monthly or quarterly basis for the different classes of water users
- Historical and projected Water System service area population and employment through the year 2050, or other suitable end year along with maps of the Water System, political jurisdiction boundaries, and study area(s)

1.4.1 Water System Input and Review

As part of the Project's collaborative approach, the draft report was provided to the Water Systems on July 18, 2016. An instructional webinar conference call was held with the Water Systems on July 26, 2016 to facilitate DRA Water Systems' understanding of and involvement in the development of the water demand projections. During the webinar, MWM reviewed the methodology using a real example with preliminary results from one of the DRA Water Systems. The goals of the webinar were: 1) to review the demand modeling approach and results, and 2) to answer Water System questions. The DRA staff and the Water Systems had the opportunity to review the draft water demand modeling results and to provide questions and comments to the MWM Project Team. MWM had multiple calls and emails with DRA staff to discuss the data submitted from the Water Systems and preliminary water demand results.

1.4.2 Report Content

The following information is included in this report and is discussed in individual sections below:

- Section 2 – Data Collection and Verification Process
- Section 3 – Demographic Data
- Section 4 – Analysis of Historical Water Demand
- Section 5 – Water Demand Projections
- Section 6 – Conclusions/Next Steps
- Section 7 – References
- Section 8 – List of Contacts
- Appendix A – DSS Model Overview and Key Assumptions
- Appendix B – Water System Specific Information
- Appendix C – Department of Water Resources Public Water System Statistics Report Sample
- Appendix D – Published Demands Methodology Comparison

2. DATA COLLECTION AND VERIFICATION PROCESS

This section presents an overview of the long-term water demand evaluation process, including the initial data collection steps.

2.1 Data Collection Process

The initial phase of this effort included a data collection process using a Data Collection and Verification File (Data Workbook). The quantitative Data Workbook was developed by MWM in Microsoft Excel to collect, organize, and verify the necessary input data for the DSS Model. The data required for the water demand projections was organized into the Data Workbooks (one per Water System). Each Water System was asked to input the requested information in the Data Workbook.

The Data Workbook was completed and verified by the Water Systems through the following steps:

1. **Distribution of Data Workbooks to Individual Water Systems**: The files were distributed to the individual Water Systems in July 2015 via e-mail.
2. **Data Workbook Completion by Water Systems**: Each Water System reviewed and completed their individual Data Workbook, which required data entry of missing production and consumption information as well as other data elements.
3. **Data Workbook Submission by Water Systems**: After completing Step 2, Water Systems submitted the files via e-mail from September 2015 through June 2016.
4. **Data Workbook Review and Refinement**: The Project Team reviewed the individual data workbooks in the order submitted. If further data and refinement were required, DRA staff contacted the individual Water System to obtain the necessary information.

2.2 Types of Data Collected

The data needs of the DSS Model drove the data collection effort. The individual data elements within each category are documented in the following table. Data such as water rates and total employment (jobs) were collected to evaluate the historical growth and future growth in the service area. The service area data was used for the demand forecasting tools in the DSS Model.

Service area demographic data, such as the number of dwelling units, was collected from the 2010 U.S. Census data and 2011-2013 American Community Survey (ACS) 3-Year Estimates or 2010-2014 ACS 5-Year Estimates, as available. Population sources include the June 2009 joint publication of the *Population Projections for the State of Tennessee, 2010-2030* by the Tennessee Advisory Commission on Intergovernmental Relations and the University of Tennessee's Center of Business and Economics Research (CBER-UT) projections and other Water System provided projections. County employment sources include the Bureau of Labor Statistics (BLS) of the U.S. Department of Labor (US Dept. of Labor, 2016). The service area demographics were used for future water demand forecasting.

Table 2-1. Data Collected for Water Systems

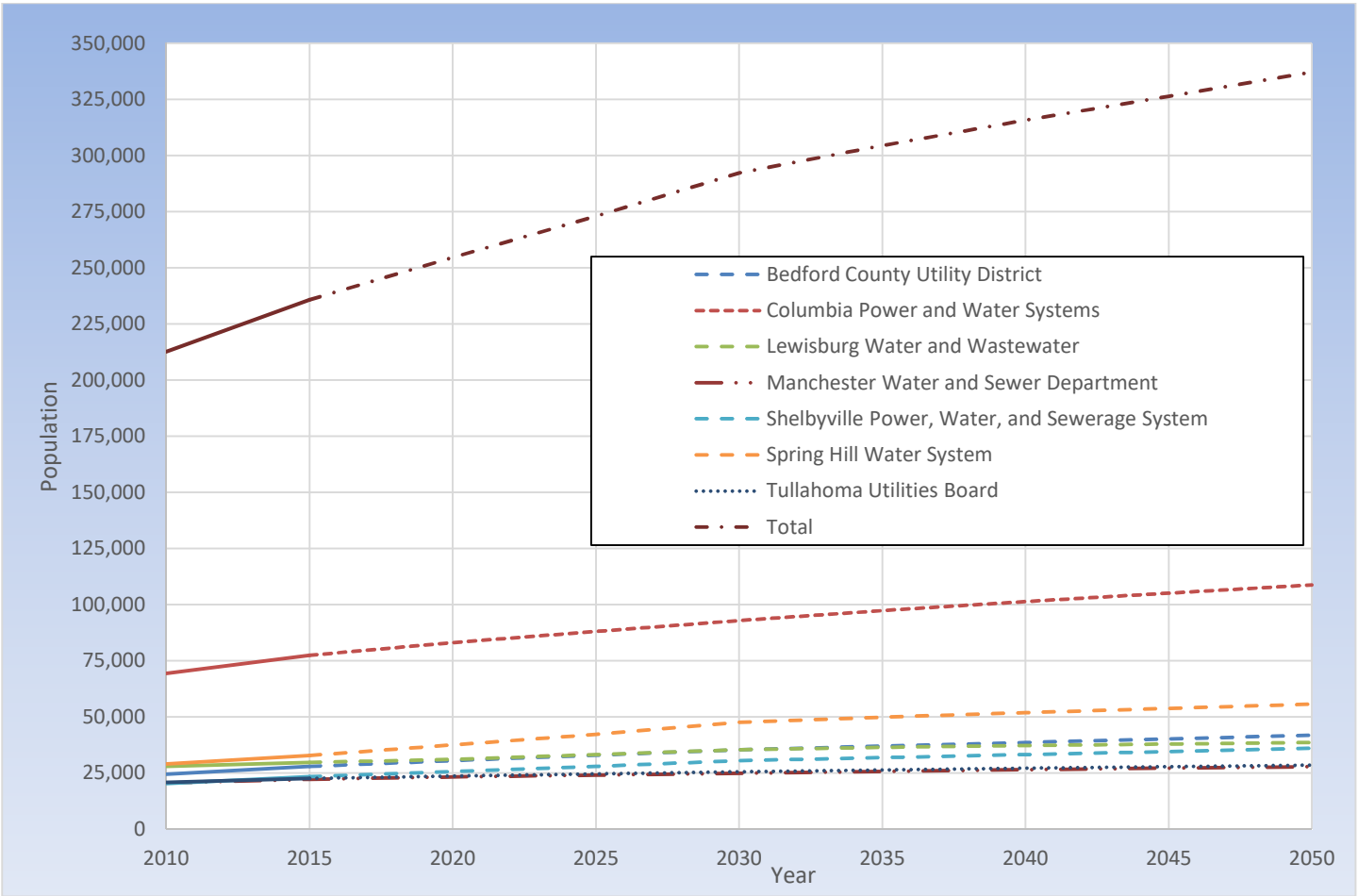
Model Input Parameter	Time Period	Units	Source(s)
Service Area Data			
Water System Info	Current	NA	Water System Provided
Contact Info	Current	Name, number, email	Water System Provided
Planning Documents	Varies	NA	Water System Provided
Abnormal Years	Varies	Years	Water System Provided
Customer Classes	Varies	NA	Water System Provided
System Input Volume (Water Production)	2000-2015 as available	Volume	Water System Provided
Consumption and Accounts	2000-2015 as available	Volume	Water System Provided
Maximum Day Demand	Varies	Date & Volume	Water System provided
Water System Audits	2010 to 2014 if available	NA	Water System Provided American Water Works Association (AWWA) Methodology
Service Area Demographics			
Historical Service Area Population	2000-2015	People	CBER-UT Water System Provided
Projected Population	2016-2050	People	CBER-UT Water System Provided
DP-1 General Profile and Housing Characteristics	2010	Various units	2010 US Census
DP04 Selected Housing Characteristics	2010 or average 2010-2014	Various units	2010 US Census 2013/2014 ACS 3-yr or 5-yr
B25033 Population in Housing Units	2010 or average 2010-2014	Dwelling units	2010 US Census 2013/2014 ACS 3-yr or 5-yr
Economy			
Historical Service Area Employment	2001-2015	County Jobs	Bureau of Labor Statistics
Projected Jobs	2016-2050	County Job Growth Rate (based on 2010-2015 County Jobs)	Bureau of Labor Statistics

3. DEMOGRAPHIC DATA

Each Water System's future population and employment (job) projections were incorporated into each DSS Model to project future water demand. Population and employment projections were provided or confirmed by each Water System through the data collection process described in the previous section. These growth projections were used to develop a projected water demand through the year 2050. Population projections were obtained through year 2030 from the June 2009 joint publication of the *Population Projections for the State of Tennessee, 2010-2030* by the Tennessee Advisory Commission (TAC) on Intergovernmental Relations and the University of Tennessee's Center of Business and Economics Research (CBER-UT). Population projections through 2050 were derived using CBER-UT's projections by county and applied as relevant to the individual Water Systems. Employment projections were based on historical County employment rates from 2010-2015 and applied as relevant to each Water System. The actual number of jobs was neither provided nor determined for the Water Systems; rather 2010-2015 average employment growth was applied to each Water System's commercial and industrial account growth through year 2050. Historical county employment was provided by the Bureau of Labor Statistics (BLS) of the U.S. Department of Labor (US Dept. of Labor, 2016).

Population and employment rate estimates used in this effort were aligned as closely as possible with Water System projections to be consistent with the Water System's planning projections. Historical and projected population for all seven Duck River Water Systems is shown in the following figure. Individual figures and tables presenting each Water System's historical and projected population and employment rate values can be found in Appendix B.

Figure 3-1. Total Historical and Projected Regional Population – DRA



Notes:

1. 2010-2030 population is taken from the June 2009 *Population Projections for the State of Tennessee, 2010-2030* by the TAC on Intergovernmental Relations and the CBER-UT. Population projections from 2035 through 2050 were derived using CBER-UT's projections by county and applied as relevant to the individual Water Systems. Population represents those served by the public water system; no population that is solely self-served by wells is included.
2. Some Water Systems serve a portion of their population by wholesale water sales or accounts and not directly by residential accounts, often through an intermediary water purveyor. This applies to the following Water Systems who have a wholesale or bulk water sale customer account category: CPWS, LWW, and MWSD.

Table 3-1. Regional Historical and Projected Population – DRA[1]

Year	Bedford County Utility District	Columbia Power and Water Systems	Lewisburg Water and Wastewater	Manchester Water & Sewer Department	Shelbyville Power, Water, and Sewerage System	Spring Hill Water System	Tullahoma Utilities Board	Total
Communities Served[2]	Bedford County outside Shelbyville incl. Unionville and Wheel	Columbia City Wholesale to unincorporated Maury County, Mt. Pleasant, and Spring Hill (partial)	Lewisburg, Cornersville, Chapel Hill, Belfast, and Petersburg	Manchester City Wholesale to Hillsville Utility District	City of Shelbyville only	Spring Hill (partial)	Tullahoma City Wholesale to Bell Buckle	N/A
% Population Served by Wholesale[3]	N/A	48%	61%	38%	N/A	N/A	N/A	N/A
2010	24,384	69,388	27,999	20,536	20,322	29,036	20,888	212,553
2015[3]	27,897	77,364	29,735	22,139	23,330	32,807	22,518	235,790
2020	30,451	83,015	31,009	23,217	25,661	37,479	23,655	254,487
2025	32,857	87,987	33,196	24,069	28,009	42,247	24,576	272,941
2030	35,387	92,918	35,376	24,901	30,481	47,565	25,581	292,209
2035	36,996	97,332	36,368	25,695	31,867	49,824	26,385	304,467
2040	38,559	101,341	37,181	26,406	33,213	51,876	27,103	315,679
2045	40,125	105,056	37,872	27,079	34,563	53,778	27,781	326,254
2050	41,786	108,759	38,563	27,779	35,993	55,674	28,486	337,040

[1] 2010-2030 population is taken from the June 2009 *Population Projections for the State of Tennessee, 2010-2030* by the TAC on Intergovernmental Relations and the CBER-UT. Population projections from 2035 through 2050 were derived using CBER-UT's projections by county and applied as relevant to the individual Water Systems. Population represents those served by the public water system; no population that is solely self-served by wells is included.

[2] Communities Served represents the communities that the listed population serves directly with residential accounts and indirectly with wholesale accounts.

[3] The year 2015 population served by wholesale sales or accounts represents the percent of the Water System's population NOT served directly by residential accounts, but rather through an intermediary water purveyor. This only applies to the following Water Systems who have a wholesale or bulk sale customer account category: CPWS, LWW, and MWSD.

Table 3-2. Regional Employment - DRA

	Bedford County Utility District	Columbia Power and Water Systems	Lewisburg Water and Wastewater	Manchester Water and Sewer Department	Shelbyville Power, Water, and Sewerage System	Spring Hill Water System	Tullahoma Utilities Board
County Used for Projection	Bedford	Maury	Marshall	Coffee	Bedford	Maury	Coffee
2015-2050 County and Water System Average Annual Employment Growth Rate*	1.48%	2.43%	3.15%	2.83%	1.48%	2.43%	2.83%

* Employment projections were based on historical County employment rates from 2010-2015 and applied as relevant to each Water System. Historical county employment from BLS.

4. ANALYSIS OF HISTORICAL WATER DEMAND

The historical water use patterns were analyzed based on water production and consumption data provided by each Duck River Water System. When available, fifteen years of monthly water consumption and production were analyzed (years 2000 to 2015) and for most Water Systems a baseline range of 2010-2015 was used to derive an average per account per day water use. Specific baseline ranges for each Water System can be found in Appendix B. Data from each major customer category were analyzed separately. Historical data was segregated into indoor and outdoor water use by customer type using the billing data.

4.1 Production and Consumption

Total water production and consumption (billed water) data was compared for each Water System over the period 2000-2015 when data was available. Water production data was measured at its respective sources. Water consumption data was measured at the customer meters. A figure of each Water System's total production versus total consumption for the Water System's service area is presented in Appendix B. Regional production versus consumption is NOT presented due to the significant data gaps in historical consumption data for many of the Water Systems; this is clearly presented in Appendix B.

Each Duck River Water System has a variety of customer categories utilized in their billing system. This Report organizes each individual Water System's customer categories according to what was provided by that particular Water System. Each Water System's customer categories are presented in Appendix B.

4.2 Water Use Data Analysis and Key Inputs to the DSS Model

The demand analysis process includes using baseline average water use per customer to forecast water demands by customer category based upon forecasted increases in population and employment to predict customer category account growth. Average water use per customer category account was based on an analysis of historical and current water use data and demographic data. This analysis includes the following elements:

- *Model Start Year* – This is the starting year for the analysis. For this project, the start year for the model is 2015. The DSS Model includes 35 years of data projecting information until the year 2050.
- *Base Year for Future Water Factors* – Based on an analysis of historical water billing data, a specific year or an average of multiple years was selected for each Water System that is representative of current water use and this current water use served as a base year demand factor for developing future water use projections. Specific Water System base water use factors are presented in Appendix B. The year(s) were chosen by DRA for the following reasons:
    - The selected year(s) shows less of an effect from the recession.
    - The year(s) selected had relatively "normal" climate conditions (i.e., not a drought or excessively wet year), so no significant weather adjustments were necessary. The water billing or production data shown in the previous section was not weather normalized for this analysis.
    - Many Water Systems elected to average a few years of data for the analysis. Some Water Systems selected an individual year as they felt it was representative in terms of weather, vacancy, and customer water use for demand projection purposes.
- *Start Year Accounts* – The start year accounts represent the average number of accounts for each customer category in 2015.

- *Average Gal/Day/Acct* – This is the average amount of water in gallons that is used per day, per account.
- *Indoor/Outdoor Water Use* – This is the amount of water per account split into the percent that is used indoors and outdoors.
- *Non-Revenue Water (NRW)* – This is the sum of all water input to the system that is not billed (metered and unmetered) water consumption, including apparent (metering accuracy) and real losses. The values were calculated by taking the difference between the amount of water produced and the amount of water that was sold. Data provided by the Water System was used, if provided, unless another more accurate value from the AWWA M36 Water Loss reports was provided.
- *Census Data* – The 2010 Census data or 2013 or 2014 American Community Survey 3-year or 5-year data was used as a general reference when determining population, housing units, and household sizes for each individual city (and/or unincorporated area) serviced by the Water Systems. Housing units and household sizes were used to estimate water use per person in the service area as well as individual residential customer categories.
- *Current Service Area Population* – The 2015 total population for each Water System is based on CBER-UT provided data or data provided directly by the Water System and presented in Appendix B.
- *Procedure for Service Areas Not Contiguous with City Boundaries* – When a Water System serves an area outside a city boundary, estimates were generated by the local Water System if known.
- *Employment Data* – No employment figures were available for the Water Systems. The employment projection basis was obtained from the selected employment source as discussed earlier in this report in Section 3.

Table 4-1 shows the key inputs and assumptions used in each Water System's DSS Model. The assumptions having the most dramatic effect on future demands are the natural replacement rate of fixtures, how residential or commercial future water use is projected, and finally the percent of estimated non-revenue water. More details on these assumptions, including screenshots of where they are incorporated into the DSS Model, can be found in Appendix A and Appendix B.

Table 4-1. Water Use Data Analysis and DSS Model Key Assumptions

Parameter	Model Input Value, Assumptions, and Key References
Model Start Year	2015
Water Demand Factor Year(s) (Base Year[s])	Varies by Water System. Water System specific value can be found in Appendix B.
Non-Revenue Water in Start Year	Varies by Water System. Water System specific value can be found in Appendix B. This value can be found in the green NRW section of each Water System's DSS Model.
Population Projection Source	CBER-UT or may vary by Water System. Water System specific value can be found in Table 3-1 and Appendix B.
Employment Projection Source	BLS and varies by Water System. Water System specific value can be found in Table 3-2 and Appendix B.
Base Year Water Use Profile	Varies by Water System. Water System specific values can be found in Appendix B.
Residential End Uses	Key Reference: CA DWR Report "California Single Family Water Use Efficiency Study," (DeOreo, 2011 – Page 28, Figure 3: Comparison of household end-uses) and Water Research Foundation (WRF) Report "Residential End Uses of Water, Version 2 - 4309" (DeOreo, 2016). Table 2-A. Water Consumption by Water-Using Plumbing Products and Appliances – 1980-2012. PERC Phase 1 Report. Plumbing Efficiency Research Coalition. 2013. http://www.map-testing.com/content/info/menu/perc.html Model Input Values are found in the "End Uses" section of the DSS Model on the "Breakdown" worksheet.
Non-Residential End Uses, %	Key Reference: AWWARF Report "Commercial and Institutional End Uses of Water" (Dziegielewski, 2000 – Appendix D: Details of Commercial and Industrial Assumptions, by End Use). Santa Clara Valley Water District Water Use Efficiency Unit. "SCVWD CII Water Use and Baseline Study." February 2008. Model Input Values are found in the "End Uses" section of the DSS Model on the "Breakdown" worksheet.
Residential Fixture Efficiency Current Installation Rates	U.S. Census, Housing age by type of dwelling plus natural replacement plus rebate program (if any). Key Reference: California Urban Water Conservation Council Potential Best Management Practice Report "High Efficiency Plumbing Fixtures – Toilets and Urinals" (Koeller, 2005 – Page 42, Table 8 and Table 9: Residential toilet installation rates in California). Key Reference: Consortium for Efficient Energy (www.cee1.org). Model Input Values are found in the "Codes and Standards" green section of the DSS Model by customer category fixtures.
Water Savings for Fixtures, gal/capita/day	Key Reference: AWWARF Report "Residential End Uses of Water, Version 2 - 4309" (DeOreo, 2016).

Parameter	Model Input Value, Assumptions, and Key References
	Key Reference: CA DWR Report "California Single Family Water Use Efficiency Study" (DeOreo, 2011 – Page 28, Figure 3: Comparison of household end-uses). Water System supplied data on costs and savings; professional judgment was made where no published data was available. Key Reference: California Energy Commission (CEC), Staff Analysis of Toilets, Urinals and Faucets, Report # CEC-400-2014-007-SD, 2014. Model Input Values are found in the "Codes and Standards" green section on the "Fixtures" worksheet of the DSS Model.
Non-Residential Fixture Efficiency Current Installation Rates	Key Reference: 2010 U.S. Census, Housing age by type of dwelling plus natural replacement plus rebate program (if any). Assume commercial establishments built at same rate as housing plus natural replacement. California Energy Commission, Staff Analysis of Toilets, Urinals and Faucets, Report # CEC-400-2014-007-SD, 2014. Santa Clara Valley Water District Water Use Efficiency Unit. "SCVWD CII Water Use and Baseline Study." February 2008. Model Input Values are found in the "Codes and Standards" green section of the DSS Model by customer category fixtures.
Residential Frequency of Use Data, Toilets, Showers, Faucets, Washers, uses/user/day	Key Reference: AWWARF Report "Residential End Uses of Water, Version 2 - 4309" (DeOreo, 2016). Summary values of the report can be found in the following presentation: http://watersmartinnovations.com/documents/pdf/2014/sessions/2014-T-1458.pdf Key Reference: California Energy Commission, Staff Analysis of Toilets, Urinals and Faucets, Report # CEC-400-2014-007-SD, 2014. Key Reference: Alliance for Water Efficiency, The Status of Legislation, Regulation, Codes & Standards on Indoor Plumbing Water Efficiency, January 2016. Model Input Values are found in the "Codes and Standards" green section on the "Fixtures" worksheet of the DSS Model and confirmed in each "Service Area Calibration End Use" worksheet by customer category.
Non-Residential Frequency of Use Data, Toilets, Urinals, and Faucets, uses/user/day	Key References: Estimated based on AWWARF Report "Commercial and Institutional End Uses of Water," Appendix D: Details of Commercial and Industrial Assumptions, by End Use (Dziegielewski, 2000). Key Reference: California Energy Commission, Staff Analysis of Toilets, Urinals and Faucets, Report # CEC-400-2014-007-SD, 2014. Based on three studies of office buildings in which the numbers varied from 2.0 to 3.45 toilet flushes per employee per day (Darell Rogers cited in Schultz Communications, 1999; Konen Plumbing Engineer, July/August 1986; and Eva Opitz cited in PMCL, 1996). Fixture uses over a 5-day work week are prorated to 7 days. Non-residential 0.5 gpm (gallons per minute) faucet standards per Table 2-A. Water Consumption by Water-Using Plumbing Products and Appliances - 1980-2012. PERC

Parameter	Model Input Value, Assumptions, and Key References
	Phase 1 Report. Plumbing Efficiency Research Coalition. 2013. http://www.map-testing.com/content/info/menu/perc.html Model Input Values are found in the "Codes and Standards" green section of the "Fixtures" worksheet of the DSS Model and confirmed in each "Service Area Calibration End Use" worksheet by customer category.
Natural Replacement Rate of Fixtures (% per year)	Residential Toilets 2% (1.28 gpf and lower), 3% (1.6 gpf toilets), 4% (3.5 gpf and higher)
	Non-Residential Toilets 2% (1.6 gpf and lower), 3% (3.5 gpf and higher toilets)
	Residential Showers 4% (corresponds to 25-year life of a new fixture)
	Residential Clothes Washers 10% (based on 10-year washer life). Key References: "Residential End Uses of Water" (DeOreo, 2016) and "Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Clothes Washers" (Department of Energy, 2012).
	Residential Faucets 10% and Non-Residential Faucets 6.7% (every 15 years). CEC uses an average life of 10 years for faucet accessories (aerators). A similar assumption can be made for public lavatories, though no hard data exists and since CII fixtures are typically replaced less frequently than residential, 15 years is assumed. CEC, Analysis of Standards Proposal for Residential Faucets and Faucet Accessories, a report prepared under CEC's Codes and Standards Enhancement Initiative, Docket #12-AAER-2C, August 6, 2013.
	Model Input Value is found in the "Codes and Standards" green section on the "Fixtures" worksheet of the DSS Model.
Residential Future Water Use	Increases based on Population Growth and Demographic Forecast
Non-Residential Future Water Use	Increases based on Employment Growth Rate and Demographic Forecast

5. WATER DEMAND PROJECTIONS

The purpose of this section is to document the water demand projections developed for the Project. This section presents an overview of the water demand methodology and the total water demand projections with and without the plumbing code savings through year 2050.

5.1 Demand Methodology Overview

Each Water System's water demand (i.e., average year demand before additional active water-use efficiency measure savings were incorporated) is forecasted through 2050 using the DSS Model. The demand analysis process includes forecasting future water demand (2015-2050) by customer category based upon forecasted increases in population and employment. Average water use per customer category account is based on an analysis of historical data between 2000 and 2015 (or a shorter period if a Water System's historical data was incomplete). To forecast water demands, the DSS Model relies on demographic and employment projections combined with the effects of natural fixture replacement due to the implementation of plumbing codes to forecast future demands. Natural fixture replacement due to the implementation of plumbing codes is part of passive conservation savings. Passive conservation refers to water savings resulting from actions and activities that do not depend on direct financial assistance or educational programs from Water Systems.

5.2 Demand Projections With and Without Passive (Plumbing Code) Savings

Since it is beneficial to model the impact of the natural changes in the different types of appliances, the DSS Model forecasts service area water fixture use. In the codes and standards part of the DSS Model, specific fixture end-use type (point of use fixture or appliance), average water use, and lifetime are compiled. Additionally, state and national plumbing codes and appliance standards for toilets, urinals, showers, and clothes washers are modeled by customer category. These fixtures and plumbing codes can be added to, edited, or deleted by the user. This yields two demand forecasts: 1) with plumbing codes, and 2) without plumbing codes.

The following tables present each Water System's projected water use. Figure 5-1 presents Duck River's regional demand with and without plumbing code savings. Information and assumptions about plumbing code and appliance standards can be found in Appendix A. Water System individual projected demands can be found in Appendix B.

The demand projections reflect average water use under average weather conditions and do **NOT** reflect drier and hotter drought conditions. Likewise, climate change (which might alter weather patterns), increased or decreased rainfall, and possible increased irrigation demand in the spring and fall (due to a warmer climate) have **NOT** been addressed in this analysis.

Plumbing code measures are based on customers following applicable current local, state, and federal laws, building codes, and ordinances.

The DSS Model shows an annual total plumbing code savings of 5 MGD by 2050 meaning the plumbing codes and appliance standards will reduce 2050 demands by 5 MGD or 12% of demands without the plumbing code. Further reductions in demand due to voluntary and regulatory conservation measures are calculated from an end-use version of the demands with the plumbing code.

Table 5-1. Average Day Water Demands WITHOUT Plumbing Code Savings (MGD)

Water System	2015	2020	2025	2030	2035	2040	2045	2050
Coffee County								
Tullahoma Utilities Board	3.08	3.39	3.73	4.12	4.55	5.03	5.57	6.18
Manchester Water and Sewer Department	2.46	2.68	2.90	3.15	3.43	3.73	4.07	4.45
Bedford County								
Shelbyville Power, Water, and Sewerage System	3.85	4.18	4.52	4.89	5.19	5.51	5.85	6.22
Bedford County Utility District	1.80	1.94	2.07	2.21	2.31	2.40	2.50	2.60
Marshall County								
Lewisburg Water and Wastewater	2.47	2.64	2.90	3.17	3.40	3.64	3.90	4.20
Maury/Southern Williamson County								
Spring Hill Water System	2.66	3.03	3.41	3.84	4.08	4.31	4.55	4.79
Columbia Power and Water Systems	7.54	8.22	8.91	9.63	10.35	11.10	11.88	12.74
Total DRA Demand Without Plumbing Code Savings	**23.86**	**26.08**	**28.44**	**31.01**	**33.31**	**35.72**	**38.32**	**41.18**

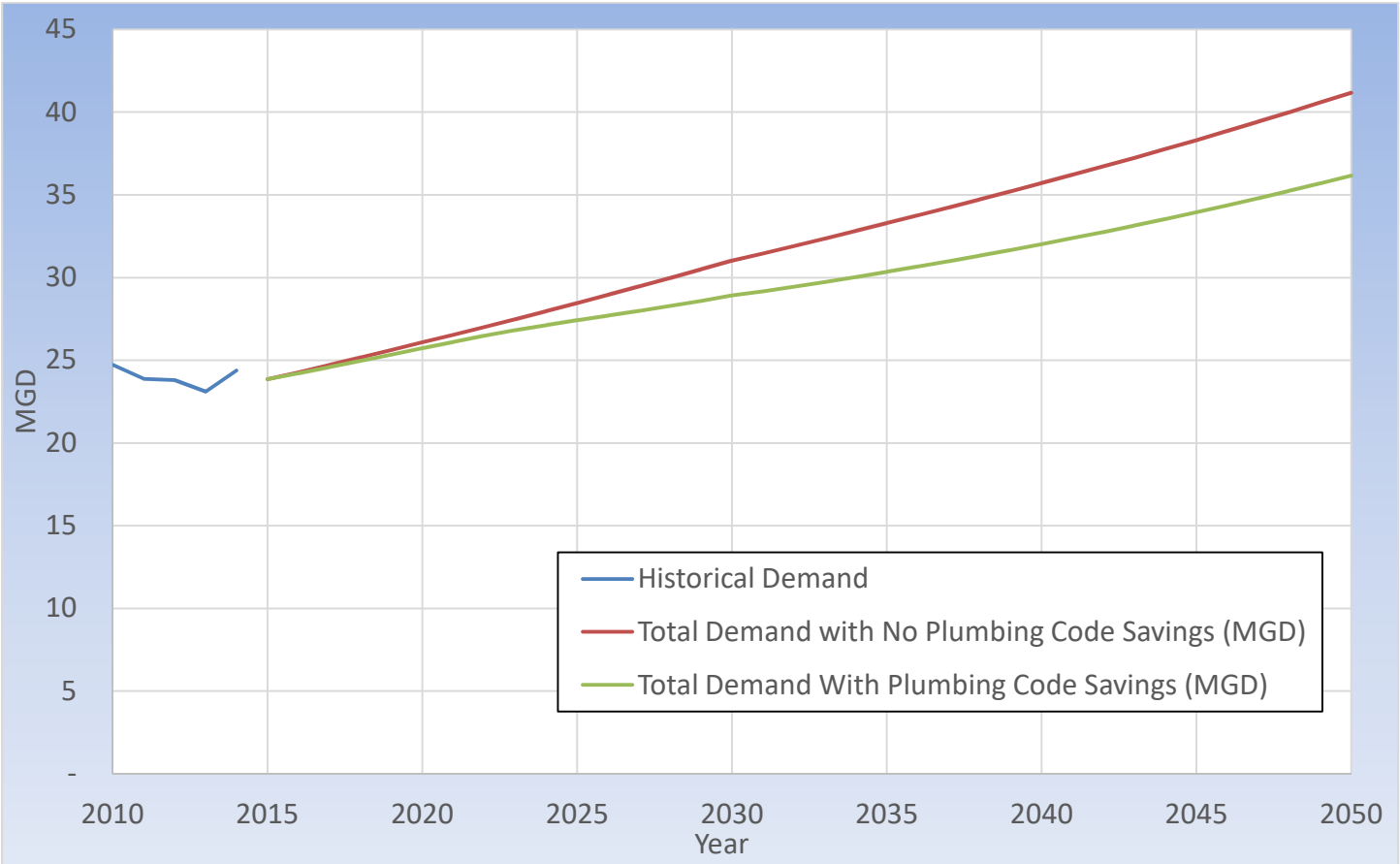
Note: Demands based on surface water supply deliveries from public water systems. Demands do not include historical, current, or future private well use by customers. Demands do not include conversion of existing private well-users to the public water system.

Table 5-2. Average Day Water Demands WITH Plumbing Code Savings (MGD)

Water System	2015	2020	2025	2030	2035	2040	2045	2050
Coffee County								
Tullahoma Utilities Board	3.08	3.33	3.57	3.82	4.12	4.49	4.92	5.43
Manchester Water and Sewer Department	2.46	2.64	2.81	2.98	3.18	3.41	3.68	3.99
Bedford County								
Shelbyville Power, Water, and Sewerage System	3.85	4.13	4.39	4.60	4.80	5.02	5.28	5.57
Bedford County Utility District	1.80	1.91	1.98	1.99	1.99	2.01	2.03	2.07
Marshall County								
Lewisburg Water and Wastewater	2.47	2.59	2.76	2.93	3.06	3.21	3.39	3.61
Maury/Southern Williamson County								
Spring Hill Water System	2.66	3.01	3.30	3.56	3.68	3.82	3.97	4.14
Columbia Power and Water Systems	7.54	8.12	8.60	9.04	9.52	10.07	10.67	11.35
Total DRA Demand WITH Plumbing Code Savings	**23.86**	**25.73**	**27.41**	**28.92**	**30.35**	**32.03**	**33.94**	**36.16**

Note: Demands based on surface water supply deliveries from public water systems. Demands do not include historical, current, or future private well use by customers. Demands do not include conversion of existing private well-users to the public water system.

Figure 5-1. Regional Average Day Water Demands (MGD)



Note: Total Demand accounts for the total projected water demand in a service area Water System regardless of source. Source can be from surface water or groundwater.

6. CONCLUSIONS/NEXT STEPS

The service areas for the Tennessee Duck River Development Agency's seven Water Systems have a relatively high portion of residential water use. Consequently, incorporating residential indoor plumbing codes into the DSS Model produces water savings on the order of 12% in year 2050. Since the service areas do not use a significant amount of water outdoors and are not as heavy in manufacturing, the water-reduction potential for outdoor water-use efficiency measures and the commercial sector is lower than that of indoor residential water use.

The amount of new growth forecasted for some of the service areas is high, indicating that measures directed at new development could produce significant water and cost savings by deferring or downsizing new capital infrastructure. It is recommended that a water-use efficiency analysis be conducted for the region, particularly in addressing the high real water losses (non-revenue water) in many of the Water Systems. Non-revenue water consists of three components: unbilled authorized consumption, apparent losses, and real losses. Unbilled authorized consumption includes fire department usage and operational flushing. Apparent losses include non-physical losses like slow meters, billing issues, and theft. Real losses are physical losses like leakage. Water loss management is critical, as is identifying and tracking any authorized non-revenue water uses (i.e., system flushing).

It is recommended that in order to improve Water System demand management each Water System should do the following as far as data management:

- Track daily water withdrawal
- Track water use and accounts by customer category on a regular time-scale – minimum monthly or bimonthly, depending upon the frequency of meter reading
- Track single family and multifamily customers separately
- Use standardized definitions of customer classes to ease regional information sharing and analysis
- Survey a random sample of the individual water accounts by customer type to better understand the population served (people per account, employees per account, etc.)
- Estimate or track the number of people served by the different residential account types on an annual basis
- Estimate or track the number of employees served by the different non-residential account types by each Water System or county on an annual basis
- Transition rate structure to be more volumetric based where applicable
- Track annual unemployment within each Water System or by county
- Track large water users' (top 100) monthly water use
- Track non-active accounts/vacancies
- Survey customers regarding fixture types – even a small sampling of the service area can provide a valuable picture of the water use profile of an account type
- Use AWWA M36 water loss management tools to track non-revenue water and real water loss
- Submit standard form/annual report to DRA with monthly or bimonthly production by source and consumption and accounts by category. Service area population and number of employees would also be tracked on this document. A sample document used by California Department of Water Resources can be found in Appendix C.
- Track the avoided cost of water; if water is saved, how much money is saved (cost of water supply, water treatment, distribution, energy, delaying new supply source, wastewater, etc.)
- Track water-use efficiency initiatives, whether they be public education, school education, water fixture rebates (toilets), water/energy fixture rebates (clothes washers), giveaways (faucet aerators), pricing re-structuring, etc.

- Develop water use targets to measure improvements of new water use efficiency practices. Water use targets might be developed on a per capita basis or for the water systems or region as a whole.
- Track residential account lot sizes to better understand their water use.

It is MWM's estimation that following some or all of the above recommendations would allow each Water System to more efficiently manage its water use and move DRA closer toward its goal of being the most efficient water management organization in the country. In the future, the Water Systems, with the support of DRA and expert consultants, would evaluate the cost-benefit relationship of these recommendations and prioritize next steps and actions. Other water sectors, such as agriculture, golf courses, and chicken farms, are included in these recommendations as far as data and demand management. This report's recommendations should be reviewed annually and updated every 3-5 years and/or when any significant changes in the water system occur.

A second phase of this analysis could involve conducting a water-use efficiency measures analysis to understand the value of investing in water demand reduction combined with and/or in lieu of other infrastructure investments. This allows for balancing revenue needs to assist with rehabilitation and replacement of aging infrastructure in addition to striving to maintain and expand services to existing and future customers.

7. REFERENCES

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8. LIST OF CONTACTS

The following presents each Water System's contact information.

Water System	Name	Phone Number	E-mail	Role
Bedford County Utility District	Martin Davis	931-684-1667	mdavisgm@bcud.net	General Manager
	Willie West	931-294-5117	williewest@united.com	Water Treatment Plant Manager
Columbia Power and Water Systems	Jonathan Hardin	931-375-7646	jonathan.hardin@cpws.com	Water System Manager
Lewisburg Water and Wastewater	Cathey Nash	931-359-3345	cathey@lewisburgwater.org	Water Plant Manager
	Trigg Cathey	931-359-6831	trigg@lewisburgwater.org	General Manger
Manchester Water and Sewer Department	Dana Douglas	931-728-4652 ext. 2002	ddouglas@cityofmanchestertn.com	Assistant Manager
	Bryan Pennington	931-728-4652 ext. 2001	water@cityofmanchestertn.com	Water System Manager
Shelbyville Power, Water, and Sewerage System	John Freeman	931-684-7171	jfreeman@shelbyvillepower.com	City Engineer
	Dennis Rankin	931-684-5817	drankin@shelbyvillepower.com	Water Plant Manager
Spring Hill Water System	Caryl A. Giles	931-489-5791	cgiles@springhilltn.org	Water Plant Manager
Tullahoma Utilities Board	Scott Young	931-571-7106	syoung@tub.net	Water/Wastewater Department Manager
	Dale Willis	931-571-7126	dwillis@tub.net	Engineering Supervisor
Maddaus Water Management	Michelle Maddaus	925-831-0194	michelle@maddauswater.com	MWM Project Manager
Tennessee Duck River Development Agency	Doug Murphy	931-684-7820	doug@duckriveragency.org	Executive Director

APPENDIX A – DSS MODEL OVERVIEW AND KEY ASSUMPTIONS

Plumbing codes and appliance standards for toilets, urinals, faucets, clothes washers, and showerheads will continue to reduce indoor residential and non-residential water demands in the future. This reduction in demand is accounted for in Maddaus Water Management's Decision Support System (DSS) Model. Background on the DSS Model as well as details on the method of determining plumbing code savings is presented in the following sections.



A.1 DSS Model Overview

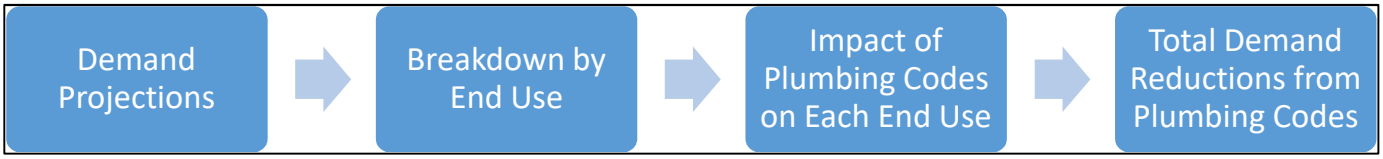
The DSS Model is used to prepare long-range, detailed demand projections. The purpose of the extra detail is to enable a more accurate assessment of the impact of water efficiency programs on demand. A rigorous modeling approach is especially important if the project will be subject to regulatory or environmental review.

The DSS Model is an end-use model that breaks down total water production (water demand in the service area) to specific water end uses. The model uses a bottom-up approach that allows for multiple criteria to be considered when estimating future demands, such as the effects of natural fixture replacement, plumbing codes, and water-use efficiency efforts. The DSS Model may also use a top-down approach with a utility-prepared water demand forecast.

To forecast urban water demands using the DSS Model, customer demand data is obtained from the water agency being modeled. The demand data is reconciled with available demographic data to characterize the water usage for each customer category in terms of number of users per account and per capita water use. The data is further analyzed to approximate the split of indoor and outdoor water usage in each customer category. The indoor/outdoor water usage is further divided into typical end uses for each customer category. Published data on average per capita indoor water use and average per capita end use is combined with the number of water users to calibrate the volume of water allocated to specific end uses in each customer category. In other words, the DSS Model checks that social norms from end-use studies on water use behavior (e.g., flushes per person per day) are not exceeded.

The DSS Model evaluates water-use efficiency measures using benefit-cost analysis with the present value of the cost of water saved ($/Acre-Foot). Benefits are based on savings in water and wastewater facility operations and maintenance (O&M). The figure below illustrates the process for forecasting water-use efficiency water savings, including the impacts of fixture replacement due to plumbing codes and standards already in place.

The DSS Model has been used for practical applications of water-use efficiency planning in over 250 service areas representing 20 million people, including extensive efforts nationally in California, Colorado, Hawaii, Idaho, Utah, Georgia, Florida, North Carolina, Tennessee, Oregon, Texas, and Ohio, and internationally in Australia, New Zealand, and Canada. The California Urban Water Conservation Council (CUWCC) did a peer review and has endorsed the model since 2006. The model is offered to all of the CUWCC members for use to estimate water demand, plumbing code, and conservaiton program savings. For more information please see the CUWCC website: https://www.cuwcc.org/Resources/Planning-Tools-and-Models?folderId=776&view=gridview&pageSize=10



The DSS Model is used to forecast service area water fixture use. In the codes and standards part of the DSS Model, specific fixture end-use type (point of use fixture or appliance), average water use, and lifetime are compiled. Additionally, state and national plumbing codes and appliance standards for toilets, urinals, showers, and clothes washers are modeled by customer category. These fixtures and plumbing codes can be added to, edited, or deleted by the user. This yields two demand forecasts: 1) with plumbing codes and 2) without plumbing codes. Plumbing code measures are independent of any water-use efficiency program; they are based on customers following applicable current local, state, and federal laws, building codes, and ordinances.

A.2 Plumbing Codes and Legislation

The DSS Model incorporates the following national plumbing code items as a "code," meaning that the savings are assumed to occur and are therefore "passive" savings.

The Federal Energy Policy Act of 1992, as amended in 2005, mandates that only fixtures meeting the following standards can be installed in new buildings:

- Toilets – 1.6 gal/flush maximum
- Urinals – 1.0 gal/flush maximum
- Showerheads – 2.5 gal/min at 80 psi
- Residential faucets – 2.2 gal/min at 60 psi
- Public restroom faucets – 0.5 gal/min at 60 psi
- Dishwashing pre-rinse spray valves – 1.6 gal/min at 60 psi

Replacement of fixtures in existing buildings is also governed by the Federal Energy Policy Act, which mandates that only devices with the specified level of efficiency (as shown above) can be sold as of 2006. The net result of the plumbing code is that new buildings will have more efficient fixtures and old, inefficient fixtures will slowly be replaced with new, more efficient models. The national plumbing code is an important piece of legislation and must be carefully taken into consideration when analyzing the overall water efficiency of a service area.

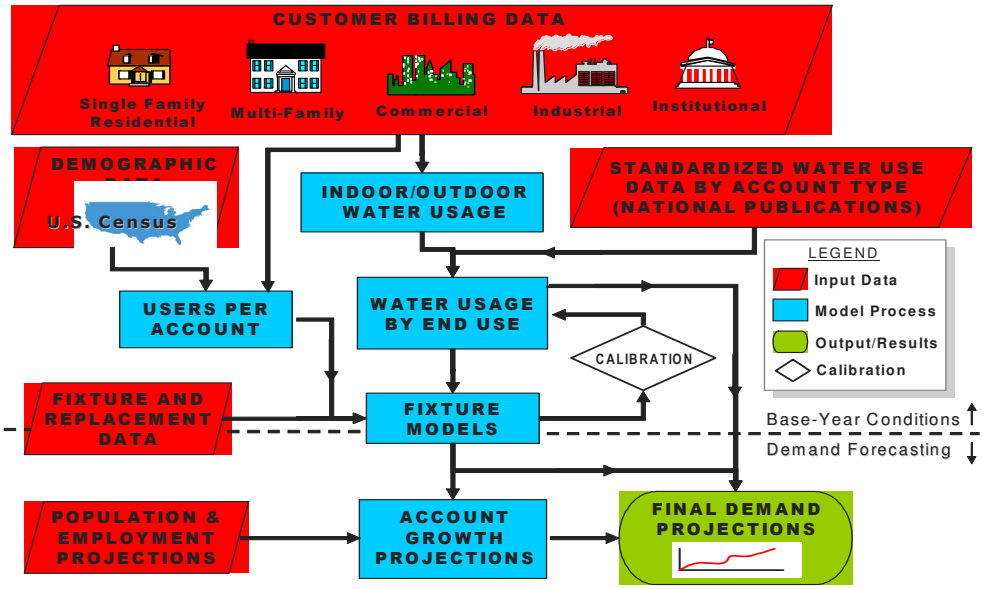
In addition to the plumbing code, the U.S. Department of Energy regulates appliances, such as residential clothes washers, further reducing indoor water demands. Regulations to make these appliances more energy efficient have driven manufactures to dramatically reduce the amount of water these machines use. Generally, front loading washing machines use 30-50% less water than conventional models (which are still available). In a typical analysis, the DSS Model forecasts a gradual transition to high efficiency clothes washers (using 12 gallons or less) so that, by the year 2025, they will be the only type of machines available for purchase.

In addition to the industry becoming more efficient, rebate programs for washers have been successful in encouraging customers to buy more water efficient models. Given that machines last about 10 years, eventually all machines on the market will be the more water efficient models. Energy Star® washing machines have a water factor (WF) of 6.0 or less – the equivalent of using 3.1 cubic feet (or 23.2 gallons) of water per load. The maximum water factor for residential clothes washers under current federal standards is 9.5. The water factor equals the number of gallons used per cycle per cubic foot of capacity. Prior to year 2000, the water factor for a typical new residential clothes washer was about 12. In March 2015, the federal standard reduced the maximum water factor for top- and front-loading machines to 8.4 and 4.7, respectively. In 2018, the maximum water factor for top-loading machines will be further reduced to 6.5.

For commercial washers, the maximum water factors were reduced in 2010 to 8.5 and 5.5 for top- and front-loading machines, respectively. Beginning in 2015, the maximum water factor for Energy Star® certified washers was changed to 4.3 for top-loading machines and 3.7 for front-loading. In 2011, the Environmental Protection Agency (EPA) estimated that Energy Star® washers comprised more that 60% of the residential market and 30% of the commercial market (Energy Star®, 2011). A new Energy Star® compliant washer uses about two-thirds less water per cycle than washers manufactured in the 1990s.

The following figure conceptually describes how plumbing codes are incorporated into the flow of information in the DSS Model.

Figure A-1. DSS Model Overview Used to Make Potable Water Demand Projections



DSS Model Fixture Replacement

The DSS Model is capable of modeling multiple types of fixtures, including fixtures with slightly different design standards. For example, currently toilets can be purchased that flush at a rate of 0.8 gallons per flush (gpf), 1.0 gpf, 1.28 gpf or 1.6 gpf. Higher than 1.6 gpf toilets still exist but can no longer be purchased in the United States. Therefore, they cannot be used for replacement or new installation of a toilet. So, the DSS Model utilizes a fixture replacement table to decide what type of fixture should be installed during replacement or new installation of a fixture. The replacement of the fixtures is listed as a percentage, as shown in the following figure. A value of 100% would indicate that all the toilets sold would be of one particular flush volume. A value of 75% means that three out of every four toilets installed would be of that particular flush volume type. The DSS Model contains a pair of replacement tables for each fixture type and customer category combination (i.e., Residential Single Family Toilets, Residential Multifamily Toilets, Commercial Toilets, Residential Clothes Washing Machines, Commercial Washing Machines, etc.).

In the following example, the DSS Model includes the effects of the Federal Policy Act on each toilet fixture type. This DSS Model feature determines the “saturation” of 1.6 gpf toilets while the Federal Policy Act was in effect from 1992-2014 for 1.6 gpf toilet replacements.

Figure A-2. Toilet Replacement Percentages by Type of Toilet

Replacement Appliance Market Shares					
Year	High Use Toilet Residential	1.6 gpf ULFT Residential	1.28 gpf HET Residential	<1.0 gpf Toilet Residential	Total
2015	0%	100%	0%	0%	100%
2020	0%	75%	25%	0%	100%
2025	0%	50%	40%	10%	100%
2035	0%	25%	50%	25%	100%
2050	0%	0%	70%	30%	100%
New Appliance Market Shares					
Year	High Use Toilet Residential	1.6 gpf ULFT Residential	1.28 gpf HET Residential	<1.0 gpf Toilet Residential	Total
2015	0%	100%	0%	0%	100%
2020	0%	65%	35%	0%	100%
2025	0%	0%	80%	20%	100%
2035	0%	0%	70%	30%	100%
2050	0%	0%	65%	35%	100%

APPENDIX B –WATER SYSTEM SPECIFIC INFORMATION

This appendix presents each Water System's specific information.

B.1 Bedford County Utility District

This section presents Bedford County Utility District's historical and projected population and employment, historical production and consumption, DSS Model input values, sources and assumptions as well as projected demands with and without plumbing codes.

B.1.1 Demographic Data

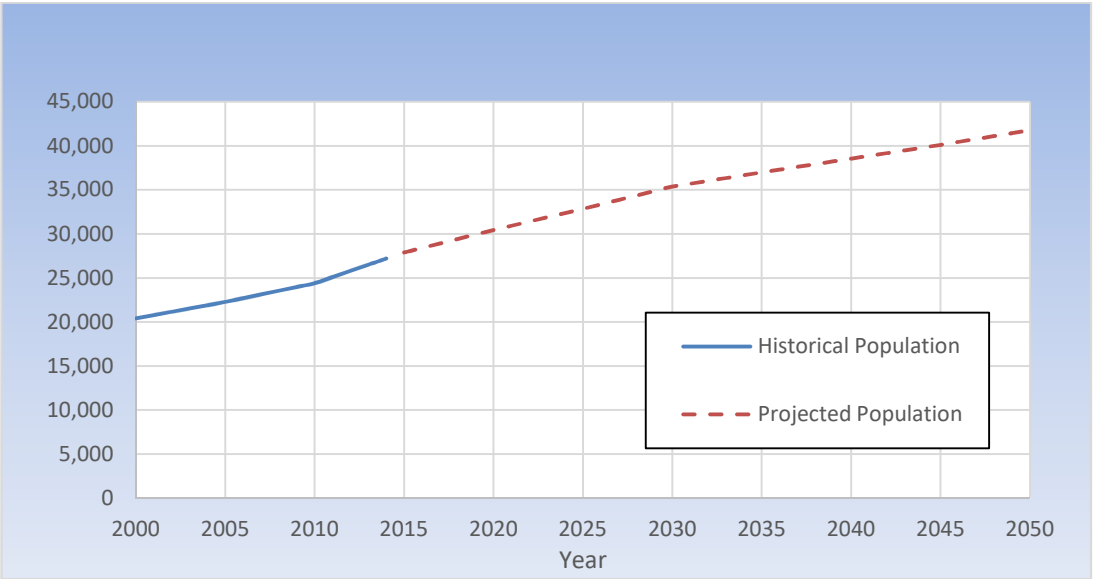
Population projections were obtained through year 2030 from the June 2009 joint publication of the *Population Projections for the State of Tennessee, 2010-2030* by the Tennessee Advisory Commission (TAC) on Intergovernmental Relations and the University of Tennessee's Center of Business and Economics Research (CBER-UT). Population projections from 2035 through 2050 were derived using CBER-UT's projections for Bedford County. Employment projections were based on Bedford County's employment rate from 2010-2015 of 1.48%. The actual number of jobs was not provided or determined for the Water System, rather the 2010-2015 average employment growth was applied to non-residential account growth through year 2050. The historical county employment was provided by the BLS of the U.S. Department of Labor (US Dept. of Labor, 2016).

The following table and figure present the historical and projected population for the water supplier.

Table B-1. Historical and Projected Population– Bedford County Utility District

	2010	2015	2020	2025	2030	2035	2040	2045	2050
Population	24,384	27,897	30,451	32,857	35,387	36,996	38,559	40,125	41,786

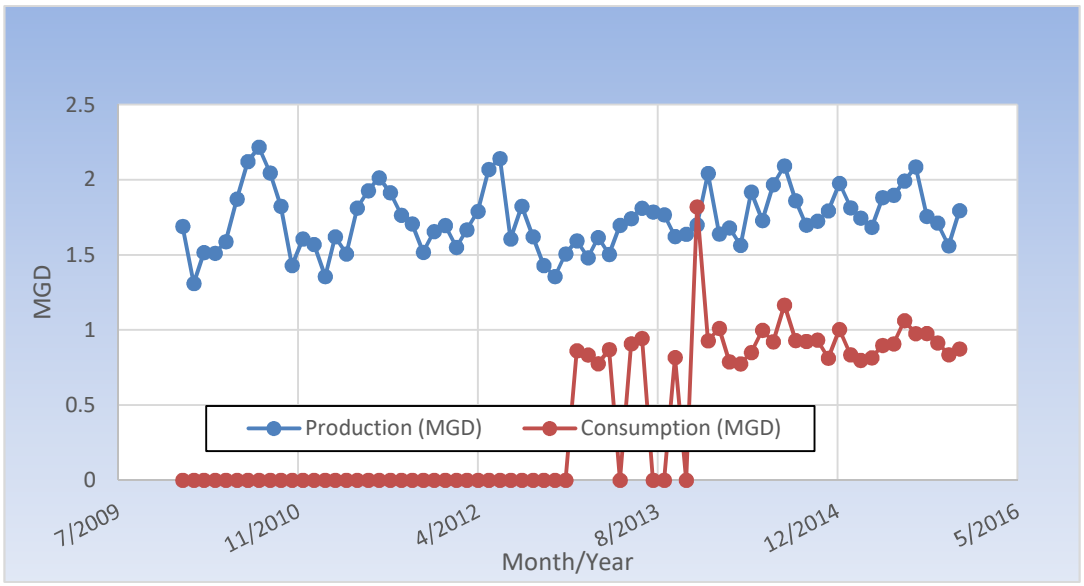
Figure B-1. Historical and Projected Population – Bedford County Utility District



B.1.2 Production and Consumption

Total water production and consumption (billed water) data was compared over the period 2010-2015. Water production data was measured at its respective sources. Water consumption data was measured at the customer meters. The Water System's total production versus total consumption for the service area is presented in the following figure. Only years 2014 and 2015 consumption data is consistently reliable.

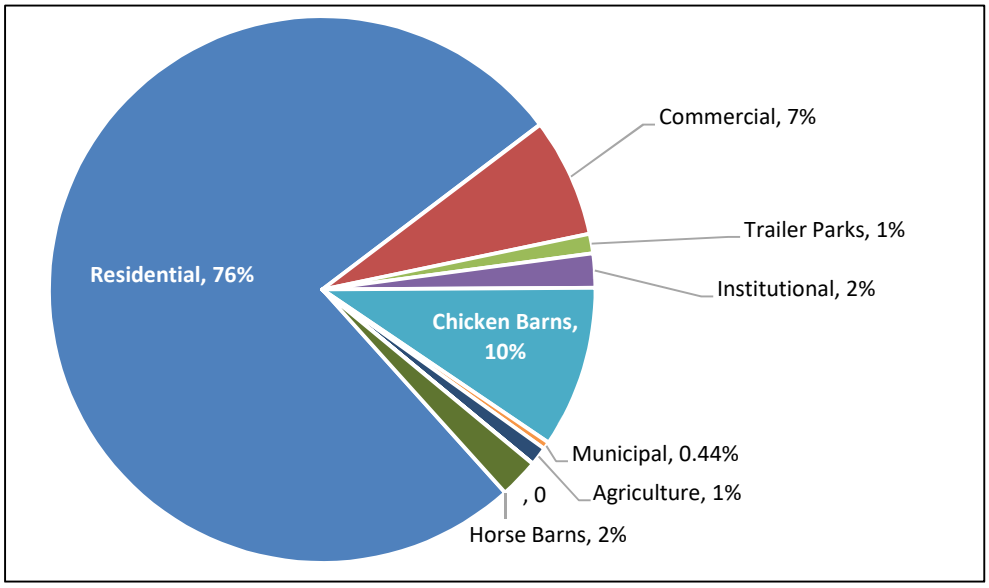
Figure B-2. Total Production vs. Total Consumption – Bedford County Utility District



Each Duck River Water System has a variety of customer categories utilized in their billing system. This Water System has organized users into Residential, Commercial, Trailer Parks, Institutional, Chicken Barns, Municipal, Agriculture, and Horse Barns categories. Residential is the largest category of water users, using more than 75% of the water consumed.

The following figure illustrates the water usage breakdowns within the Water System's service area based on historical water use in years 2014-2015.

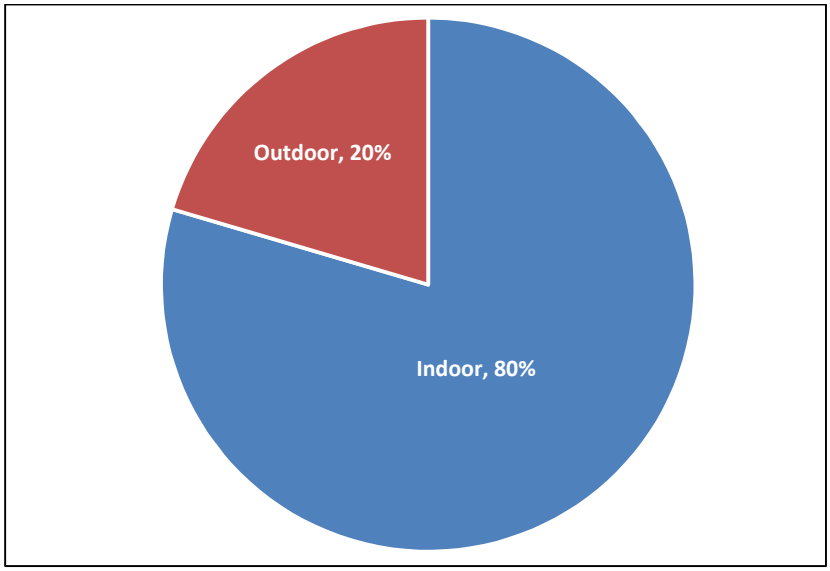
Figure B-3. Consumption by Customer Category – Bedford County Utility District



Note: Figure is based on water use in years 2014-2015.

The following figure shows the breakdown of water use into indoor and outdoor components based on the assumption that indoor use is approximately equal to the minimum use in the winter. While there may be minimal landscape watering in the winter, or leakage from irrigation systems, it is assumed that this is minor at less than 5-10% of the average winter water use. Residential indoor water use is assumed to be 95% of total water use due to a high number of private wells which are used for outdoor purposes and an overall low percentage of irrigation.

Figure B-4. Overall Use: Indoor vs. Outdoor – Bedford County Utility District



Note: Figure is based on average water use in years 2014-2015.

B.1.3 Water Use Data Analysis and Key Inputs to the DSS Model

The following table shows the key inputs and assumptions used in the Water System's DSS Model.

Table B-2. Water Use Data Analysis and DSS Model Key Inputs and Assumptions – Bedford County Utility District

Parameter	Model Input Values, Sources and Assumptions				
Model Start Year	2015				
Water Demand Factor Year(s) [Base Year(s)]	2014-2015				
Non-Revenue Water in Start Year	33.9%				
	This value is based on year 2014 and 2015 production and consumption data and can be found in the green NRW section of each Water System's DSS Model.				
Population Projection Source	CBER-UT				
Employment Projection Source	BLS 2010-2015 average annual historical employment for Bedford County				
Base Year Water Use Profile					
Customer Categories	**Start Year Accounts**	**Total Water Use Distribution**	**Demand Factors (gpd/acct)**	**Indoor Use %**	**Residential Indoor Water Use**
Residential	6,421	76%	141	95%	43
Commercial	70	7%	1,191	59%	N/A
Trailer Parks	15	1%	913	90%	N/A
Institutional	5	2%	4,785	70%	N/A
Chicken Barns	47	10%	2,426	0%	N/A
Municipal	2	0%	2,608	88%	N/A
Agriculture	6	1%	2,287	0%	N/A
Horse Barns	58	2%	479	0%	N/A
Total	**6,623**	**100%**	**N/A**	**80%**	N/A

B.1.4 Water System Demand Projections

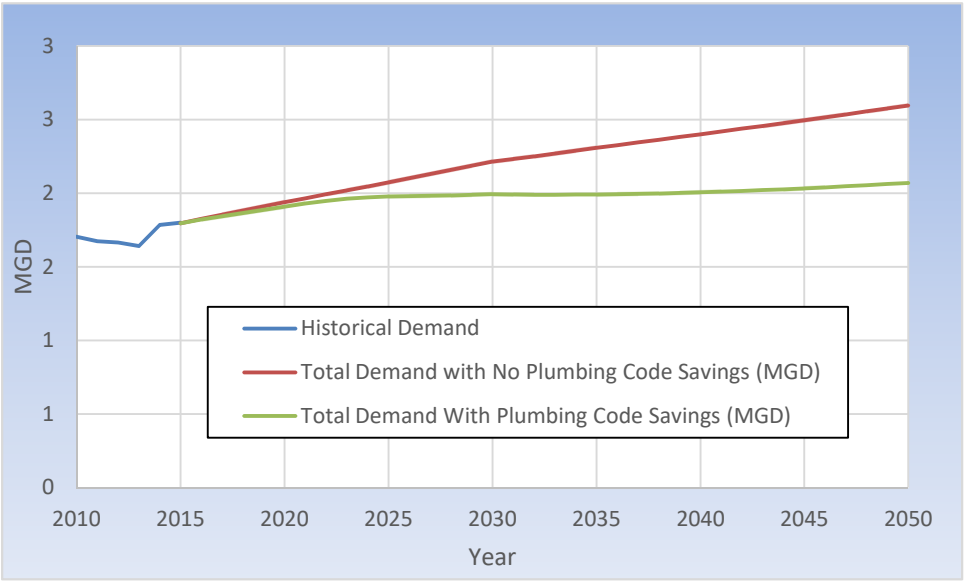
The following table and figure present the average day water demand projections for the Water System.

Table B-3. Demand Projections – Bedford County Utility District

Demand Forecast	2015	2020	2025	2030	2035	2040	2045	2050
Total Demand Without Plumbing Code Savings (MGD)	1.80	1.94	2.07	2.21	2.31	2.40	2.50	2.60
Total Demand With Plumbing Code Savings (MGD)	1.80	1.91	1.98	1.99	1.99	2.01	2.03	2.07

Note: Total Demand accounts for the total projected water demand in a service area Water System regardless of source. Source can be from surface water or groundwater.

Figure B-5. Demand Projection – Bedford County Utility District



B.2 Columbia Power and Water Systems

This section presents Columbia Power and Water Systems' historical and projected population and employment, historical production and consumption, DSS Model input values, sources and assumptions as well as projected demands with and without plumbing codes.

B.2.1 Demographic Data

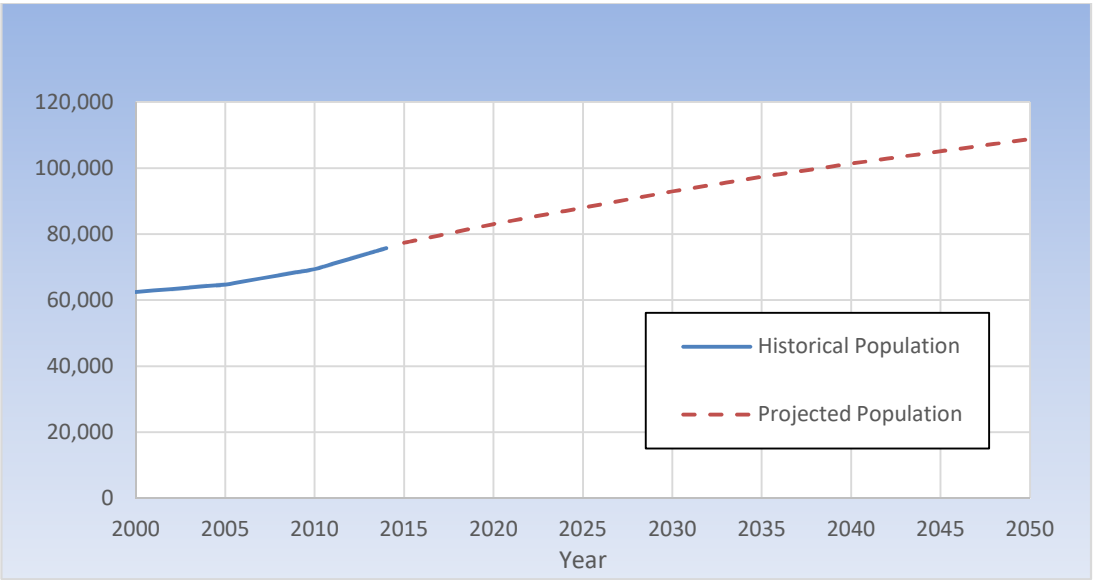
Population projections were obtained through year 2030 from the June 2009 joint publication of the *Population Projections for the State of Tennessee, 2010-2030* by the TAC on Intergovernmental Relations and the CBER-UT. Population projections from 2035 through 2050 were derived using CBER-UT's projections for Maury County. Employment projections were based on Maury County's employment rate from 2010-2015 of 2.43%. The actual number of jobs was not provided or determined for the Water System, rather the 2010-2015 average employment growth was applied to non-residential account growth through year 2050. The historical county employment was provided by the BLS of the U.S. Department of Labor (US Dept. of Labor, 2016).

The following table and figure present the historical and projected population for the water supplier.

Table B-4. Historical and Projected Population – Columbia Power and Water Systems

	2010	2015	2020	2025	2030	2035	2040	2045	2050
Population	69,388	77,364	83,015	87,987	92,918	97,332	101,341	105,056	108,759

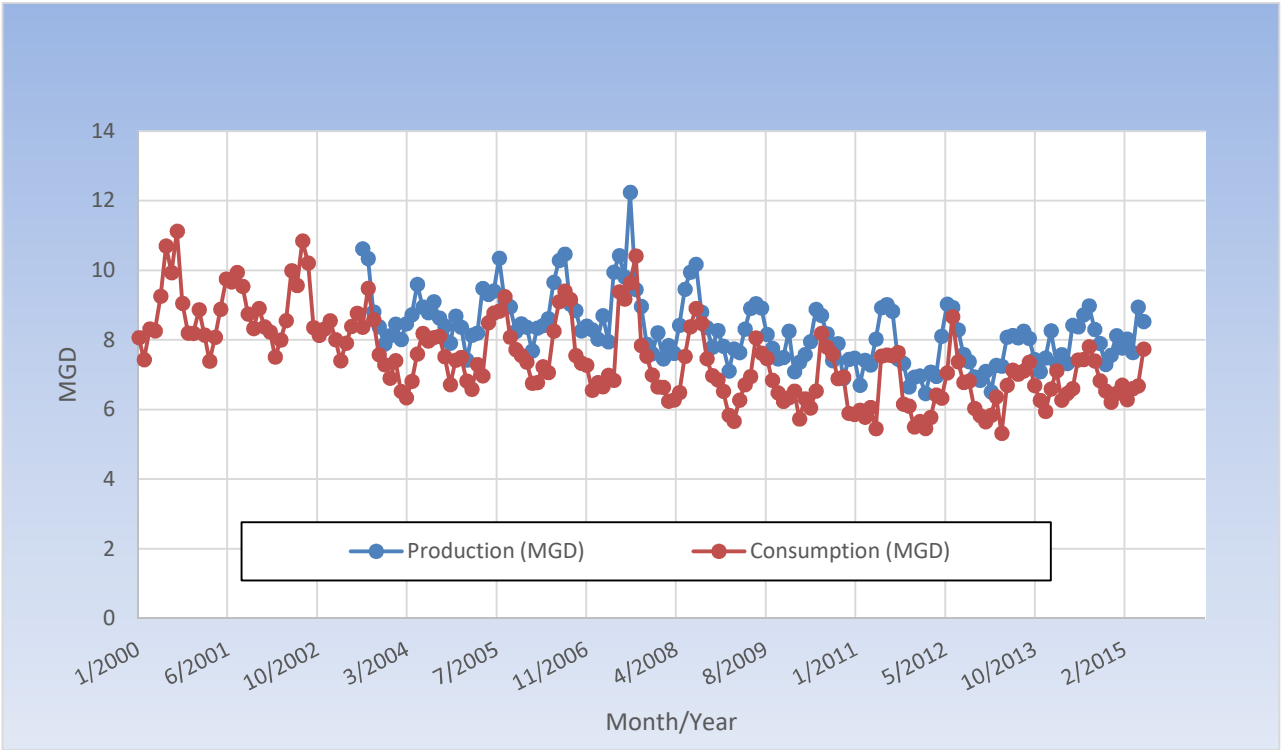
Figure B-6. Historical and Projected Population – Columbia Power and Water Systems



B.2.2 Production and Consumption

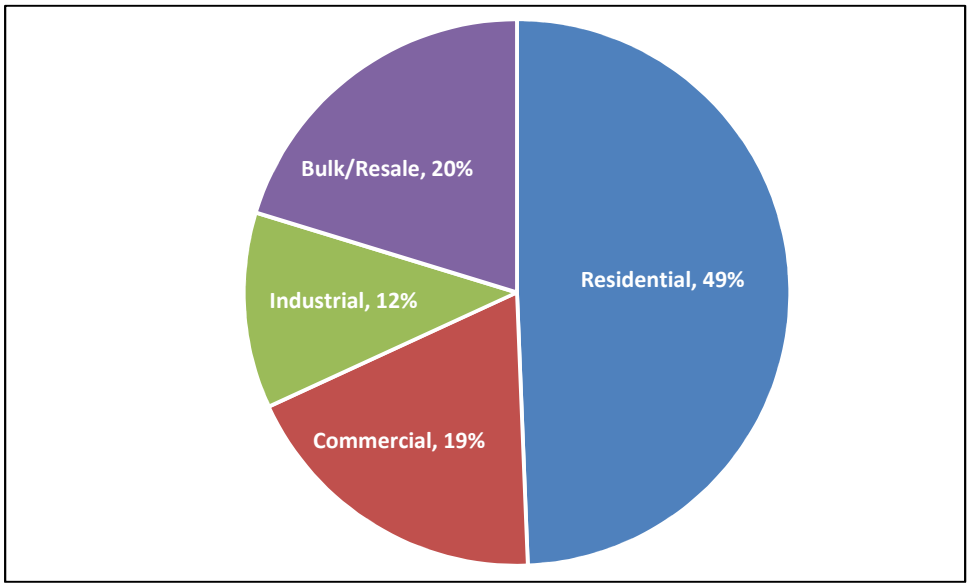
Total water production and consumption (billed water) data was compared over the period 2000-2015. Water production data was measured at its respective sources. Water consumption data was measured at the customer meters. The Water System's total production versus total consumption for the service area is presented in the following figure. By year 2008, CPWS account Saturn car manufacturer closed yielding a reduction in demand. More specifically, the assembly line for Saturn closed in 2007, with the final day of production March 30, 2007 (Daily Herald, 2015). The plant continued to make parts through 2007 and was officially closed in 2008.

Figure B-7. Total Production vs. Total Consumption – Columbia Power and Water Systems



Each Duck River Water System has a variety of customer categories utilized in their billing system. This Water System has organized users into Residential, Commercial, Industrial, and Bulk/Resale categories. Residential is the largest category of water users, using 49% of the water consumed. The following figure illustrates the water usage breakdowns within the Water System's service area based on historical water use in years 2010-2015.

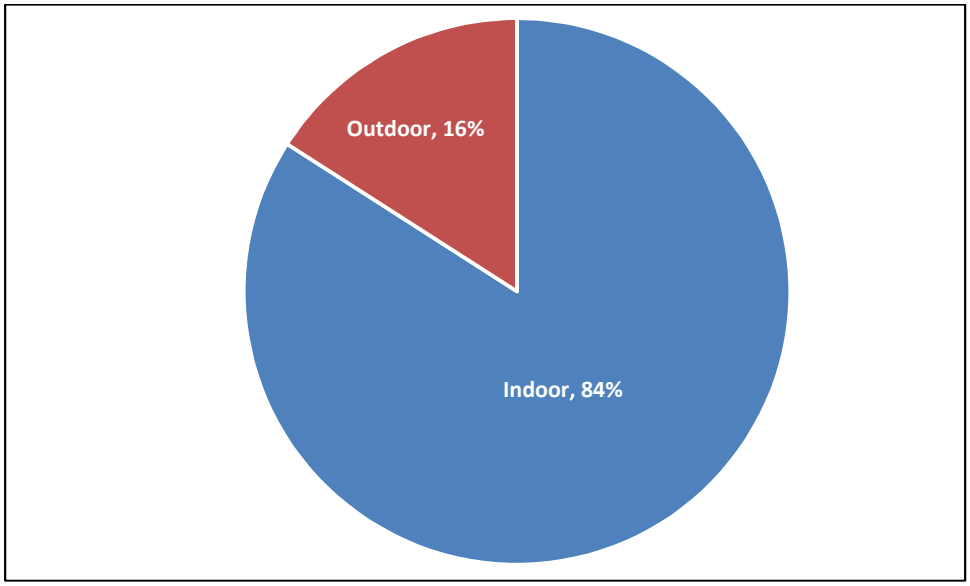
Figure B-8. Consumption by Customer Category – Columbia Power and Water Systems



Note: Figure is based on water use in years 2010-2015.

The following figure shows the breakdown of water use into indoor and outdoor components based on the assumption that indoor use is approximately equal to the minimum use in the winter. While there may be minimal landscape watering in the winter, or leakage from irrigation systems, it is assumed that this is minor at less than 5-10% of the average winter water use.

Figure B-9. Overall Use: Indoor vs. Outdoor – Columbia Power and Water Systems



Note: Figure is based on average water use in years 2010-2014.

B.2.3 Water Use Data Analysis and Key Inputs to the DSS Model

The following table shows the key inputs and assumptions used in the Water System's DSS Model.

Table B-5. Water Use Data Analysis and DSS Model Key Inputs and Assumptions – Columbia Power and Water Systems

Parameter	Model Input Values, Sources and Assumptions
Model Start Year	2015
Water Demand Factor Year(s) [Base Year(s)]	2010-2015
Non-Revenue Water in Start Year	14.4%
	This value is based on 2010-2014 and can be found in the green NRW section of each Water System's DSS Model.
Population Projection Source	CBER-UT
Employment Projection Source	BLS 2010-2015 average annual historical employment for Maury County
Base Year Water Use Profile	

Parameter	Model Input Values, Sources and Assumptions				
Customer Categories	**Start Year Accounts**	**Total Water Use Distribution**	**Demand Factors (gpd/acct)**	**Indoor Use %**	**Residential Indoor Water Use**
Residential	18,236	49%	175	87%	69
Commercial	2,175	19%	557	79%	N/A
Industrial	25	12%	29,894	64%	N/A
Bulk/Resale	45	20%	28,956	93%	N/A
Total	20,481	100%	N/A	84%	N/A

B.2.4 Water System Demand Projections

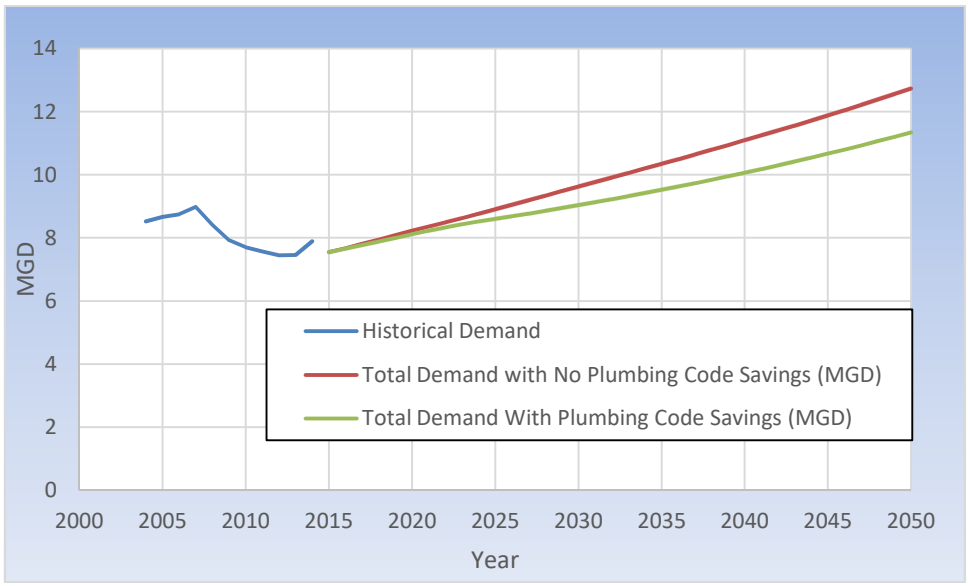
The following table and figure present the average day water demand projections for the Water System.

Table B-6. Demand Projections – Columbia Power and Water Systems

Demand Forecast	2015	2020	2025	2030	2035	2040	2045	2050
Total Demand Without Plumbing Code Savings (MGD)	7.54	8.22	8.91	9.63	10.35	11.10	11.88	12.74
Total Demand With Plumbing Code Savings (MGD)	7.54	8.12	8.60	9.04	9.52	10.07	10.67	11.35

Note: Total Demand accounts for the total projected water demand in a service area Water System regardless of source. Source can be from surface water or groundwater.

Figure B-10. Demand Projection – Columbia Power and Water Systems



B.3 Lewisburg Water and Wastewater

This section presents Lewisburg Water and Wastewater's historical and projected population and employment, historical production and consumption, DSS Model input values, sources and assumptions as well as projected demands with and without plumbing codes.

B.3.1 Demographic Data

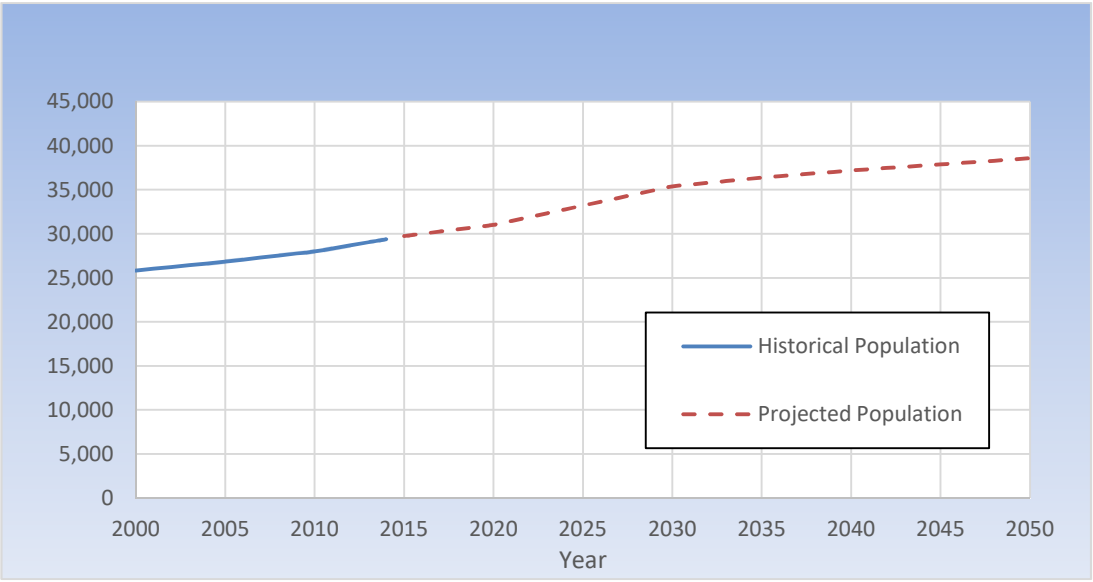
Population projections were obtained through year 2030 from the June 2009 joint publication of the *Population Projections for the State of Tennessee, 2010-2030* by the TAC on Intergovernmental Relations and the CBER-UT. Population projections from 2035 through 2050 were derived using CBER-UT's projections for Marshall County. Employment projections were based on Marshall County's employment rate from 2010-2015 of 3.15%. The actual number of jobs was not provided or determined for the Water System, rather the 2010-2015 average employment growth was applied to non-residential account growth through year 2050. The historical county employment was provided by the BLS of the U.S. Department of Labor (US Dept. of Labor, 2016).

The following table and figure present the historical and projected population for the water supplier.

Table B-7. Historical and Projected Population – Lewisburg Water and Wastewater

	2010	2015	2020	2025	2030	2035	2040	2045	2050
Population	27,999	29,735	31,009	33,196	35,376	36,368	37,181	37,872	38,563

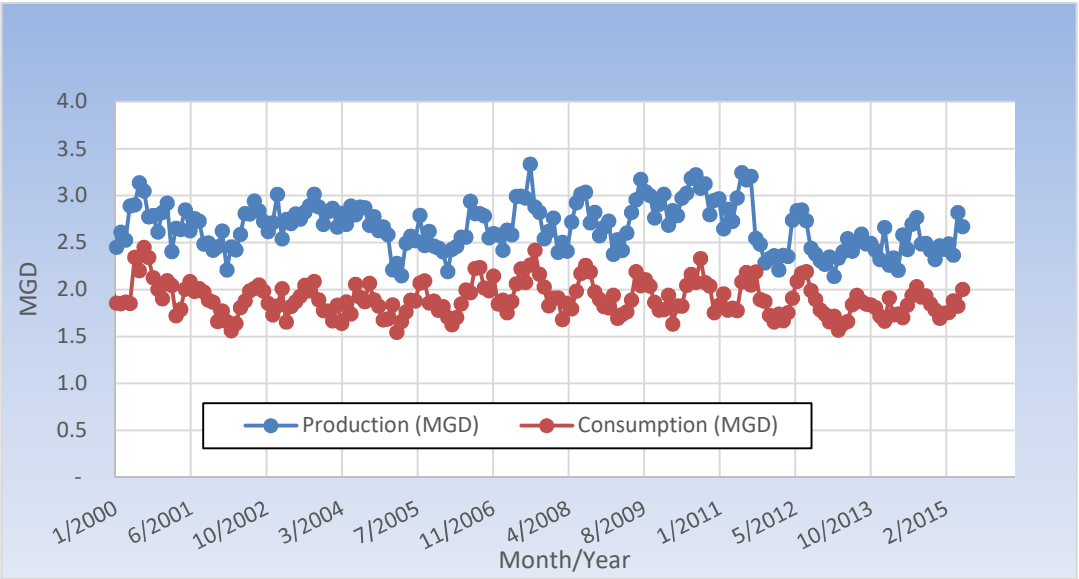
Figure B-11. Historical and Projected Population – Lewisburg Water and Wastewater



B.3.2 Production and Consumption

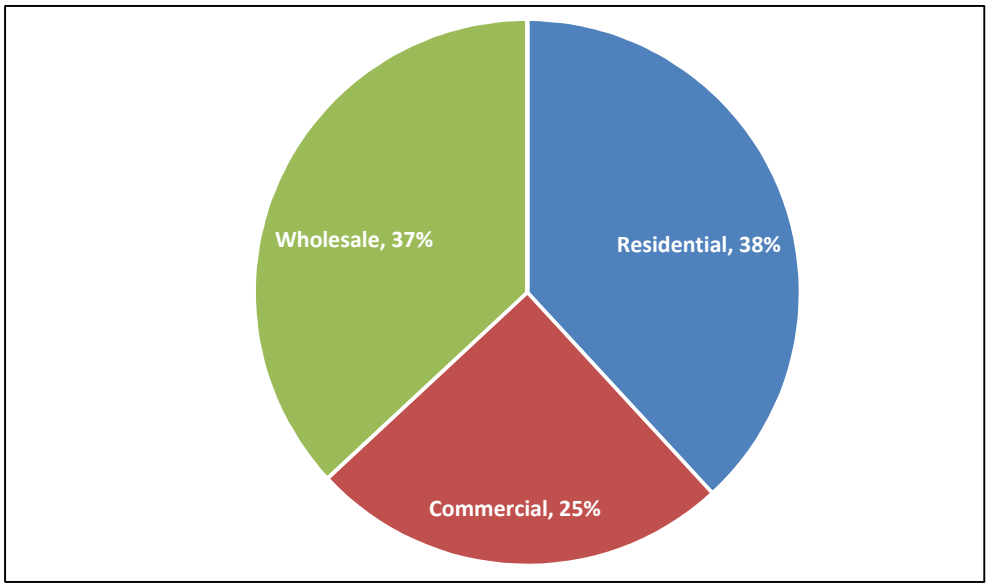
Total water production and consumption (billed water) data was compared over the period 2000-2015. Water production data was measured at its respective sources. Water consumption data was measured at the customer meters. The Water System's total production versus total consumption for the service area is presented in the following figure.

Figure B-12. Total Production vs. Total Consumption – Lewisburg Water and Wastewater



Each Duck River Water System has a variety of customer categories utilized in their billing system. This Water System has organized users into Residential, Commercial, and Wholesale categories. Residential is the largest category of water users, using 38% of the water consumed. The following figure illustrates the water usage breakdowns within the Water System's service area based on historical water use in years 2010-2015.

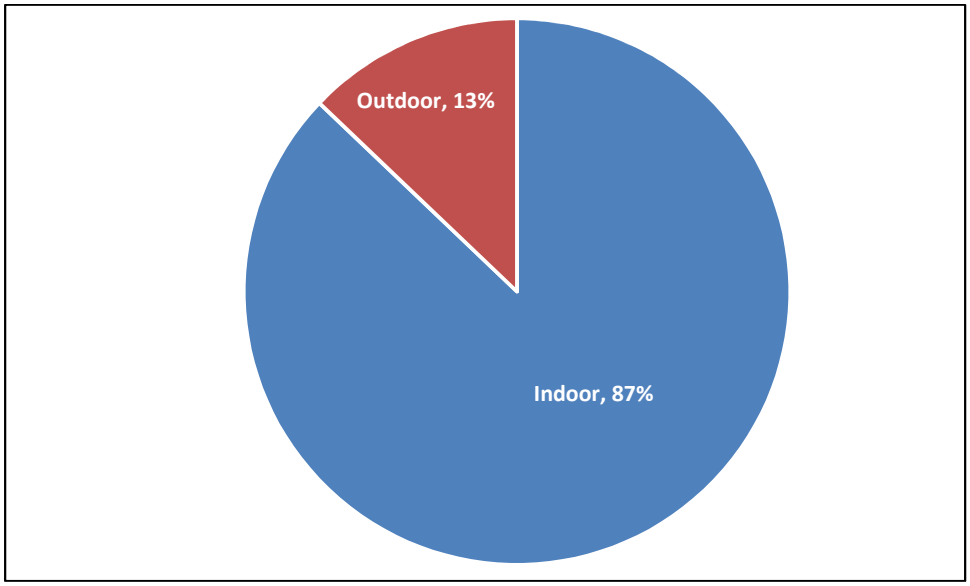
Figure B-13. Consumption by Customer Category – Lewisburg Water and Wastewater



Note: Figure is based on water use in years 2010-2015.

The following figure shows the breakdown of water use into indoor and outdoor components based on the assumption that indoor use is approximately equal to the minimum use in the winter. While there may be minimal landscape watering in the winter, or leakage from irrigation systems, it is assumed that this is minor at less than 5-10% of the average winter water use.

Figure B-14. Overall Use: Indoor vs. Outdoor – Lewisburg Water and Wastewater



Note: Figure is based on average water use in years 2010-2014.

B.3.3 Water Use Data Analysis and Key Inputs to the DSS Model

The following table shows the key inputs and assumptions used in the Water System's DSS Model.

Table B-8. Water Use Data Analysis and DSS Model Key Inputs and Assumptions – Lewisburg Water and Wastewater

Parameter	Model Input Values, Sources and Assumptions				
Model Start Year	2015				
Water Demand Factor Year(s) [Base Year(s)]	2010-2015				
Non-Revenue Water in Start Year	28.7%				
	This value is based on 2010-2014 and can be found in the green NRW section of each Water System's DSS Model.				
Population Projection Source	CBER-UT				
Employment Projection Source	BLS 2010-2015 average annual historical employment for Marshall County				
Base Year Water Use Profile					
Customer Categories	**Start Year Accounts**	**Total Water Use Distribution**	**Demand Factors (gpd/acct)**	**Indoor Use %**	**Residential Indoor Water Use**
Residential	5,616	38%	119	89%	51
Commercial	672	25%	652	86%	N/A

Parameter	Model Input Values, Sources and Assumptions				
Wholesale	11	37%	58,974	86%	N/A
Total	6,299	100%	N/A	87%	N/A

B.3.4 Water System Demand Projections

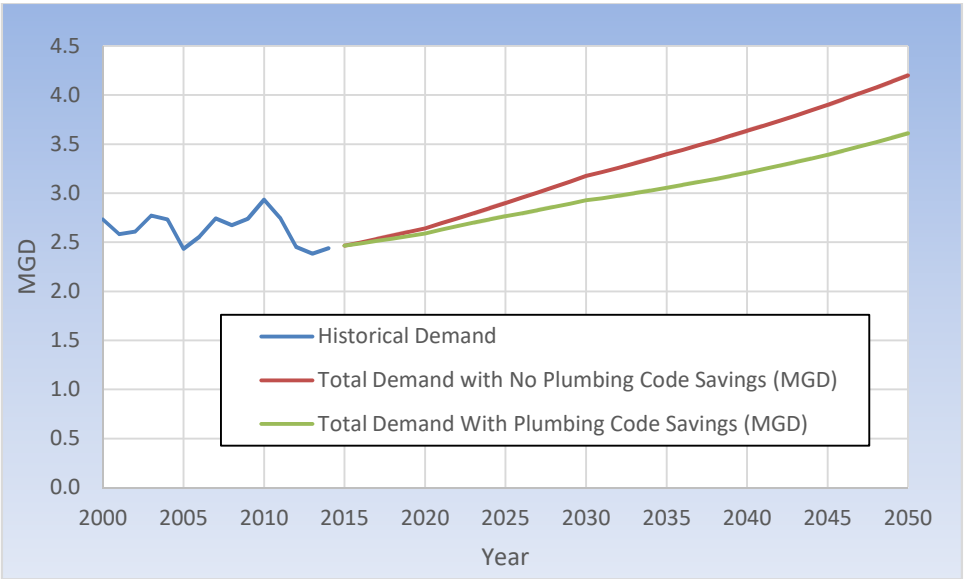
The following table and figure present the average day water demand projections for the Water System.

Table B-9. Demand Projections – Lewisburg Water and Wastewater

Demand Forecast	2015	2020	2025	2030	2035	2040	2045	2050
Total Demand Without Plumbing Code Savings (MGD)	2.47	2.64	2.90	3.17	3.40	3.64	3.90	4.20
Total Demand With Plumbing Code Savings (MGD)	2.47	2.59	2.76	2.93	3.06	3.21	3.39	3.61

Note: Total Demand accounts for the total projected water demand in a service area Water System regardless of source. Source can be from surface water or groundwater.

Figure B-15. Demand Projection – Lewisburg Water and Wastewater



B.4 Manchester Water and Sewer Department

This section presents Manchester Water and Sewer Department's historical and projected population and employment, historical production and consumption, DSS Model input values, sources and assumptions as well as projected demands with and without plumbing codes.

B.4.1 Demographic Data

Population projections were obtained through year 2030 from the June 2009 joint publication of the *Population Projections for the State of Tennessee, 2010-2030* by the TAC on Intergovernmental Relations and the CBER-UT.

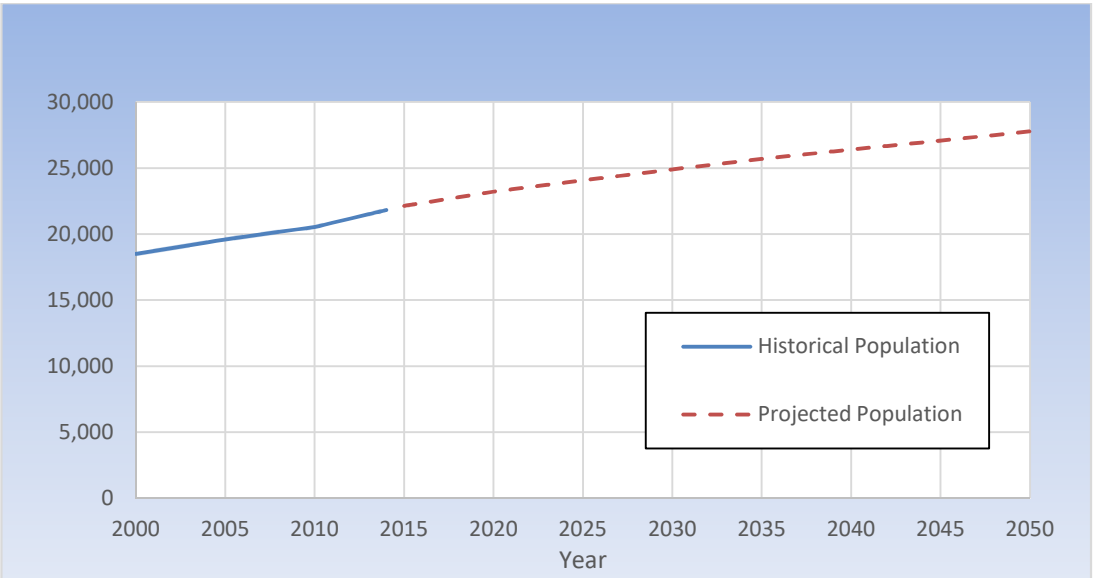
Population projections from 2035 through 2050 were derived using CBER-UT's projections for Coffee County. Employment projections were based on Coffee County's employment rate from 2010-2015 of 2.83%. The actual number of jobs was not provided or determined for the Water System, rather the 2010-2015 average employment growth was applied to non-residential account growth through year 2050. The historical county employment was provided by the BLS of the U.S. Department of Labor (US Dept. of Labor, 2016).

The following table and figure present the historical and projected population for the water supplier.

Table B-10. Historical and Projected Population – Manchester Water and Sewer Department

	2010	2015	2020	2025	2030	2035	2040	2045	2050
Population	20,536	22,139	23,217	24,069	24,901	25,695	26,406	27,079	27,779

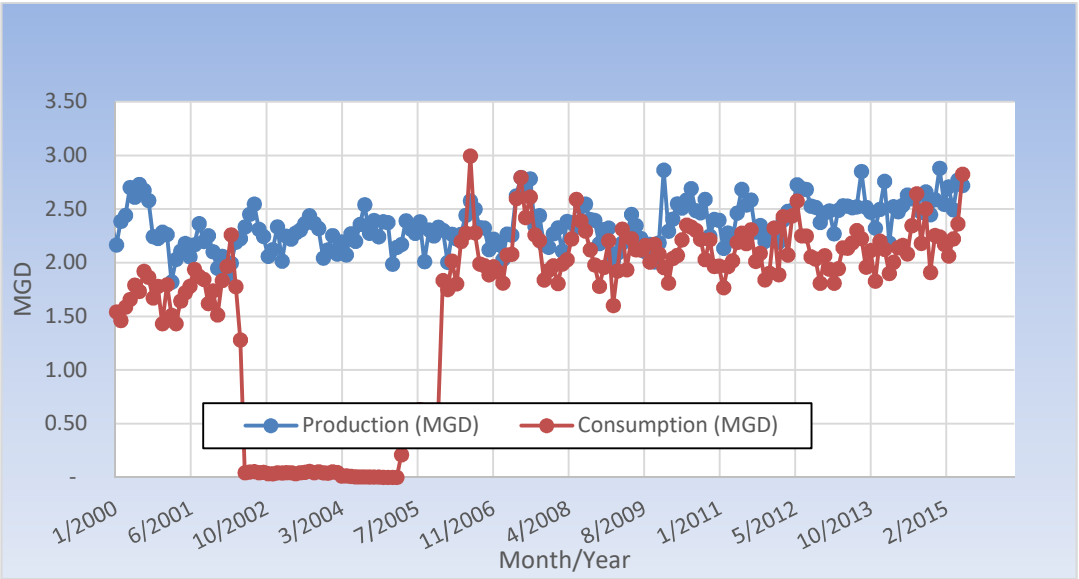
Figure B-16. Historical and Projected Population – Manchester Water and Sewer Department



B.4.2 Production and Consumption

Total water production and consumption (billed water) data was compared over the period 2000-2015. Please note 2002-2005 consumption data is NOT accurately presented. Water production data was measured at its respective sources. Water consumption data was measured at the customer meters. The Water System's total production versus total consumption for the service area is presented in the following figure.

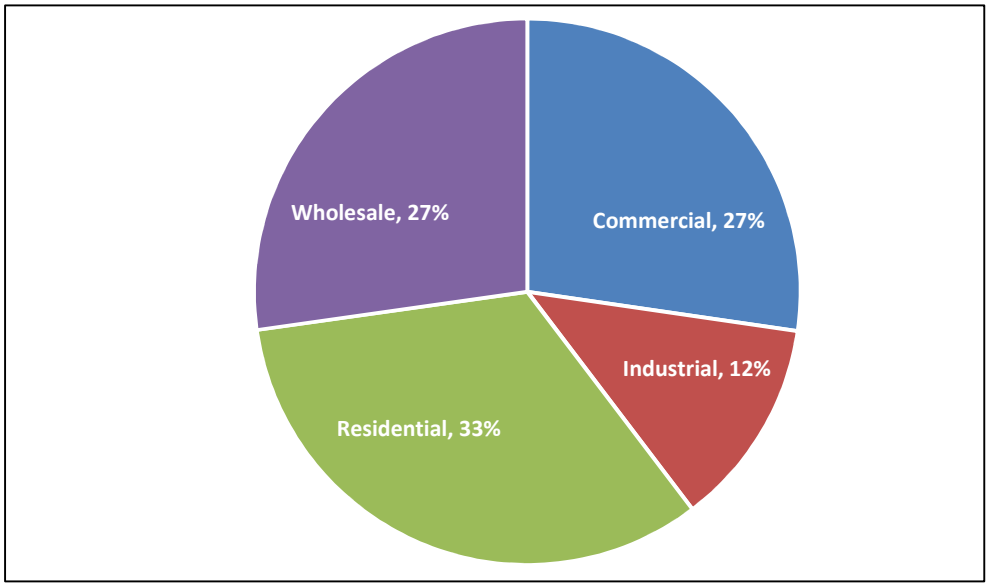
Figure B-17. Total Production vs. Total Consumption – Manchester Water and Sewer Department



Note: 2002-2005 consumption data is NOT accurately presented.

Each Duck River Water System has a variety of customer categories utilized in their billing system. This Water System has organized users into Residential, Commercial, Industrial, and Wholesale categories. Residential is the largest category of water users, using 33% of the water consumed. The following figure illustrates the water usage breakdowns within the Water System's service area based on historical water use in years 2010-2015.

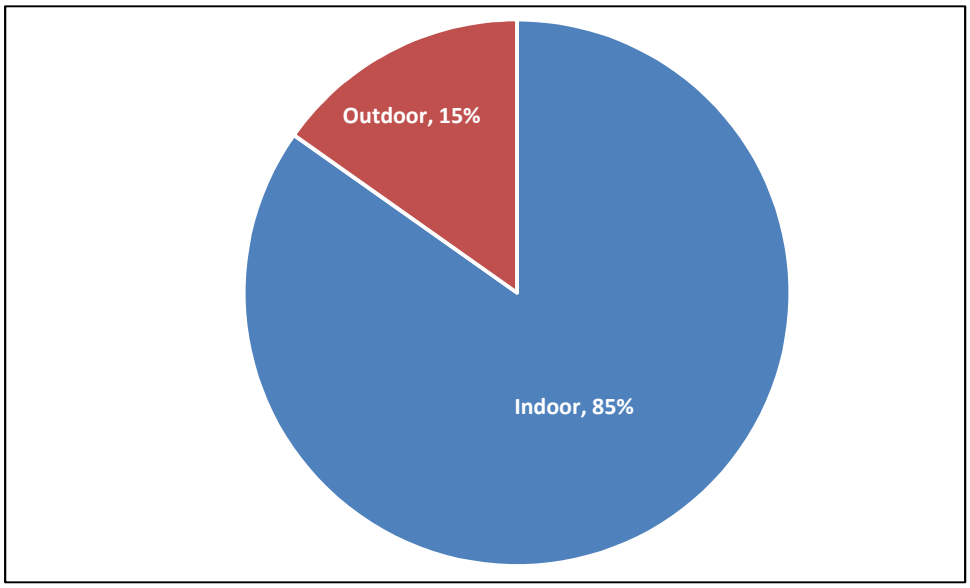
Figure B-18. Consumption by Customer Category – Manchester Water and Sewer Department



Note: Figure is based on water use in years 2010-2015.

The following figure shows the breakdown of water use into indoor and outdoor components based on the assumption that indoor use is approximately equal to the minimum use in the winter. While there may be minimal landscape watering in the winter, or leakage from irrigation systems, it is assumed that this is minor at less than 5-10% of the average winter water use.

Figure B-19. Overall Use: Indoor vs. Outdoor – Manchester Water and Sewer Department



Note: Figure is based on average water use in years 2010-2014.

B.4.3 Water Use Data Analysis and Key Inputs to the DSS Model

The following table shows the key inputs and assumptions used in the Water System's DSS Model.

Table B-11. Water Use Data Analysis and DSS Model Key Inputs and Assumptions – Manchester Water and Sewer Department

Parameter	Model Input Values, Sources and Assumptions				
Model Start Year	2015				
Water Demand Factor Year(s) [Base Year(s)]	2010-2015				
Non-Revenue Water in Start Year	14.5%				
	This value is based on 2010-2014 and can be found in the green NRW section of each Water System's DSS Model.				
Population Projection Source	CBER-UT				
Employment Projection Source	BLS 2010-2015 average annual historical employment for Coffee County				
Base Year Water Use Profile					
Customer Categories	**Start Year Accounts**	**Total Water Use Distribution**	**Demand Factors (gpd/acct)**	**Indoor Use %**	**Residential Indoor Water Use**
Commercial	751	27%	766	81%	N/A
Industrial	47	12%	5,554	79%	N/A
Residential	5,704	33%	122	86%	44
Wholesale	8	27%	71,653	90%	N/A

Parameter	Model Input Values, Sources and Assumptions				
Total	6,509	100%	N/A	85%	N/A

B.4.4 Water System Demand Projections

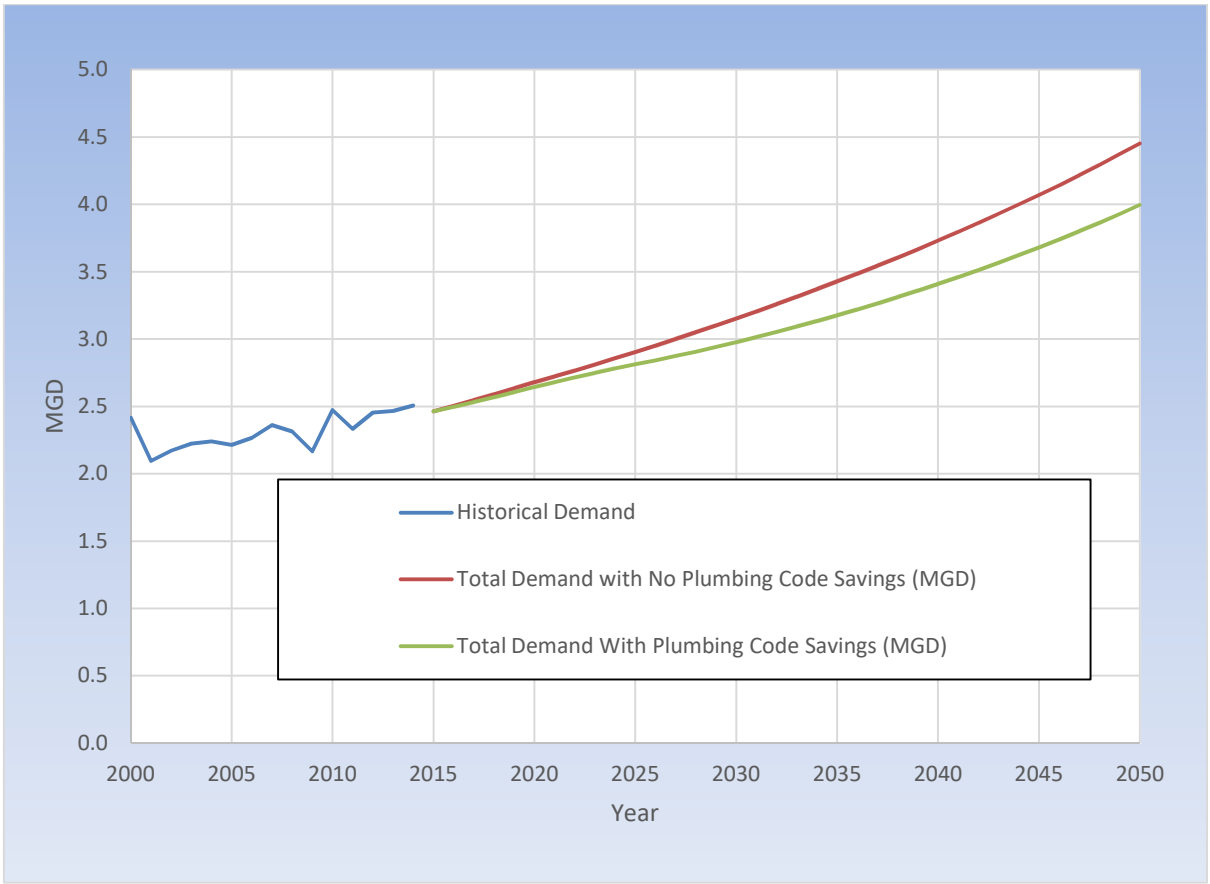
The following table and figure present the average day water demand projections for the Water System.

Table B-12. Demand Projections – Manchester Water and Sewer Department

Demand Forecast	2015	2020	2025	2030	2035	2040	2045	2050
Total Demand Without Plumbing Code Savings (MGD)	2.46	2.68	2.90	3.15	3.43	3.73	4.07	4.45
Total Demand With Plumbing Code Savings (MGD)	2.46	2.64	2.81	2.98	3.18	3.41	3.68	3.99

Note: Total Demand accounts for the total projected water demand in a service area Water System regardless of source. Source can be from surface water or groundwater.

Figure B-20. Demand Projection – Manchester Water and Sewer Department



B.5 Shelbyville Power, Water, and Sewerage System

This section presents Shelbyville Power, Water, and Sewerage System's historical and projected population and employment, historical production and consumption, DSS Model input values, sources and assumptions as well as projected demands with and without plumbing codes.

B.5.1 Demographic Data

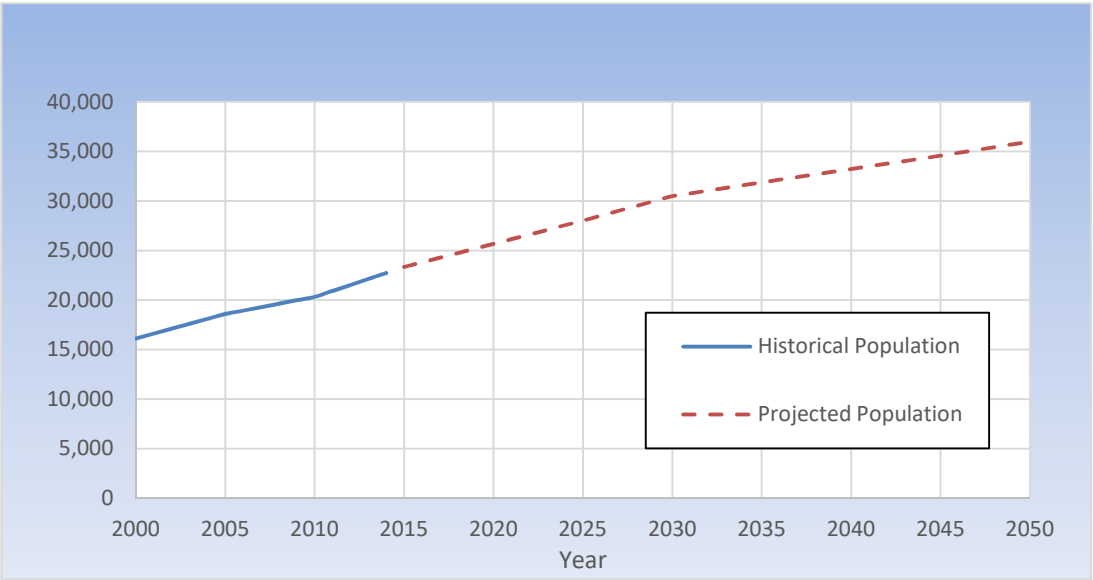
Population projections were obtained through year 2030 from the June 2009 joint publication of the *Population Projections for the State of Tennessee, 2010-2030* by the TAC on Intergovernmental Relations and the CBER-UT. Population projections from 2035 through 2050 were derived using CBER-UT's projections for Bedford County. Employment projections were based on Bedford County's employment rate from 2010-2015 of 1.48%. The actual number of jobs was not provided or determined for the Water System, rather the 2010-2015 average employment growth was applied to non-residential account growth through year 2050. The historical county employment was provided by the BLS of the U.S. Department of Labor (US Dept. of Labor, 2016).

The following table and figure present the historical and projected population for the water supplier.

Table B-13. Historical and Projected Population – Shelbyville Power, Water, and Sewerage System

	2010	2015	2020	2025	2030	2035	2040	2045	2050
Population	20,322	23,330	25,661	28,009	30,481	31,867	33,213	34,563	35,993

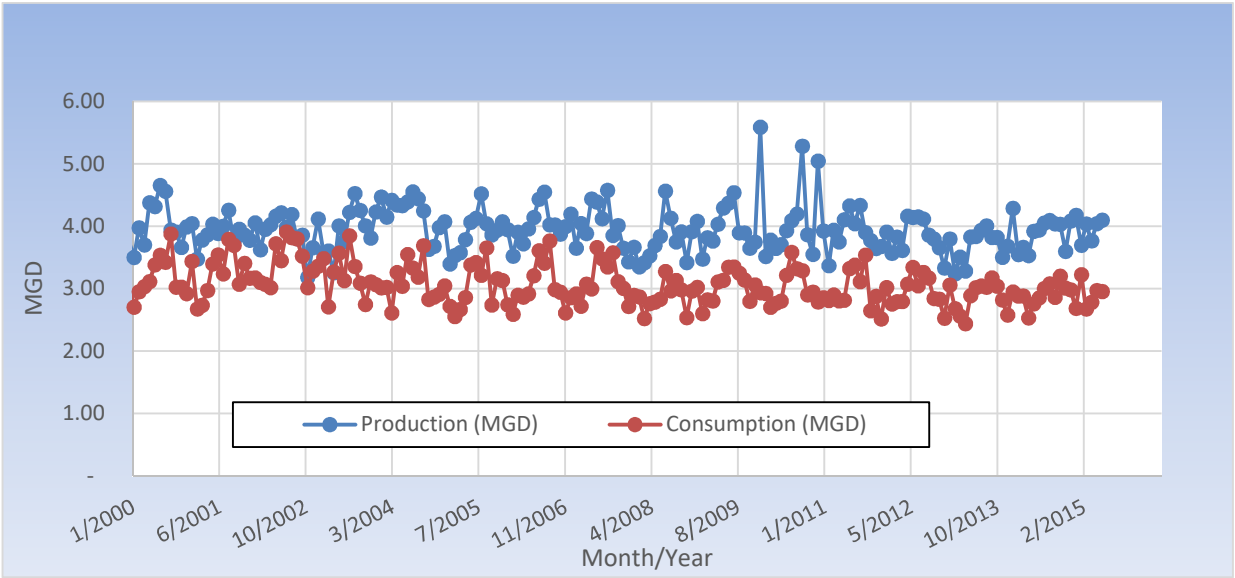
Figure B-21. Historical and Projected Population – Shelbyville Power, Water, and Sewerage System



B.5.2 Production and Consumption

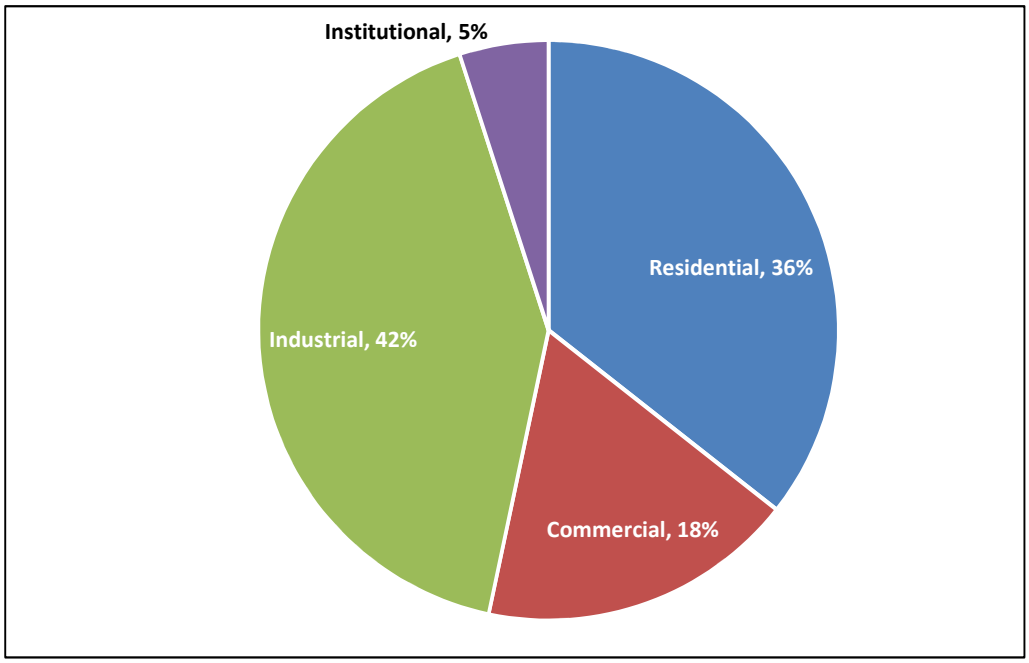
Total water production and consumption (billed water) data was compared over the period 2000-2015. Water production data was measured at its respective sources. Water consumption data was measured at the customer meters. The Water System's total production versus total consumption for the service area is presented in the following figure.

Figure B-22. Total Production vs. Total Consumption – Shelbyville Power, Water, and Sewerage System



Each Duck River Water System has a variety of customer categories utilized in their billing system. This Water System has organized users into Residential, Commercial, Industrial, and Institutional categories. Industrial is the largest category of water users, using 42% of the water consumed. The following figure illustrates the water usage breakdowns within the Water System's service area based on historical water use in years 2010-2015.

Figure B-23. Consumption by Customer Category – Shelbyville Power, Water, and Sewerage System

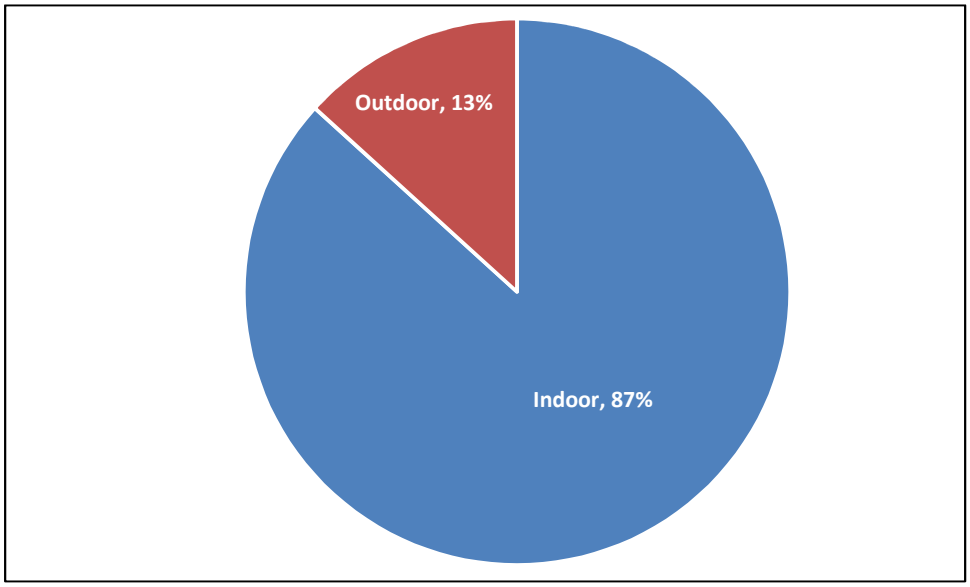


Note: Figure is based on water use in years 2010-2015.

The following figure shows the breakdown of water use into indoor and outdoor components based on the assumption that indoor use is approximately equal to the minimum use in the winter. While there may be minimal landscape watering in the winter, or leakage from irrigation systems, it is assumed that this is minor at less than 5-10% of the

average winter water use. Residential indoor water use is assumed to be 95% of total water use due to minimal irrigation.

Figure B-24. Overall Use: Indoor vs. Outdoor – Shelbyville Power, Water, and Sewerage System



Note: Figure is based on average water use in years 2010-2014.

B.5.3 Water Use Data Analysis and Key Inputs to the DSS Model

The following table shows the key inputs and assumptions used in the Water System's DSS Model. NRW is high due to the large number of dead-end lines and the size of distribution lines required for fire protection in the Water System which requires frequent flushing. Flushing is needed to meet state limits for halocitic and trihalomethane levels in the distribution system.

Table B-14. Water Use Data Analysis and DSS Model Key Inputs and Assumptions – Shelbyville Power, Water, and Sewerage System

Parameter	Model Input Values, Sources and Assumptions
Model Start Year	2015
Water Demand Factor Year(s) [Base Year(s)]	2010-2015
Non-Revenue Water in Start Year	24.6%
	This value is based on 2010-2014 and can be found in the green NRW section of each Water System's DSS Model.
Population Projection Source	CBER-UT
Employment Projection Source	BLS 2010-2015 average annual historical employment for Bedford County

Parameter	Model Input Values, Sources and Assumptions				
Base Year Water Use Profile					
Customer Categories	**Start Year Accounts**	**Total Water Use Distribution**	**Demand Factors (gpd/acct)**	**Indoor Use %**	**Residential Indoor Water Use**
Residential	7,786	36%	133	95%	42
Commercial	1,077	18%	476	78%	N/A
Industrial	38	42%	31,824	83%	N/A
Institutional	1	5%	143,819	87%	N/A
Total	8,902	100%	N/A	87%	N/A

B.5.4 Water System Demand Projections

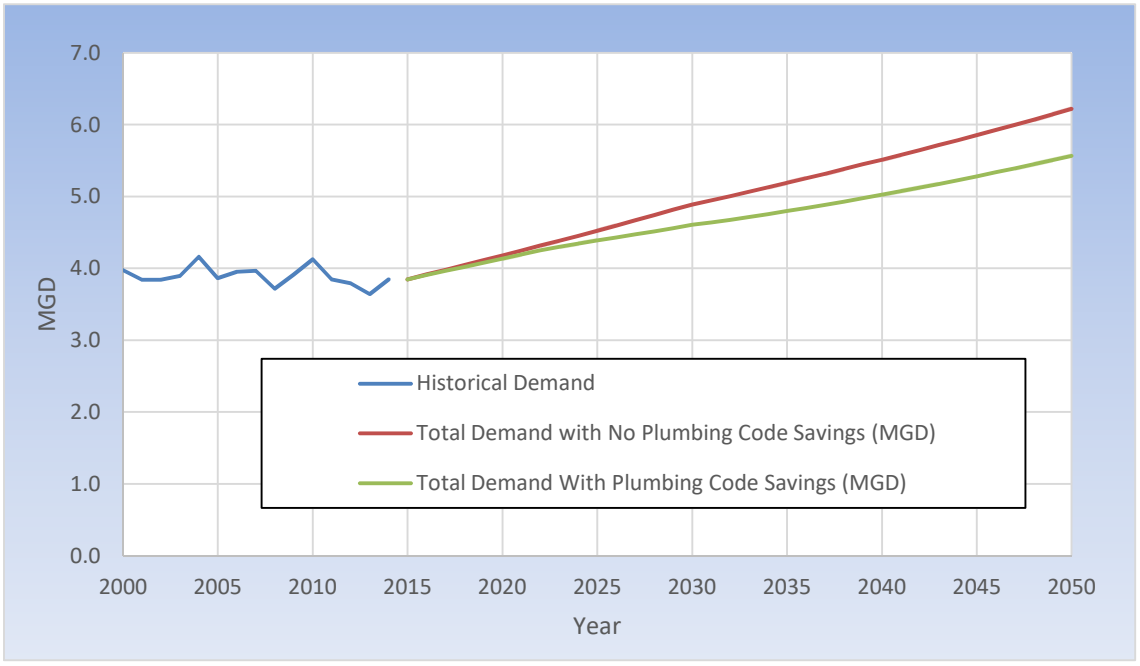
The following table and figure present the average day water demand projections for the Water System.

Table B-15. Demand Projections – Shelbyville Power, Water, and Sewerage System

Demand Forecast	2015	2020	2025	2030	2035	2040	2045	2050
Total Demand Without Plumbing Code Savings (MGD)	3.85	4.18	4.52	4.89	5.19	5.51	5.85	6.22
Total Demand With Plumbing Code Savings (MGD)	3.85	4.13	4.39	4.60	4.80	5.02	5.28	5.57

Note: Total Demand accounts for the total projected water demand in a service area Water System regardless of source. Source can be from surface water or groundwater.

Figure B-25. Demand Projection – Shelbyville Power, Water, and Sewerage System



B.6 Spring Hill Water System

This section presents Spring Hill Water System's historical and projected population and employment, historical production and consumption, DSS Model input values, sources and assumptions as well as projected demands with and without plumbing codes.

B.6.1 Demographic Data

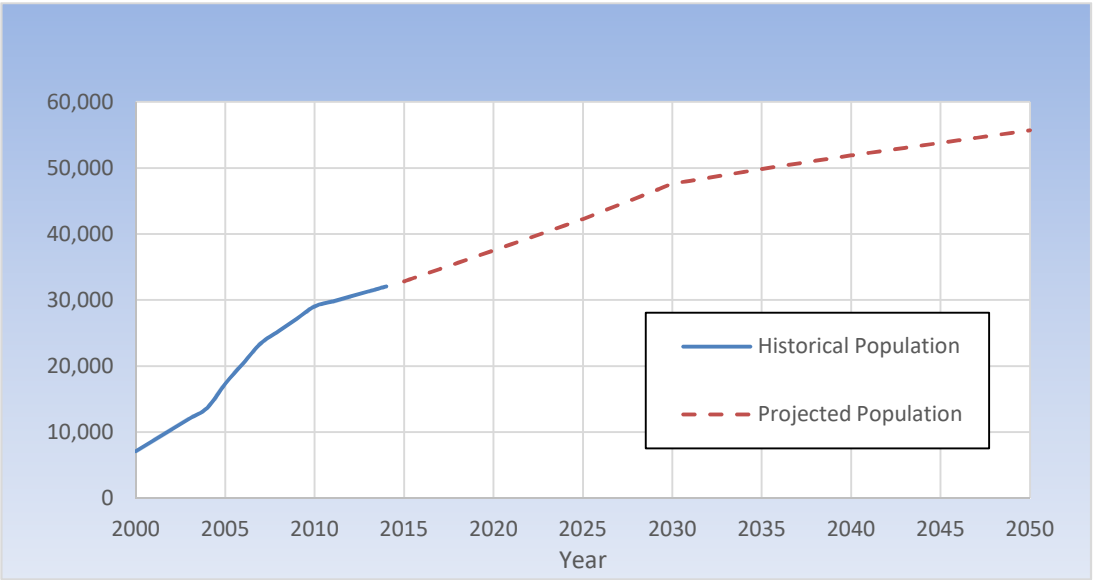
Population projections were obtained through year 2030 from the June 2009 joint publication of the *Population Projections for the State of Tennessee, 2010-2030* by the TAC on Intergovernmental Relations and the CBER-UT. Population projections from 2035 through 2050 were derived using CBER-UT's projections for Maury County. Employment projections were based on Maury County's employment rate from 2010-2015 of 2.43%. The actual number of jobs was not provided or determined for the Water System, rather the 2010-2015 average employment growth was applied to non-residential account growth through year 2050. The historical county employment was provided by the BLS of the U.S. Department of Labor (US Dept. of Labor, 2016).

The following table and figure present the historical and projected population for the water supplier.

Table B-16. Historical and Projected Population – Spring Hill Water System

	2010	2015	2020	2025	2030	2035	2040	2045	2050
Population	29,036	32,807	37,479	42,247	47,565	49,824	51,876	53,778	55,674

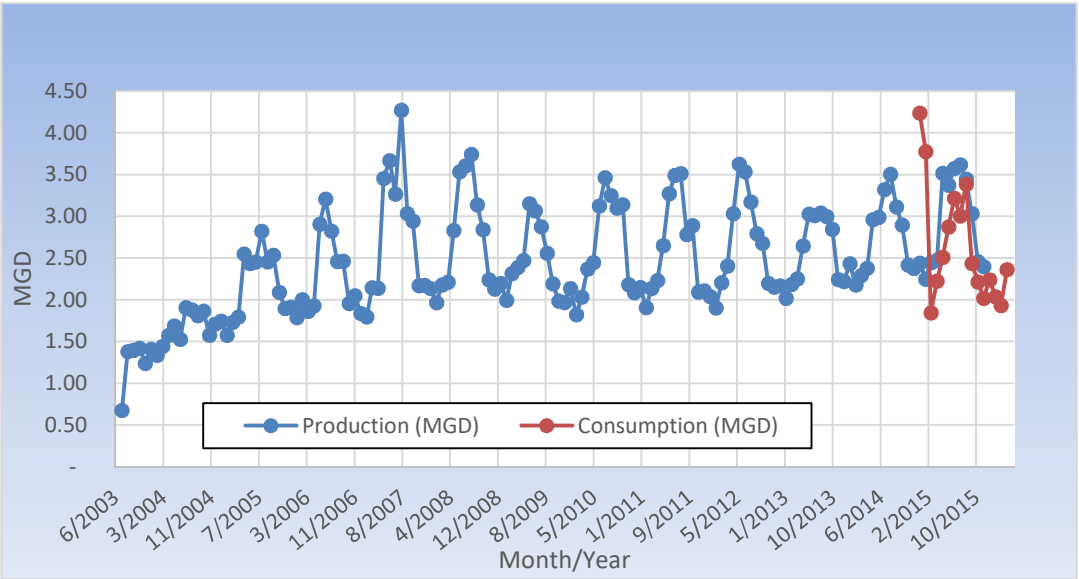
Figure B-26. Historical and Projected Population – Spring Hill Water System



B.6.2 Production and Consumption

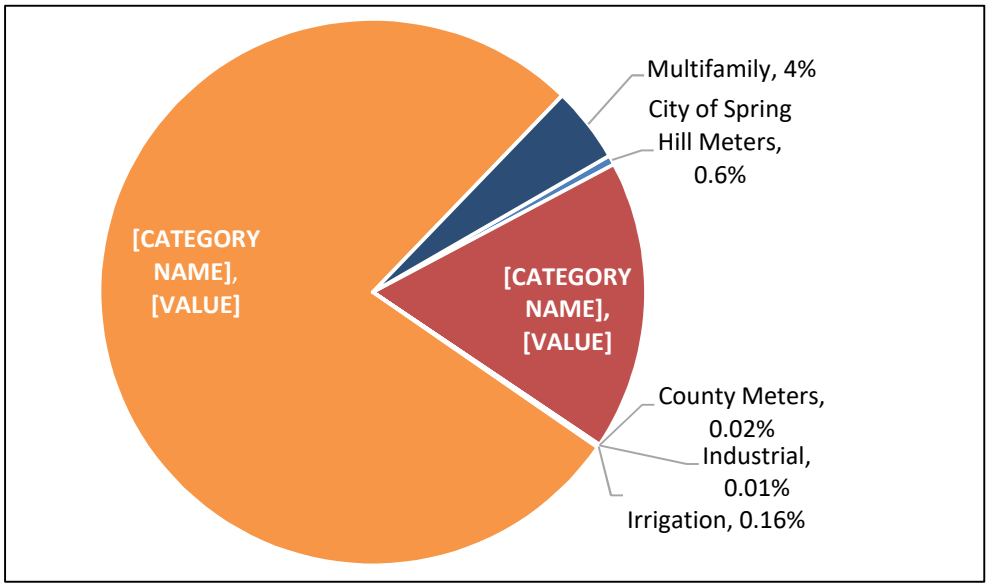
Total water production and consumption (billed water) data was compared over the period 2003-2015. Water production data was measured at its respective sources. Water consumption data was measured at the customer meters. The Water System's total production versus total consumption for the service area is presented in the following figure. Only year 2015 consumption data was available and provided by Spring Hill for the analysis.

Figure B-27. Total Production vs. Total Consumption – Spring Hill Water System



Each Duck River Water System has a variety of customer categories utilized in their billing system. This Water System has organized users into City of Spring Hill Meters, Commercial, County Meters, Industrial, Irrigation, Residential, and Multifamily categories. Residential is the largest category of water users, using 78% of the water consumed. The following figure illustrates the water usage breakdowns within the Water System's service area based on historical water use in year 2015.

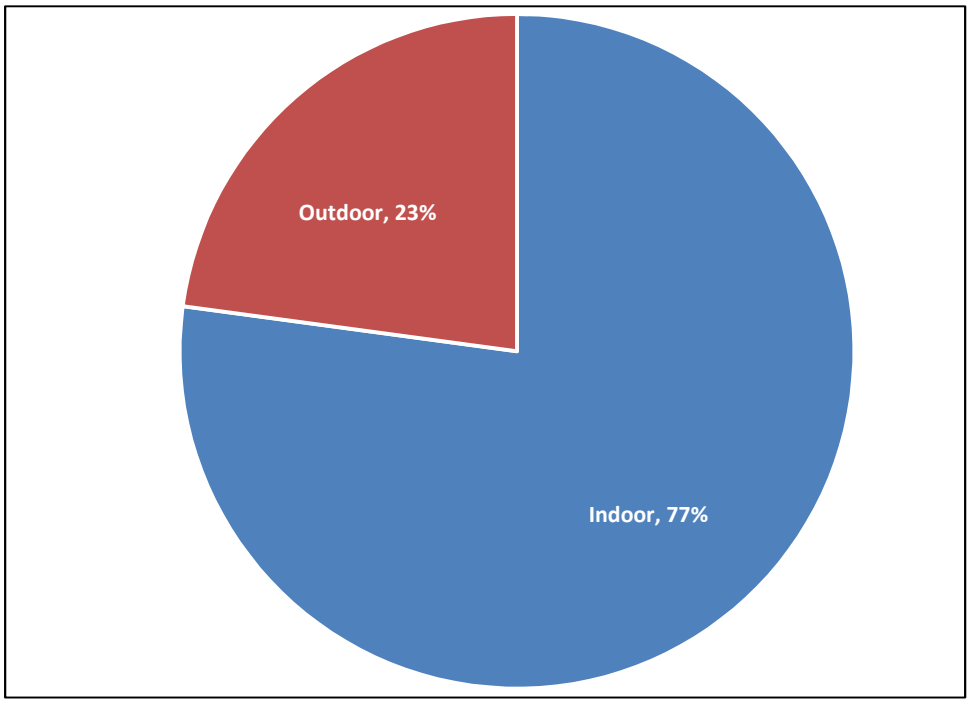
Figure B-28. Consumption by Customer Category – Spring Hill Water System



Note: Figure is based on water use in year 2015.

The following figure shows the breakdown of water use into indoor and outdoor components based on the assumption that indoor use is approximately equal to the minimum use in the winter. While there may be minimal landscape watering in the winter, or leakage from irrigation systems, it is assumed that this is minor at less than 5-10% of the average winter water use.

Figure B-29. Overall Use: Indoor vs. Outdoor – Spring Hill Water System



Note: Figure is based on average water use in year 2015.

B.6.3 Water Use Data Analysis and Key Inputs to the DSS Model

The following table shows the key inputs and assumptions used in the Water System's DSS Model.

Table B-17. Water Use Data Analysis and DSS Model Key Inputs and Assumptions – Spring Hill Water System

Parameter	Model Input Values, Sources and Assumptions				
Model Start Year	2015				
Water Demand Factor Year(s) [Base Year(s)]	2015				
Non-Revenue Water in Start Year	7.0%				
	Since minimal consumption data was available to compare to production data, a conservative value of 7% NRW (which is typical of a new water system) was used. This value can be found in the green NRW section of each Water System's DSS Model.				
Population Projection Source	CBER-UT				
Employment Projection Source	BLS 2010-2015 average annual historical employment for Maury County				
Base Year Water Use Profile					
Customer Categories	**Start Year Accounts**	**Total Water Use Distribution**	**Demand Factors (gpd/acct)**	**Indoor Use %**	**Residential Indoor Water Use**

Parameter	Model Input Values, Sources and Assumptions				
City of Spring Hill Meters	39	1%	370	46%	N/A
Commercial	663	17%	640	65%	N/A
County Meters	3	0%	189	55%	N/A
Industrial	1	0%	198	90%	N/A
Irrigation	2	0%	2,402	0%	N/A
Residential	12,370	78%	155	80%	50
Multifamily	5	4%	21,998	80%	38
Total	**13,082**	**100%**	**N/A**	**77%**	**N/A**

B.6.4 Water System Demand Projections

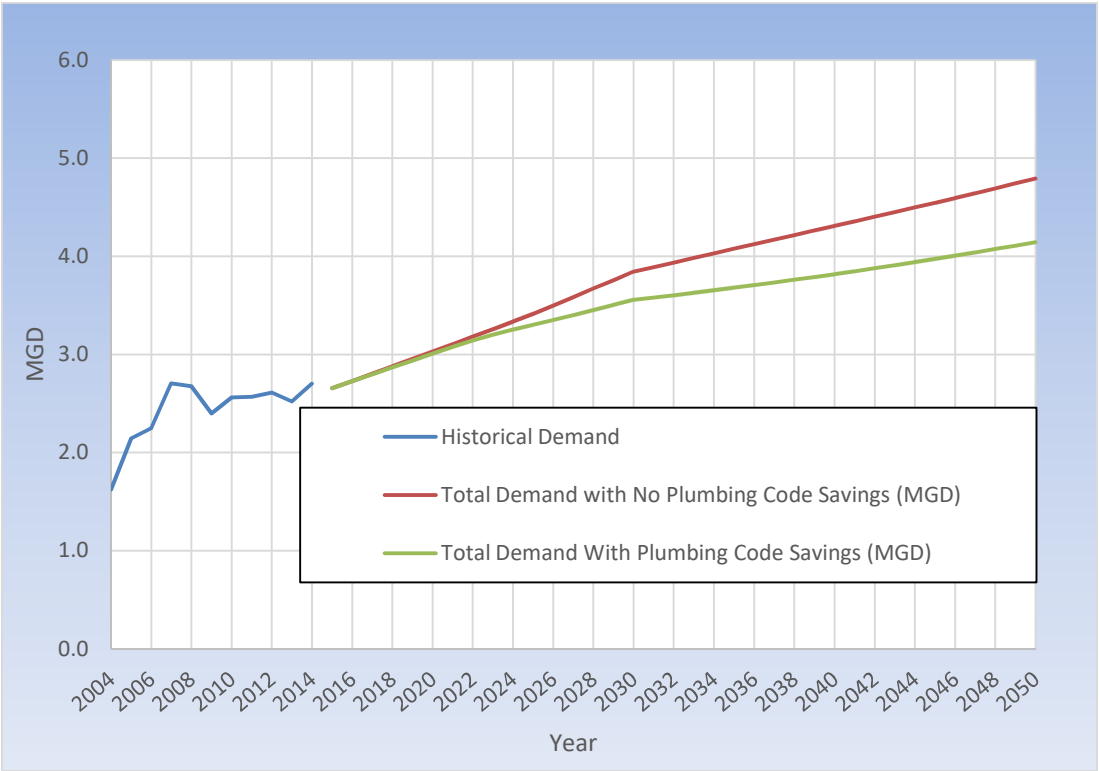
The following table and figure present the average day water demand projections for the Water System.

Table B-18. Demand Projections – Spring Hill Water System

Demand Forecast	2015	2020	2025	2030	2035	2040	2045	2050
Total Demand Without Plumbing Code Savings (MGD)	2.66	3.03	3.41	3.84	4.08	4.31	4.55	4.79
Total Demand With Plumbing Code Savings (MGD)	2.66	3.01	3.30	3.56	3.68	3.82	3.97	4.14

Note: Total Demand accounts for the total projected water demand in a service area Water System regardless of source. Source can be from surface water or groundwater.

Figure B-30. Demand Projection – Spring Hill Water System



B.7 Tullahoma Utilities Board

This section presents Tullahoma Utilities Board's historical and projected population and employment, historical production and consumption, DSS Model input values, sources and assumptions as well as projected demands with and without plumbing codes.

B.7.1 Demographic Data

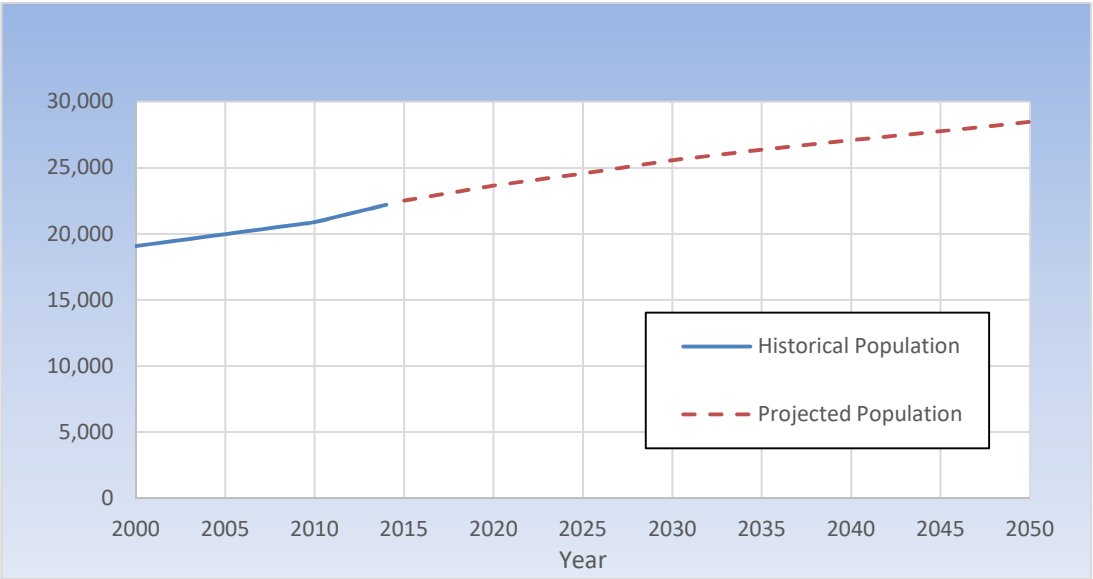
Population projections were obtained through year 2030 from the June 2009 joint publication of the *Population Projections for the State of Tennessee, 2010-2030* by the TAC on Intergovernmental Relations and the CBER-UT. Population projections from 2035 through 2050 were derived using CBER-UT's projections for Coffee County. Employment projections were based on Coffee County's employment rate from 2010-2015 of 2.83%. The actual number of jobs was not provided or determined for the Water System, rather the 2010-2015 average employment growth was applied to non-residential account growth through year 2050. The historical county employment was provided by the BLS of the U.S. Department of Labor (US Dept. of Labor, 2016).

The following table and figure present the historical and projected population for the water supplier.

Table B-19. Historical and Projected Population – Tullahoma Utilities Board

	2010	2015	2020	2025	2030	2035	2040	2045	2050
Population	20,888	22,518	23,655	24,576	25,581	26,385	27,103	27,781	28,486

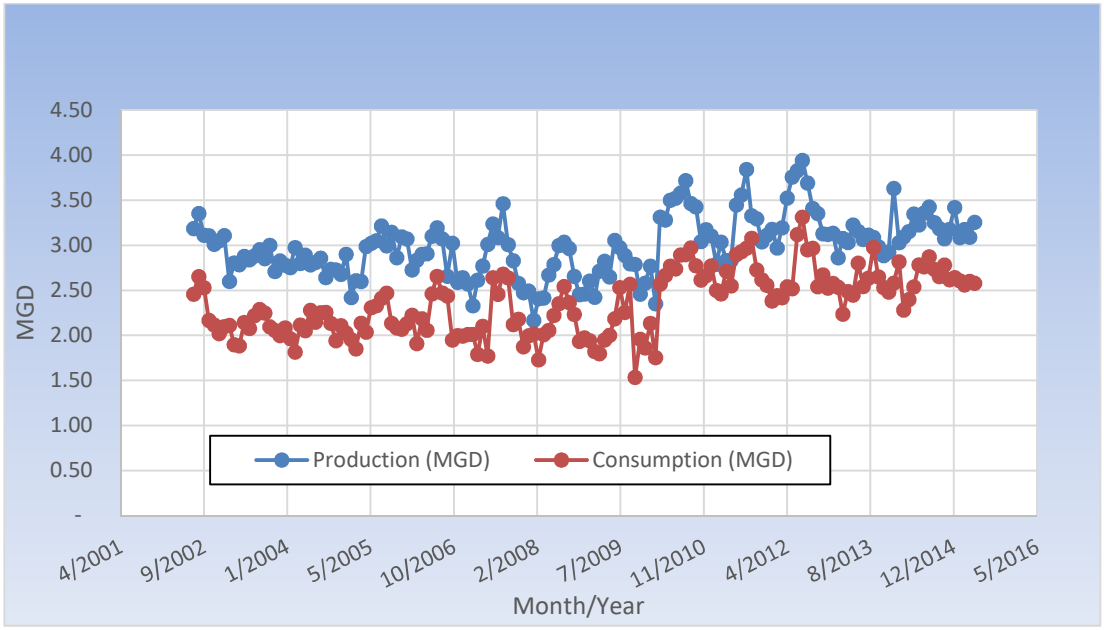
Figure B-31. Historical and Projected Population – Tullahoma Utilities Board



B.7.2 Production and Consumption

Total water production and consumption (billed water) data was compared over the period 2002-2015. Water production data was measured at its respective sources. Water consumption data was measured at the customer meters. The Water System's total production versus total consumption for the service area is presented in the following figure.

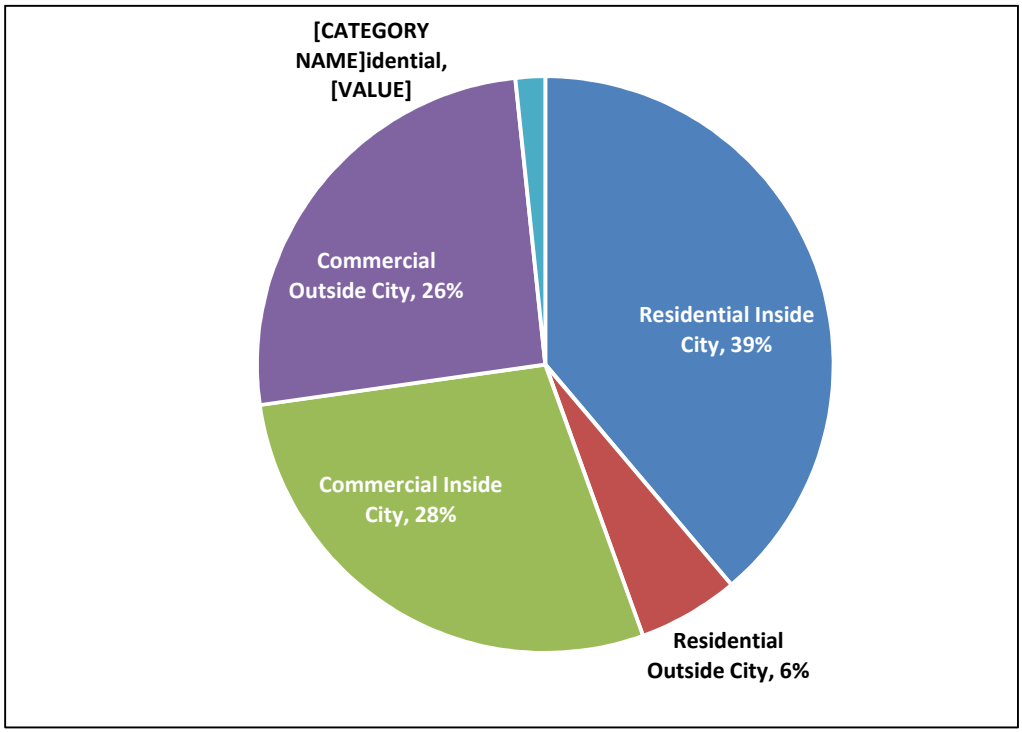
Figure B-32. Total Production vs. Total Consumption – Tullahoma Utilities Board



Each Duck River Water System has a variety of customer categories utilized in their billing system. This Water System has organized users into Residential Inside City, Residential Outside City, Commercial Inside City, Commercial Outside City, and County Line Co-Op Residential categories. Residential Inside City customer category water use is the largest

category of water users, using 39% of the water consumed. The following figure illustrates the water usage breakdowns within the Water System's service area based on historical water use in years 2010-2015.

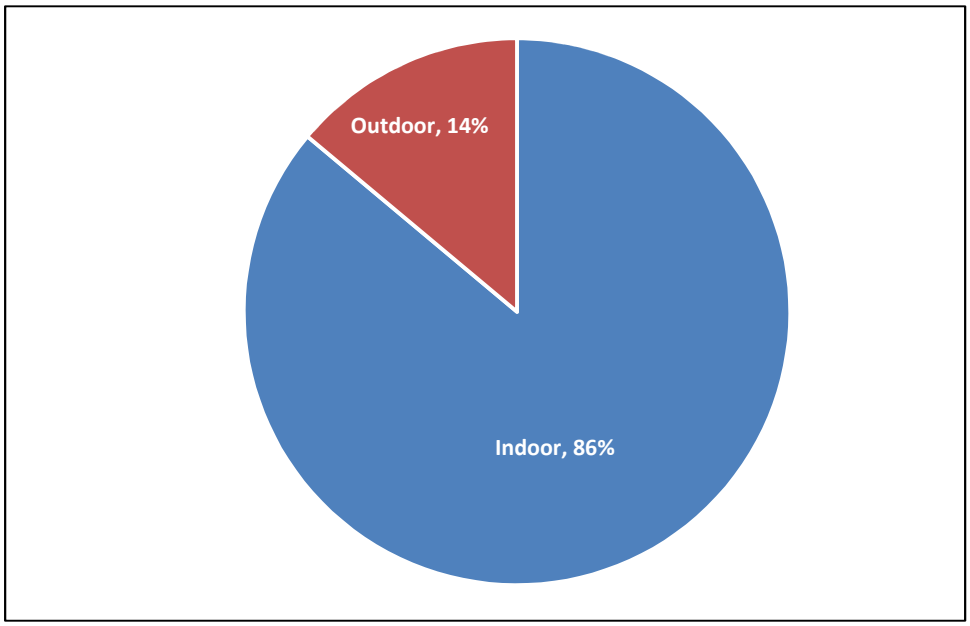
Figure B-33. Consumption by Customer Category – Tullahoma Utilities Board



Note: Figure is based on water use in years 2010-2015.

The following figure shows the breakdown of water use into indoor and outdoor components based on the assumption that indoor use is approximately equal to the minimum use in the winter. While there may be minimal landscape watering in the winter, or leakage from irrigation systems, it is assumed that this is minor at less than 5-10% of the average winter water use. Residential indoor water use is assumed to be 95% of total water use due to minimal irrigation.

Figure B-34. Overall Use: Indoor vs. Outdoor – Tullahoma Utilities Board



Note: Figure is based on average water use in years 2010-2014.

B.7.3 Water Use Data Analysis and Key Inputs to the DSS Model

The following table shows the key inputs and assumptions used in the Water System's DSS Model.

Table B-20. Water Use Data Analysis and DSS Model Key Inputs and Assumptions – Tullahoma Utilities Board

Parameter	Model Input Values, Sources and Assumptions				
Model Start Year	2015				
Water Demand Factor Year(s) [Base Year(s)]	2010-2015				
Non-Revenue Water in Start Year	17.8%				
	This value is based on 2010-2014 and can be found in the green NRW section of each Water System's DSS Model.				
Population Projection Source	CBER-UT				
Employment Projection Source	BLS 2010-2015 average annual historical employment for Coffee County				
Base Year Water Use Profile					
Customer Categories	**Start Year Accounts**	**Total Water Use Distribution**	**Demand Factors (gpd/acct)**	**Indoor Use %**	**Residential Indoor Water Use**

Parameter	Model Input Values, Sources and Assumptions				
Residential Inside City	7,409	39%	132	95%	44
Residential Outside City	988	6%	145	95%	N/A
Commercial Inside City	1,043	28%	685	88%	N/A
Commercial Outside City	46	26%	14,177	69%	N/A
County Line Co-Op Res	278	2%	151	76%	N/A
Total	9,764	100%	N/A	86%	N/A

B.7.4 Water System Demand Projections

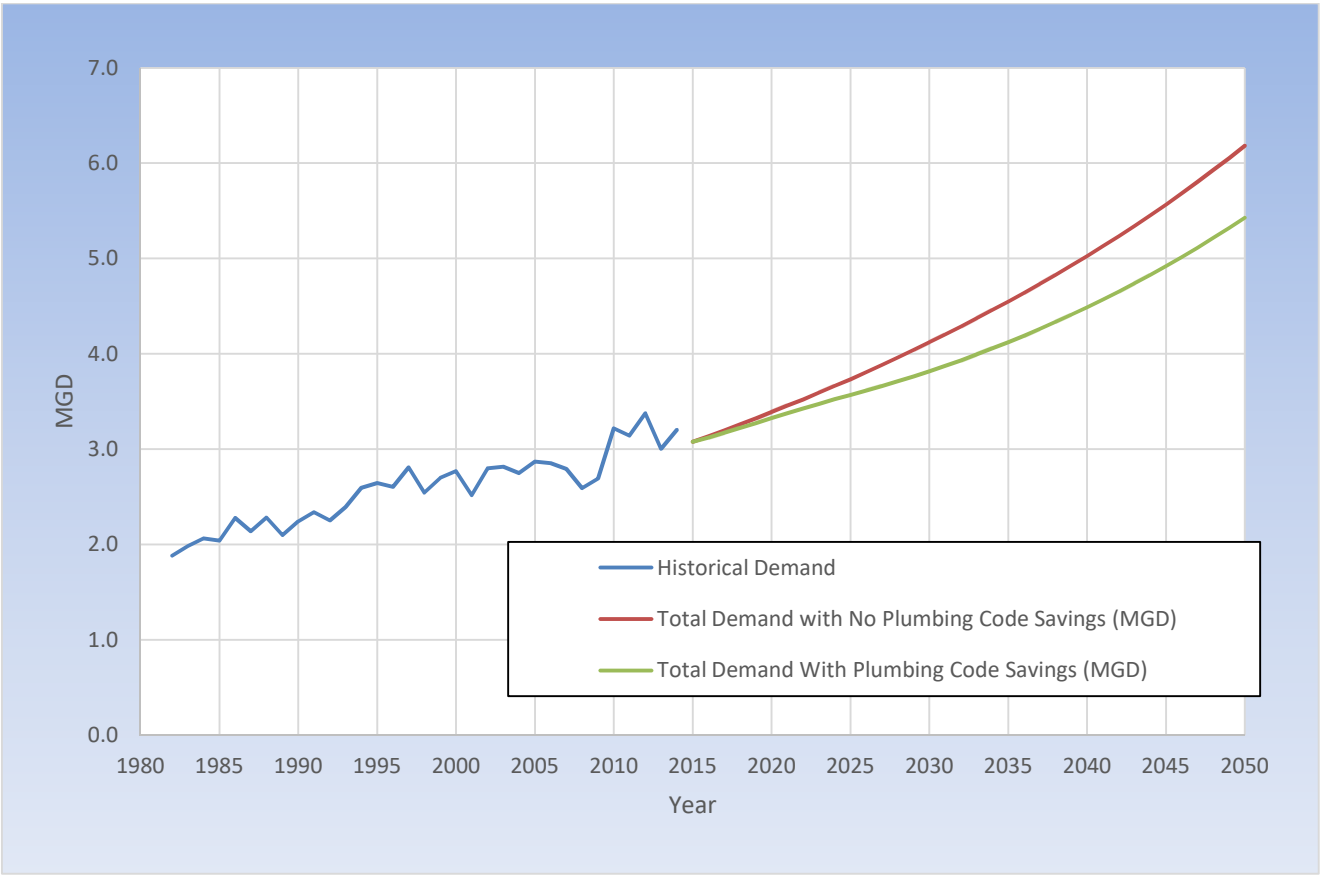
The following table and figure present the average day water demand projections for the Water System.

Table B-21. Demand Projections – Tullahoma Utilities Board

Demand Forecast	2015	2020	2025	2030	2035	2040	2045	2050
Total Demand Without Plumbing Code Savings (MGD)	3.08	3.39	3.73	4.12	4.55	5.03	5.57	6.18
Total Demand With Plumbing Code Savings (MGD)	3.08	3.33	3.57	3.82	4.12	4.49	4.92	5.43

Note: Total Demand accounts for the total projected water demand in a service area Water System regardless of source. Source can be from surface water or groundwater.

Figure B-35. Demand Projection – Tullahoma Utilities Board



APPENDIX C – DEPARTMENT OF WATER RESOURCES PUBLIC WATER SYSTEM STATISTICS REPORT SAMPLE

It is recommended that Water Systems submit standard form/annual report to DRA with monthly or bimonthly production by source and consumption and accounts by category. Service area population and number of employees would also be tracked on this document. A sample document used by California Department of Water Resources is provided below.

State of California — DEPARTMENT OF WATER RESOURCES — California Natural Resources Agency

PUBLIC WATER SYSTEM STATISTICS — Calendar Year **2013**

Mailing Label

1. General Information

Please follow the provided instructions.

Contact : Misty Smith
Title: Senior Water Operator/CPO
Phone: (555) 927-6227
Fax: (555) 927-6224
E-mail: Msmith@watercsd.org
Website: watercsd.org
County: **San Piper**
Population served: **6200**
Names of communities served: Waterville

2. Active Service Connections

Customer Class	Potable Water		Recycled Water	
	Metered	Unmetered	Metered	Unmetered
Single Family Residential	3642			
Multi-family Residential	136			
Commercial/Institutional	229			
Industrial	0			
Landscape Irrigation	0			
Other	24			
Agricultural Irrigation	1			
TOTAL	4032			

3. Total Water Into the System - Units of production: **AF** (Select: **AF**=acre-feet; **MG**=million gallons; **CCF**=hundred cubic feet)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Potable	*Wells*	50.55	46.55	54.72	55.27	63.18	46.01	60.82	72.32	65.41	52.4	52.1	54.22	673.55
	Surface	0	0	0	4.27	5.28	27.57	18.12	3.5	0	0	0	0	58.74
	Purchased 1/	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total Potable	50.55	46.55	54.72	59.54	68.46	73.58	78.94	75.82	65.41	52.4	52.1	54.22	732.29
Untreated Water														
Recycled 2/														

1/ Potable wholesale supplier(s):

2/ Recycled wholesale supplier(s):

Level of treatment: Chlorination

4. Metered Water Deliveries - Units of delivery: **CCF** (Select: **AF**=acre-feet; **MG**=million gallons; **CCF**=hundred cubic feet)

If recycled is included, X box ↓		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
A.SingleFamilyResidential		14601	14601	15534.5	15534.5	19449	19449	22161	22161	16186	16186	13858.5	13858.5	203580
B.Multi-family Residential		844	844	835	835	920	920	940.5	940.5	770	770	665	665	9949
C.Commercial/Institutional		4770	4770	5440.5	5440.5	6231.5	6231.5	7810.5	7810.5	6257	6257	4474	4474	69967
D.Industrial		0	0	0	0	0	0	0	0	0	0	0	0	0
E.Landscape Irrigation		0	0	0	0	0	0	0	0	0	0	0	0	0
F.Other		0.52	0.52	0.4	0.41	0.84	0.84	1.3	1.31	1.15	1.15	0.82	0.82	10.08
Total Urban Retail *(A thru F)*		20215.52	20215.52	21810.4	21810.41	26601.34	26601.34	30913.3	30913.31	23214.15	23214.15	18998.32	18998.32	283506.1
Agricultural Irrigation														
Wholesale*(to other agencies)*														

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APPENDIX D – PUBLISHED DEMANDS METHODOLOGY COMPARISON

A different approach to modeling demands was used by DRA's engineering consultants O'Brien and Gere (OBG) in their ongoing water supply planning analysis and more specifically in their most recently published 2013 Regional Drought Management Plan (DMP). The OBG water supply planning approach used gross per capita demand and held the per capita use constant through the planning period. This appendix compares the demands published in this report to the demands published in the OBG 2013 analysis.

In Spring 2013, OBG and DRA collaborated to revise previously developed 2011 water demands from the 2011 Water Supply Plan (WSP) based on the recent availability of 2010 historic raw water withdrawal data for each Water System. It was agreed by DMP participants that the DMP would be a 10-year plan, so revised water demands for 2010 and 2020 were published. Revised water demands for each water system for the year 2020 were based on a straight-line difference in the 2010 WSP values vs. the 2010 raw water withdrawals. The April 2013 revised water demands for each Water System were developed through year 2060 using the straight-line difference between the 2010 WSP values and the 2010 raw water withdrawals.

In making a comparison between OBG's 2013 projection methodology and the 2016 analysis presented in this report, it is important to note that OBG did not break down water use into sub-sectors or customer category accounts, nor did the analysis account for employment conditions. As explained in more detail throughout the 2016 report, this analysis uses more recent, post-2007 drought data: average year 2010-2015 baseline consumption and production data, when available.

The following graphs present a comparison of Water System demands between this 2016 demand projection analysis and the OBG water supply planning analysis conducted in 2013.

Despite the differing modeling approaches briefly summarized above and introduced previously in Section 1.3, for most of the Water Systems, the water use projections are comparable, except for the demands projected for CPWS between the two analysis techniques. This difference has been investigated and is considered to be a result not only of the differing demand development methodology and varying base year water use, but also due to the fact that the large account Saturn car manufacturer ceased operations by 2008. More specifically, the assembly line for Saturn closed in 2007, with the final day of production being March 30, 2007. The plant continued to make parts through 2007 and was officially closed in 2008. The difference in CPWS projected water use, therefore, can be attributed to the following: 1) the closure of the Saturn assembly line; 2) a difference in base year per capita and per account water use as a result of a different base time period being used; and 3) a slightly different population growth in addition to the use of Maury County's 2010-2015 employment growth to grow non-residential accounts.

Figure D-1. 2016 MWM vs. 2013 OBG Water Demand Projection Analysis – Bedford County Utility District

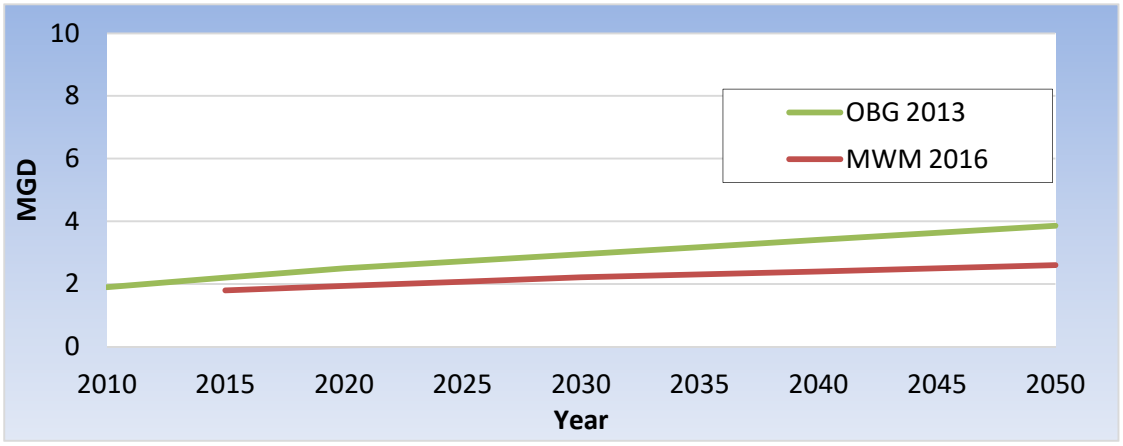
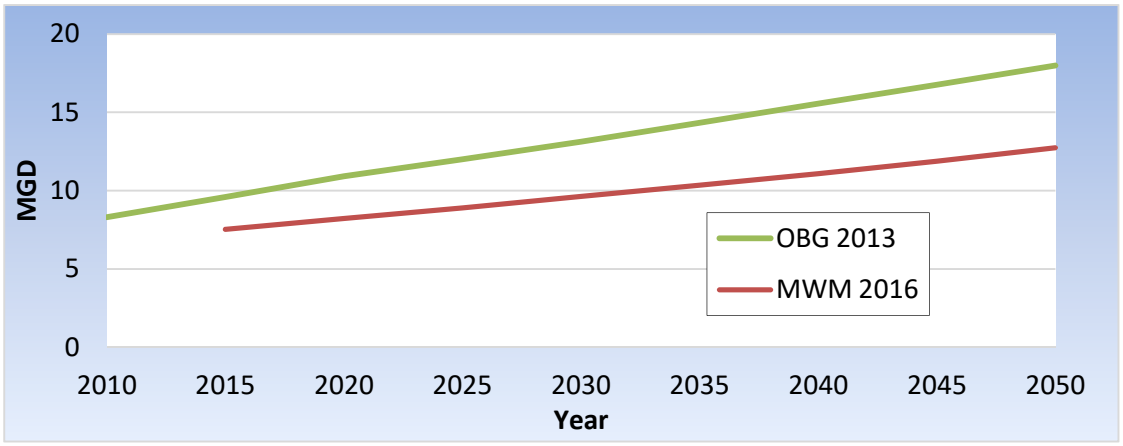


Figure D-2. 2016 MWM vs. 2013 OBG Water Demand Projection Analysis – Columbia Power and Water Systems*



* Note y-axis extends to 20 MGD versus 10 MGD like the other Water System figures.

Figure D-3. 2016 MWM vs. 2013 OBG Water Demand Projection Analysis – Lewisburg Water and Wastewater

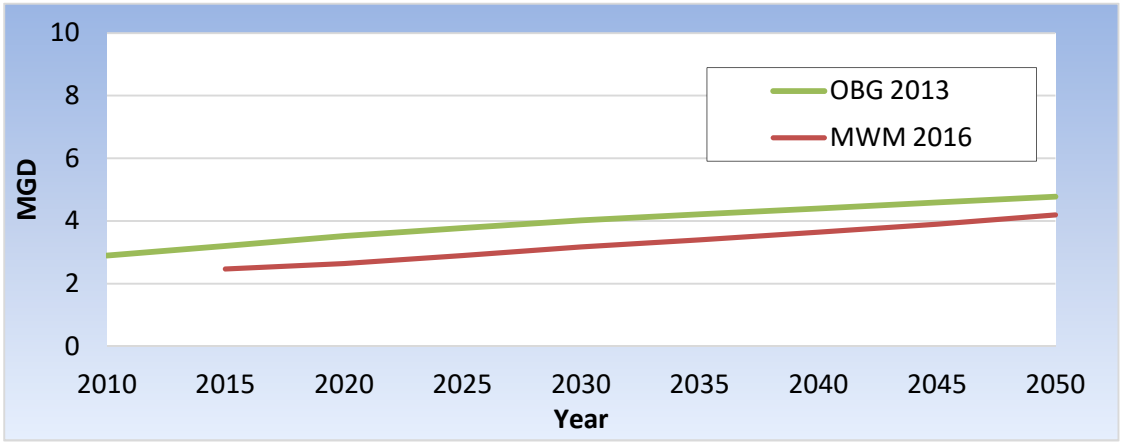


Figure D-4. 2016 MWM vs. 2013 OBG Water Demand Projection Analysis – Manchester Water and Sewer Department

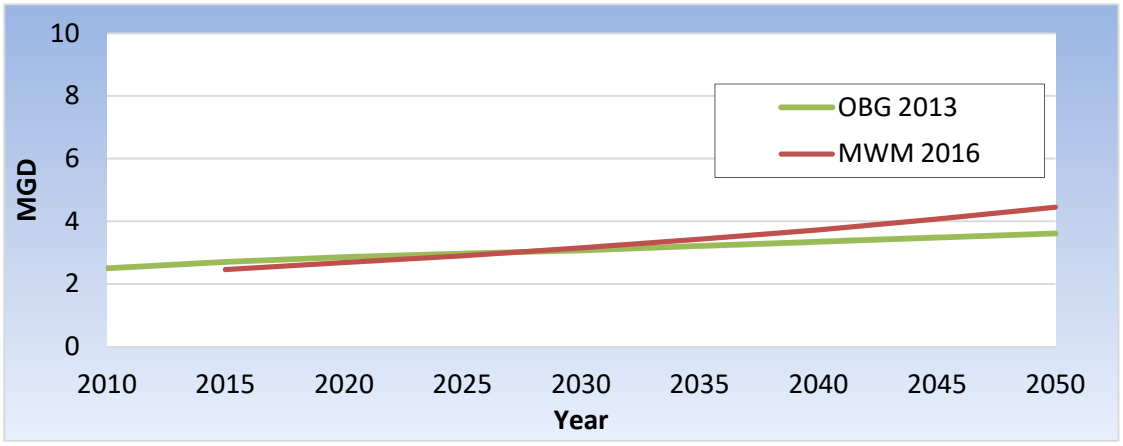


Figure D-5. 2016 MWM vs. 2013 OBG Water Demand Projection Analysis – Shelbyville Power, Water, and Sewerage System

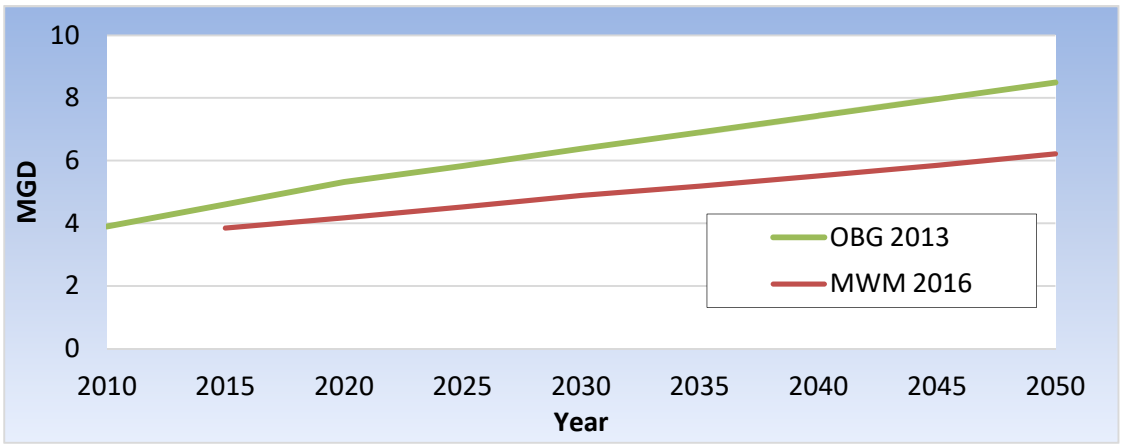


Figure D-6. 2016 MWM vs. 2013 OBG Water Demand Projection Analysis – Spring Hill Water System

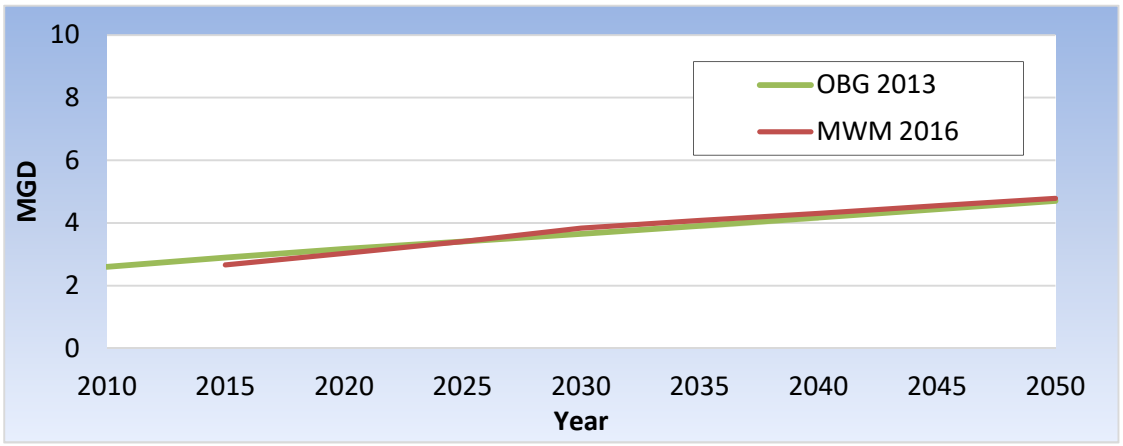


Figure D-7. 2016 MWM vs. 2013 OBG Water Demand Projection Analysis – Tullahoma Utilities Board

