TENNESSEE VALLEY AUTHORITY
River & Resources Stewardship

Water Use in the Tennessee Valley for 2020 and Projected Use in 2045

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EXECUTIVE SUMMARY

WATER USE IN 2020

In 2004, the U.S. Geological Survey (USGS) in cooperation with the Tennessee Valley Authority (TVA) published a report on water use in the Tennessee River watershed based on 2000 water use data. These data were used by TVA in the development of the reservoir operating policy and to identify potential areas of water supply concerns throughout the watershed. Because of the importance of water supply planning, TVA, in cooperation with the USGS, prepared another report on water use in the watershed based on 2005 data. In 2010, TVA began preparing the water use reports independently. This report is based on 2020 water use data.

Off-stream water use in the Tennessee River watershed is estimated for 2020. Water use is categorized as thermoelectric power, industrial, public supply, and irrigation. Water use is summarized by source of water (surface water or groundwater) and location of withdrawal (reservoir catchment area). Water returns to the watershed are used to estimate consumptive use. A projection of water use for 2045 is also provided.

Total water withdrawals during 2020 were estimated to average 8,368 million gallons per day (mgd) for off-stream uses. The 2020 total withdrawal was 16.5 percent lower than it was in 2015. This was in large measure due to a reduction in thermoelectric withdrawal of 20.5 percent.

Water withdrawals by category, as shown in Figure ES-1, are:

- Thermoelectric - 6,536 mgd (78.1 percent of total use)
- Industrial - 1,043 mgd (12.5 percent of total use)
- Public supply - 695 mgd (8.3 percent of total use)
- Irrigation - 94 mgd (1.1 percent of total use)

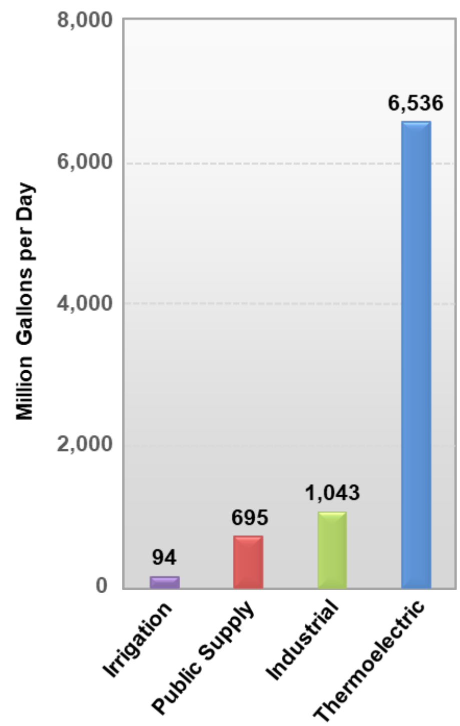

Figure ES-1: Water Withdrawals in 2020

The return flow was estimated at 7,965 mgd or 95.2 percent of the water withdrawn. Net water demand (total withdrawal minus total return) accounts for the other 4.8 percent of total withdrawal, or 403 mgd.

As shown in Figure ES-2, water returns to the river system were estimated as:

- Thermoelectric - 6,463 mgd (98.9 percent of thermoelectric withdrawal, 81.1 percent of total return)
- Industrial - 980 mgd (93.9 percent of industrial withdrawal, 12.3 percent of total return)
- Public supply - 522 mgd (75.1 percent of public supply withdrawal, 6.6 percent of total return)
- Irrigation - 0 mgd

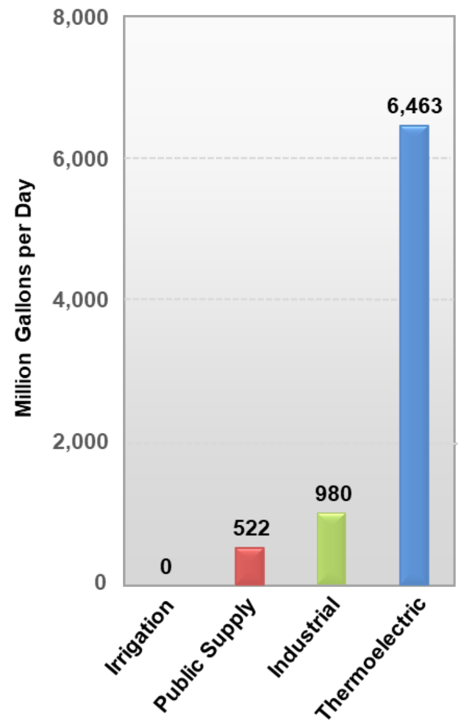

Figure ES-2: Water Returns in 2020

Water that evaporates, transpires, is incorporated into products or crops, or is consumed by humans or livestock is consumptive use. The net water demand is used as an estimate of consumptive use. The net water demands for each category as shown in Figure ES-3 were estimated as:

- Thermoelectric - 73 mgd (18.1 percent of total net water demand)
- Industrial - 63 mgd (15.7 percent of total net water demand)
- Public supply - 173 mgd (42.9 percent of total net water demand)
- Irrigation - 94 mgd (23.3 percent of total net water demand)

Surface water withdrawals were 8,182 mgd, or 97.8 percent of total withdrawal, with groundwater accounting for the remaining 2.2 percent of total withdrawals or 186 mgd.

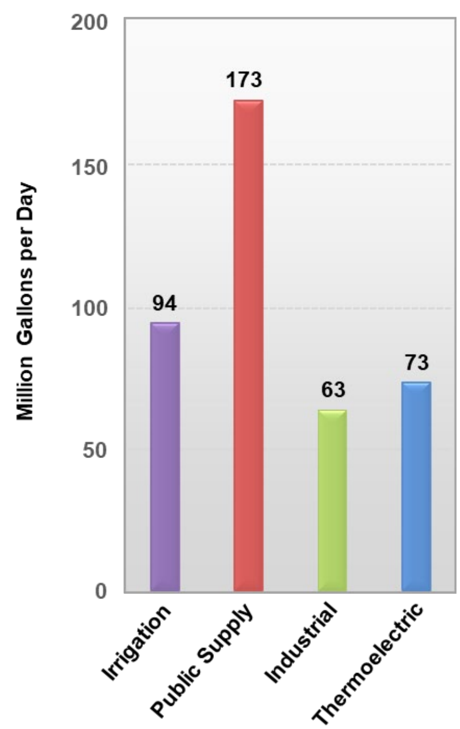

Figure ES-3: Net Water Demand in 2020

PROJECTED WATER USE IN 2045

By 2045, water withdrawals are projected to decline 11 percent from 2020 levels to 7,463 mgd. Water withdrawals by category for 2020 and projections for 2045 are shown in Figure ES-4. The withdrawals are projected to change from 2020 levels as follows:

- Thermoelectric - decrease of 16 percent to 5,501 mgd, reflecting changes in both generating and cooling technologies for power plants
- Industrial - decrease of 1 percent to 1,035 mgd
- Public supply - increase of 12 percent to 778 mgd
- Irrigation - increase of 58 percent to 149 mgd

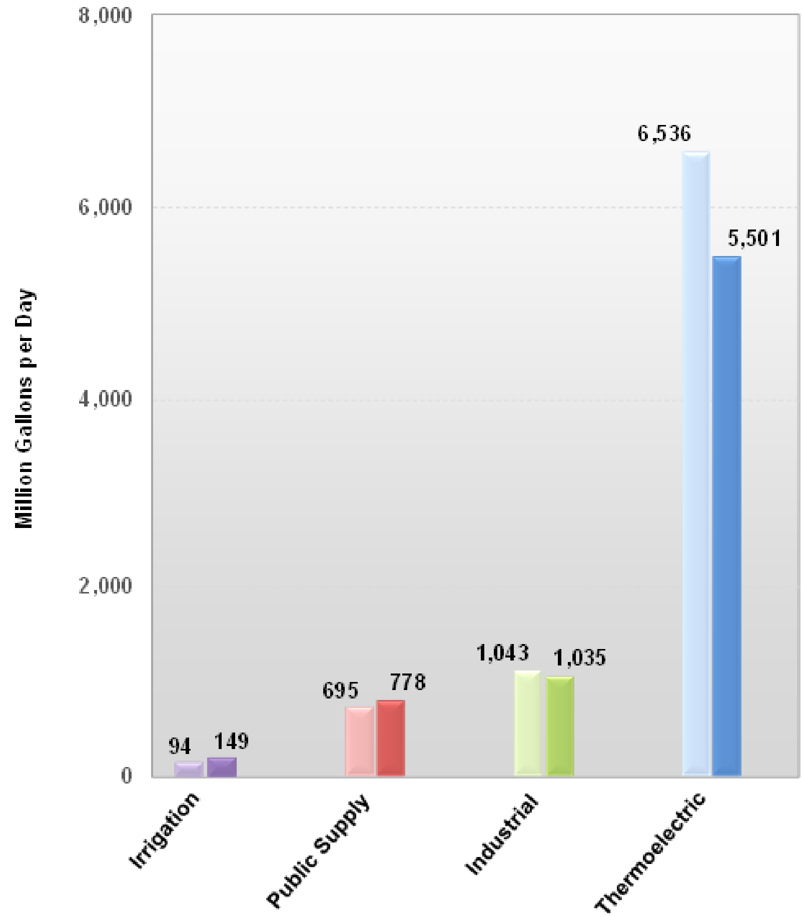

Figure ES-4: Water Withdrawals in 2020 (left bar) and 2045 Projections (right bar)

By 2045, net water demand is projected to increase 18 percent from 2020 levels to 475 mgd. Net water demand by category for 2020 and projections for 2045 are shown in Figure ES-5. The net water demand is projected to change from 2020 levels as follows:

- Thermoelectric - decrease of 7 percent to 68 mgd
- Industrial - increase of 4 percent to 66 mgd
- Public supply - increase of 11 percent to 192 mgd
- Irrigation - increase of 58 percent to 149 mgd

Although total withdrawals are expected to decrease, total net water demand shows an 18 percent increase to 475 mgd. This is due to projected economic growth and continued population growth in the Tennessee Valley, as well as continued growth of irrigated agriculture.

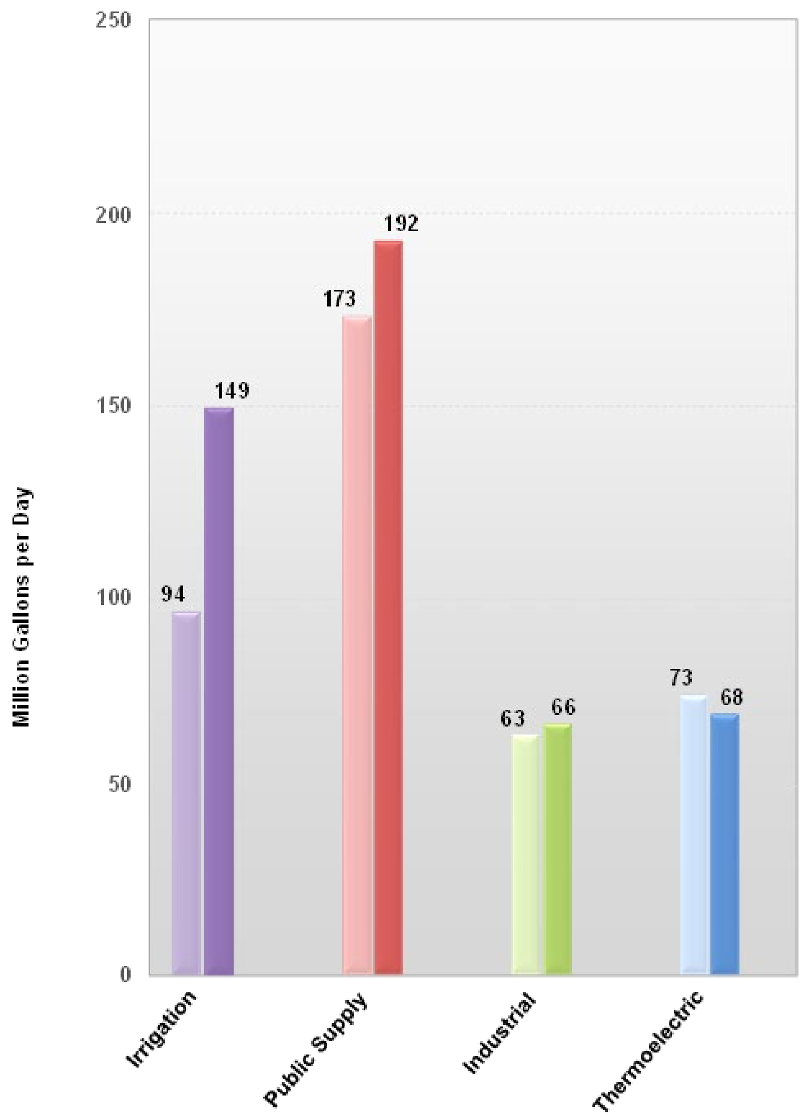

Figure ES-5: Net Water Demand in 2020 (left bar) and 2045 Projections (right bar)

1 INTRODUCTION

BACKGROUND

The Tennessee River system is the fifth largest river system in the United States. The Tennessee River watershed drains 40,910 square miles, including portions of Alabama, Georgia, Kentucky, Mississippi, North Carolina, Tennessee, and Virginia, as shown in Figure 1-1.

In 2004, the USGS and the TVA prepared a water use estimate for the Tennessee River watershed based on data collected in 2000 (Hutson and others, 2004). Utilizing these data, water use estimates were projected to 2030 to aid in the water supply analyses associated with TVA's Reservoir Operations Study (ROS). The ROS was a study conducted by TVA to examine alternative reservoir operations policies in an effort to increase overall public value of the reservoir system. The ROS developed a new operating policy that was implemented by TVA in 2004 (Tennessee Valley Authority, 2004). The 2000 water use data were also used by TVA in 2004 to identify areas with potential concerns regarding water supply (Bohac and Koroa, 2004). A second estimate of water use was prepared by Bohac and McCall (2008) using 2005 data. The third estimate of water use was prepared by Bohac and Bowen (2012) using 2010 data and furthered the projections to 2035. A fourth study of water use was prepared by Bowen and Springston (2018) using 2015 data, which projected data to 2040.

PURPOSE AND SCOPE

The purpose of this report is to present water use estimates for the Tennessee River watershed based on 2020 data with water use projections to 2045. Water use estimates focus on four categories of off-stream water use: thermoelectric power, industrial, public supply, and irrigation.

HYDROLOGIC SETTING

The Tennessee River system is regulated by a series of dams and reservoirs managed by TVA. TVA operates the Tennessee River system to provide year-round navigation, flood-damage reduction, power generation, improved water quality, water supply, recreation, and economic growth.

Average annual rainfall over the Tennessee River watershed is approximately 51 inches. Subsequent average runoff of 22 inches per year usually provides enough water to meet the off-stream water use demands on the Tennessee River system. However, periodic droughts may severely limit the ability of the Tennessee River system to meet these competing demands, particularly in unregulated portions of the Tennessee River system. Unregulated portions of the river system are streams or rivers without upstream dams. Recognizing that annual hydrology will impact the trends in off-stream water use demands, it is important to consider the variability in hydrology since 2000 for this report. In 2000, 2005, 2010, and 2015, the watershed received 76 percent, 79 percent, 80 percent, and 115 percent of average rainfall, respectively. The rainfall in 2020 was roughly 138 percent of average rainfall (70.36 inches), which was the wettest year in recorded history.

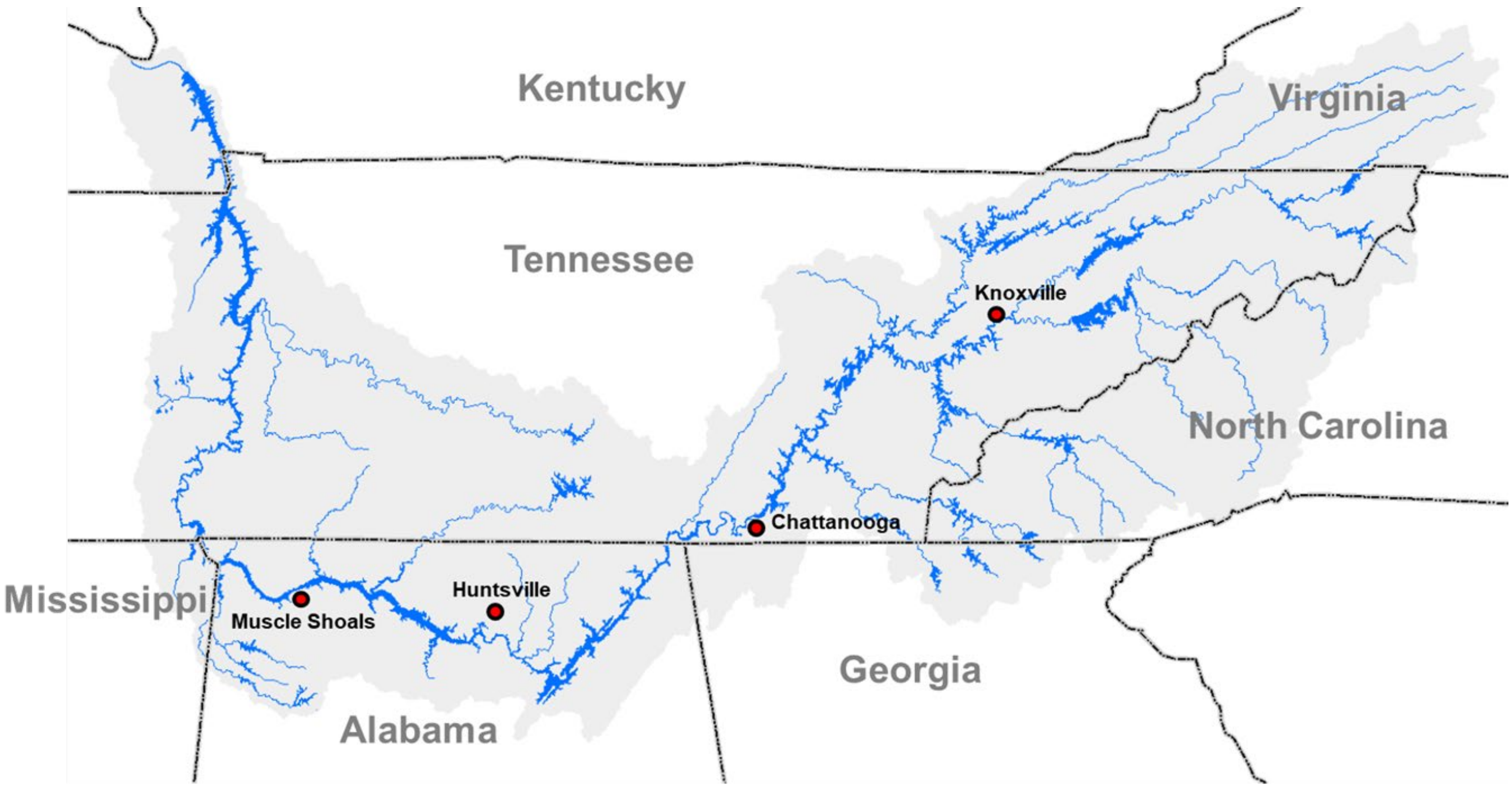

Figure 1-1: Tennessee River Watershed

DATA SOURCES AND ANALYSIS METHODS

Every five years, TVA updates the Water Use Database with the most up-to-date water use information. Each record in the database is labeled as a withdrawal or return flow water use transaction. Each water use transaction for a site in the database is assigned to a Water Use Tabulation Area (WUTA) and a Reservoir Catchment Area (RCA). The RCA, as defined by Hutson and others (2004), is a natural drainage area truncated by a dam. The WUTA groups the RCAs to account for the complete site-specific water use transactions between adjoining RCAs and is used to estimate consumptive use on a large scale.

The database contains industrial, public supply, and irrigation water use data for 2020 directly obtained from the seven Tennessee Valley states. For instances of unreported industrial or public supply data, estimates were made based on a 2015 and 2020 withdrawal and return ratio. The appendix of this report summarizes the source and type of withdrawal data for Alabama, Georgia, Kentucky, Mississippi, North Carolina, Tennessee, and Virginia.

Thermoelectric data were obtained from internal TVA sources, particularly those data submitted to the U. S. Department of Energy for EIA-923: Power Plant Operations Report (U.S. Department of Energy, 2020). Non-TVA thermoelectric generation data was obtained directly from the U.S. Department of Energy for EIA-923: Power Plant Operations Report. Water withdrawal data for non-TVA thermoelectric plants was obtained from the states.

The U.S. Environmental Protection Agency, National Pollutant Discharge Elimination System Program, Permit Compliance System (U. S. Environmental Protection Agency, 2020) provided return flow data for municipalities, industry (including mining), and thermoelectric plants.

Actual irrigation data for 2015 was not available. Therefore, TVA set the 2015 irrigation values to the higher of the 2005 or 2010 data to be conservative. Again in 2020, actual irrigation data was not available for analyses. Since 2020 precipitation was well above normal, TVA chose to set the 2020 withdrawal volumes for known irrigators without state-reported 2020 withdrawal data equal to that of 2015 to be conservative in water use estimates. This accounted for approximately seven percent of the total irrigation withdrawal volume. For the county aggregate irrigation analyses, withdrawal volumes from the most recently published irrigation data were obtained from the U. S. Department of Agriculture (U. S. Department of Agriculture 2017). The county-specific irrigation withdrawal volumes in the Tennessee River watershed were determined based on the percentage of the county that was in the watershed.

Net Demand is calculated as the difference between water withdrawals and return flow. It is an estimate of the water that is evaporated, transported, incorporated into products or crops, consumed by humans or livestock, or otherwise removed from the immediate environment.

Estimates of population and future water use were made using data provided by Woods and Poole Economics Inc. (Woods and Poole, 2020) and the U.S. Census.

Water use numerical data presented in this report are the daily quantities averaged over the year. Although irrigation data are applied seasonally at a rate higher than annual average daily quantities, the application rates were averaged over the year to make them compatible with the other data.

In Chapter 2 of this report, entries for Tables 2-2 through 2-9 contain two decimal places and totals are shown as integers. All numbers were rounded independently. The sums of independently rounded numbers may not equal the totals (expressed as integers) in the report. The majority of the percentages listed in this document will therefore be consistent with those in Table 3-1. Due to rounding, the figures in Chapter 2 show a range of numbers and are not intended to be precise.

2 WATER USE

INTRODUCTION

Information is presented by source of water, category of use, and type of transaction. Water sources are surface water and groundwater. Use categories are thermoelectric, industrial (including mining), public supply, and irrigation. Transactions are either withdrawals or returns. Returns are water discharges from thermoelectric power plants, industries, and municipal wastewater treatment plants.

Prior to the 2015 Water Use Report, water use reports for the Tennessee River organized water use in three ways: by WUTA and RCA, hydrologic unit code (HUC), and by state and county. In 2015 and 2020, water use is only organized based on WUTA and RCA. This decision was made because the need of the water use report for TVA is to analyze transactions by reservoirs on a regional scale. USGS prepares a similar report on the same time series for state- and county-level summaries, so it is no longer necessary for TVA to also include this data in their report.

WUTAs group RCAs to account for the complete site-specific water use transactions between adjoining RCAs and to determine consumptive use at a large scale. The WUTA-grouped RCAs also demonstrate TVA’s integrated management of the Tennessee River.

The nomenclature of the WUTAs in the 2020 Water Use Report differs from previous reports. Beginning with the 2020 report, the WUTAs are grouped by river name. The past and present WUTA names are shown in Table 2-1.

Figure 2-1 shows the Tennessee River watershed divided into WUTAs, and Figure 2-2 shows the Tennessee River watershed divided into the RCAs that make up each WUTA. Tables 2-2 through 2-9 show the WUTAs in bold type with the RCAs comprising the WUTAs listed below.

Hutson and others (2004) define net water demand as the quantitative difference between water withdrawals and return flow. Consumptive use is that part of the water withdrawn that is evaporated, transported, incorporated into products or crops, consumed by humans or livestock, or otherwise removed from the immediate environment. In this report, 100 percent of the water used for irrigation is considered net water demand.

If the net water demand for a RCA is negative, there is a larger return than withdrawal in that RCA. This is common for thermoelectric plants and industrial entities in which the intake is in the reservoir pool upstream of the dam and the discharge is located downstream of the dam in the tailrace. The area upstream of the dam is a different RCA than the area downstream. It is also common for public users with an intake in the reservoir and a wastewater treatment plant downstream in a different RCA to have a negative net water demand.

Using the methodology of Hutson and others (2004), the net water demand is accumulated at the downstream boundary of the WUTA to calculate an estimate of total consumptive use for the watershed. Cumulative net water demand was calculated at key junctures of the WUTAs, which included Fort Loudoun, Watts Bar-Chickamauga, Nickajack, Guntersville, Wheeler-Wilson, Pickwick-Bear, and Kentucky. The cumulative net water demand is an estimate of the sum of consumptive use in the watershed at that juncture. The net water demand accumulated at Kentucky Dam is the estimate of total consumptive use for the entire TVA watershed.

Table 2-1: Nomenclature of Water Use Tabulation Areas

2020 Water Use Tabulation Areas (WUTA)	WUTA in Previous Reports	Coverage Area
Holston	Cherokee	Holston River drainage area above Cherokee Dam
French Broad	Douglas	French Broad River drainage area above Douglas Dam
Fort Loudoun	Fort Loudoun	Drainage area between Fort Loudoun Dam and Cherokee/Douglas Dams
Little Tennessee	Fontana-Tellico	Little Tennessee River drainage area above Tellico Dam
Clinch	Norris	Clinch River drainage area above Melton Hill Dam
Hiwassee-Ocoee	Hiwassee-Ocoee	Hiwassee River drainage area above Apalachia Dam; Ocoee River drainage area above Ocoee 1 Dam
Watts Bar-Chickamauga	Watts Bar-Chickamauga	Drainage area between Chickamauga Dam and Melton Hill/Fort Loudoun/Apalachia/Ocoee 1 Dams
Nickajack	Nickajack	Drainage area between Nickajack Dam and Chickamauga Dam
Guntersville	Guntersville	Drainage area between Guntersville Dam to Nickajack Dam
Elk	Tims Ford	Elk River drainage area above Tims Ford Dam
Wheeler-Wilson	Wheeler-Wilson	Drainage area between Wilson Dam and Guntersville/Tims Ford Dams
Pickwick-Bear	Pickwick	Drainage area between Pickwick Dam and Wilson Dam
Duck	Normandy	Duck River drainage area above Columbia, Tennessee
Kentucky	Kentucky	Drainage area between Kentucky Dam and Pickwick Dam/ Columbia, Tennessee

Figure 2-1: Tennessee River Watershed by Water Use Tabulation Areas

Figure 2-2: Tennessee River Watershed by Reservoir Catchment Areas

OFF-STREAM WATER USE

Total Off-Stream Water Use

Total off-stream water use for 2020 is shown in Table 2-2.

Total withdrawal was 8,368 mgd, of which 97.8 percent, or 8,182 mgd, came from surface water. Groundwater supplied the remaining 2.2 percent, or 186 mgd. Return flow totaled 7,965 mgd, or 95.2 percent of total withdrawal. Total net water demand was 403 mgd, or 4.8 percent of total withdrawal.

Figures 2-3, 2-4, and 2-5 show the total withdrawal, return, and net demand by RCA, respectively. This is a visual representation of the data provided in Table 2-2. The Wheeler RCA had the largest withdrawal at 3,537 mgd, but it also had the largest return at 3,489 mgd. The greatest net demand was the Ft. Patrick Henry RCA at 536 mgd. The net demand was high for this RCA due to an industry that relies on the Ft. Patrick Henry RCA for water withdrawals but returns water to the Cherokee RCA (-483 mgd). Figure 2-6 shows the cumulative net water demand at major WUTA junctures and the net water demand for RCAs.

Water Use Summarized by Category

Table 2-3 breaks down total water use by category (thermoelectric, industrial, public supply, and irrigation).

Thermoelectric water use was the category with the largest total withdrawal at 6,536 mgd, or 78.1 percent of total withdrawal. Total industrial withdrawal was 1,043 mgd, or 12.5 percent of total withdrawal. Total public supply withdrawal was 695 mgd, or 8.3 percent of total withdrawal. Total irrigation withdrawal was 94 mgd, or 1.1 percent of total withdrawal.

Of the total return flow of 7,965 mgd, thermoelectric return was 6,463 mgd or 81.1 percent of the total return; industrial return was 980 mgd, or 12.3 percent of total return; and public supply return was 522 mgd, or 6.6 percent of total return. It was assumed that there was no irrigation return flow.

The WUTA with the largest thermoelectric water use (3,294 mgd) is the Wheeler-Wilson WUTA. The Wheeler-Wilson WUTA also has the largest public supply withdrawal (133 mgd) and the highest irrigation withdrawal (30 mgd). The largest industrial water withdrawal (593 mgd) is from the Holston WUTA.

Water Use Summarized by Source

Tables 2-4 and 2-5 summarize surface water and groundwater withdrawals by category. Total withdrawal was 8,182 mgd for surface water (Table 2-4; Figure 2-7) and 186 mgd for groundwater (Table 2-5; Figure 2-8).

Surface water supplied the entire thermoelectric withdrawal of 6,536 mgd. Surface water was the source for 1,005 mgd, or 96.4 percent of the industrial withdrawal; 573 mgd, or 82.4 percent of the public supply withdrawal; and 68 mgd, or 72.8 percent of the irrigation withdrawal.

Groundwater withdrawal was 38 mgd, or 3.6 percent of total industrial withdrawal; 122 mgd, or 17.6 percent of total public supply use; and 26 mgd, or 27.2 percent of total irrigation use.

Wheeler-Wilson was the WUTA with the highest surface withdrawal, at 3,520 mgd (Table 2-4; Figure 2-7), and highest groundwater withdrawal, at 43 mgd (Table 2-5; Figure 2-8).

Water Use Described by Category

Thermoelectric

Total thermoelectric withdrawal was 6,536 mgd, of which 6,463 mgd, or 98.9 percent, was returned.

Table 2-6 and Figure 2-9 show thermoelectric withdrawal by RCA and WUTA. The largest WUTA withdrawal was 3,294 mgd from the Wheeler-Wilson WUTA. This accounted for 50.4 percent of total thermoelectric withdrawal. The Wheeler-Wilson withdrawal was used to generate 33,105 million kilowatt hours of electricity, or 40.2 percent of the total power generated in the Tennessee River watershed. Figures 2-10 and 2-11 show thermoelectric return and net demand, respectively.

The largest withdrawal from the Wheeler-Wilson WUTA was Browns Ferry Nuclear Plant in Limestone County, Alabama, and its location is shown in Figure 2-12. All plants shown in Figure 2-12 are TVA-owned except Asheville, Clinch River, Decatur, and Morgan.

The second largest withdrawal was from the Watts Bar-Chickamauga WUTA (2,601 mgd, or 39.8 percent of total thermoelectric withdrawal). This was used to generate 39,602 million kilowatt hours of electricity, or 48.1 percent of the total power generated in the Tennessee River watershed.

Industrial

Table 2-7 and Figure 2-13 show the total industrial withdrawal at 1,043 mgd, or 12.5 percent of total withdrawal. Industrial return flow (Figure 2-14) was 980 mgd, and total net water demand (Figure 2-15) was 63 mgd, or 6.1 percent of the industrial withdrawal. Surface water supplied 1,005 mgd, or 96.4 percent of the water for industrial use.

Holston was the WUTA with the highest industrial withdrawal at 593 mgd, or 56.9 percent of the total industrial withdrawal. The Wheeler-Wilson WUTA withdrawal of 105 mgd was the next highest.

The Holston WUTA also had the highest net water demand of 31 mgd, or 49.2 percent of the total industrial net water demand. Some RCAs and WUTAs show a negative net water demand, which means there was more water returned to the reservoir than withdrawn from that specific area. This typically occurs at locations where an industrial plant is located near a dam and uses the reservoir upstream of the dam for withdrawal. The industrial plant is then able to use the flow releases from the dam to their advantage for their NPDES permit. The return flow downstream of the dam they withdrew from creates a negative net demand in the upstream RCA.

Public Supply

Withdrawal for public supply use was 695 mgd as shown in Table 2-8 and Figure 2-16, which was 8.3 percent of total water withdrawal. Total return for public supply (Figure 2-17) was 75.1% of the withdrawal or 522 mgd. Public supply net water demand (Figure 2-18) was the highest of the four uses and totaled 173 mgd. This was 24.9 percent of total public supply withdrawal. Surface water supplied 573 mgd, or 82.4 percent of withdrawal for public supply use.

Wheeler-Wilson was the WUTA with the highest public supply withdrawal at 133 mgd. The highest net water demand was the French Broad WUTA at 33 mgd.

The population in 2020 for the Tennessee River watershed was 5,181,863 (Woods & Poole, 2020). The per capita public supply use was about 134 gallons per day, down from 137 gallons per day in 2015 and 145 gallons per day in 2010.

Irrigation

Table 2-9 and Figure 2-19 show that surface water supplied 68 mgd, or 72.8 percent of the total withdrawal for irrigation use. The Wheeler-Wilson WUTA had the highest withdrawal at 30 mgd, or 31.9 percent of the total irrigation withdrawal.

Whereas groundwater supplied only 2.2 percent of the total withdrawal for the watershed for all uses, groundwater supplied 26 mgd or 27.2 percent of the withdrawal for irrigation.

Table 2-2: Total Off-Stream Water Use by Source and WUTA in 2020

[Figures may not add to totals because of independent rounding. All values in million gallons per day]

WUTA RCA	Surface Water Withdrawals	Groundwater Withdrawals	Total Withdrawals	Total Return Flow	Net Water Demand
Holston					
Watauga	18.43	7.52	25.96	3.23	22.73
South Holston	17.57	5.80	23.37	8.15	15.22
Boone	0.17	0.35	0.53	29.78	-29.26
Ft Patrick Henry	539.58	0.00	539.58	3.42	536.16
Cherokee	88.99	7.99	96.98	580.04	-483.06
WUTA total	**664.74**	**21.67**	**686.41**	**624.61**	**61.79**
Cumulative	*665*	*22*	*686*	*625*	*62*
French Broad					
Douglas	232.03	21.27	253.30	182.32	70.98
WUTA total	**232.03**	**21.27**	**253.30**	**182.32**	**70.98**
Cumulative	*897*	*43*	*940*	*807*	*133*
Fort Loudoun					
Fort Loudoun	75.99	6.49	82.48	103.10	-20.62
WUTA total	**75.99**	**6.49**	**82.48**	**103.10**	**-20.62**
Cumulative	*973*	*49*	*1,022*	*910*	*112*
Little Tennessee					
Fontana	32.29	4.87	37.16	28.11	9.05
Tellico	12.93	0.91	13.84	7.81	6.03
WUTA total	**45.22**	**5.78**	**51.00**	**35.92**	**15.08**
Cumulative	*1,018*	*55*	*1,073*	*946*	*127*
Clinch					
Norris	26.76	1.88	28.63	17.92	10.71
Melton Hill	574.84	0.12	574.96	550.76	24.20
WUTA total	**601.60**	**1.99**	**603.59**	**568.68**	**34.91**
Cumulative	*1,620*	*57*	*1,677*	*1,515*	*162*
Hiwassee-Ocoee					
Chatuge	2.42	1.87	4.28	0.49	3.79
Nottely	1.43	0.54	1.97	0.35	1.62
Hiwassee	1.17	1.12	2.29	2.10	0.19
Apalachia	3.43	0.00	3.43	0.01	3.42
Blue Ridge	3.95	0.15	4.10	1.96	2.14
Ocoee	0.54	0.42	0.96	0.94	0.01
WUTA total	**12.94**	**4.09**	**17.03**	**5.85**	**11.18**
Cumulative	*1,633*	*61*	*1,694*	*1,520*	*173*
Watts Bar-Chickamauga					
Watts Bar	961.50	0.76	962.26	841.39	120.87
Chickamauga	1,745.21	23.53	1,768.74	1,825.43	-56.68
WUTA total	**2,706.71**	**24.29**	**2,731.00**	**2,666.82**	**64.19**
Cumulative	*4,339*	*86*	*4,425*	*4,187*	*238*

Table 2-2: Total Off-Stream Water Use by Source and WUTA in 2020 (continued)

[Figures may not add to totals because of independent rounding. All values in million gallons per day]

WUTA RCA	Surface Water Withdrawals	Groundwater Withdrawals	Total Withdrawals	Total Return Flow	Net Water Demand
Nickajack					
Nickajack	43.07	6.41	49.48	54.75	-5.27
WUTA total	**43.07**	**6.41**	**49.48**	**54.75**	**-5.27**
Cumulative	*4,382*	*92*	*4,474*	*4,242*	*232*
Guntersville					
Guntersville	61.43	5.31	66.74	33.20	33.54
WUTA total	**61.43**	**5.31**	**66.74**	**33.20**	**33.54**
Cumulative	*4,444*	*97*	*4,541*	*4,275*	*266*
Elk					
Tims Ford	29.47	0.99	30.47	5.52	24.95
WUTA total	**29.47**	**0.99**	**30.47**	**5.52**	**24.95**
Cumulative	*4,473*	*98*	*4,572*	*4,281*	*291*
Wheeler-Wilson					
Wheeler	3,495.86	41.30	3,537.15	3,488.69	48.47
Wilson	24.26	1.50	25.76	5.33	20.43
WUTA total	**3,520.12**	**42.79**	**3,562.91**	**3,494.02**	**68.89**
Cumulative	*7,993*	*141*	*8,134*	*7,775*	*360*
Pickwick-Bear					
Pickwick	63.69	6.59	70.29	47.88	22.41
Cedar Creek	3.60	0.33	3.93	5.58	-1.65
Upper Bear Creek	2.78	0.00	2.78	0.00	2.78
Bear Creek	0.72	0.00	0.72	0.79	-0.07
WUTA total	**70.80**	**6.93**	**77.73**	**54.24**	**23.48**
Cumulative	*8,064*	*148*	*8,212*	*7,829*	*383*
Duck					
Normandy	30.81	1.09	31.90	19.36	12.54
WUTA total	**30.81**	**1.09**	**31.90**	**19.36**	**12.54**
Cumulative	*8,095*	*149*	*8,244*	*7,848*	*396*
Kentucky					
Kentucky	87.47	36.64	124.12	116.65	7.46
WUTA total	**87.47**	**36.64**	**124.12**	**116.65**	**7.46**
Cumulative	*8,182*	*186*	*8,368*	*7,965*	*403*

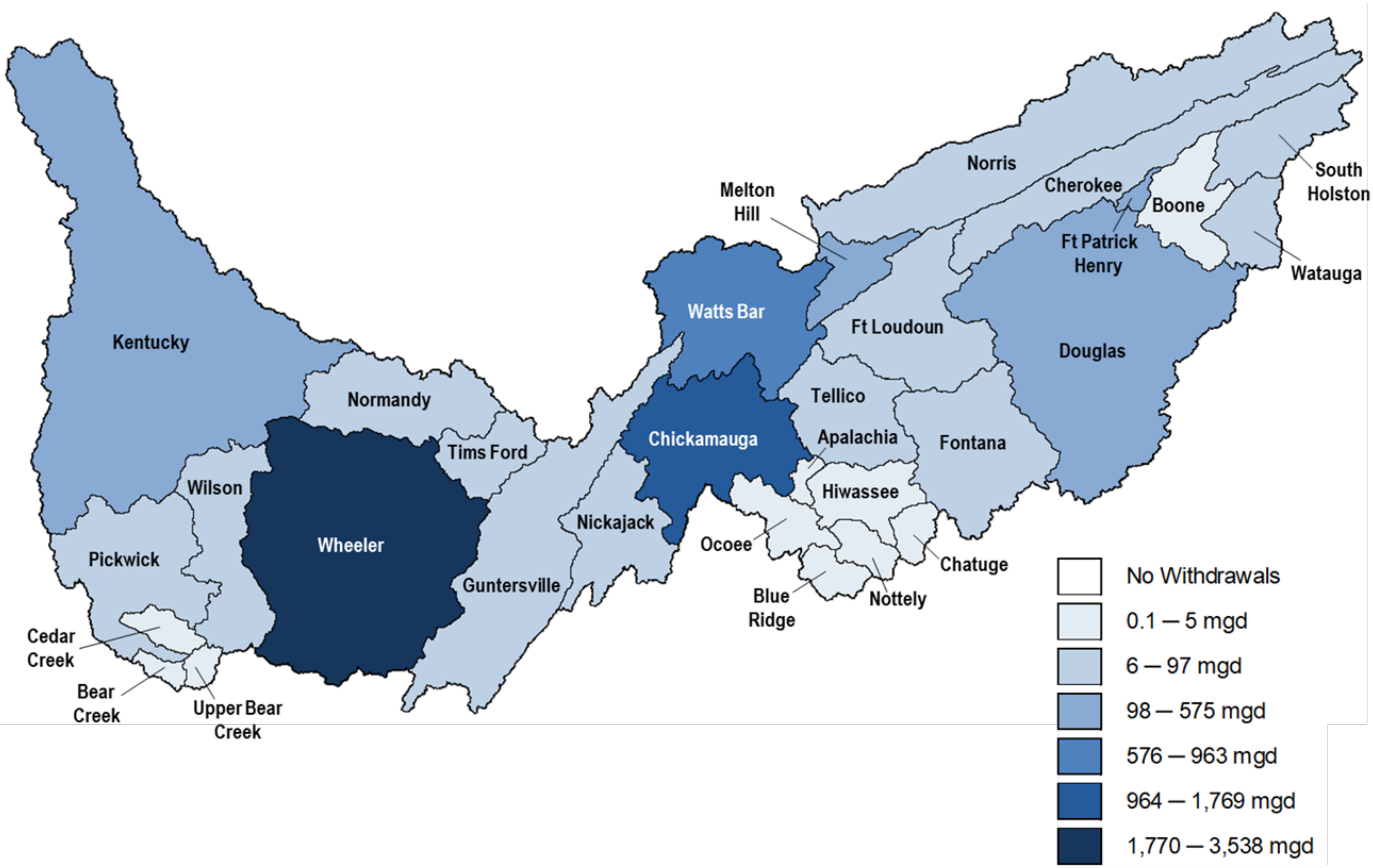

Figure 2-3: Total Withdrawal by RCA in 2020

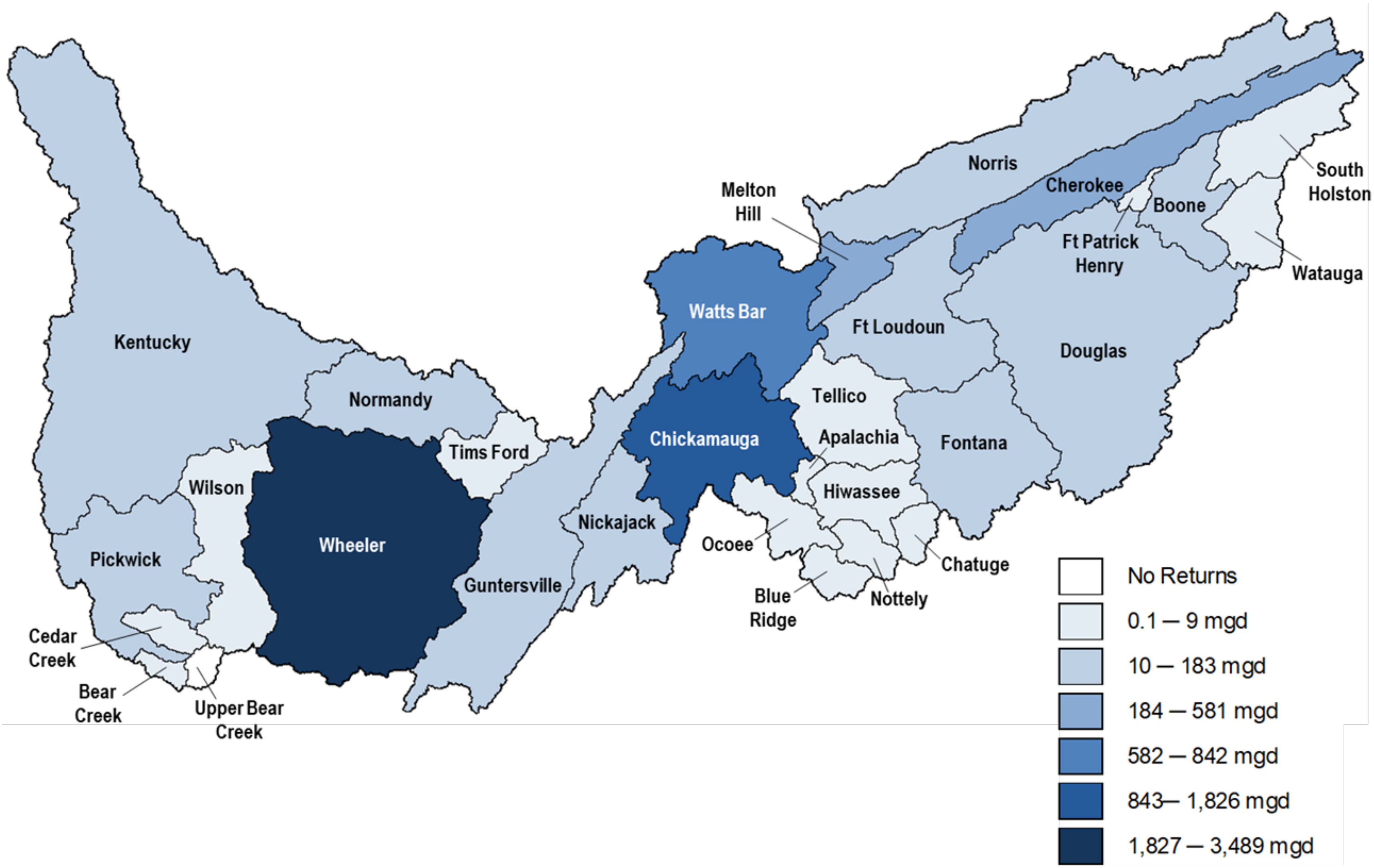

Figure 2-4: Total Returns by RCA in 2020

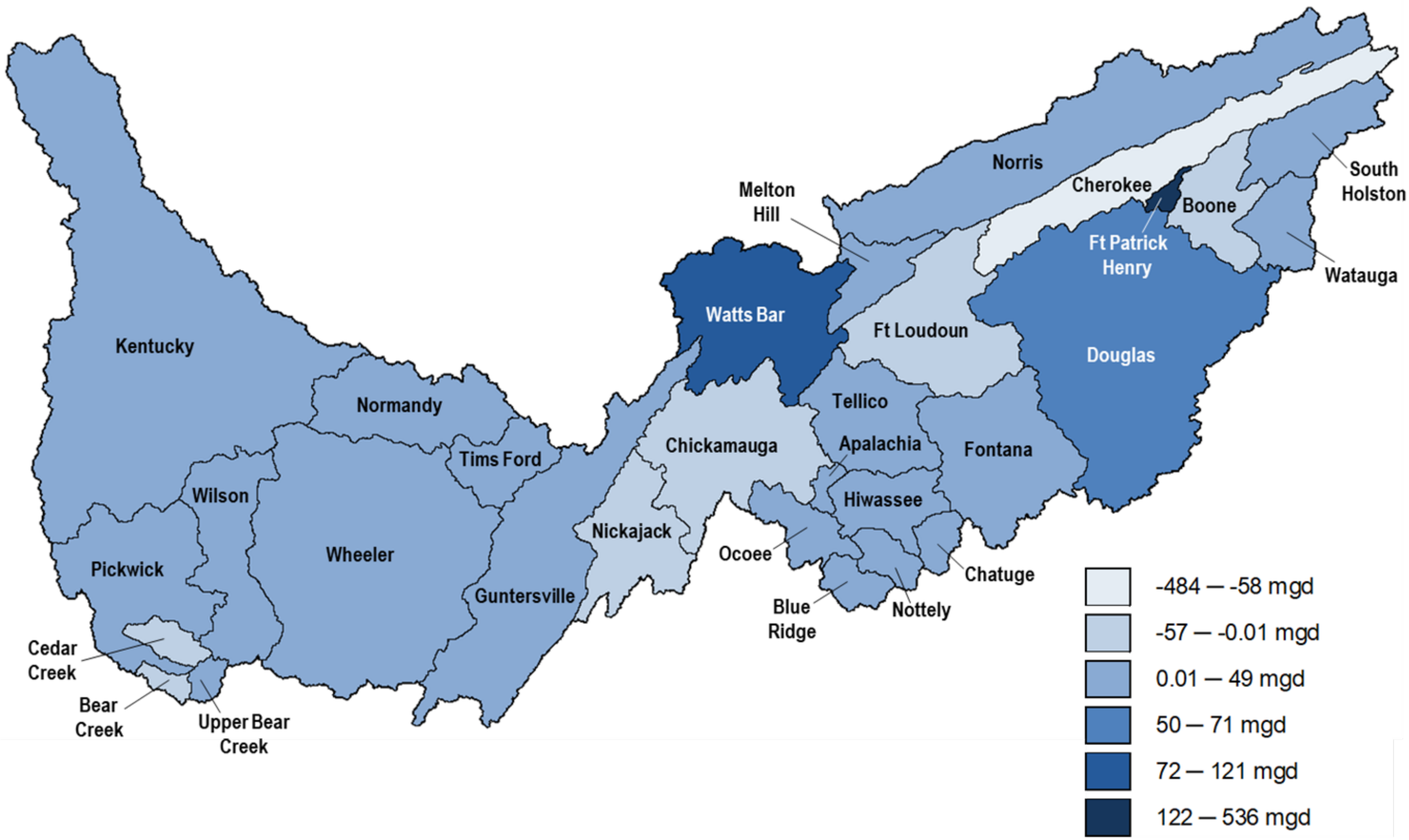

Figure 2-5: Total Net Demand by RCA in 2020

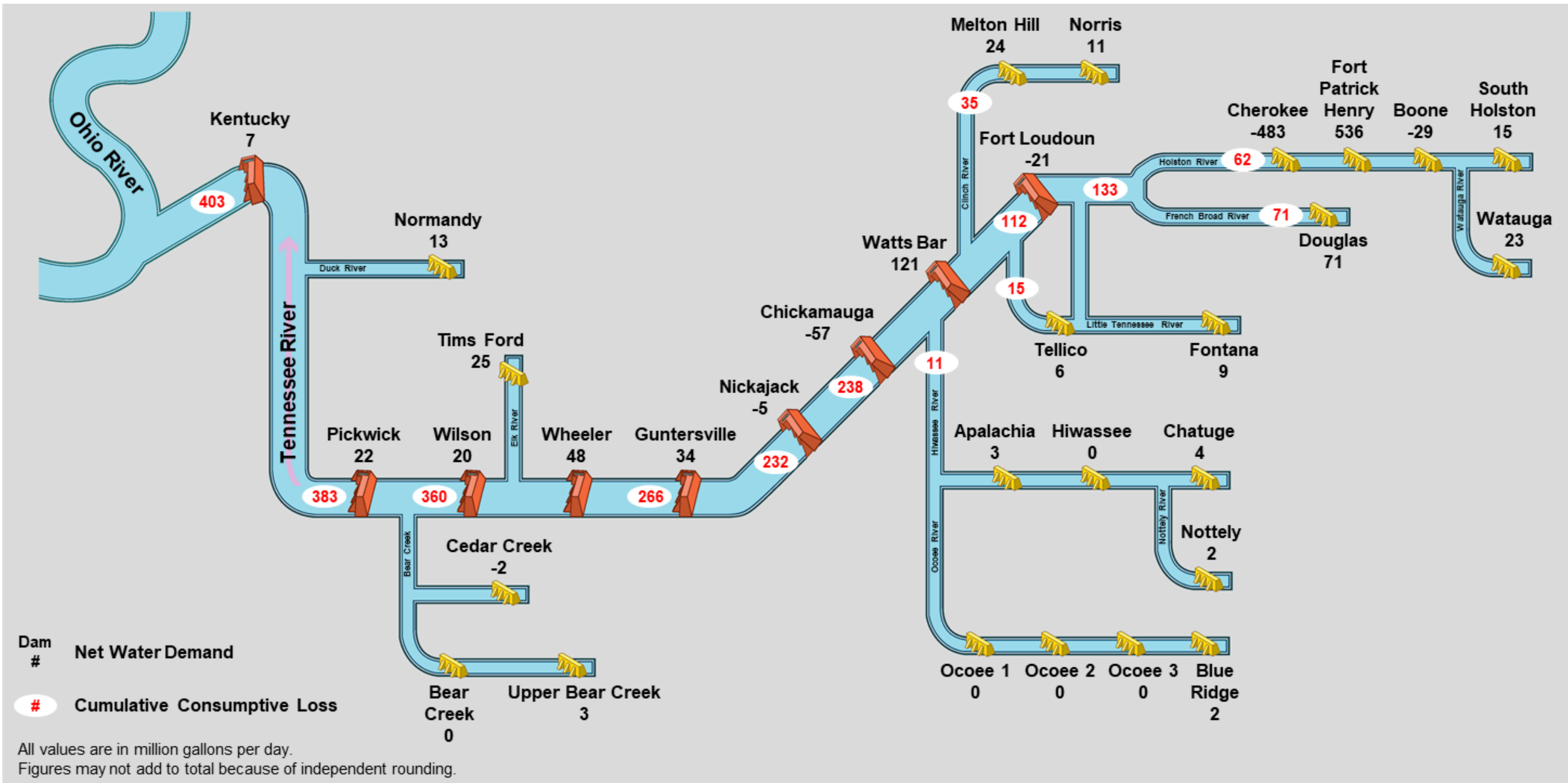

Figure 2-6: Cumulative Net Water Demand for RCAs and WUTAs

Table 2-3: Total Water Use by Category and WUTA in 2020

[Figures may not add to totals because of independent rounding. All values in million gallons per day]

WUTA	Thermoelectric		Industrial		Public Supply		Irrigation	Total	
RCA	Withdrawal	Return	Withdrawal	Return	Withdrawal	Return	Withdrawal	Withdrawal	Return
Holston									
Watauga	0.00	0.00	0.90	0.89	22.77	2.34	2.29	25.96	3.23
South Holston	0.00	0.00	3.16	1.93	19.87	6.22	0.34	23.37	8.15
Boone	0.00	0.00	0.19	0.00	0.00	29.78	0.34	0.53	29.78
Ft Patrick Henry	0.00	0.00	523.55	0.00	16.00	3.42	0.02	539.58	3.42
Cherokee	7.85	0.92	64.70	558.61	23.83	20.50	0.60	96.98	580.04
WUTA total	**7.85**	**0.92**	**592.50**	**561.43**	**82.47**	**62.26**	**3.59**	**686.41**	**624.61**
Cumulative	*8*	*1*	*592*	*561*	*82*	*62*	*4*	*686*	*625*
French Broad									
Douglas	78.16	78.07	66.52	53.14	84.16	51.11	24.46	253.30	182.32
WUTA total	**78.16**	**78.07**	**66.52**	**53.14**	**84.16**	**51.11**	**24.46**	**253.30**	**182.32**
Cumulative	*86*	*79*	*659*	*615*	*167*	*113*	*28*	*940*	*807*
Fort Loudoun									
Fort Loudoun	0.00	0.00	15.19	27.79	66.08	75.31	1.21	82.48	103.10
WUTA total	**0.00**	**0.00**	**15.19**	**27.79**	**66.08**	**75.31**	**1.21**	**82.48**	**103.10**
Cumulative	*86*	*79*	*674*	*642*	*233*	*189*	*29*	*1,022*	*910*
Little Tennessee									
Fontana	0.00	0.00	22.35	21.33	10.65	6.79	4.16	37.16	28.11
Tellico	0.00	0.00	4.80	5.64	8.74	2.17	0.30	13.84	7.81
WUTA total	**0.00**	**0.00**	**27.15**	**26.96**	**19.39**	**8.95**	**4.46**	**51.00**	**35.92**
Cumulative	*86*	*79*	*701*	*669*	*252*	*198*	*34*	*1,073*	*946*
Clinch									
Norris	6.04	1.42	0.77	0.26	21.07	16.25	0.75	28.63	17.92
Melton Hill	548.77	535.17	0.00	2.06	25.62	13.53	0.57	574.96	550.76
WUTA total	**554.81**	**536.59**	**0.77**	**2.31**	**46.69**	**29.78**	**1.32**	**603.59**	**568.68**
Cumulative	*641*	*616*	*702*	*672*	*299*	*227*	*35*	*1,677*	*1,515*
Hiwassee-Ocoee									
Chatuge	0.00	0.00	0.00	0.00	3.99	0.49	0.30	4.28	0.49
Nottely	0.00	0.00	0.00	0.00	1.65	0.35	0.32	1.97	0.35
Hiwassee	0.00	0.00	0.12	0.00	1.54	2.10	0.63	2.29	2.10
Apalachia	0.00	0.00	0.00	0.00	3.43	0.01	0.00	3.43	0.01
Blue Ridge	0.00	0.00	1.96	1.96	1.91	0.00	0.23	4.10	1.96
Ocoee	0.00	0.00	0.00	0.00	0.93	0.94	0.03	0.96	0.94
WUTA total	**0.00**	**0.00**	**2.07**	**1.96**	**13.45**	**3.89**	**1.51**	**17.03**	**5.85**
Cumulative	*641*	*616*	*704*	*674*	*312*	*231*	*37*	*1,694*	*1,520*
Watts Bar-Chickamauga									
Watts Bar	930.86	806.68	6.49	5.66	23.27	29.04	1.64	962.26	841.39
Chickamauga	1,669.94	1,758.90	47.45	45.06	48.64	21.47	2.71	1,768.74	1,825.43
WUTA total	**2,600.81**	**2,565.58**	**53.94**	**50.72**	**71.91**	**50.51**	**4.35**	**2,731.00**	**2,666.82**
Cumulative	*3,242*	*3,181*	*758*	*724*	*384*	*282*	*41*	*4,425*	*4,187*

Table 2-3: Total Water Use by Category and WUTA in 2020 (continued)

[Figures may not add to totals because of independent rounding. All values in million gallons per day]

WUTA	Thermoelectric		Industrial		Public Supply		Irrigation	Total	
RCA	Withdrawal	Return	Withdrawal	Return	Withdrawal	Return	Withdrawal	Withdrawal	Return
Nickajack									
Nickajack	0.00	0.00	9.29	8.62	36.77	46.13	3.43	49.48	54.75
WUTA total	**0.00**	**0.00**	**9.29**	**8.62**	**36.77**	**46.13**	**3.43**	**49.48**	**54.75**
Cumulative	*3,242*	*3,181*	*767*	*733*	*421*	*328*	*44*	*4,474*	*4,242*
Guntersville									
Guntersville	0.23	0.00	9.88	7.86	53.84	25.34	2.79	66.74	33.20
WUTA total	**0.23**	**0.00**	**9.88**	**7.86**	**53.84**	**25.34**	**2.79**	**66.74**	**33.20**
Cumulative	*3,242*	*3,181*	*777*	*741*	*475*	*353*	*47*	*4,541*	*4,275*
Elk									
Tims Ford	0.00	0.00	27.00	0.00	2.71	5.52	0.76	30.47	5.52
WUTA total	**0.00**	**0.00**	**27.00**	**0.00**	**2.71**	**5.52**	**0.76**	**30.47**	**5.52**
Cumulative	*3,242*	*3,181*	*804*	*741*	*477*	*359*	*48*	*4,572*	*4,281*
Wheeler-Wilson									
Wheeler	3,294.22	3,282.01	96.82	108.10	118.53	98.58	27.59	3,537.15	3,488.69
Wilson	0.00	0.00	8.43	0.00	14.44	5.33	2.89	25.76	5.33
WUTA total	**3,294.22**	**3,282.01**	**105.25**	**108.10**	**132.97**	**103.92**	**30.48**	**3,562.91**	**3,494.02**
Cumulative	*6,536*	*6,463*	*910*	*849*	*610*	*463*	*78*	*8,134*	*7,775*
Pickwick-Bear									
Pickwick	0.25	0.00	48.46	31.12	18.14	16.76	3.44	70.29	47.88
Cedar Creek	0.00	0.00	0.00	0.00	3.93	5.58	0.00	3.93	5.58
Upper Bear Creek	0.00	0.00	0.00	0.00	2.78	0.00	0.00	2.78	0.00
Bear Creek	0.00	0.00	0.00	0.00	0.72	0.79	0.00	0.72	0.79
WUTA total	**0.25**	**0.00**	**48.46**	**31.12**	**25.58**	**23.12**	**3.44**	**77.73**	**54.24**
Cumulative	*6,536*	*6,463*	*958*	*880*	*636*	*486*	*82*	*8,212*	*7,829*
Duck									
Normandy	0.00	0.00	2.59	16.42	28.38	2.94	0.93	31.90	19.36
WUTA total	**0.00**	**0.00**	**2.59**	**16.42**	**28.38**	**2.94**	**0.93**	**31.90**	**19.36**
Cumulative	*6,536*	*6,463*	*961*	*896*	*664*	*489*	*83*	*8,244*	*7,848*
Kentucky									
Kentucky	0.00	0.00	82.44	83.48	30.61	33.17	11.07	124.12	116.65
WUTA total	**0.00**	**0.00**	**82.44**	**83.48**	**30.61**	**33.17**	**11.07**	**124.12**	**116.65**
Cumulative	*6,536*	*6,463*	*1,043*	*980*	*695*	*522*	*94*	*8,368*	*7,965*

Table 2-4: Surface Water Withdrawals by Category and WUTA in 2020

[Figures may not add to totals because of independent rounding. All values in million gallons per day]

WUTA RCA	Thermoelectric	Industrial	Public Supply	Irrigation	Total Withdrawals
Holston					
Watauga	0.00	0.90	15.41	2.12	18.43
South Holston	0.00	3.16	14.16	0.25	17.57
Boone	0.00	0.01	0.00	0.16	0.17
Ft Patrick Henry	0.00	523.55	16.00	0.02	539.58
Cherokee	7.85	59.79	21.07	0.28	88.99
WUTA total	**7.85**	**587.41**	**66.64**	**2.84**	**664.74**
Cumulative	*8*	*587*	*67*	*3*	*665*
French Broad					
Douglas	78.16	63.86	70.26	19.75	232.03
WUTA total	**78.16**	**63.86**	**70.26**	**19.75**	**232.03**
Cumulative	*86*	*651*	*137*	*23*	*897*
Fort Loudoun					
Fort Loudoun	0.00	9.30	66.01	0.69	75.99
WUTA total	**0.00**	**9.30**	**66.01**	**0.69**	**75.99**
Cumulative	*86*	*661*	*203*	*23*	*973*
Little Tennessee					
Fontana	0.00	22.25	6.03	4.01	32.29
Tellico	0.00	4.80	7.99	0.14	12.93
WUTA total	**0.00**	**27.05**	**14.03**	**4.15**	**45.22**
Cumulative	*86*	*688*	*217*	*27*	*1,018*
Clinch					
Norris	6.04	0.75	19.31	0.65	26.76
Melton Hill	548.77	0.00	25.62	0.46	574.84
WUTA total	**554.81**	**0.75**	**44.93**	**1.11**	**601.60**
Cumulative	*641*	*688*	*262*	*29*	*1,620*
Hiwassee-Ocoee					
Chatuge	0.00	0.00	2.13	0.28	2.42
Nottely	0.00	0.00	1.11	0.32	1.43
Hiwassee	0.00	0.08	0.62	0.47	1.17
Apalachia	0.00	0.00	3.43	0.00	3.43
Blue Ridge	0.00	1.96	1.77	0.22	3.95
Ocoee	0.00	0.00	0.53	0.01	0.54
WUTA total	**0.00**	**2.03**	**9.60**	**1.31**	**12.94**
Cumulative	*641*	*690*	*271*	*30*	*1,633*
Watts Bar-Chickamauga					
Watts Bar	930.86	6.49	22.81	1.33	961.50
Chickamauga	1,669.94	46.43	27.19	1.65	1,745.21
WUTA total	**2,600.81**	**52.92**	**50.00**	**2.98**	**2,706.71**
Cumulative	*3,242*	*743*	*321*	*33*	*4,339*

Table 2-4: Surface Water Withdrawals by Category and WUTA in 2020 (continued)

[Figures may not add to totals because of independent rounding. All values in million gallons per day]

WUTA RCA	Thermoelectric	Industrial	Public Supply	Irrigation	Total Withdrawals
Nickajack					
Nickajack	0.00	4.37	36.67	2.03	43.07
WUTA total	**0.00**	**4.37**	**36.67**	**2.03**	**43.07**
Cumulative	*3,242*	*748*	*358*	*35*	*4,382*
Guntersville					
Guntersville	0.23	9.88	49.34	1.97	61.43
WUTA total	**0.23**	**9.88**	**49.34**	**1.97**	**61.43**
Cumulative	*3,242*	*758*	*407*	*37*	*4,444*
Elk					
Tims Ford	0.00	26.71	2.58	0.18	29.47
WUTA total	**0.00**	**26.71**	**2.58**	**0.18**	**29.47**
Cumulative	*3,242*	*784*	*410*	*37*	*4,473*
Wheeler-Wilson					
Wheeler	3,294.22	96.81	87.65	17.18	3,495.86
Wilson	0.00	8.43	13.53	2.30	24.26
WUTA total	**3,294.22**	**105.24**	**101.17**	**19.49**	**3,520.12**
Cumulative	*6,536*	*890*	*511*	*56*	*7,993*
Pickwick-Bear					
Pickwick	0.25	48.44	12.41	2.60	63.69
Cedar Creek	0.00	0.00	3.60	0.00	3.60
Upper Bear Creek	0.00	0.00	2.78	0.00	2.78
Bear Creek	0.00	0.00	0.72	0.00	0.72
WUTA total	**0.25**	**48.44**	**19.51**	**2.60**	**70.80**
Cumulative	*6,536*	*938*	*531*	*59*	*8,064*
Duck					
Normandy	0.00	2.20	28.38	0.23	30.81
WUTA total	**0.00**	**2.20**	**28.38**	**0.23**	**30.81**
Cumulative	*6,536*	*940*	*559*	*59*	*8,095*
Kentucky					
Kentucky	0.00	65.03	13.50	8.95	87.47
WUTA total	**0.00**	**65.03**	**13.50**	**8.95**	**87.47**
Cumulative	*6,536*	*1,005*	*573*	*68*	*8,182*

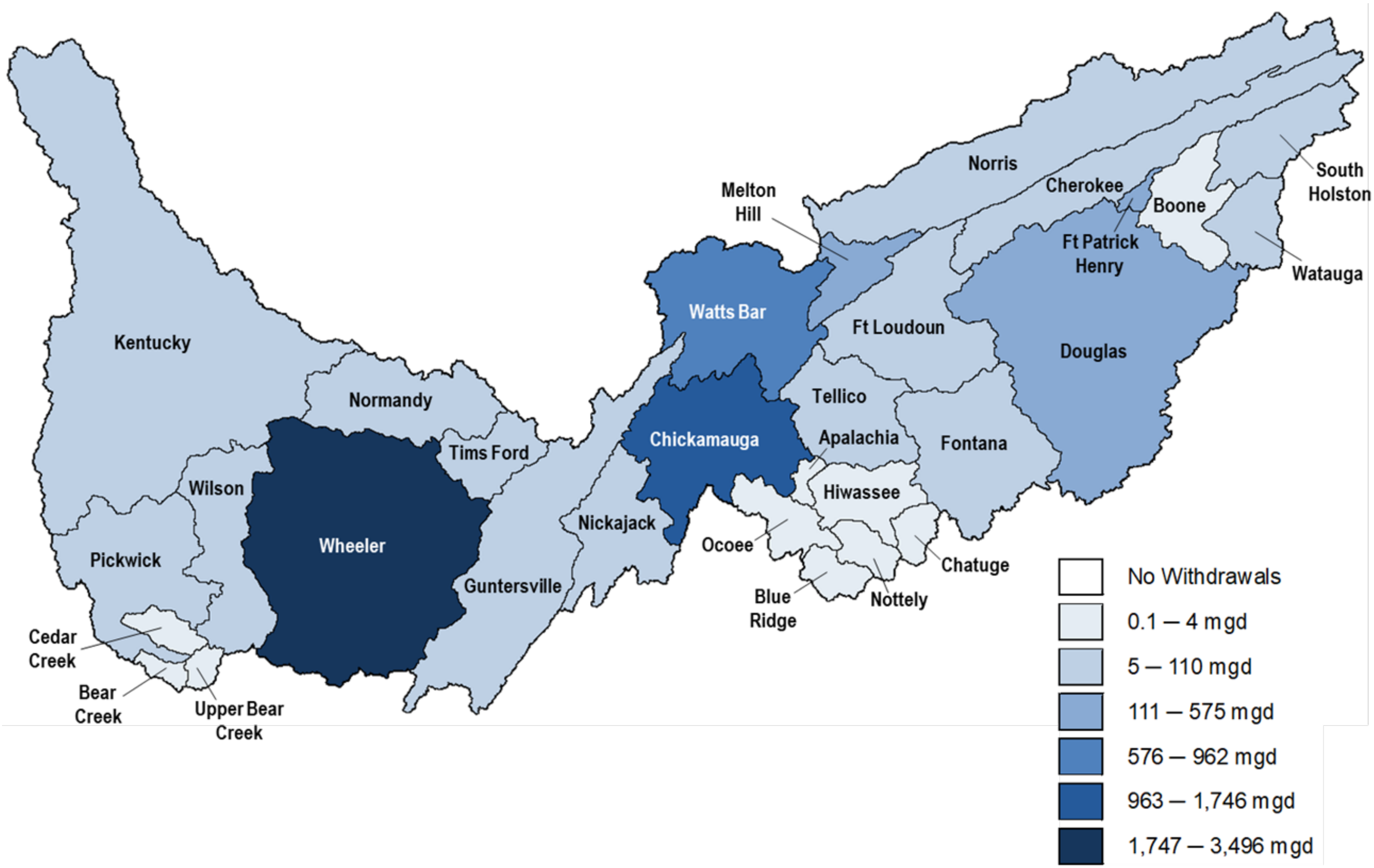

Figure 2-7: Total Surface Water Withdrawal by RCA in 2020

Table 2-5: Groundwater Withdrawals by Category and WUTA in 2020

[Figures may not add to totals because of independent rounding. All values in million gallons per day]

WUTA RCA	Industrial	Public Supply	Irrigation	Total Withdrawals
Holston				
Watauga	0.00	7.36	0.16	7.52
South Holston	0.00	5.71	0.08	5.80
Boone	0.17	0.00	0.18	0.35
Ft Patrick Henry				0.00
Cherokee	4.91	2.76	0.32	7.99
WUTA total	**5.08**	**15.83**	**0.75**	**21.67**
Cumulative	*5*	*16*	*1*	*22*
French Broad				
Douglas	2.66	13.90	4.71	21.27
WUTA total	**2.66**	**13.90**	**4.71**	**21.27**
Cumulative	*8*	*30*	*5*	*43*
Fort Loudoun				
Fort Loudoun	5.89	0.07	0.52	6.49
WUTA total	**5.89**	**0.07**	**0.52**	**6.49**
Cumulative	*14*	*30*	*6*	*49*
Little Tennessee				
Fontana	0.11	4.62	0.14	4.87
Tellico	0.00	0.75	0.16	0.91
WUTA total	**0.11**	**5.37**	**0.31**	**5.78**
Cumulative	*14*	*35*	*6*	*55*
Clinch				
Norris	0.02	1.76	0.10	1.88
Melton Hill	0.00	0.00	0.12	0.12
WUTA total	**0.02**	**1.76**	**0.21**	**1.99**
Cumulative	*14*	*37*	*7*	*57*
Hiwassee-Ocoee				
Chatuge	0.00	1.85	0.01	1.87
Nottely	0.00	0.54	0.00	0.54
Hiwassee	0.04	0.92	0.16	1.12
Apalachia				0.00
Blue Ridge	0.00	0.14	0.01	0.15
Ocoee	0.00	0.40	0.02	0.42
WUTA total	**0.04**	**3.85**	**0.20**	**4.09**
Cumulative	*14*	*41*	*7*	*61*
Watts Bar-Chickamauga				
Watts Bar	0.00	0.46	0.30	0.76
Chickamauga	1.01	21.45	1.06	23.53
WUTA total	**1.02**	**21.91**	**1.36**	**24.29**
Cumulative	*15*	*63*	*8*	*86*

Table 2-5: Groundwater Withdrawals by Category and WUTA in 2020 (continued)

[Figures may not add to totals because of independent rounding. All values in million gallons per day]

WUTA RCA	Industrial	Public Supply	Irrigation	Total Withdrawals
Nickajack				
Nickajack	4.92	0.10	1.39	6.41
WUTA total	**4.92**	**0.10**	**1.39**	**6.41**
Cumulative	*20*	*63*	*9*	*92*
Guntersville				
Guntersville	0.00	4.49	0.82	5.31
WUTA total	**0.00**	**4.49**	**0.82**	**5.31**
Cumulative	*20*	*67*	*10*	*97*
Elk				
Tims Ford	0.29	0.13	0.58	0.99
WUTA total	**0.29**	**0.13**	**0.58**	**0.99**
Cumulative	*20*	*67*	*11*	*98*
Wheeler-Wilson				
Wheeler	0.00	30.88	10.41	41.30
Wilson	0.00	0.91	0.59	1.50
WUTA total	**0.00**	**31.80**	**10.99**	**42.79**
Cumulative	*20*	*99*	*22*	*141*
Pickwick-Bear				
Pickwick	0.02	5.73	0.84	6.59
Cedar Creek	0.00	0.33	0.00	0.33
Upper Bear Creek				0.00
Bear Creek				0.00
WUTA total	**0.02**	**6.07**	**0.84**	**6.93**
Cumulative	*20*	*105*	*23*	*148*
Duck				
Normandy	0.39	0.01	0.70	1.09
WUTA total	**0.39**	**0.01**	**0.70**	**1.09**
Cumulative	*20*	*105*	*23*	*149*
Kentucky				
Kentucky	17.41	17.12	2.12	36.64
WUTA total	**17.41**	**17.12**	**2.12**	**36.64**
Cumulative	*38*	*122*	*26*	*186*

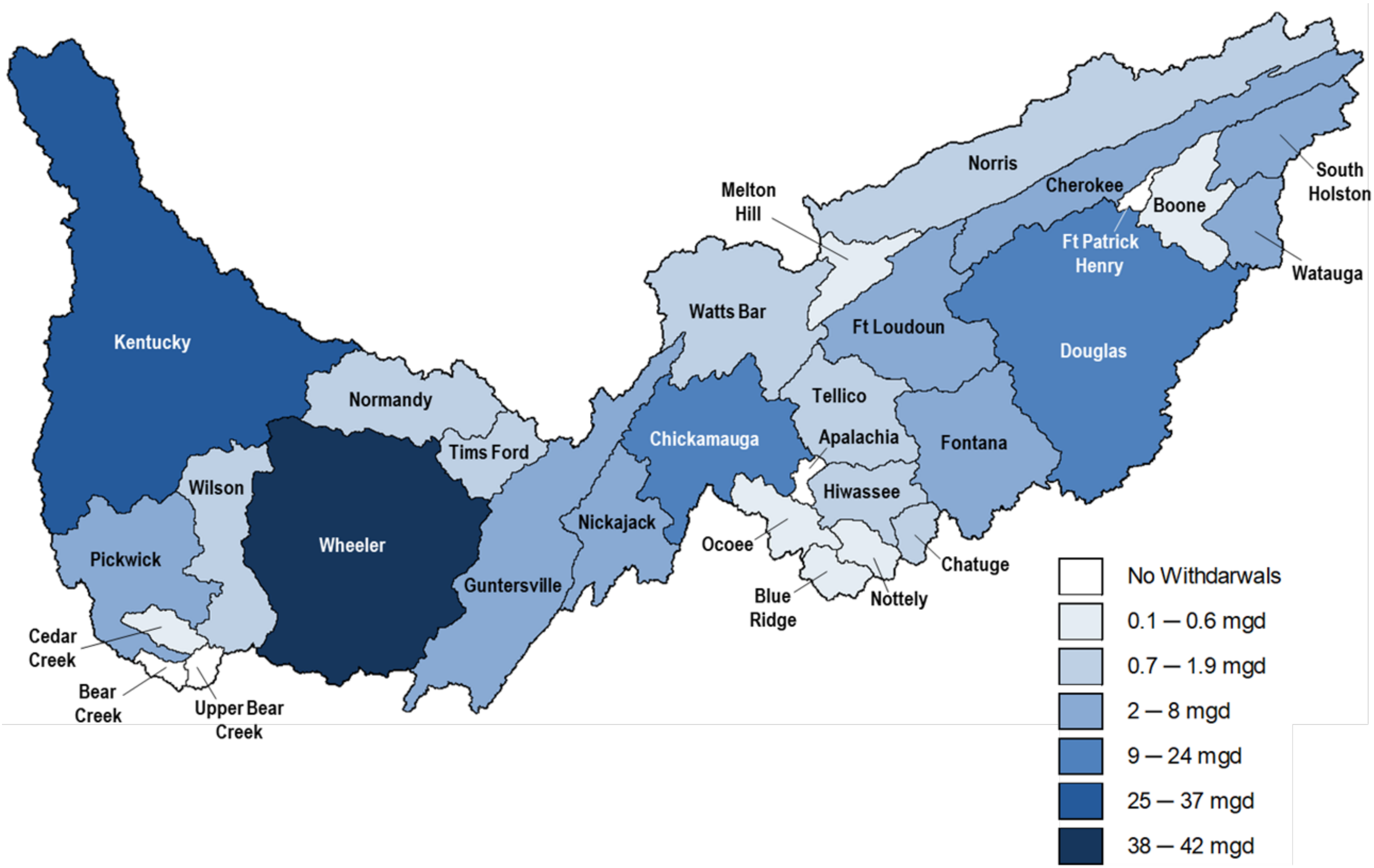

Figure 2-8: Total Groundwater Withdrawal by RCA in 2020

Table 2-6: Thermoelectric Power Withdrawals by WUTA in 2020

[Figures may not add to totals because of independent rounding. All values in million gallons per day]

WUTA RCA	Surface Water Withdrawals	Return Flow	Net Water Demand	Power Generated (million KWh)
Holston				
Cherokee	7.85	0.92	6.93	5,017
WUTA total	**7.85**	**0.92**	**6.93**	**5,017**
Cumulative	*8*	*1*	*7*	*5,017*
French Broad				
Douglas	78.16	78.07	0.09	2,975
WUTA total	**78.16**	**78.07**	**0.09**	**2,975**
Cumulative	*86*	*79*	*7*	*7,992*
Clinch				
Norris	6.04	1.42	4.63	271
Melton Hill	548.77	535.17	13.59	1,286
WUTA total	**554.81**	**536.59**	**18.22**	**1,557**
Cumulative	*641*	*616*	*25*	*9,550*
Watts Bar-Chickamauga				
Watts Bar	930.86	806.68	124.18	20,503
Chickamauga	1,669.94	1,758.90	-88.96	19,099
WUTA total	**2,600.81**	**2,565.58**	**35.22**	**39,602**
Cumulative	*3,242*	*3,181*	*60*	*49,151*
Guntersville				
Guntersville	0.23	0.00	0.23	0
WUTA total	**0.23**	**0.00**	**0.23**	**0**
Cumulative	*3,242*	*3,181*	*61*	*49,151*
Wheeler-Wilson				
Wheeler	3,294.22	3,282.01	12.21	33,105
WUTA total	**3,294.22**	**3,282.01**	**12.21**	**33,105**
Cumulative	*6,536*	*6,463*	*73*	*82,257*
Pickwick-Bear				
Pickwick	0.25	0.00	0.25	0
WUTA total	**0.25**	**0.00**	**0.25**	**0**
Cumulative	*6,536*	*6,463*	*73*	*82,257*

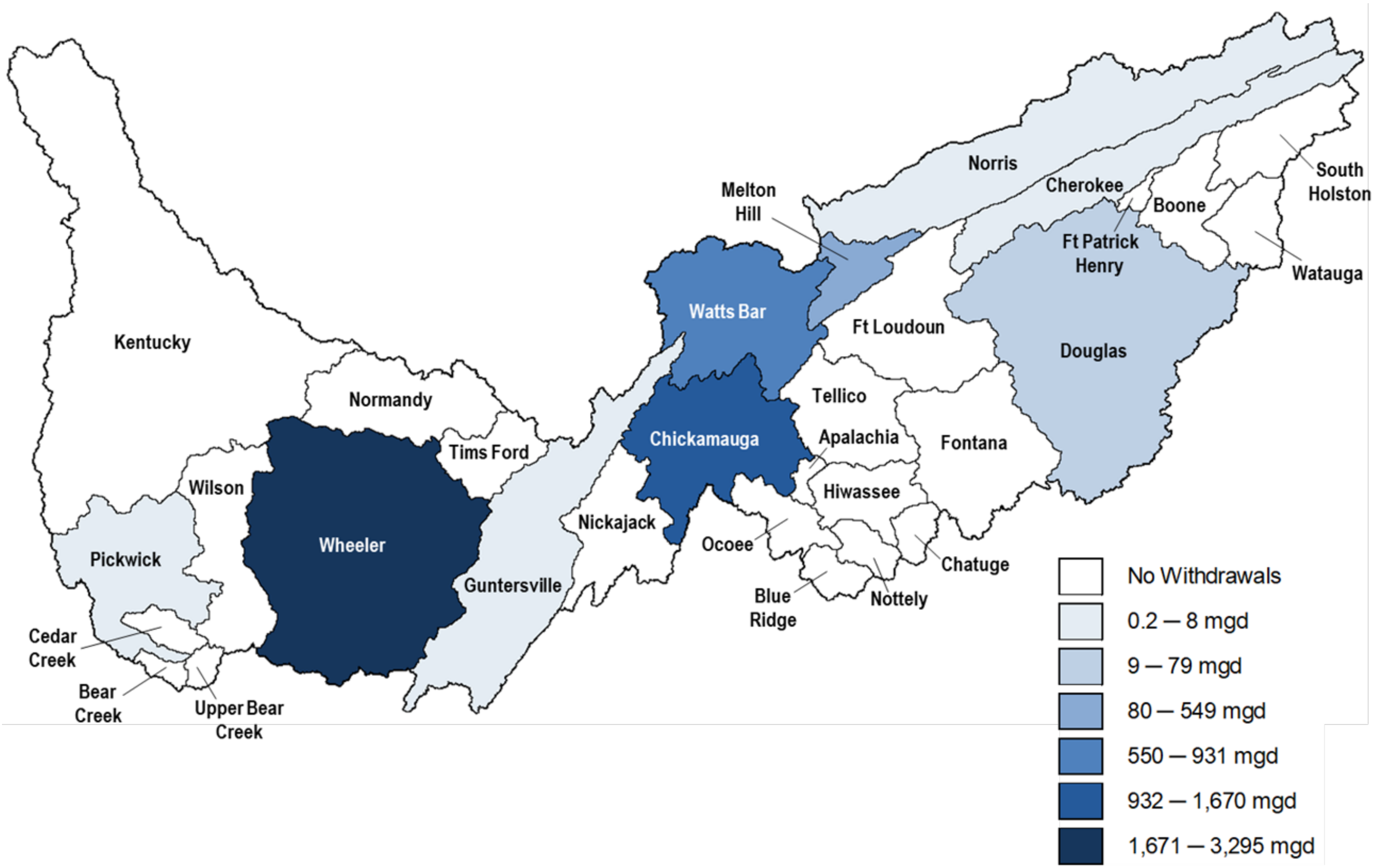

Figure 2-9: Thermoelectric Withdrawal by RCA in 2020

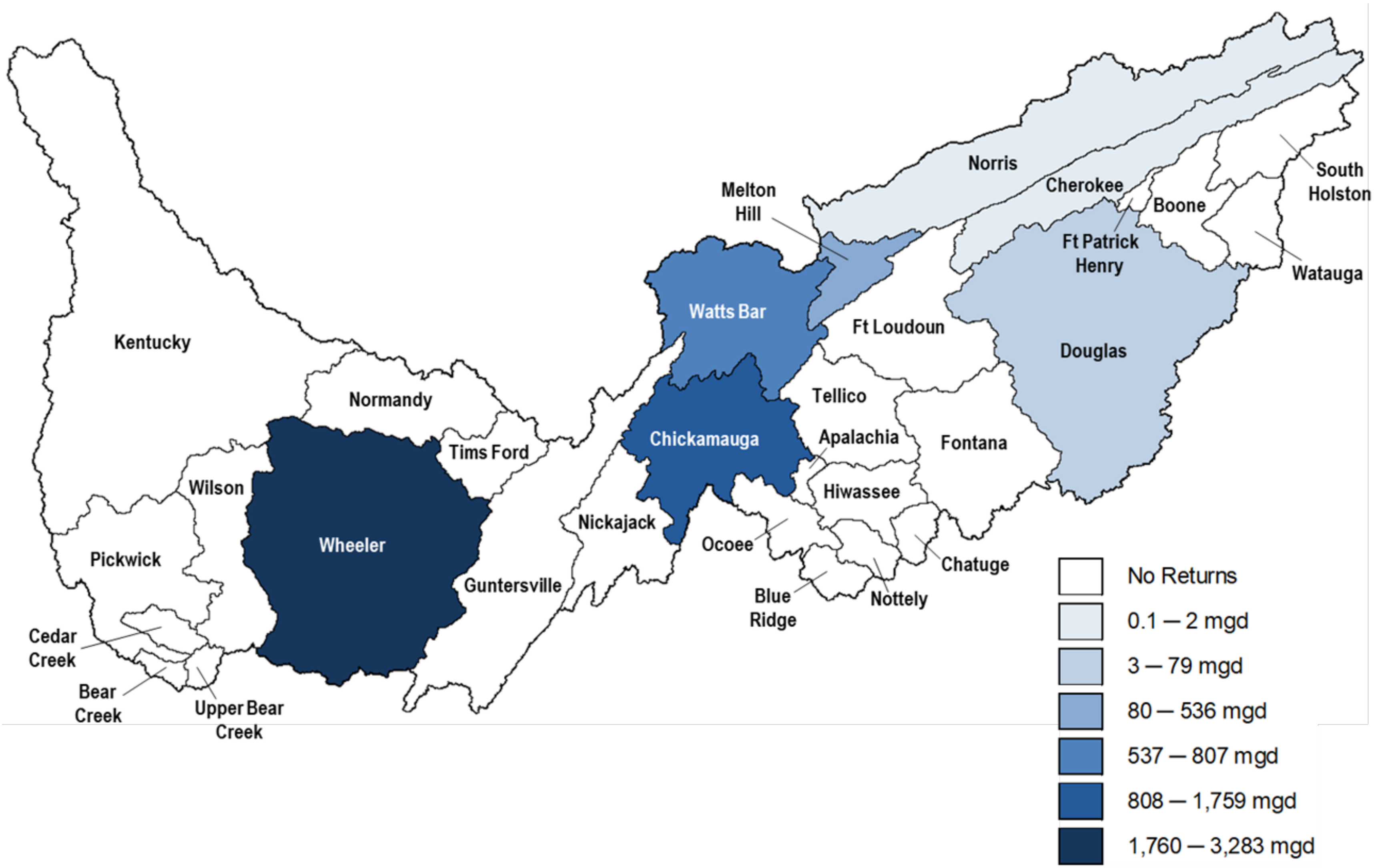

Figure 2-10: Thermoelectric Return by RCA in 2020

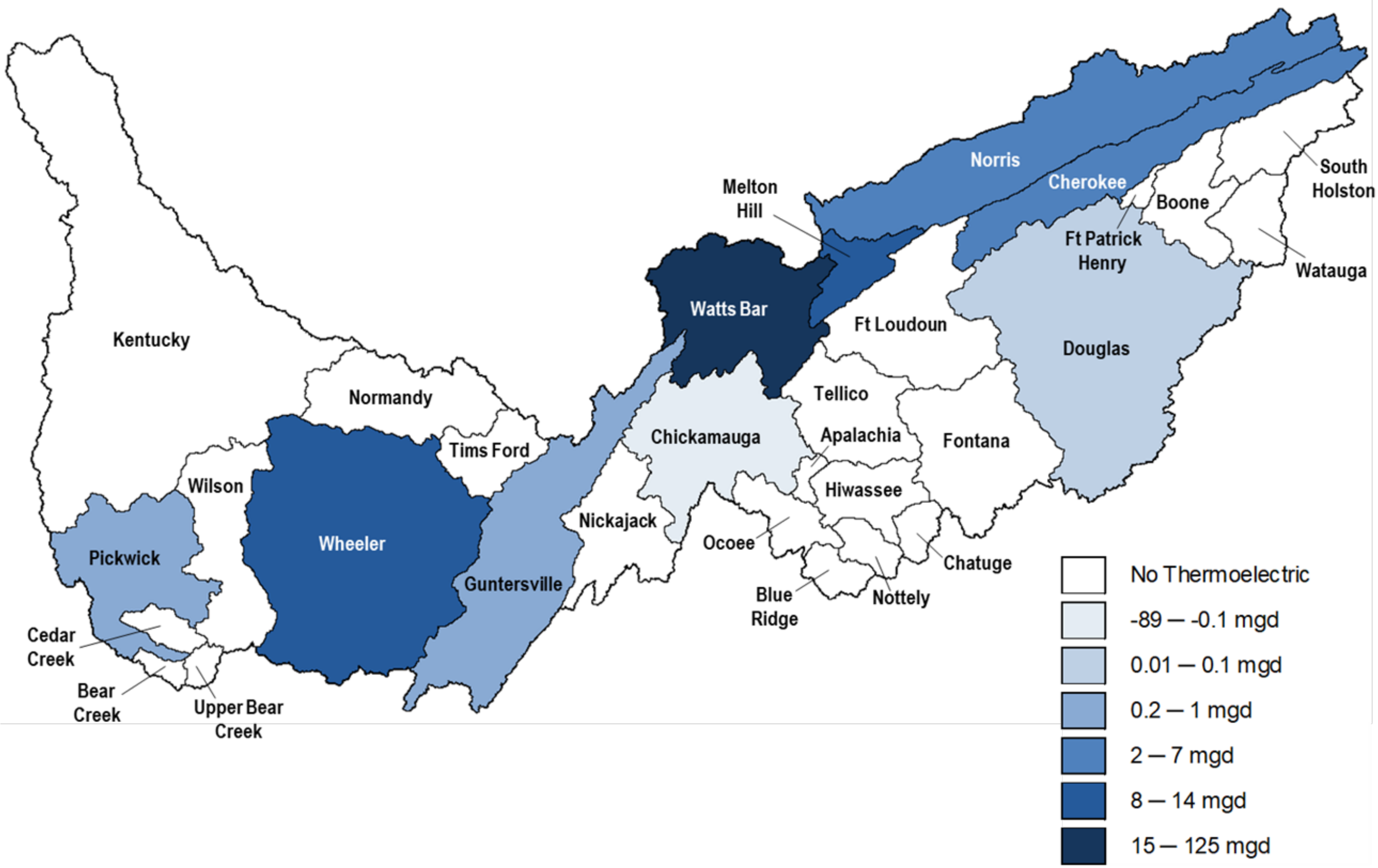

Figure 2-11: Thermoelectric Net Demand by RCA in 2020

Figure 2-12: Location of Thermoelectric Power Plants in the Tennessee River Watershed

Table 2-7: Industrial Withdrawals by Source and WUTA in 2020

[Figures may not add to totals because of independent rounding. All values in million gallons per day]

WUTA RCA	**Groundwater Withdrawals**	**Surface Water Withdrawals**	**Total Withdrawals**	**Total Return Flow**	**Net Water Demand**
Holston					
Watauga	0.00	0.90	0.90	0.89	0.01
South Holston	0.00	3.16	3.16	1.93	1.23
Boone	0.17	0.01	0.19	0.00	0.19
Ft Patrick Henry	0.00	523.55	523.55	0.00	523.55
Cherokee	4.91	59.79	64.70	558.61	-493.92
WUTA total	**5.08**	**587.41**	**592.50**	**561.43**	**31.07**
Cumulative	*5*	*587*	*592*	*561*	*31*
French Broad					
Douglas	2.66	63.86	66.52	53.14	13.38
WUTA total	**2.66**	**63.86**	**66.52**	**53.14**	**13.38**
Cumulative	*8*	*651*	*659*	*615*	*44*
Fort Loudoun					
Fort Loudoun	5.89	9.30	15.19	27.79	-12.60
WUTA total	**5.89**	**9.30**	**15.19**	**27.79**	**-12.60**
Cumulative	*14*	*661*	*674*	*642*	*32*
Little Tennessee					
Fontana	0.11	22.25	22.35	21.33	1.03
Tellico	0.00	4.80	4.80	5.64	-0.84
WUTA total	**0.11**	**27.05**	**27.15**	**26.96**	**0.19**
Cumulative	*14*	*688*	*701*	*669*	*32*
Clinch					
Norris	0.02	0.75	0.77	0.26	0.51
Melton Hill	0.00	0.00	0.00	2.06	-2.05
WUTA total	**0.02**	**0.75**	**0.77**	**2.31**	**-1.54**
Cumulative	*14*	*688*	*702*	*672*	*30*
Hiwassee-Ocoee					
Chatuge			0		0.00
Nottely	0.00	0.00	0.00	0.00	0.00
Hiwassee	0.04	0.08	0.12	0.00	0.12
Apalachia			0		0.00
Blue Ridge	0.00	1.96	1.96	1.96	0.00
Ocoee	0.00	0.00	0.00	0.00	0.00
WUTA total	**0.04**	**2.03**	**2.07**	**1.96**	**0.12**
Cumulative	*14*	*690*	*704*	*674*	*31*
Watts Bar-Chickamauga					
Watts Bar	0.00	6.49	6.49	5.66	0.83
Chickamauga	1.01	46.43	47.45	45.06	2.39
WUTA total	**1.02**	**52.92**	**53.94**	**50.72**	**3.22**
Cumulative	*15*	*743*	*758*	*724*	*34*

Table 2-7: Industrial Withdrawals by Source and WUTA in 2020 (continued)

[Figures may not add to totals because of independent rounding. All values in million gallons per day]

WUTA RCA	Groundwater Withdrawals	Surface Water Withdrawals	Total Withdrawals	Total Return Flow	Net Water Demand
Nickajack					
Nickajack	4.92	4.37	9.29	8.62	0.66
WUTA total	**4.92**	**4.37**	**9.29**	**8.62**	**0.66**
Cumulative	*20*	*748*	*767*	*733*	*34*
Guntersville					
Guntersville	0.00	9.88	9.88	7.86	2.02
WUTA total	**0.00**	**9.88**	**9.88**	**7.86**	**2.02**
Cumulative	*20*	*758*	*777*	*741*	*37*
Elk					
Tims Ford	0.29	26.71	27.00	0.00	27.00
WUTA total	**0.29**	**26.71**	**27.00**	**0.00**	**27.00**
Cumulative	*20*	*784*	*804*	*741*	*64*
Wheeler-Wilson					
Wheeler	0.00	96.81	96.82	108.10	-11.29
Wilson	0.00	8.43	8.43	0.00	8.43
WUTA total	**0.00**	**105.24**	**105.25**	**108.10**	**-2.86**
Cumulative	*20*	*890*	*910*	*849*	*61*
Pickwick-Bear					
Pickwick	0.02	48.44	48.46	31.12	17.35
Cedar Creek			0		0.00
Upper Bear Creek			0		0.00
Bear Creek			0		0.00
WUTA total	**0.02**	**48.44**	**48.46**	**31.12**	**17.35**
Cumulative	*20*	*938*	*958*	*880*	*78*
Duck					
Normandy	0.39	2.20	2.59	16.42	-13.83
WUTA total	**0.39**	**2.20**	**2.59**	**16.42**	**-13.83**
Cumulative	*20*	*940*	*961*	*896*	*64*
Kentucky					
Kentucky	17.41	65.03	82.44	83.48	-1.05
WUTA total	**17.41**	**65.03**	**82.44**	**83.48**	**-1.05**
Cumulative	*38*	*1,005*	*1,043*	*980*	*63*

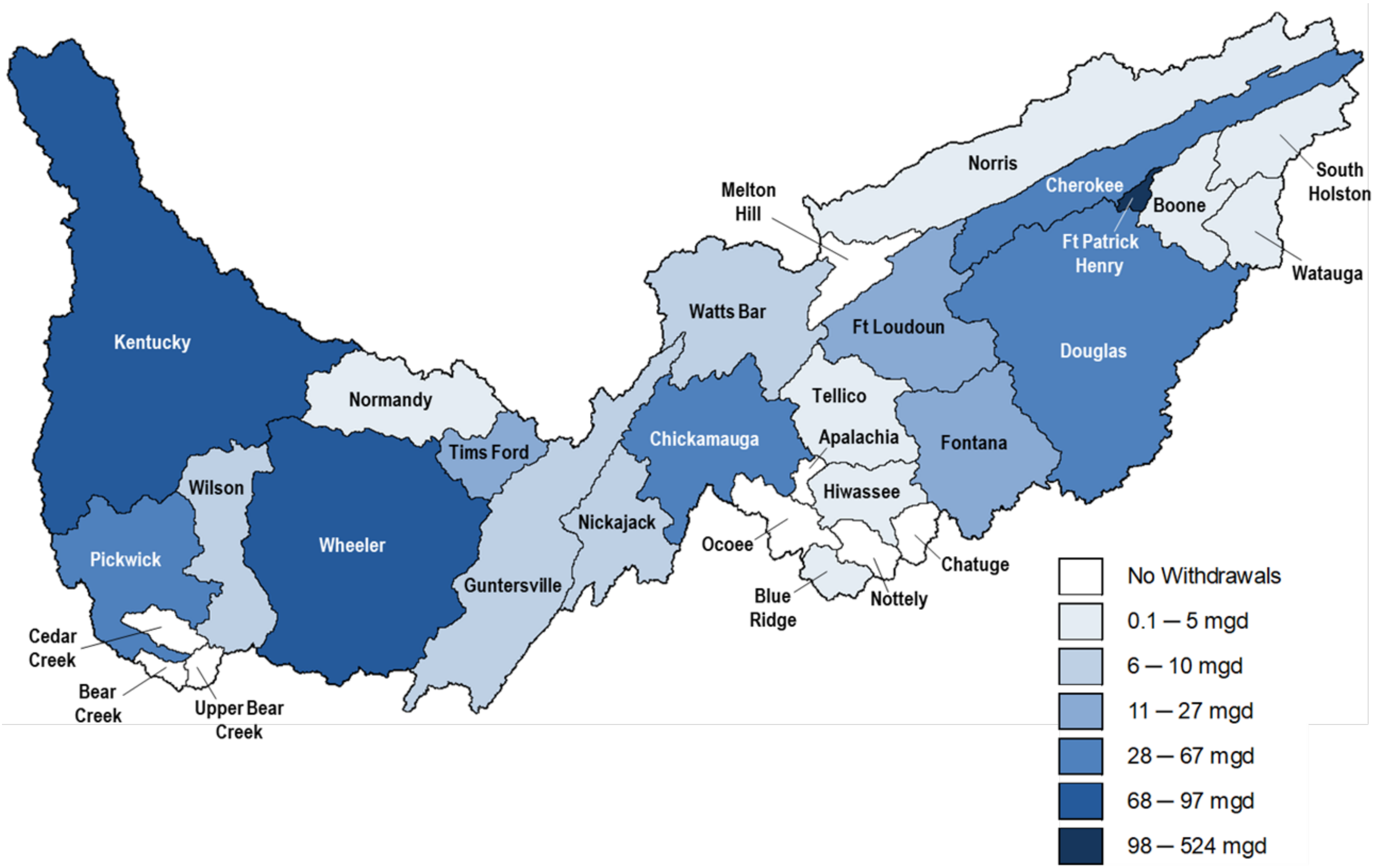

Figure 2-13: Industrial Withdrawal by RCA in 2020

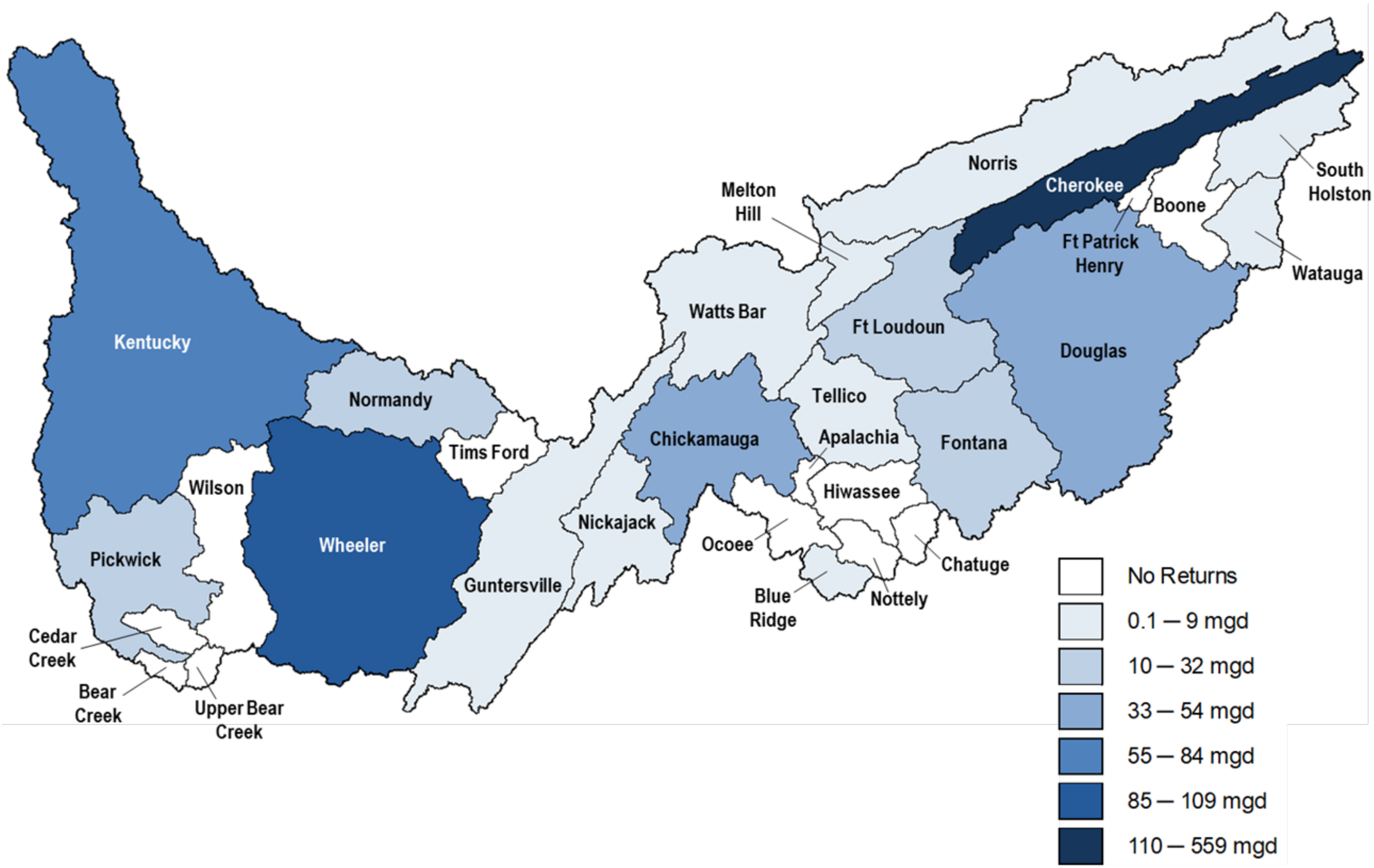

Figure 2-14: Industrial Return by RCA in 2020

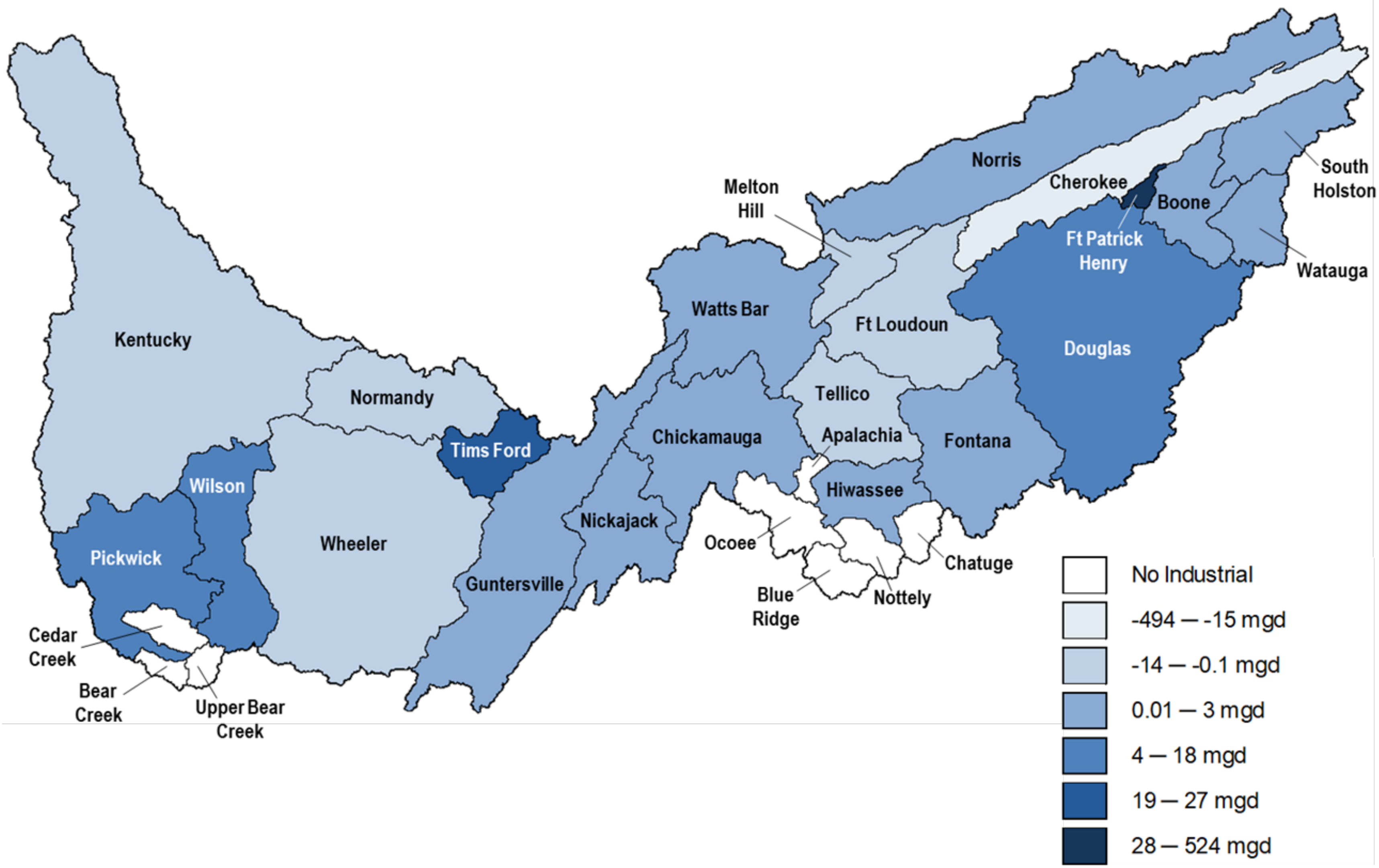

Figure 2-15: Industrial Net Demand by RCA in 2020

Table 2-8: Public Supply Withdrawals by Source and WUTA in 2020

[Figures may not add to totals because of independent rounding. All values in million gallons per day]

WUTA RCA	Groundwater Withdrawals	Surface Water Withdrawals	Total Withdrawals	Total Return Flow	Net Water Demand
Holston					
Watauga	7.36	15.41	22.77	2.34	20.43
South Holston	5.71	14.16	19.87	6.22	13.66
Boone	0.00	0.00	0.00	29.78	-29.78
Ft Patrick Henry	0.00	16.00	16.00	3.42	12.58
Cherokee	2.76	21.07	23.83	20.50	3.32
WUTA total	**15.83**	**66.64**	**82.47**	**62.26**	**20.21**
Cumulative	*16*	*67*	*82*	*62*	*20*
French Broad					
Douglas	13.90	70.26	84.16	51.11	33.05
WUTA total	**13.90**	**70.26**	**84.16**	**51.11**	**33.05**
Cumulative	*30*	*137*	*167*	*113*	*53*
Fort Loudoun					
Fort Loudoun	0.07	66.01	66.08	75.31	-9.23
WUTA total	**0.07**	**66.01**	**66.08**	**75.31**	**-9.23**
Cumulative	*30*	*203*	*233*	*189*	*44*
Little Tennessee					
Fontana	4.62	6.03	10.65	6.79	3.86
Tellico	0.75	7.99	8.74	2.17	6.57
WUTA total	**5.37**	**14.03**	**19.39**	**8.95**	**10.44**
Cumulative	*35*	*217*	*252*	*198*	*54*
Clinch					
Norris	1.76	19.31	21.07	16.25	4.82
Melton Hill	0.00	25.62	25.62	13.53	12.09
WUTA total	**1.76**	**44.93**	**46.69**	**29.78**	**16.91**
Cumulative	*37*	*262*	*299*	*227*	*71*
Hiwassee-Ocoee					
Chatuge	1.85	2.13	3.99	0.49	3.49
Nottely	0.54	1.11	1.65	0.35	1.30
Hiwassee	0.92	0.62	1.54	2.10	-0.55
Apalachia	0.00	3.43	3.43	0.01	3.42
Blue Ridge	0.14	1.77	1.91	0.00	1.91
Ocoee	0.40	0.53	0.93	0.94	-0.01
WUTA total	**3.85**	**9.60**	**13.45**	**3.89**	**9.56**
Cumulative	*41*	*271*	*312*	*231*	*81*
Watts Bar-Chickamauga					
Watts Bar	0.46	22.81	23.27	29.04	-5.78
Chickamauga	21.45	27.19	48.64	21.47	27.18
WUTA total	**21.91**	**50.00**	**71.91**	**50.51**	**21.40**
Cumulative	*63*	*321*	*384*	*282*	*102*

Table 2-8: Public Supply Withdrawals by Source and WUTA in 2020 (continued)

[Figures may not add to totals because of independent rounding. All values in million gallons per day]

WUTA RCA	Groundwater Withdrawals	Surface Water Withdrawals	Total Withdrawals	Total Return Flow	Net Water Demand
Nickajack					
Nickajack	0.10	36.67	36.77	46.13	-9.36
WUTA total	**0.10**	**36.67**	**36.77**	**46.13**	**-9.36**
Cumulative	*63*	*358*	*421*	*328*	*93*
Guntersville					
Guntersville	4.49	49.34	53.84	25.34	28.50
WUTA total	**4.49**	**49.34**	**53.84**	**25.34**	**28.50**
Cumulative	*67*	*407*	*475*	*353*	*121*
Elk					
Tims Ford	0.13	2.58	2.71	5.52	-2.81
WUTA total	**0.13**	**2.58**	**2.71**	**5.52**	**-2.81**
Cumulative	*67*	*410*	*477*	*359*	*119*
Wheeler-Wilson					
Wheeler	30.88	87.65	118.53	98.58	19.95
Wilson	0.91	13.53	14.44	5.33	9.10
WUTA total	**31.80**	**101.17**	**132.97**	**103.92**	**29.05**
Cumulative	*99*	*511*	*610*	*463*	*148*
Pickwick-Bear					
Pickwick	5.73	12.41	18.14	16.76	1.38
Cedar Creek	0.33	3.60	3.93	5.58	-1.65
Upper Bear Creek	0.00	2.78	2.78	0.00	2.78
Bear Creek	0.00	0.72	0.72	0.79	-0.07
WUTA total	**6.07**	**19.51**	**25.58**	**23.12**	**2.45**
Cumulative	*105*	*531*	*636*	*486*	*150*
Duck					
Normandy	0.01	28.38	28.38	2.94	25.45
WUTA total	**0.01**	**28.38**	**28.38**	**2.94**	**25.45**
Cumulative	*105*	*559*	*664*	*489*	*176*
Kentucky					
Kentucky	17.12	13.50	30.61	33.17	-2.56
WUTA total	**17.12**	**13.50**	**30.61**	**33.17**	**-2.56**
Cumulative	*122*	*573*	*695*	*522*	*173*

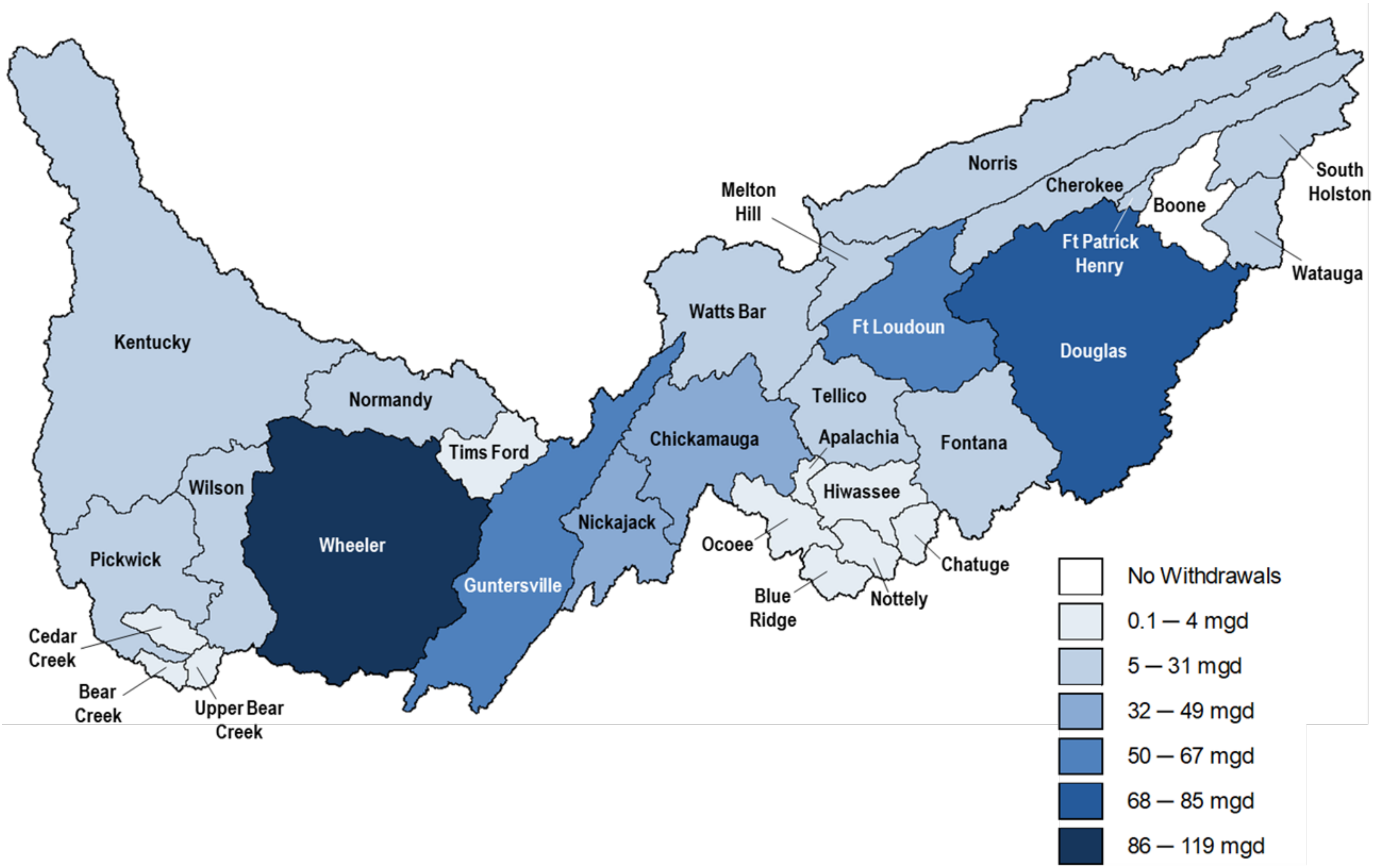

Figure 2-16: Public Supply Withdrawal by RCA in 2020

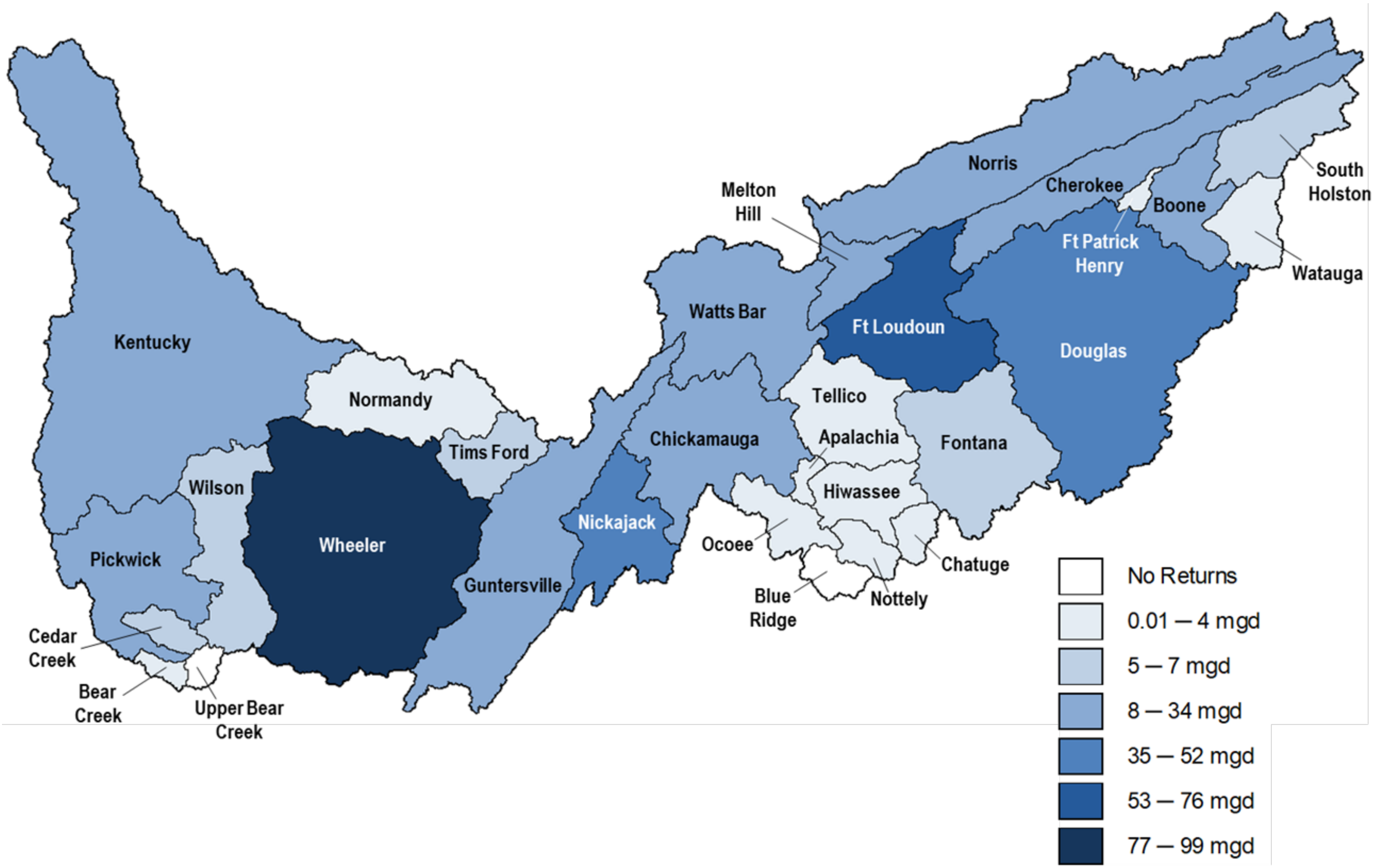

Figure 2-17: Public Supply Return by RCA in 2020

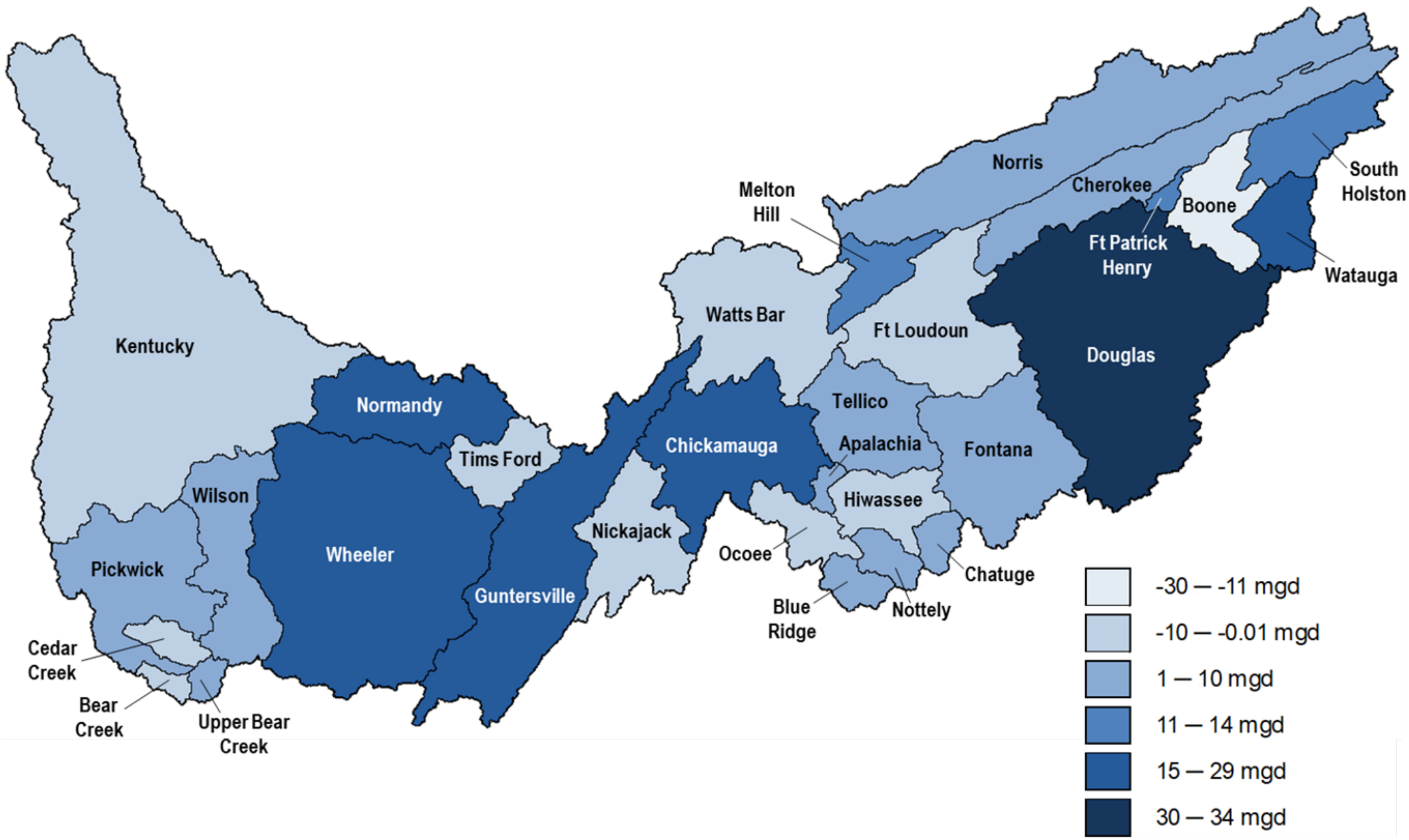

Figure 2-18: Public Supply Net Demand by RCA in 2020

Table 2-9: Irrigation Withdrawals by Source and WUTA in 2020

[Figures may not add to totals because of independent rounding. All values in million gallons per day]

WUTA RCA	Groundwater Withdrawals	Surface Water Withdrawals	Total Withdrawals
Holston			
Watauga	0.16	2.12	2.29
South Holston	0.08	0.25	0.34
Boone	0.18	0.16	0.34
Ft Patrick Henry	0.00	0.02	0.02
Cherokee	0.32	0.28	0.60
WUTA total	**0.75**	**2.84**	**3.59**
Cumulative	*1*	*3*	*4*
French Broad			
Douglas	4.71	19.75	24.46
WUTA total	**4.71**	**19.75**	**24.46**
Cumulative	*5*	*23*	*28*
Fort Loudoun			
Fort Loudoun	0.52	0.69	1.21
WUTA total	**0.52**	**0.69**	**1.21**
Cumulative	*6*	*23*	*29*
Little Tennessee			
Fontana	0.14	4.01	4.16
Tellico	0.16	0.14	0.30
WUTA total	**0.31**	**4.15**	**4.46**
Cumulative	*6*	*27*	*34*
Clinch			
Norris	0.10	0.65	0.75
Melton Hill	0.12	0.46	0.57
WUTA total	**0.21**	**1.11**	**1.32**
Cumulative	*7*	*29*	*35*
Hiwassee-Ocoee			
Chatuge	0.01	0.28	0.30
Nottely	0.00	0.32	0.32
Hiwassee	0.16	0.47	0.63
Apalachia			0.00
Blue Ridge	0.01	0.22	0.23
Ocoee	0.02	0.01	0.03
WUTA total	**0.20**	**1.31**	**1.51**
Cumulative	*7*	*30*	*37*
Watts Bar-Chickamauga			
Watts Bar	0.30	1.33	1.64
Chickamauga	1.06	1.65	2.71
WUTA total	**1.36**	**2.98**	**4.35**
Cumulative	*8*	*33*	*41*

Table 2-9: Irrigation Withdrawals by Source and WUTA in 2020 (continued)

[Figures may not add to totals because of independent rounding. All values in million gallons per day]

WUTA RCA	Groundwater Withdrawals	Surface Water Withdrawals	Total Withdrawals
Nickajack			
Nickajack	1.39	2.03	3.43
WUTA total	**1.39**	**2.03**	**3.43**
Cumulative	*9*	*35*	*44*
Guntersville			
Guntersville	0.82	1.97	2.79
WUTA total	**0.82**	**1.97**	**2.79**
Cumulative	*10*	*37*	*47*
Elk			
Tims Ford	0.58	0.18	0.76
WUTA total	**0.58**	**0.18**	**0.76**
Cumulative	*11*	*37*	*48*
Wheeler-Wilson			
Wheeler	10.41	17.18	27.59
Wilson	0.59	2.30	2.89
WUTA total	**10.99**	**19.49**	**30.48**
Cumulative	*22*	*56*	*78*
Pickwick-Bear			
Pickwick	0.84	2.60	3.44
Cedar Creek			0.00
Upper Bear Creek			0.00
Bear Creek			0.00
WUTA total	**0.84**	**2.60**	**3.44**
Cumulative	*23*	*59*	*82*
Duck			
Normandy	0.70	0.23	0.93
WUTA total	**0.70**	**0.23**	**0.93**
Cumulative	*23*	*59*	*83*
Kentucky			
Kentucky	2.12	8.95	11.07
WUTA total	**2.12**	**8.95**	**11.07**
Cumulative	*26*	*68*	*94*

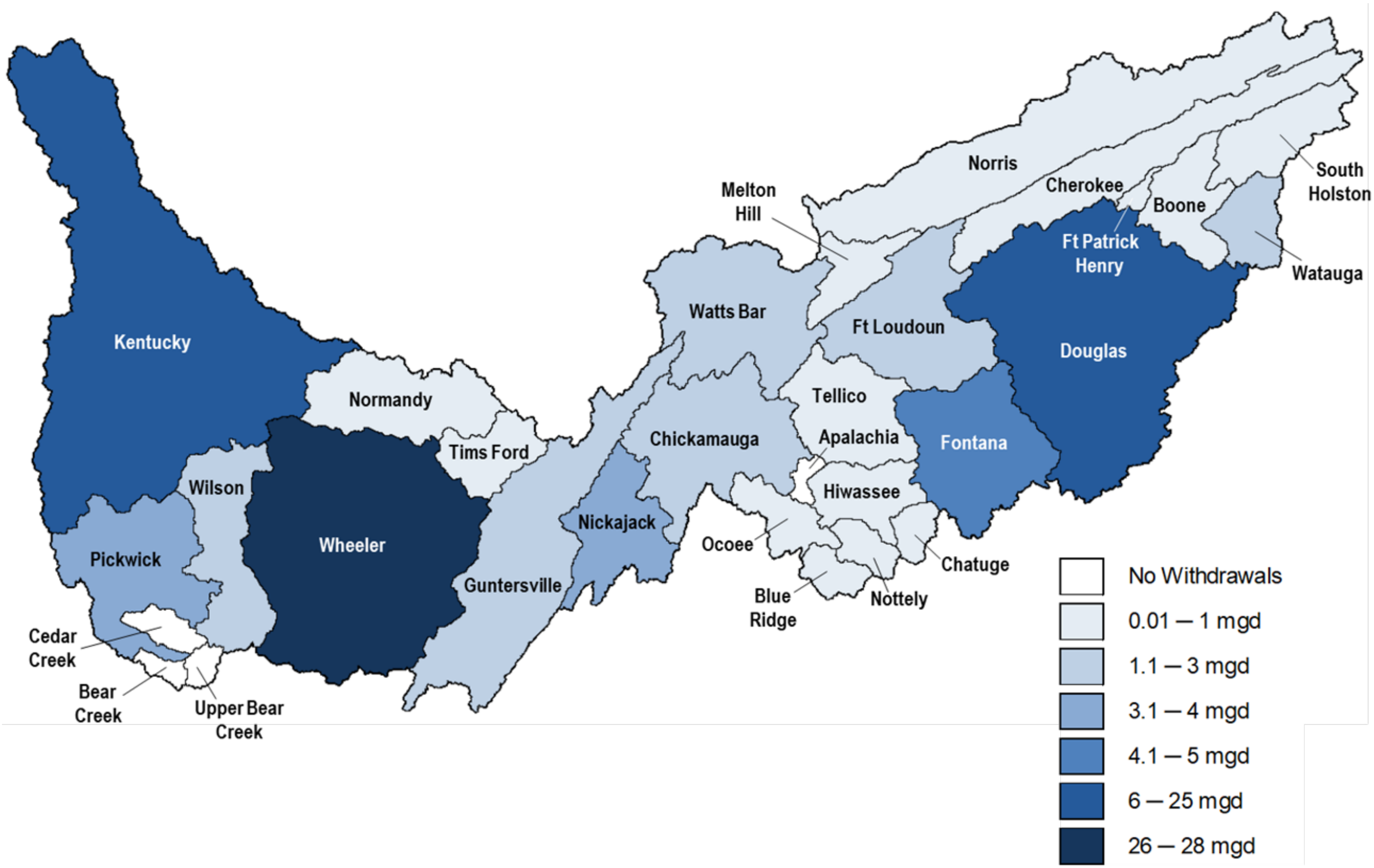

Figure 2-19: Irrigation Withdrawal by RCA in 2020

3 COMPARISON TO PREVIOUS UPDATES, INTERBASIN TRANSFERS, AND DIVERSIONS

COMPARISON TO PREVIOUS UPDATES

The Tennessee River watershed is one of the few watersheds in the nation that has continuous trend data since 1995. Table 3-1 compares 2020 water use to 2015, 2010, 2005, 2000 and 1995. The 1995 data were provided by the USGS and are contained in the 2000 water use report (Hutson and others, 2004).

All line numbers in the following discussion refer to Table 3-1. Figures in this section will include data from 2000 to 2020 due to the limited information available for 1995.

Overall Trends in Withdrawal, Return, and Net Demand

Figure 3-1 displays withdrawal, return, and net demand totals from 2000 to 2020.

Total withdrawal grew by 22 percent from 1995 to 2000 as the result of major power plant additions in the watershed, then peaked in 2005. Total withdrawal in 2020 was 16.5 percent below 2015 total withdrawal (line 2).

As has been the case since return flow data were first collected in 2000, most of the water withdrawn is returned to the river system. In 2020, 95.2 percent of the withdrawal was returned (line 8).

Net water demand decreased 8 percent from 2015 to 2020 (line 9) but increased from 4.4 to 4.8 percent of total withdrawal from 2015 to 2020 (line 10). The reduction in net water demand between 2015 and 2020 was due mainly to increases in public supply returns, while the public supply withdrawals remained unchanged since 2015.

The watershed population increased by 23.4 percent from 1995 to 2020 (line 84).

Trends by Category of Use

Trends in withdrawal by category of use are shown in Figures 3-2, 3-3, and 3-4. Trends in returns and net demand by category of use are shown in Figures 3-5 and 3-6, respectively.

The decrease in withdrawal from 2015 to 2020 was largely the result of a reduction in thermoelectric withdrawal of 1,688 mgd (line 11), which was caused by generating assets being taken offline or being converted to combined cycle assets. Industrial use slightly increased by 8 mgd in 2020 compared to 2015 (line 29). Public supply use in 2020 remained relatively unchanged since 2015 (line 38). Irrigation increased 48.9 percent to 94 mgd (lines 49 and 47). Total withdrawal excluding thermoelectric was 40 mgd more in 2020 than it was in 2015 (line 23).

Thermoelectric

The average percent of total withdrawal for thermoelectric use between 2000 and 2015 was 83.8 percent (line 13). Thermoelectric withdrawal in 2020 was 20.5 percent lower than it was in 2015 (line 12), and the percent of total withdrawal in 2020 dropped to 78.1 percent (line 13). Nearly 99 percent of the water withdrawn for thermoelectric use was returned (line 15). In 2020 thermoelectric net water demand was 18.1 percent of total net water demand (line 19).

In 2000 and 2005, the thermoelectric unit water requirement for power generation was 39 gallons per kilowatt-hour (gal/KWh). It rose in 2010 to 42 gal/KWh and remained nearly the same at 43 gal/KWh in 2015. In 2020, the thermoelectric unit water requirement for power generation dropped to 29 gal/KWh (line 21). From 2015 to 2020, there was an increase in power generation of 16.9 percent (line 20). However, during the same period, there was a 20.5 percent reduction in water withdrawal (line 12). Changes in cooling technology, closure of three fossil plants, conversions to combined cycle plants, and increased hydrogeneration due to record-setting rainfall led to the decrease in the thermoelectric unit water requirement in 2020.

Industrial

Industrial withdrawal in 2020 remained relatively unchanged (< 1 percent) from 2015 and was 9.1 percent lower than in 2010 (line 31). However, industrial use's percent of total withdrawal increased to 12.5 percent (line 30). Industrial net water demand was 15.7 percent of total net water demand, which was lower than it was in 2000, 2005, and 2010 (line 37).

As shown in Figure 3-6, industrial net water demand showed a significant decrease from 2000 to 2005, which was due primarily to company process changes, differences in reporting, and larger return flow in 2005, as mentioned in the Water Use Report for 2005 (Bohac and McCall 2008).

Public Supply

Public supply withdrawal remained unchanged from 2015 (line 38), even though the population between 2015 and 2020 increased almost 2 percent. The lack of an increase in public water withdrawal with respect to an increase in population can be attributed to a wetter-than-normal 2020. In 2000, 2005, and 2010, the watershed received 76 percent, 79 percent, and 80 percent of average rainfall, respectively. Whereas the rainfall in 2015 and 2020 was 115 percent and 138 percent of average, respectively. The lack of an increase in public water withdrawal with respect to an increase in population can also likely be attributed to increased efficiencies in distribution systems at many of the major municipalities and increased efficiencies by the general public, such as low flow toilets, high efficiency appliances, and a general awareness of reducing water use (U.S. Geological Survey, 2017). Increased efficiency can also be seen in the decrease in net water demand as a percent of public supply's withdrawal. Public supply's net water demand as a percent of public supply's withdrawal increased from 39.9 percent in 2005 to

42.8 percent in 2010, decreased to 35.4 percent in 2015, and further decreased to 24.9 percent in 2020 (line 45).

Irrigation

Irrigation declined from 2000 to 2010 but increased significantly in 2015. As previously discussed in Data Sources and Analysis Methods (Chapter 1), TVA was no longer able to receive actual irrigation data beginning in 2015 and used conservative estimates instead.

The largest percent growth was irrigation (line 49) at almost 49 percent. Increases in withdrawal volumes from individual irrigators only accounted for a small portion of the total increase from 2015. However, the big contributions were the increases in county aggregate withdrawal volumes due to increases in irrigated acreages throughout the Tennessee River watershed.

Irrigation's contribution to total net water demand increased from 14.1 percent in 2015 to 23.3 percent in 2020 (line 51). It is assumed in this report that 100 percent of the withdrawal is evaporated, transported, incorporated into products or crops, consumed by humans or livestock, or otherwise removed from the immediate environment.

Trends in Surface and Groundwater Use

Figures 3-7 and 3-8 show the changes in surface and groundwater use from 2000 to 2020.

Groundwater use has shown a decreasing trend from 1995 to 2020, with the exception of 2010. In 2020, groundwater withdrawals were at its lowest level since 1995 (line 5). Surface water continued to supply the majority of the water used in the watershed in 2020 (97.8 percent, line 4).

In 2020, surface water supplied 100 percent of the thermoelectric withdrawal, 96.4 percent of the industrial withdrawal, 82.4 percent of the public supply withdrawal, and 72.8 percent of the irrigation withdrawal (lines 68, 70, 72, and 74). With the exception of the 2020 public supply surface water withdrawals, these percentages have remained relatively constant over the 2000 to 2020 period.

Table 3-1. Comparing 2020 Water Use with Previous Years

[Units are mgd or as noted]

	Summary	1995	2000	2005	2010	2015	2020
1	Total withdrawal	10,008	12,211	12,437	11,951	10,016	8,368
2	Percent change		22	1.9	-3.9	-16.2	-16.5
3	Total surface water withdrawal	9,750	11,996	12,247	11,747	9,828	8,182
4	Percent of total withdrawal	97.4	98.2	98.5	98.3	98.1	97.8
5	Total groundwater withdrawal	258	215	190	204	189	186
6	Percent of total withdrawal	2.6	1.8	1.5	1.7	1.9	2.2
7	Total return flow		11,562	12,005	11,480	9,577	7,965
8	Percent of total withdrawal		94.7	96.5	96.1	95.6	95.2
9	Net water demand (consumptive use)		649	432	471	439	403
10	Percent of total withdrawal		5.3	3.5	3.9	4.4	4.8
	Thermoelectric	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**
11	Total thermoelectric withdrawal	8,010	10,276	10,531	10,046	8,224	6,536
12	Percent change		28.5	2.5	-4.6	-18.1	-20.5
13	Percent of total withdrawal	80	84.2	84.7	84.1	82.1	78.1
14	Total thermoelectric return		10,244	10,498	9,994	8,156	6,463
15	Percent of thermoelectric withdrawal		99.7	99.7	99.5	99.2	98.9
16	Percent of total return		88.6	87.4	87.1	85.2	81.1
17	Total thermoelectric net water demand		32	33	52	68	73
18	Percent of thermoelectric withdrawal		0.3	0.3	0.5	0.8	1.1
19	Percent of total net water demand		4.9	7.6	11.1	15.5	18.1
20	Power generated (million KWh)		96,343	99,519	87,529	70,367	82,257
21	Total thermoelectric unit water requirement (gal/KWh)		39	39	42	43	29
22	Consumptive thermoelectric unit water requirement (gal/KWh)		0.1	0.1	0.2	0.4	0.3
	Totals (excluding thermoelectric)	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**
23	Total withdrawal excluding thermoelectric	1,998	1,935	1,906	1,905	1,792	1,832
24	Percent of total withdrawal	20	15.8	15.3	15.9	17.9	21.9
25	Percent change		-3.2	-1.5	0	-5.9	2.2
26	Total returns excluding thermoelectric		1,318	1,507	1,486	1,421	1,502
27	Percent change			14.3	-1.4	-4.4	5.7
28	Net water demand excluding thermoelectric		617	399	419	371	330

Table 3-1. Continued

[Units are mgd or as noted]

	Industrial	1995	2000	2005	2010	2015	2020
29	Total industrial withdrawal	1,030	1,205	1,179	1,148	1,035	1,043
30	Percent of total withdrawal	10.3	9.9	9.5	9.6	10.3	12.5
31	Percent change		17	-2.2	-2.6	-9.8	0.8
32	Total industrial return		942	1,097	1,073	971	980
33	Percent of total return		8.1	9.1	9.3	10.1	12.3
34	Percent of industrial withdrawal		78.2	93	93.5	93.8	93.9
35	Industrial net water demand		263	82	75	63	63
36	Percent of industrial withdrawal		21.8	7	6.5	6.1	6.1
37	Percent of total net water demand		40.5	19	15.9	14.4	15.7
	Public Supply	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**
38	Public supply total withdrawal	574	662	684	723	695	695
39	Percent of total withdrawal	5.7	5.4	5.5	6	6.9	8.3
40	Percent change		15.3	3.3	5.6	-3.9	0.0
41	Total public supply return		377	411	413	450	522
42	Percent of total return		3.3	3.4	3.6	4.7	6.6
43	Percent of public supply withdrawal		56.9	60.1	57.2	64.7	75.1
44	Public supply net water demand		285	273	310	246	173
45	Percent of public supply withdrawal		43.1	39.9	42.8	35.4	24.9
46	Percent of total net water demand		43.9	63.2	65.7	56	42.9
	Irrigation	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**
47	Irrigation total withdrawal	48	69	43	34	63	94
48	Percent of total withdrawal	0.5	0.6	0.3	0.3	0.6	1.1
49	Percent change		43.8	-37.7	-20.9	85.3	48.9
50	Irrigation net water demand	48	69	43	34	63	94
51	Percent of total net water demand		10.6	10	7.2	14.1	23.3

Table 3-1. Continued

[Units are mgd or as noted]

	Net Water Demand by WUTA	1995	2000	2005	2010	2015	2020
52	Holston (Cherokee)		88	90	79	78	62
53	French Broad (Douglas)		65	53	70	75	71
54	Fort Loudoun		23	1	8	-32	-21
55	Little Tennessee (Fontana-Tellico)		7	7	9	16	15
56	Clinch (Norris)		45	28	21	45	35
57	Hiwassee-Ocoee		16	10	8	11	11
58	Watts Bar-Chickamauga		45	40	57	65	64
59	Nickajack		12	-3	-13	-9	-5
60	Guntersville		16	30	32	29	34
61	Elk (Tims Ford)		21	8	8	13	25
62	Wheeler-Wilson		196	112	129	85	69
63	Pickwick-Bear (Pickwick)		29	-13	-2	25	23
64	Duck (Normandy)		26	25	26	25	13
65	Kentucky		60	43	41	15	29
66	Total net water demand		649	431	473	439	425
	Surface Water Withdrawal	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**
67	Thermoelectric		10,276	10,531	10,046	8,224	6,536
68	Percent of total thermoelectric		100	100	100	100	100
69	Industrial		1,134	1,149	1,116	1,012	1,005
70	Percent of total industrial		94.1	97.5	97.2	97.8	96.4
71	Public supply		526	534	558	542	573
72	Percent of total public supply		79.5	78.1	77.2	78	82.4
73	Irrigation		61	32	27	50	68
74	Percent of total irrigation		88.4	74.4	79.4	79.4	72.8
	Groundwater Withdrawal	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**
75	Thermoelectric		0	0	0	0	0
76	Percent of total thermoelectric		0	0	0	0	0
77	Industrial		71	30	32	23	38
78	Percent of total industrial		5.9	2.5	2.8	2.2	3.6
79	Public supply		136	150	165	153	122
80	Percent of total public supply		20.5	21.9	22.8	22	17.6
81	Irrigation		7.6	11	7	13	26
82	Percent of total irrigation		11	25.6	20.6	20.6	27.2
	Miscellaneous	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**
83	Diversions to the Tennessee-Tombigbee Waterway		200	190	200	195	143
84	Watershed population (1,000s)	4,198	4,506	4,705	4,982	5,084	5,182

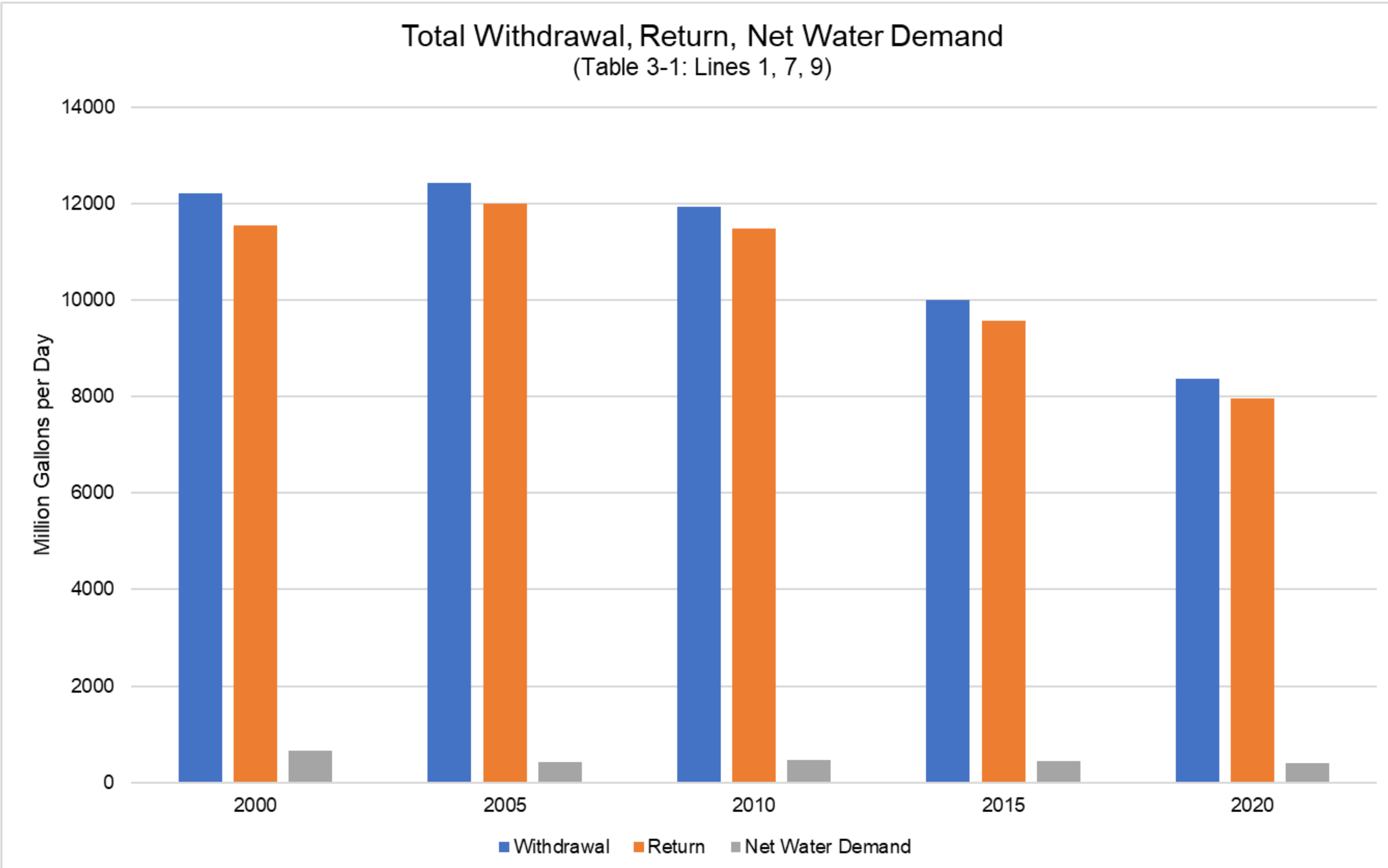

Figure 3-1: Total Withdrawal, Return, and Net Water Demand from 2000 to 2020

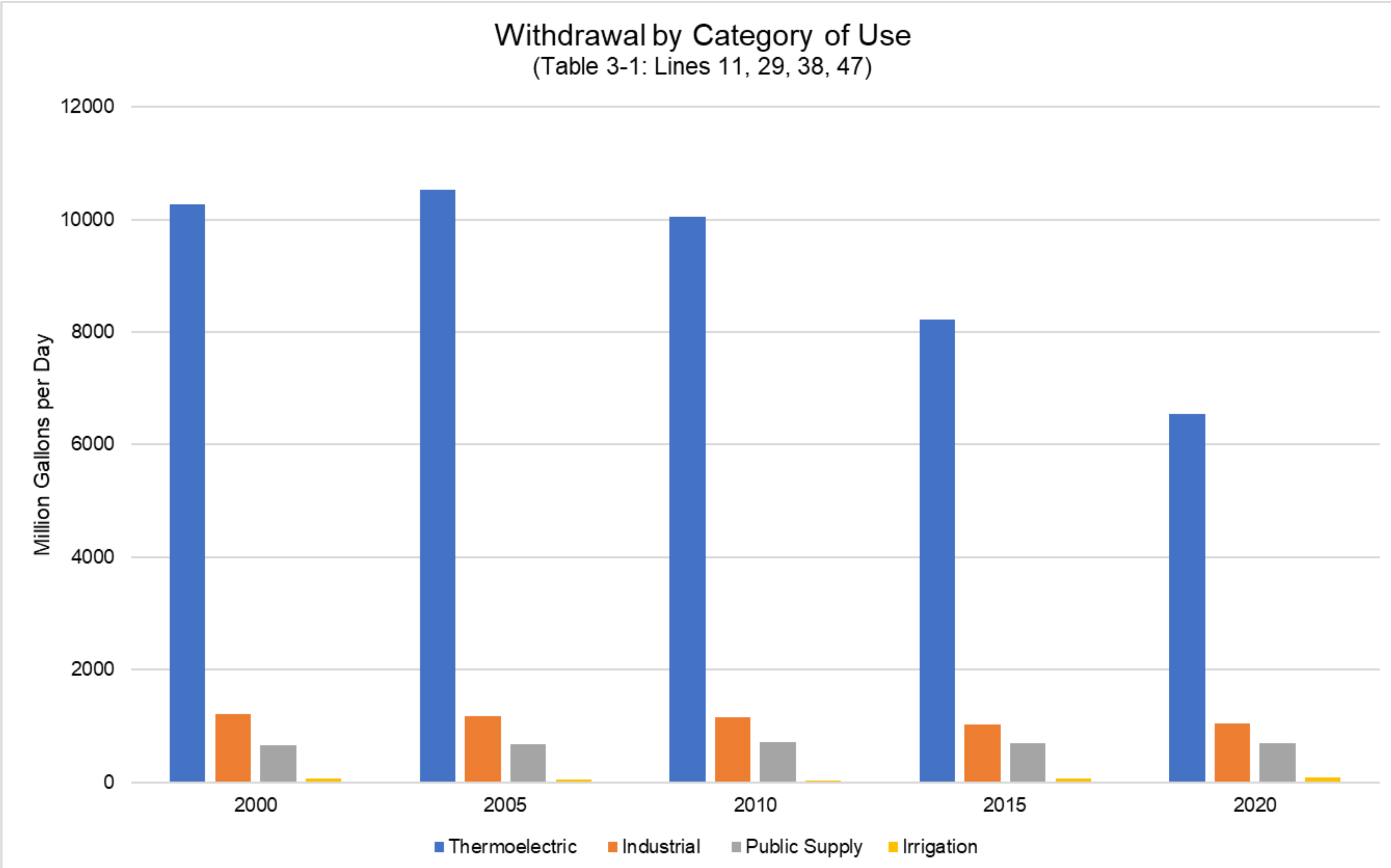

Figure 3-2: Total Withdrawal by Category of Use from 2000 to 2020

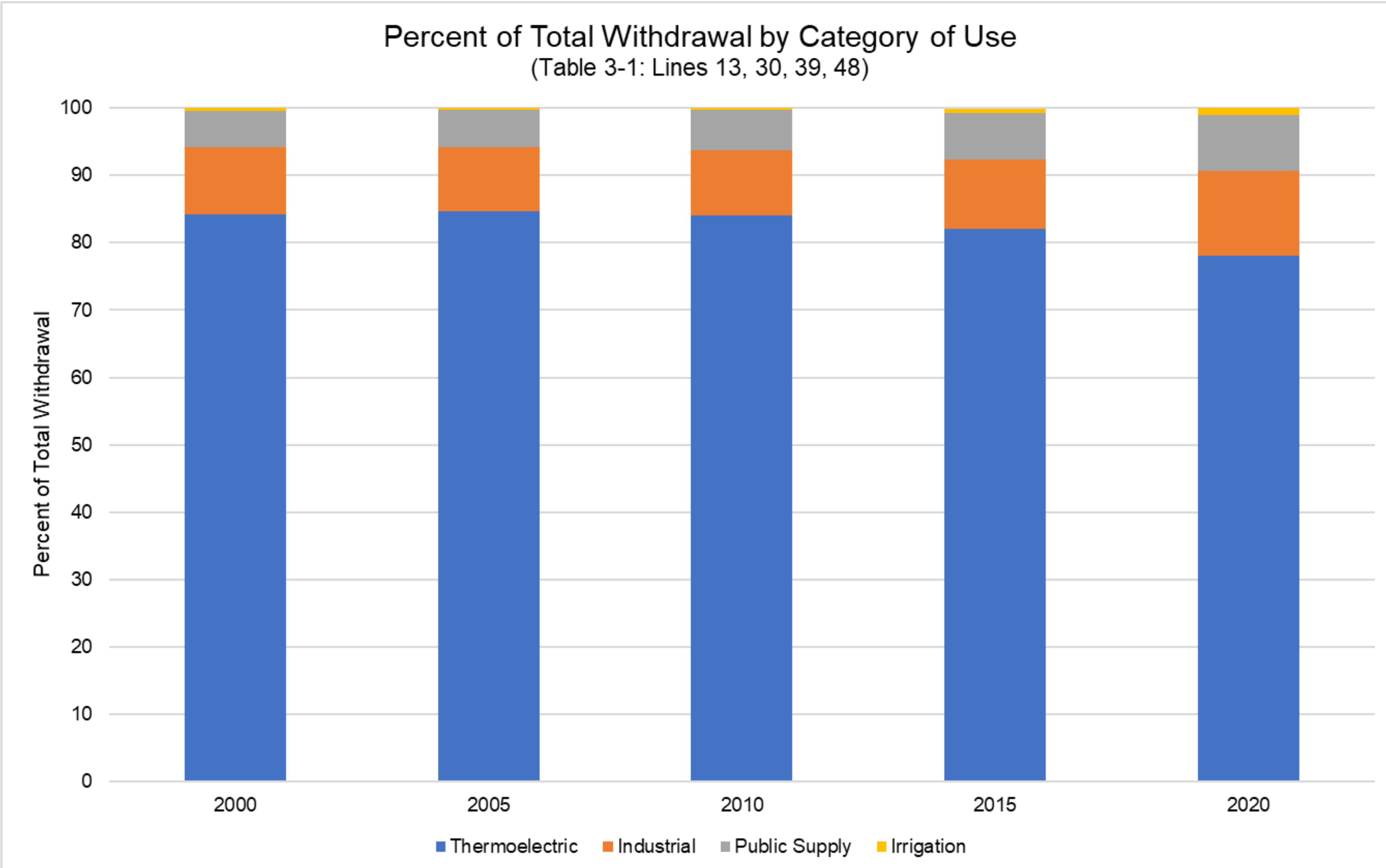

Figure 3-3: Percent of Total Withdrawal by Category of Use from 2000 to 2020

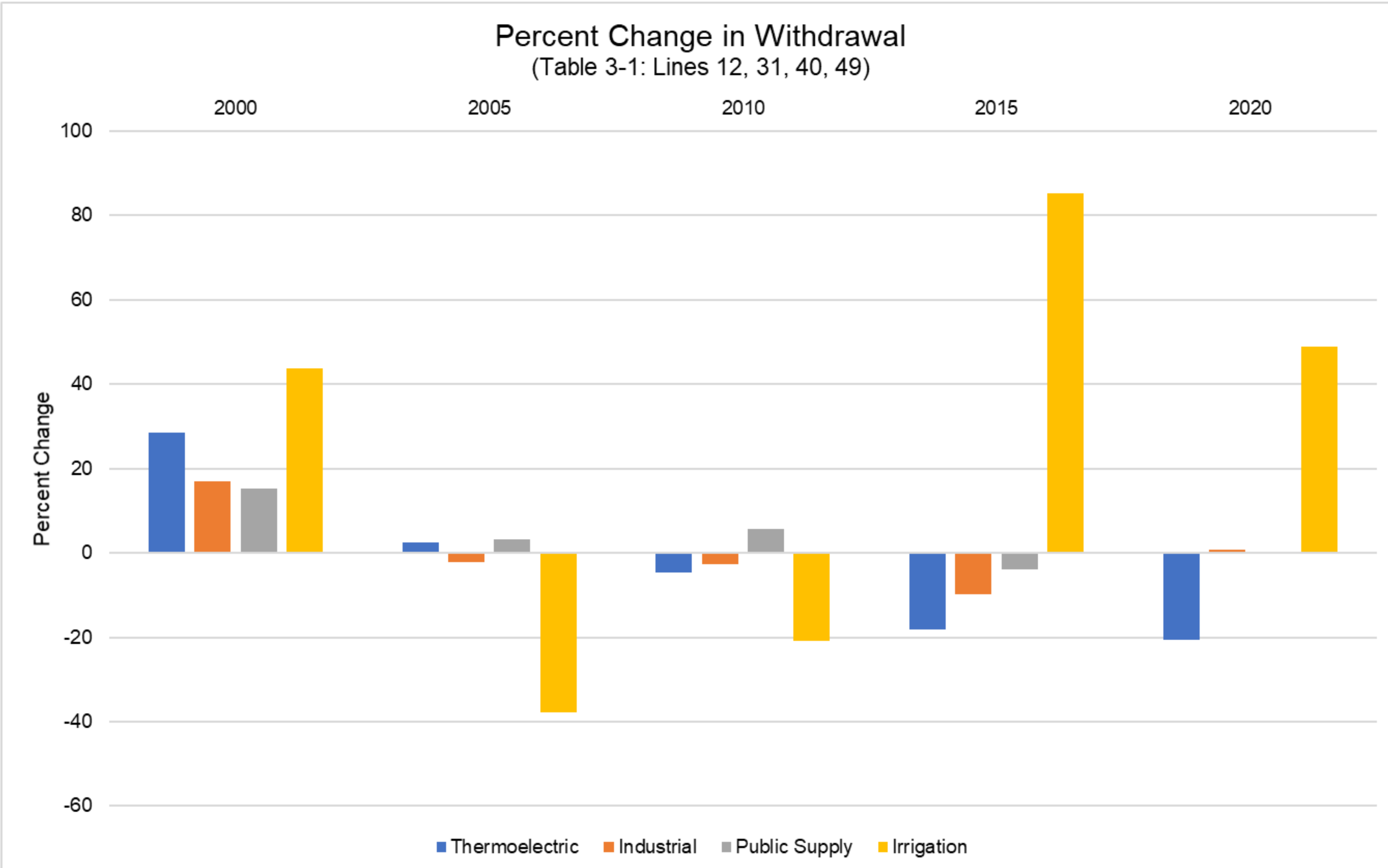

Figure 3-4: Percent Change in Withdrawal by Category of Use from 2000 to 2020

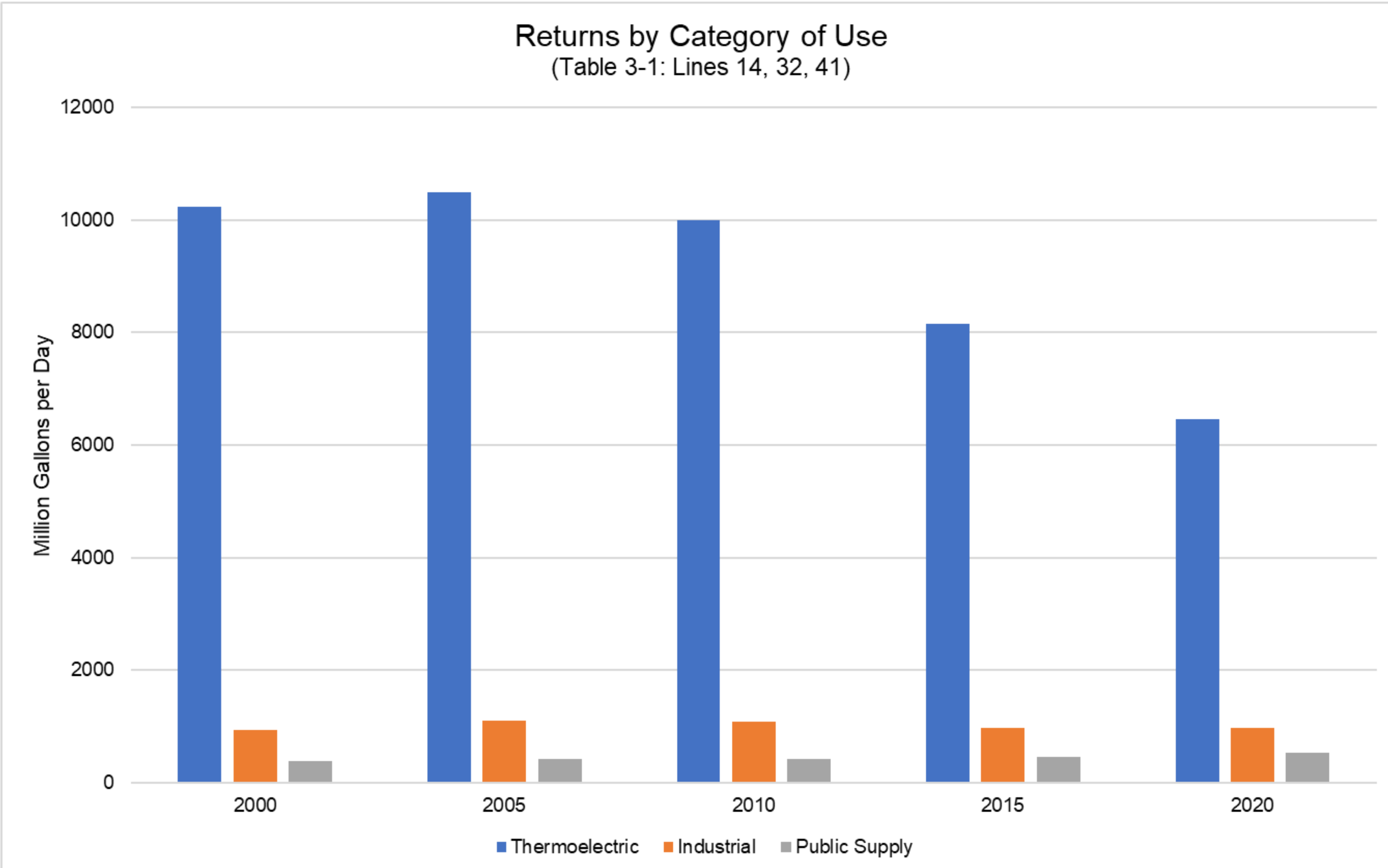

Figure 3-5: Returns by Category of Use from 2000 to 2020

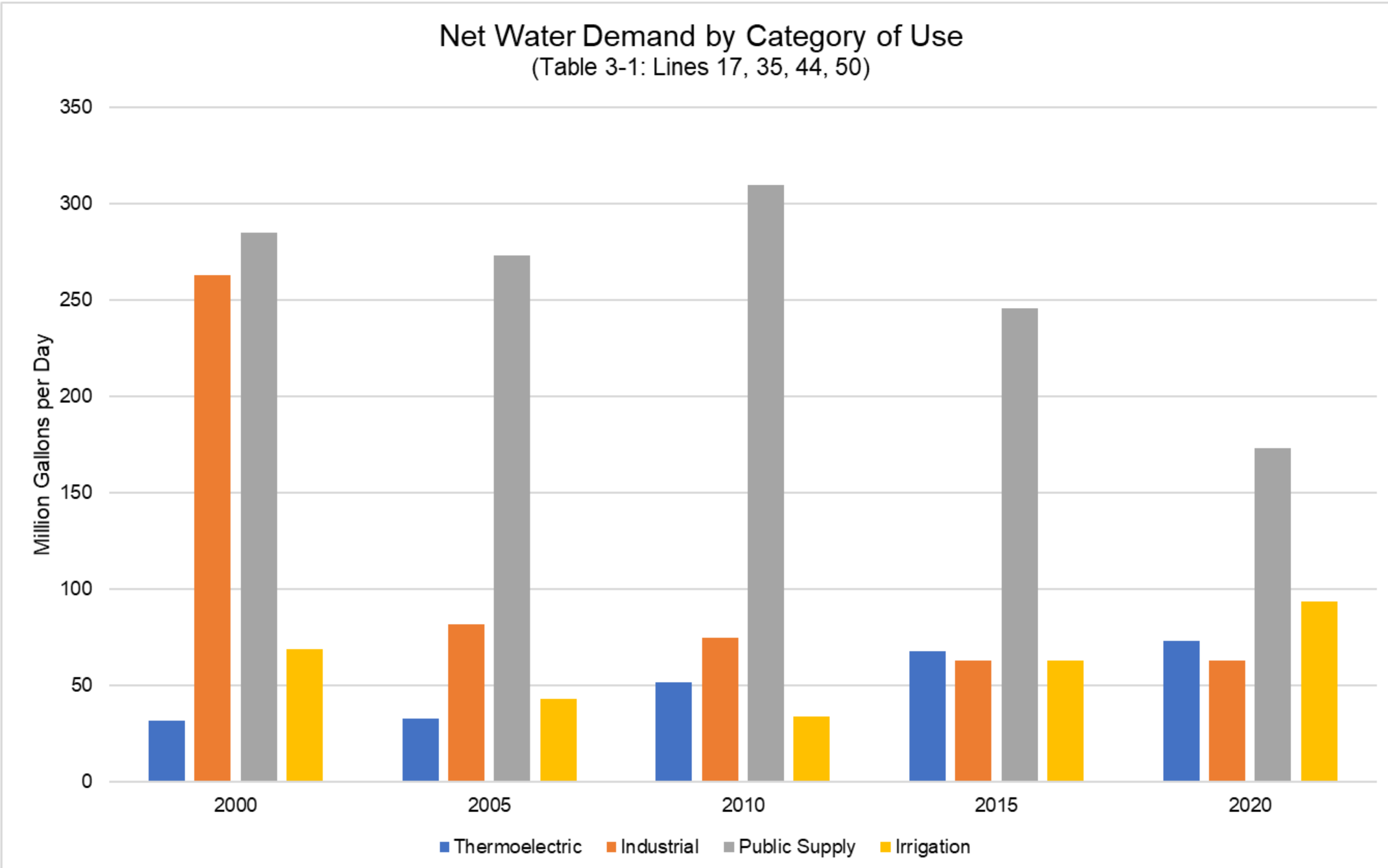

Figure 3-6: Net Water Demand by Category of Use from 2000 to 2020

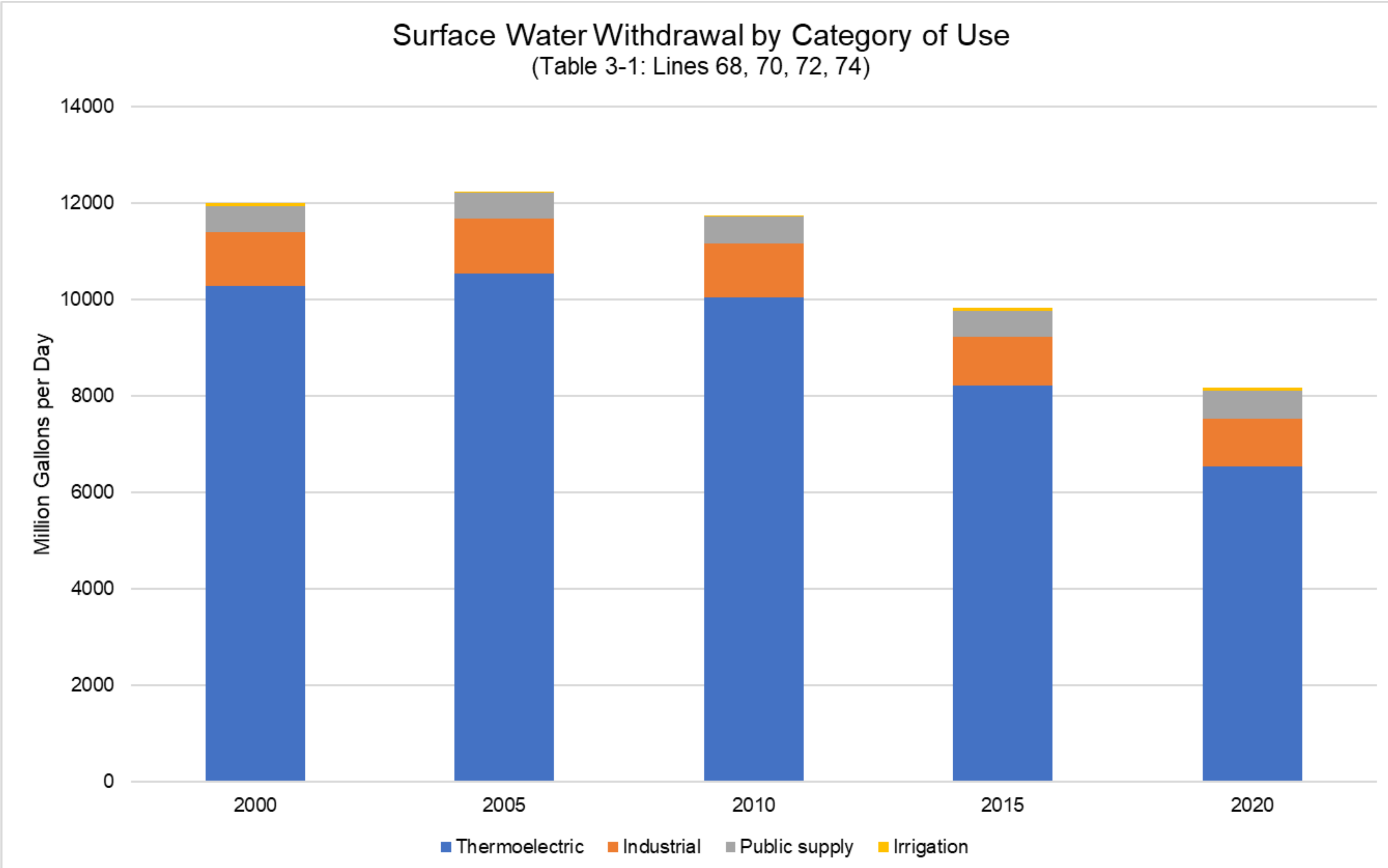

Figure 3-7: Surface Water Withdrawal by Category of Use from 2000 to 2020

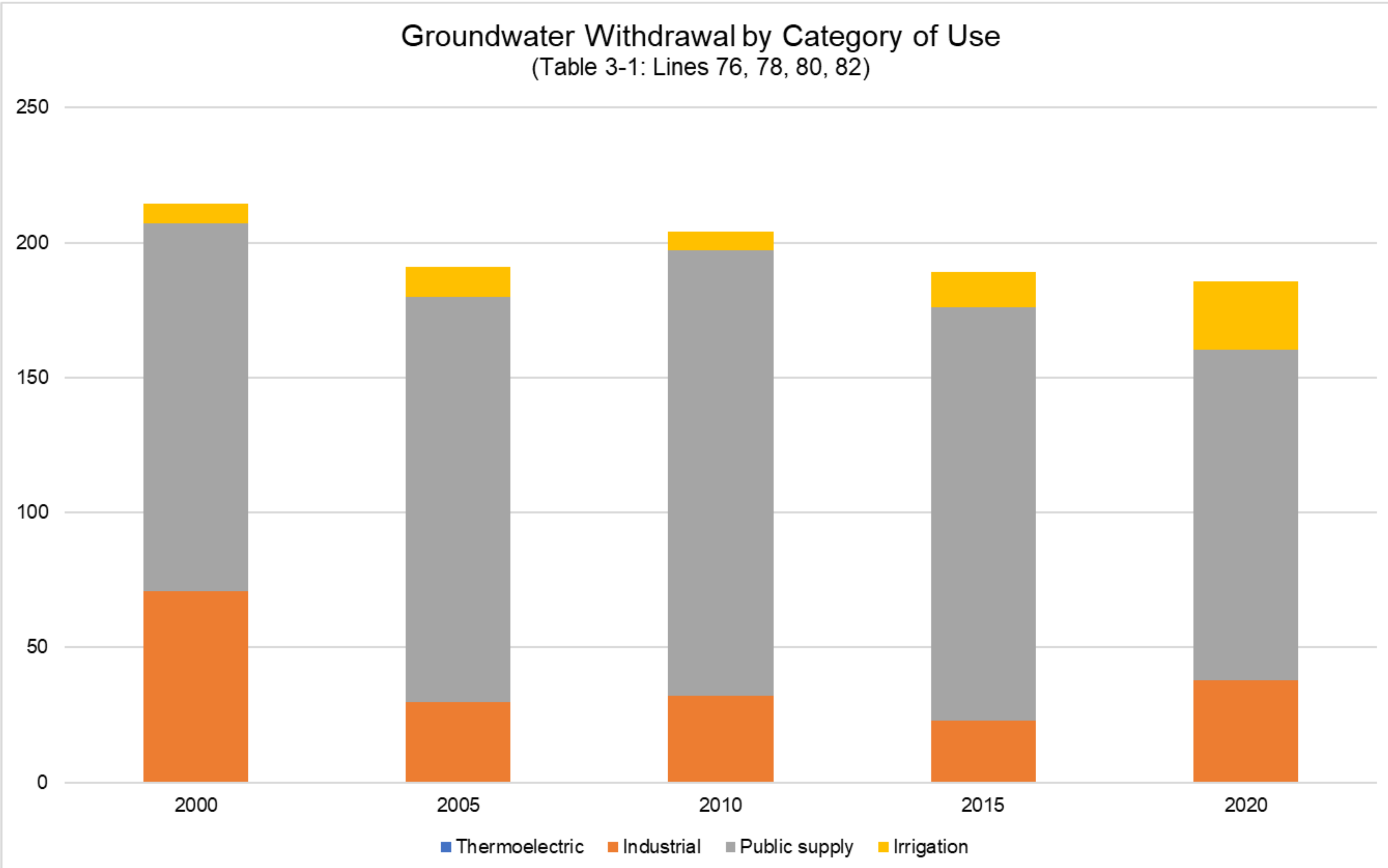

Figure 3-8: Groundwater Withdrawal by Category of Use from 2000 to 2020

INTERBASIN TRANSFERS

An interbasin transfer (IBT), in the context of this report, is a transfer of water across the Tennessee River watershed boundary.

The volume of water that leaves the valley via an IBT is captured in the withdrawal volumes in the overall water use analyses. The volume of water that comes into the valley via an IBT is captured in the wastewater return data in the overall water use analyses.

Although there are other transfers between river basins within the Tennessee River watershed, an IBT as discussed below refers only to a transfer across the watershed boundary.

IBTs from the Tennessee River watershed are of concern because of the following:

1. After the water is transferred, no water is returned to the Tennessee River for reuse.
2. Impacts may not occur at the point of withdrawal, but on reservoirs far from the point of withdrawal.
3. IBTs could impair TVA's ability to carry out mandated responsibilities for managing the Tennessee River system depending on when and where IBTs occur and the volume that is transferred.
4. IBTs will reduce hydrogeneration and may reduce water availability for cooling power plants.
5. IBTs at some locations would create environmental conflicts with in-stream uses including fish and aquatic life.
6. IBTs are sensitive issues in all watershed states and are sources of potential conflict among the states.

IBTs existing in 2020 are shown in Table 3-2 and Table 3-3. The values shown are average annual transfers. The net water leaving the Tennessee River watershed (Table 3-2 total minus Table 3-3 total) in 2020 was 8.53 mgd, an increase of 2.63 mgd since 2015. Three IBTs were not active in 2020. These include Cumberland Utility District, Franklin County Water Service Authority[1], and Rabun County Water and Sewer Authority. Water transfer data on eight other IBTs were not available for 2020. These include Crossville, Lexington Water System, Ocoee Utility District (into and out of the basin), Selmer Water System, Spring City Water System, Tennessee-American Water Company, West Warren-Viola Utility District.

The estimated values in Table 3-2 and Table 3-3 are based on state permit limits.

[1] Franklin County Water Service Authority doesn't have an IBT permit due to state policies, so there is no known permitted volume to report.

Table 3-2: Interbasin transfers from the Tennessee River in 2020

Transfer From			Transfer To			2020
System	State	Basin	System	State	Basin	mgd
Albertville Municipal Utilities Board	AL	Tennessee	Albertville Service Area and Boaz	AL	Black Warrior	2.73
Arab Water Works	AL	Tennessee	Joppa	AL	Black Warrior	0.37
Fort Payne Water Works	AL	Tennessee	Fort Payne Water Works Service Area	AL	Coosa	0.03
Upper Bear Creek Water Authority	AL	Tennessee	Haleyville	AL	Tombigbee	1.57
Franklin County Water Service Authority	AL	Tennessee	Franklin County WSA Service Area	AL	Tombigbee	0
Corinth Utilities Commission	MS	Tennessee	Corinth UC Service Area	MS	Tombigbee	2.85
Highlands	NC	Tennessee	Highlands Service Area	NC	Savannah	0.02
Hendersonville Water and Sewer	NC	Tennessee	Saluda	NC	Broad	0.18
Tennessee-American Water Company	TN	Tennessee	Walker County	GA	Coosa	No Data
Cleveland Utilities	TN	Tennessee	Ocoee UD	TN	Coosa	0.68
Eastside Utility District	TN	Tennessee	Dalton Utilities	GA	Coosa	1.59
Lexington Water System	TN	Tennessee	Jackson Energy Authority	TN	Mississippi	No Data
Spring City Water System	TN	Tennessee		TN	Cumberland	No Data
Ocoee Utility District	TN	Tennessee	Ocoee UD Service Area	TN	Coosa	No Data
Cumberland Utility District	TN	Tennessee	Sunbright	TN	Cumberland	0
Plateau Utility District	TN	Tennessee	Sunbright	TN	Cumberland	0.08
Duck River Utility Commission	TN	Tennessee	Hillsville UD	TN	Cumberland	0.1
Crossville	TN	Tennessee	Crossville Service Area	TN	Cumberland	No Data

Table 3-3: Interbasin transfers into the Tennessee River in 2020

Transfer From			Transfer To			2020
System	State	Basin	System	State	Basin	mgd
Rabun County Water and Sewer Authority	GA	Savannah	Rabun County W&SA Service Area	GA	Tennessee	0
Cleveland Utilities	TN	Coosa	Cleveland Utilities Service Area	TN	Tennessee	1.04
Huntsville Utility District	TN	Cumberland	Sunbright Service Area	TN	Tennessee	0.2
Ocoee Utility District	TN	Coosa	Ocoee UD Service Area	TN	Tennessee	No Data
Selmer Water System	TN	Mississippi	Michie	TN	Tennessee	No Data
West Warren-Viola Utility District	TN	Cumberland	West Warren- Viola UD Service Area	TN	Tennessee	No Data
Crossville	TN	Cumberland	Crossville Service Area	TN	Tennessee	0.22
Tazewell County Public Service Authority	VA	New	Tazewell County PSA Service Area	VA	Tennessee	0.21

DIVERSIONS

Routing of water away from the Tennessee River System for navigational purposes, or diversions, are not factored into the overall water use analyses.

Water is diverted from Pickwick Reservoir on the Tennessee River to the Tennessee-Tombigbee Waterway under agreement with the U.S. Army Corps of Engineers (USACE) to support operations. In 2020, this diversion averaged 143 mgd (Table 3-1), which was 27.1 percent lower than normal due to a lock closure in July 2020.

In western Kentucky at the northwest tip of Land Between the Lakes, the Barkley Canal connects the Tennessee River to the Cumberland River. Historic reservoir operations have resulted in a net flow of Tennessee River water through the Barkley Canal into the Cumberland River watershed. This has historically averaged about 3,900 mgd and provides electrical generating capacity during peak power demands for USACE's Barkley Dam. The operation is authorized through agreements between TVA and USACE. In 2020, the net flow of water through the Barkley Canal averaged 1,793 mgd from Kentucky Reservoir to Barkley Reservoir.

4 PROJECTED WATER USE

INTRODUCTION

Projections of water use for 2045 were prepared for the four use categories of thermoelectric, industrial, public supply, and irrigation. The projection methods used for each category of water use are described below, and do not account for climate change. However, TVA is investigating impacts of climate change within the Tennessee River basin. The results from that study are expected to be available by 2025. Once the data is published, the results may be incorporated into future reports.

THERMOELECTRIC WATER USE

Projected water use was based on an estimate of future power generation and the generation technology used to provide it. Table 4-1 shows electrical energy generated by the entire TVA system and within the Tennessee River watershed for 2000 to 2020 measured in gigawatt hours (GWh). The percent of TVA's generation that comes from Coal-Fired and Nuclear generation within the Tennessee River watershed decreased steadily from 2000 through 2015. This percentage increased slightly in 2020 due primarily to Watts Bar Unit 2 going online in 2016.

Table 4-1: Power Generation from TVA-Operated Generation Facilities

	2000	2005	2010	2015	2020
Total Generation (GWh)	153,394	161,057	151,014	143,046	142,230
Coal-Fired and Nuclear Generation from Tennessee River Watershed (GWh)	91,194	92,163	81,287	65,408	69,663
Percent of Coal-Fired and Nuclear Generation from Tennessee River Watershed	59.45%	57.22%	53.83%	45.73%	48.98%

Thermoelectric water use for 2045 was estimated based on TVA's proprietary power supply plan. The plan considers the most economical mix of generating facilities to meet the power demand in the TVA region based on factors such as fuel prices, air quality constraints, and unit-operating efficiency. Power supply options include generation from existing and new TVA units, purchases from existing and new merchant plants, and purchases from other utilities. The projection includes all thermoelectric generating units in the Tennessee River watershed, not just those owned or leased by TVA.

After eighteen months of development, TVA completed its Integrated Resource Plan in 2019. This plan and the associated Environmental Impact Statement are the result of extensive analysis and collaboration with TVA partners and stakeholders (2019). It is a comprehensive study of options and strategies and their potential economic and environmental outcomes. The plan was shaped by input from the businesses, industries, and regional leaders, as well as members of the public, whose lives and livelihoods depend on the electricity supplied by Tennessee Valley Authority. Table 4-2 shows recommendations developed by the Integrated Resource Plan to help guide TVA's future generation portfolio.

The implications of the Integrated Resource Plan recommendations are that energy efficiency and demand response (EEDR) and renewables such as wind power will slow the need for new water for thermoelectric use. Idling of coal-fired plants will reduce thermoelectric withdrawal substantially, because all the coal-fired plants in the watershed use once-through (open-cycle) cooling. Although the nuclear and natural gas additions will represent new withdrawals of cooling water, these new plants will use closed-cycle cooling (cooling towers), which will result in substantially less withdrawal than open-cycle cooling. However, the difference between the withdrawal and return for the new closed-cycle cooled plants will be larger than for the open-cycle plants they replace; hence, the net water demand will increase.

INDUSTRIAL AND PUBLIC SUPPLY

For the industrial (including mining) and public supply categories, the 2020 water use estimates serve as the basis for the 2045 projections. Economic and demographic data at the county level projected to 2045 (Woods and Poole Economics Inc., 2020) were used to project water use to 2045. The change in population was used to project public supply withdrawal and return flow, and changes in manufacturing and mining earnings were used for the industrial withdrawal and return flow projections. The county-specific projection factor, or multiplier for the population and industrial and mining earnings, was applied to each water use record in the 2020 water use database to produce estimates of 2045 water use.

IRRIGATION

Irrigation water use is reported as essentially two types: agricultural irrigation and nonagricultural irrigation (primarily golf course irrigation). Nonagricultural irrigation was projected using the public supply projection factors while agricultural irrigation was projected using the trends in increasing acres of irrigated farmland (U.S. Department of Agriculture, 2017).

Table 4-2: Recommendations from the Integrated Resource Plan

	Recommendation
Coal	Continue with announced plans to retire Paradise in 2020 and Bull Run in 2023. Evaluate retirements of up to 2,200 MW of additional coal capacity if cost-effective.
Hydro	All portfolios reflect continued investment in the hydro fleet to maintain capacity. Consider additional hydro capacity where feasible.
Energy Efficiency	Achieve savings of up to 1,800 MW by 2028 and up to 2,200 MW by 2038. Work with our local power company partners to expand programs for low-income residents and refine program designs and delivery mechanisms with the goal of lowering total cost.
Demand Response	Add up to 500 MW of demand response by 2038 depending on availability and cost of the resource.
Nuclear	Pursue option for second license renewal of Browns Ferry for an additional 20 years. Continue to evaluate emerging nuclear technologies, including small modular reactors (SMR), as part of technology innovation efforts.
Wind	Existing wind contracts expire in the early 2030s. Consider the addition of up to 1,800 MW of wind by 2028 and up to 4,200 MW by 2038 if cost-effective.
Storage	Add up to 2,400 MW of storage by 2028 and up to 5,300 MW by 2038. Additions may be a combination of utility and distributed scale. The trajectory and timing of additions will be highly dependent on the evolution of storage technologies.
Gas Combustion Turbine	Evaluate retirements of up to 2,000 MW of existing combustion turbines if cost-effective. Add up to 5,200 MW of combustion turbines by 2028 and up to 8,600 MW by 2038 if a high level of load growth materializes. Future CT needs are driven by demand for electricity, solar penetration, and evolution of other peaking technologies.
Gas Combined Cycle	Add between 800 and 5,700 MW of combined cycle by 2028 and up to 9,800 MW by 2038 if a high level of load growth materializes. Future CC needs are driven by demand for electricity and gas prices, as well as by solar penetration that tends to drive CT instead of CC additions.
Solar	Add between 1,500 and 8,000 MW of solar by 2028 and up to 14,000 MW by 2038 if a high level of load growth materializes. Additions may be a combination of utility and distributed scale. Future solar needs are driven by pricing, customer demand, and demand for electricity.

TRANSFERS FROM THE WATERSHED

In 2020, 26 public supply IBTs resulted in a net loss of 8.53 mgd from the Tennessee River watershed. The projection for 2045 is that this volume will increase at the same rate that water withdrawal for public supply increases.

TVA estimated the increase in diversions to the Tennessee-Tombigbee Waterway based on a projection of the increase in commercial lockages between the waterway and the Tennessee River. The estimated diversions to the waterway by 2045 range from 300 to 500 mgd with a midpoint of 400 mgd.

Water transfer from Kentucky Reservoir to Barkley Reservoir in 2045 is assumed to be the long-term average of 3,900 mgd.

PROJECTED WATER USE IN 2045

Total withdrawal for 2045 is projected to be 7,463 mgd with net water demand projected as 475 mgd, as shown in Table 4-3 and Figure 4-1. The projected 2045 withdrawal will decrease by 11 percent compared to 2020. This is the result of a 1 percent decline in industrial withdrawal and a 16 percent decline in thermoelectric water withdrawal, brought about by the idling of coal-fired power plants that have high withdrawal rates to supply their open-cycle cooling systems. Net water demand increases by 18 percent because of increased withdrawal for public supply and a substantial increase in irrigation withdrawals.

Table 4-3: Estimated Water Use in the Tennessee River Watershed 1995 to 2045

Off-Stream Use (mgd)	1995	2000	2005	2010	2015	2020	2045	Percent Change 2020-2045
Withdrawal								
Total withdrawals	10,008	12,211	12,437	11,951	10,016	8,368	7,463	-11%
Thermoelectric	8,010	10,276	10,531	10,046	8,224	6,536	5,501	-16%
Industrial	1,030	1,205	1,179	1,148	1,035	1,043	1,035	-1%
Public supply	574	662	684	723	695	695	778	12%
Irrigation	48	69	43	34	63	94	149	58%
Source of water								
Surface	9,750	11,996	12,237	11,747	9,828	8,182	7,245	-11%
Ground	258	215	200	204	189	186	218	17%
Net Water Demand								
Total consumptive use		649	432	471	439	403	475	18%
Thermoelectric		32	33	52	68	73	68	-7%
Industrial		263	82	75	64	63	66	4%
Public supply		285	273	310	245	173	192	11%
Irrigation		69	43	34	63	94	149	58%
Transfers								
To the Tennessee-Tombigbee		200	190	200	195	143	400	
To Barkley Reservoir*		4,524	4,246	1,636	-1,534	-1,793	3,900	

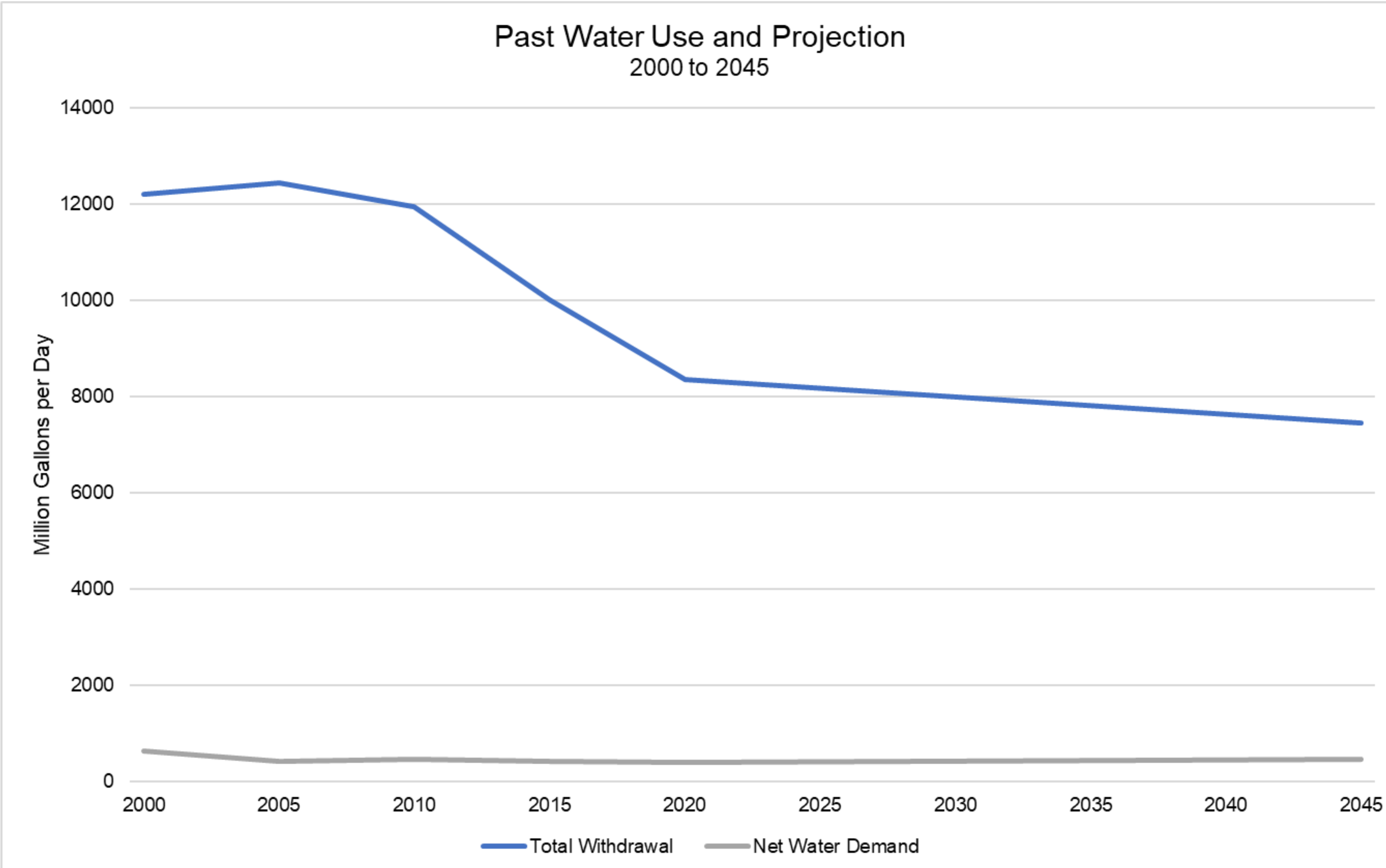

Figure 4-1: Past Water Use and Projection from 2000 to 2045

5 SUMMARY AND CONCLUSIONS

WATER USE IN 2020

Water withdrawals during 2020 were estimated to average 8,368 mgd for off-stream uses, or 16.5 percent less than the 2015 withdrawals. Return flow was estimated to be 7,965 mgd, or 95.2 percent of water withdrawn in 2020. Net water demand, which is an estimate of consumptive use, was 403 mgd, and accounted for the remaining 4.8 percent of withdrawal.

In 2020, thermoelectric withdrawals were 6,536 mgd, or 78.1 percent of total withdrawal. As a percentage of total withdrawal, this was a decrease from its 2015 value of 82.1 percent. Thermoelectric withdrawal has been declining since peaking in 2005, due to a 17.3 percent decline of electrical power generation over that period caused by generating assets being taken offline or being converted to combined cycle assets. Thermoelectric net water demand in 2020 was only 73 mgd, or 1.1 percent of thermoelectric withdrawal (98.9 percent of the withdrawal was returned), but it was 18.1 percent of the total net water demand.

The total of all other withdrawals, excluding thermoelectric, was 1,832 mgd, which is a 2.2 percent increase from 2015 (1,792 mgd). The total of all other withdrawals in 2015 slightly decreased from 2010 (1,905 mgd), 2005 (1,906 mgd), 2000 (1,935 mgd), and 1995 (1,998 mgd). Total returns excluding thermoelectric were 1,502 mgd in 2020, or about 5.7 percent higher than they were in 2015, when the returns totaled 1,421 mgd.

Withdrawals for industrial use in 2020 were 1,043 mgd, which was a slight increase from the withdrawals in 2015 (1,035 mgd). From 2000 to 2015, industrial withdrawals ranged from 9.5 to 10.3 percent of total withdrawal. In 2020, industrial withdrawals were 12.5 percent of total withdrawal. Industrial net water demand was 63 mgd in 2020, or 6.1 percent of total industrial withdrawal. This was equivalent to the industrial net demand in 2015, and slightly less than the industrial net demand in 2010.

Public supply withdrawals in 2020 totaled 695 mgd, which was the same as the public supply withdrawal in 2015. In 2015, public supply withdrawals had a 3.9 percent decline from 2010 (723 mgd) but were not as low as 2005 withdrawals (684 mgd). 2020 public supply withdrawal was 8.3 percent of total withdrawal, which was an increase from 2015 (6.9 percent). Public supply net water demand was the largest component of total net water demand at 173 mgd in 2020, or 42.9 percent of total net water demand. This is a significant decrease from 2015 and 2010, when public supply net water demand was 56.0 percent and 65.7 percent of total net water demand, respectively.

Irrigation withdrawal was 94 mgd in 2020, or 1.1 percent of total withdrawal. The irrigation withdrawal was higher than it had been in previous studies. From 1995 through 2015, irrigation had always been below one percent of total withdrawal. However, because there is no return flow from irrigation, irrigation's 2020 net water demand was 23.3 percent of the total net water demand. This is an increase in irrigation's net water demand in 2015 of 14.1 percent.

Almost all water was supplied by surface water. In 2020, 97.8 percent of the total withdrawal came from surface water, which was roughly the same as it was in 2015 (98.1 percent), 2010 (98.3 percent), 2005 (98.5 percent), and 2000 (98.2 percent). As has always been the case, all water for thermoelectric use came from surface water. In 2020, surface water supplied 96.4 percent of the industrial withdrawal (97.8 percent in 2015), 82.4 percent of the public supply withdrawal (78.0 percent in 2015), and 72.8 percent of the irrigation withdrawal (79.4 percent in 2015).

Diversions to the Tennessee-Tombigbee Waterway were 143 mgd in 2020, which was a decrease from the past 20 years. The diversions through the Barkley Canal were 1,793 mgd into the Kentucky Reservoir in 2020. The diversions through the canal at Barkley were into Barkley Reservoir from 2000 to 2010 and into Kentucky Reservoir in 2015.

PROJECTED WATER USE FOR 2045

Total water withdrawals in 2045 are projected to be 7,463 mgd, which is an 11 percent decrease from the 2020 withdrawal. This is the result of the anticipated decrease of 1,035 mgd in thermoelectric withdrawal brought about by the retirement of old power plants using once-through cooling and the introduction of new plants using closed-cycle cooling. Water use by industry is projected to decrease by one percent, or 8 mgd, to 1,035 mgd. Public supply use is projected to increase by 12 percent, or 83 mgd, to 778 mgd. A 58 percent increase in irrigation is anticipated, which increases irrigation from 94 mgd to 149 mgd. Although a large reduction in total withdrawal will occur, net water demand is projected to increase by 18 percent, or 72 mgd, to 475 mgd.

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APPENDIX

2020 WATER USE DATA SOURCES FOR THE TENNESSEE RIVER WATERSHED

State/Agency/Entity	Source	Department/Organization	Data Type	Date
Alabama	Michael Harper	Office of Water Resources	WD	11/4/2021
Georgia	Bill Frechette	Environmental Protection Division	WD	1/25/2021
Georgia	Airyne Sengchanh	Environmental Protection Division	WD	1/25/2021
Kentucky	Bill Caldwell	Division of Water	WD	7/29/2021
Mississippi	Mary McKay	Department of Environmental Quality	WD	11/22/2021
North Carolina	Linwood Peele	Department of Environmental Quality	WD	8/4/2021
North Carolina	Klaus Albertin	Department of Environmental Quality	WD	1/13/2022
North Carolina	Harold Brady	Department of Environmental Quality	WD	10/1/2021
North Carolina	John Barr	Department of Environmental Quality	WD	1/7/2022
North Carolina	Louis Murray	Department of Environmental Quality	WD	1/5/2022
Tennessee	Seth McCormick	Department of Environment and Conservation	WD	5/7/2021
Tennessee	Jim McAdoo	Department of Environment and Conservation	WD	9/9/2021
Virginia	Janet Mineva	Department of Environmental Quality	WD	5/21/2021
Virginia	Trevor Lawson	Department of Environmental Quality	WD	6/9/2021
Environmental Protection Agency	David Apanian	Region 4	RT	5/13/2021

Data Abbreviations:
WD - Withdrawal
RT - Return (discharge)
TH - Thermoelectric (generation, fuel consumption, operational cooling water data)
PROJ - Projection Data (generation, population growth, mining earnings, and manufacturing earnings)

APPENDIX

2020 WATER USE DATA SOURCES FOR THE TENNESSEE RIVER WATERSHED

State/Agency/Entity	Source	Department/Organization	Data Type	Date
Tennessee Valley Authority	Gwendolyn Bertram	Fuel Accounting	TH, WD, RT	4/1/2021
Tennessee Valley Authority	Peter Danek	Fuel Accounting	TH, WD, RT	4/1/2021
Tennessee Valley Authority	Tara Springston	Enterprise Planning	PROJ	8/31/2021
U.S. Department of Energy	Online	Energy Information Administration (EIA)	TH	9/14/2021
Woods and Poole Economics Inc	CD-ROM	Complete Economic and Demographic Data Source	PROJ	11/18/2020

Data Abbreviations:
WD - Withdrawal
RT - Return (discharge)
TH - Thermoelectric (generation, fuel consumption, operational cooling water data)
PROJ - Projection Data (generation, population growth, mining earnings, and manufacturing earnings)

GLOSSARY, TERMS AND ABBREVIATIONS

Cooling water	Water used for industry and thermoelectric power generation. There are two general types of cooling technology: open-cycle and closed-cycle.
Closed-cycle cooling	The use of evaporation for cooling (the changing of water from a liquid to a vapor with a very large transfer of heat from the water to the atmosphere)
Consumptive use	Water that is evaporated, transpired, or incorporated into crops or manufactured products, metabolized by humans or livestock, or otherwise removed from the immediate water environment
EEDR	Energy efficiency and demand response
Evapotranspiration	A collective term that includes water discharged to the atmosphere as a result of evaporation from the soil and surface water bodies, and as a result of plant transpiration
Groundwater	Generally, all subsurface water as distinct from surface water; specifically, water stored in pores of soil or rock saturated with water
Industrial water use	Water used for industrial purposes such as fabrication, processing, washing, and cooling, in industries including steel, chemical and allied products, paper and allied products, mining, and petroleum refining. The water may be obtained from a public supply or be self-supplied.
Interbasin transfer	The act of moving water across a watershed boundary to another watershed
Irrigation water use	Artificial application of water on lands to assist in the growing of crops and pastures or to maintain vegetative growth in recreational lands such as parks and golf courses
Kilowatt-hour (KWh)	A unit of energy equivalent to one thousand watt-hours
Million gallons per day (mgd)	A rate of flow of water
Mining water use	Water used for the extraction of minerals occurring naturally, including solids such as coal or ores, liquids such as crude petroleum, and gases such as natural gas. Also includes uses associated with quarrying, well operations (dewatering), milling (crushing, screening, washing, floatation, etc.), and other

	preparations customarily done at the mine site or as part of a mining activity. Does not included water used in processing, such as smelting, refining petroleum, or slurry pipeline operations; these uses are included in industrial water use.
Net water demand	The quantitative difference between water withdrawals and return flow
Off-stream use	Water withdrawn or diverted from a groundwater or surface water source for thermoelectric, industrial, public supply or irrigation use
Per capita use	The average amount of water used per person during a standard time period, generally per day
Public supply water use	Water withdrawn by public and private water suppliers and delivered to users for residential, domestic, commercial, industrial and municipal (firefighting, street washing, parks, swimming pools, etc.) purposes
Return flow	The water that reaches a surface water source after release from the point of use and thus becomes available for reuse
Reservoir catchment area (RCA)	The drainage area for a reservoir extending from the watershed boundary to a dam or the reservoir drainage area between the dam and an upstream dam
Surface water	An open body of water, such as a stream, lake or reservoir
Thermoelectric power use	Water used in the generation of thermoelectric power
Transpiration	The process by which water is absorbed by plants, usually through the roots, and evaporated into the atmosphere from the plant surface
Wastewater	Water that carries wastes from homes, businesses, and industries
Wastewater treatment	The processing of wastewaters for the removal or reduction of contained solids or other undesirable constituents
Wastewater treatment return flow	Water returned to the hydrologic system by wastewater treatment facilities
Water use	Water that is actually used for a specific purpose, such as for domestic use, irrigation, industrial processing, or thermoelectric power generation

Water use tabulation area (WUTA)	The boundaries of a water use tabulation area are determined by the natural drainage area to account for water availability and the water use transactions that occur within that drainage area. For this report, the water use tabulation area accounts for the complete site-specific, water use transactions between adjoining reservoir catchment areas and is used to determine net water demand (consumptive use) on a large scale
Water use transaction	A water use activity that is a water withdrawal, water delivery, water release, return flow, water transfer, or withdrawal
Withdrawal	Water removed from the ground or diverted from a surface water source for use