TENNESSEE VALLEY AUTHORITY
Land & River Management

Water Use in the Tennessee Valley for 2015 and Projected Use in 2040

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ACKNOWLEDGMENTS

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EXECUTIVE SUMMARY

WATER USE IN 2015

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 solely prepared the third water use report. This report is the fourth in the water use series and is based on the 2015 water use data.

Off-stream water use in the Tennessee River watershed is estimated for 2015. 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 2040 is also provided.

Total water withdrawals during 2015 were estimated to average 10,016 million gallons per day (mgd) for off-stream uses. The 2015 total withdrawal was about 16 percent lower than it was in 2010. This was in large measure due to a reduction in thermoelectric withdrawal of about 18 percent as a result of lower energy generation in the watershed compared to 2010.

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

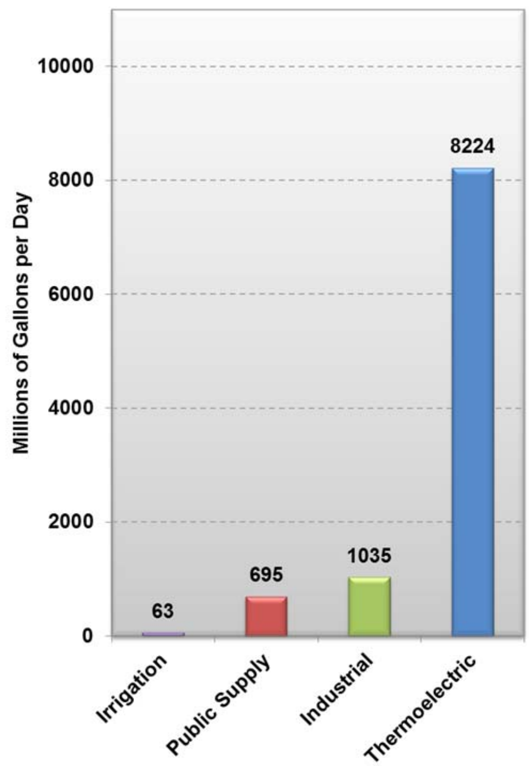

Figure ES-1: Water Withdrawals in 2015

- Thermoelectric - 8,224 mgd (82.1 percent of total use)
- Industrial - 1,035 mgd (10.3 percent of total use)
- Public supply - 695 mgd (6.9 percent of total use)
- Irrigation - 63 mgd (less than 1 percent of total use)

The return flow was estimated at 9,577 mgd or 95.6 percent of the water withdrawn. Net water demand (total withdrawal minus total return) accounts for the other 4.4 percent of total withdrawal, or 439 mgd.

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

- Thermoelectric - 8,156 mgd
  (99.2 percent of thermoelectric withdrawal, 85.2 percent of total return)
- Industrial - 971 mgd
  (93.8 percent of industrial withdrawal, 10.1 percent of total return)
- Public supply - 450 mgd
  (64.7 percent of public supply withdrawal, 4.7 percent of total return)
- Irrigation - 0 mgd

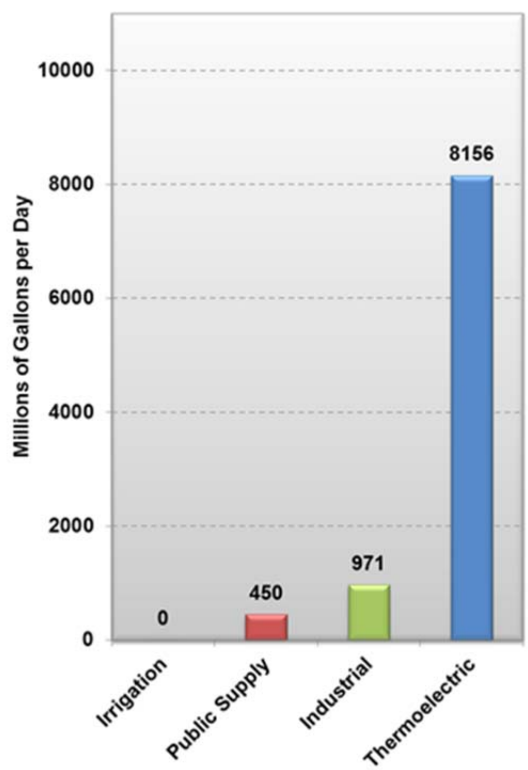

Figure ES-2: Water Returns in 2015

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 - 68 mgd (15.5 percent of total net water demand)
- Industrial - 64 mgd (14.4 percent of total net water demand)
- Public supply - 246 mgd (56 percent of total net water demand)
- Irrigation - 63 mgd (14.1 percent of total net water demand)

Surface water withdrawals were 9,828 mgd or 98.1 percent of total withdrawal with groundwater accounting for the remaining 1.9 percent of total withdrawals or 189 mgd.

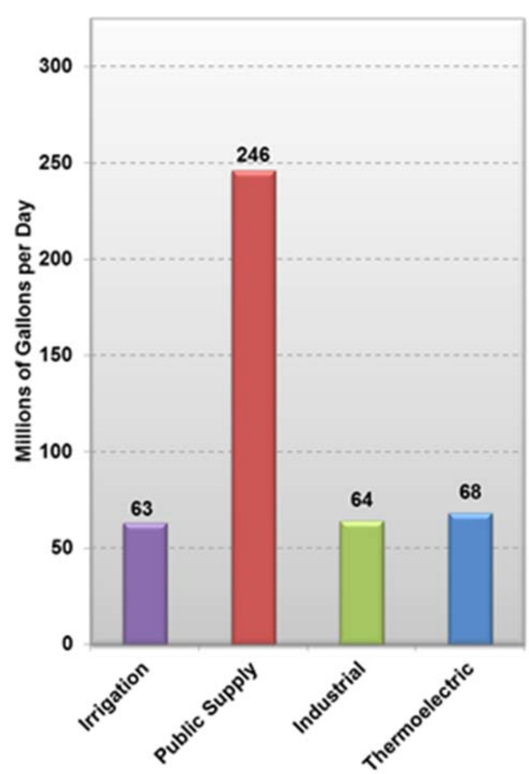

Figure ES-3: Net Water Demand in 2015

PROJECTED WATER USE IN 2040

By 2040 water withdrawals are projected to decline 19 percent from 2015 levels, to 8,108 mgd. By category, water withdrawals are projected to change from 2015 levels as follows: industrial will increase by 16 percent to 1,197 mgd, public supply will increase by 21 percent to 842 mgd, and irrigation will increase by 40 percent to 88 mgd. Thermoelectric water withdrawal is expected to decline by 27 percent to 5,981 mgd, reflecting changes in both generating and cooling technologies for power plants. These are shown in Figure ES-4.

Although total withdrawals are expected to decrease, total net water demand will rise by 24 percent to 543 mgd. This is due to projected economic growth and continued population growth in the Tennessee Valley, as well as continued growth of irrigated agriculture.

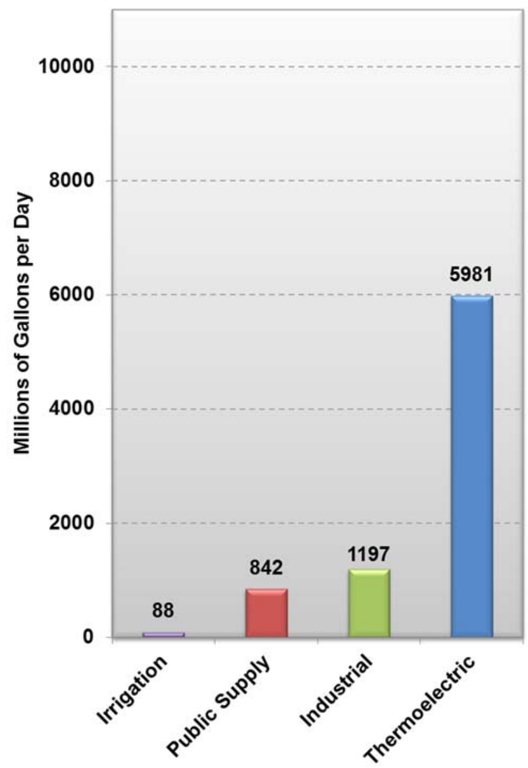

Figure ES-4: Projected Withdrawal in 2040

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 U.S. Geological Survey (USGS) and the Tennessee Valley Authority (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 out to 2035.

PURPOSE AND SCOPE

The purpose of this report is to present water use estimates for the Tennessee River watershed based on 2015 data with water use projections to 2040. 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 yearly 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 all of these competing demands, particularly in unregulated portions (streams or rivers without dams) of the Tennessee River system.

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, and 2010, the watershed received 76 percent, 79 percent, and 80 percent, of average rainfall respectively. The rainfall in 2015 was 59 inches or 115 percent of average.

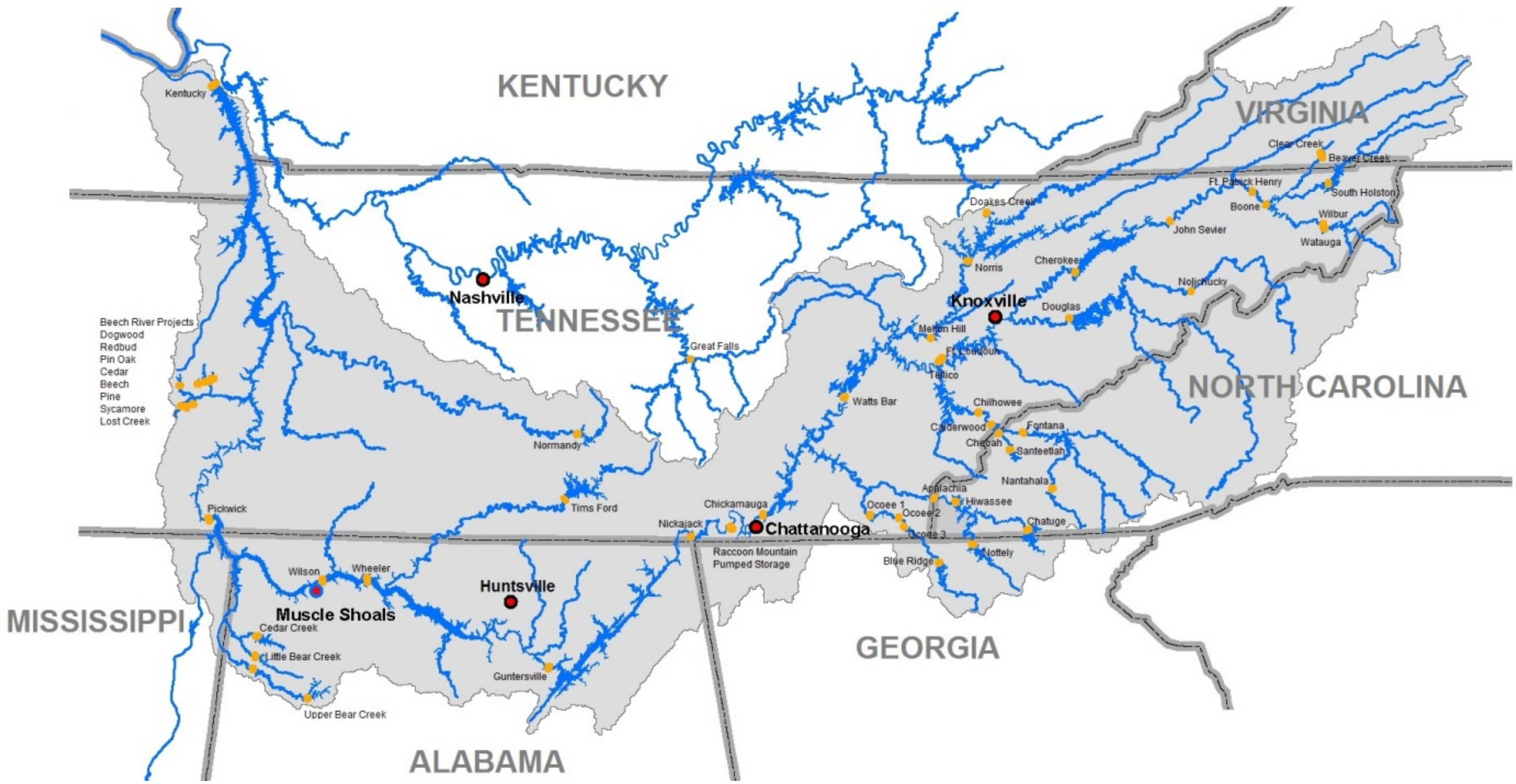

Figure 1-1: Tennessee River Watershed

DATA SOURCES AND ANALYSIS METHODS

Similar to the water use estimates prepared for previous reports, the data for this report are stored in the TVA Water Use Data System. 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 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 2015 directly obtained from the seven Tennessee Valley states. 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: Steam-Electric Plant Operation and Design Report (U.S. Department of Energy, 2015).

The U.S. Environmental Protection Agency, National Pollutant Discharge Elimination System Program, Permit Compliance System (U. S. Environmental Protection Agency, 2016) provided return flow data for municipalities, industry (including mining), and thermoelectric plants.

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, 2015) 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 2–1 through 2–8 contain two decimal places and totals are shown as integers. All numbers were rounded independently. Therefore, the sums of independently rounded numbers may not equal the totals (expressed as integers) in the report.

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 public supply, industrial (including mining), thermoelectric, and irrigation. Transactions are either withdrawals or returns. Returns are water discharges from thermoelectric power plants, industries, and municipal wastewater treatment plants.

Previous Water Use in the Tennessee River reports organized water use in three ways: by Water Use Tabulation Area (WUTA) and Reservoir Catchment Area (RCA), hydrologic unit code (HUC), and by state and county. For 2015, water use is only organized based on Water Use Tabulation Area (WUTA) and Reservoir Catchment Area (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 the state and county level summaries, so it is no longer necessary for TVA to also report this data in their report.

Figure 2–1 shows the Tennessee River watershed divided into RCAs. The Water Use Tabulation Area (WUTA) groups RCAs to account for the complete site-specific water use transactions between adjoining RCAs and is used to determine consumptive use at a large scale. The WUTA groups RCAs to account for TVA's integrated management of the Tennessee River. Table 2–1 shows 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.

The difference between withdrawal and return is the net water demand at the RCA level. 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 that have the intake in the reservoir pool just upstream of the dam, but have their discharge downstream in the tailrace of the dam in the downstream RCA. It is also common for public users who have an intake in the reservoir, but the wastewater treatment plant is located downstream in a different RCA.

As in the case 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 (Fort Loudoun, Watts Bar-Chickamauga, Nickajack, Guntersville, Wheeler-Wilson, Pickwick and Kentucky) in the river system and estimates a sum of consumptive use in the watershed to that juncture. The net water demand accumulated at Kentucky Dam is the estimate for total consumptive use for the watershed.

In this report, 100 percent of the water used for irrigation is considered to be net water demand.

Figure 2-1: Tennessee River Watershed by Reservoir Catchment Areas

OFF-STREAM WATER USE

Total Off-stream Water Use

Total off-stream water use for 2015 by RCA and WUTA is shown in Table 2–1.

Total withdrawal was 10,016 million gallons per day (mgd) of which 98.1 percent or 9,828 mgd came from surface water. Groundwater supplied the remaining 1.9 percent or 189 mgd. Return flow totaled 9,577 mgd or 95.6 percent of total withdrawal. Total net water demand was 439 mgd or 4.4 percent of total withdrawal.

Figures 2–2, 2–3, and 2–4 show the total withdrawal, return, and net demand by RCA, respectively. This is a visual representation of the data provided in Table 2–1. The Wheeler RCA had the largest withdrawal at 3,087 mgd, but it also had the largest return at 3,026 mgd. The greatest net demand was the Ft Patrick Henry RCA (537 mgd), which is due to an industry that relies on Ft Patrick Henry for water withdrawals, but the returns are in the Cherokee RCA (-481 mgd).

Figure 2–5 shows the cumulative net water demand at major WUTA junctures and net water demand for reservoir catchment areas. The Wheeler-Wilson WUTA had the largest withdrawal, at 3,076 mgd (Table 2‒1; Figure 2‒4), or 30.7 percent of the total withdrawal, followed by Watts Bar-Chickamauga at 2,774 mgd, which is 27.7 percent of total withdrawal.

Water Use Summarized by Category

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

Thermoelectric water use was the category with the largest total withdrawal, at 8,224 mgd or 82.1 percent of total withdrawal. Total industrial withdrawal was 1,035 mgd or 10.3 percent of total withdrawal, total public supply withdrawal was 695 mgd or 6.9 percent of total withdrawal, and total irrigation withdrawal was 63 mgd, which was less than 1 percent of total withdrawal.

Of the total return flow of 9,577 mgd, thermoelectric return was 8,156 mgd or 85.2 percent of the total return, industrial return was 971 mgd or 10.1 percent of total return, and public supply return was 450 mgd, or 4.7 percent of total return. It was assumed that there was no irrigation return flow.

The WUTA with the largest thermoelectric water use (2,853 mgd) is the Wheeler-Wilson WUTA. The Wheeler-Wilson WUTA also has the largest public supply withdrawal (110 mgd) and irrigation withdrawal (21 mgd). The largest industrial water withdrawal (590 mgd) is from the Cherokee WUTA.

Water Use Summarized by Source

Tables 2–3 and 2–4 summarize surface water and groundwater withdrawals by category and by WUTA. Total withdrawal was 9,828 mgd for surface water (Table 2−3; Figure 2−6) and 189 mgd for groundwater (Table 2−4; Figure 2−7).

Surface water supplied all of the thermoelectric withdrawal of 8,224 mgd. Surface water was the source for 1,012 mgd or of 97.8 percent of the industrial withdrawal, 542 mgd or 78.0 percent of the public supply withdrawal, and 50 mgd or 79.4 percent of the irrigation withdrawal.

Groundwater withdrawal for industry was 23 mgd, which was 2.2 percent of total industrial withdrawal; for public supply groundwater withdrawal was 153 mgd or 22.0 percent of total public supply use, and for irrigation it was 13 mgd or 20.6 percent of total irrigation use.

Wheeler-Wilson was the WUTA with the highest surface withdrawal, at 3,076 mgd (Table 2−3; Figure 2−6), and highest groundwater withdrawal, at 44 mgd (Table 2−4; Figure 2−7).

Water Use Described by Category

Thermoelectric

Total thermoelectric withdrawal was 8,224 mgd of which 8,156 mgd or 99.2 percent was returned.

Table 2–5 and Figure 2−8 shows thermoelectric withdrawal by RCA and WUTA. The largest WUTA withdrawal was 2,853 mgd from the Wheeler-Wilson WUTA. This accounted for 34.7 percent of total thermoelectric withdrawal. This withdrawal was used to generate 30,914 million kilowatt hours of electricity, or 43.9 percent of the total power generated in the Tennessee River watershed. Figures 2−9 and 2−10 show thermoelectric return and net demand, respectively.

The largest withdrawal from the Wheeler-Wilson WUTA was Browns Ferry Nuclear Plant (2,851 mgd) in Limestone County, Ala., and its location is shown in Figure 2–11. All the plants shown on Figure 2−11 are TVA's except Asheville, Clinch River, and Decatur.

The second largest WUTA withdrawal was from the Watts Bar - Chickamauga WUTA (2,669 mgd or 32.5 percent of total thermoelectric withdrawal). This was used to generate 28,823 million kilowatt hours of electricity, or 41.0 percent of the total power generated in the Tennessee River watershed.

Industrial

Table 2–6 and Figure 2–12 shows that the total industrial withdrawal was 1,035 mgd, or 10.3 percent of total withdrawal. Industrial return flow (Figure 2–13) was 971 mgd, and total net water demand (Figure 2–14) was 63 mgd or 6.1 percent of the industrial withdrawal. Surface water supplied 97.8 percent, or 1,012 mgd of the water for industrial use.

Cherokee was the WUTA with the highest industrial withdrawal, which was 590 mgd, or 57.0 percent of the total industrial withdrawal. The Wheeler-Wilson WUTA withdrawal of 109 mgd was the next highest.

The Cherokee WUTA also had the highest net water demand of 36 mgd, or 57.1 percent of the total industrial net water demand. Some RCA's and WUTA's 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 2–7 and Figure 2‒15, which was 6.9 percent of total water withdrawal. Total return for public supply (Figure 2‒16) was 64.7% of the withdrawal or 450 mgd. Public supply net water demand (Figure 2‒17) was the highest of the four uses, and totaled 246 mgd. This was 35.4 percent of total public supply withdrawal. Surface water supplied 542 mgd, or 78.0 percent of withdrawal for public supply use.

Wheeler-Wilson was the WUTA with the highest public supply withdrawal at 137 mgd, and it also had the highest net water demand at 52 mgd.

The population in 2015 for the Tennessee River watershed was about 5,084,150 (Woods & Poole, 2015). The per capita public supply use was about 137 gallons per day, down from 145 gallons per day in 2010.

Irrigation

Table 2–8 and Figure 2‒18 shows that surface water supplied 50 mgd, or 79.4 percent of the total withdrawal for irrigation use. Once again, the Wheeler-Wilson WUTA had the highest withdrawal at 21 mgd, or 33.3 percent of the total irrigation withdrawal.

Whereas groundwater supplied only 1.9 percent of the total withdrawal for the watershed for all uses, groundwater supplied 13 mgd or 20.6 percent of the withdrawal for irrigation.

Table 2-1. Total off-stream water use by source and WUTA in 2015

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

WUTA RCA	Withdrawals **Surface water**	 **Ground-water**	 **Total water**	**Total return flow**	**Net water demand**
Cherokee					
Watauga	17.09	8.76	25.85	1.74	24.11
South Holston	20.24	6.20	26.44	7.19	19.25
Boone	0.18	3.01	3.19	25.00	-21.82
Ft Patrick Henry	537.02		537.02		537.02
Cherokee	84.44	3.69	88.13	569.23	-481.10
WUTA total	***658.96***	***21.65***	***680.61***	***603.16***	***77.46***
Cumulative	*659*	*22*	*681*	*603*	*77*
Douglas					
Douglas	382.94	21.62	404.56	330.00	74.57
WUTA total	***382.94***	***21.62***	***404.56***	***330.00***	***74.57***
Cumulative	*1,042*	*43*	*1,085*	*933*	*152*
Fort Loudoun					
Fort Loudoun	56.63	2.56	59.19	91.15	-31.96
WUTA total	***56.63***	***2.56***	***59.19***	***91.15***	***-31.96***
Cumulative	*1,099*	*46*	*1,144*	*1,024*	*120*
Fontana-Tellico					
Fontana	24.96	4.69	29.66	20.55	9.10
Tellico	14.64	1.09	15.72	8.42	7.30
WUTA total	***39.60***	***5.78***	***45.38***	***28.97***	***16.41***
Cumulative	*1,138*	*52*	*1,190*	*1,053*	*136*
Norris					
Norris	31.54	3.36	34.90	19.23	15.68
Melton Hill	555.95	1.38	557.33	527.29	30.03
WUTA total	***587.49***	***4.74***	***592.23***	***546.52***	***45.71***
Cumulative	*1,726*	*56*	*1,782*	*1,600*	*182*
Hiwassee-Ocoee					
Chatuge	2.71	1.48	4.19	0.24	3.94
Nottely	1.39	0.43	1.81	0.34	1.47
Hiwassee	1.23	1.05	2.28	1.93	0.35
Apalachia	2.10		2.10	0.01	2.09
Blue Ridge	4.08	0.93	5.01	2.37	2.64
Ocoee	0.04	0.49	0.53	0.45	0.07
WUTA total	***11.55***	***4.37***	***15.92***	***5.36***	***10.56***
Cumulative	*1,737*	*61*	*1,798*	*1,605*	*193*
Watts Bar-Chickamauga					
Watts Bar	1,127.41	2.23	1,129.64	984.06	145.58
Chickamauga	1,646.84	28.86	1,675.70	1,756.20	-80.50
WUTA total	***2,774.25***	***31.09***	***2,805.34***	***2,740.26***	***65.08***
Cumulative	*4,511*	*92*	*4,603*	*4,345*	*258*
Nickajack					
Nickajack	44.40	5.03	49.44	57.92	-8.48
WUTA total	***44.40***	***5.03***	***49.44***	***57.92***	***-8.48***
Cumulative	*4,556*	*97*	*4,653*	*4,403*	*249*

Table 2-1 Continued.

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

WUTA RCA	Withdrawals **Surface water**	**Ground-water**	**Total water**	**Total return flow**	**Net water demand**
Guntersville					
Guntersville	518.84	7.67	526.51	498.42	28.09
WUTA total	***518.84***	***7.67***	***526.51***	***498.42***	***28.09***
Cumulative	*5,075*	*105*	*5,179*	*4,902*	*277*
Tims Ford					
Tims Ford	32.09	3.03	35.13	22.33	12.79
WUTA total	***32.09***	***3.03***	***35.13***	***22.33***	***12.79***
Cumulative	*5,107*	*108*	*5,214*	*4,924*	*290*
Wheeler-Wilson					
Wheeler	3,046.76	39.82	3,086.57	3,026.40	60.17
Wilson	28.98	4.07	33.05	9.05	24.00
WUTA total	***3,075.74***	***43.88***	***3,119.62***	***3,035.45***	***84.17***
Cumulative	*8,182*	*151*	*8,334*	*7,960*	*374*
Pickwick					
Pickwick	1,019.99	6.05	1,026.04	1,005.20	20.84
Cedar Creek	3.73	0.26	3.99	3.55	0.43
Upper Bear Creek	2.85		2.85		2.85
Bear Creek	0.66		0.66	0.13	0.54
WUTA total	***1,027.23***	***6.30***	***1,033.53***	***1,008.88***	***24.66***
Cumulative	*9,210*	*158*	*9,367*	*8,968*	*399*
Normandy					
Normandy	27.32	0.66	27.97	3.05	24.92
WUTA total	***27.32***	***0.66***	***27.97***	***3.05***	***24.92***
Cumulative	*9,237*	*158*	*9,395*	*8,971*	*424*
Kentucky					
Kentucky	590.49	30.44	620.92	605.86	15.06
WUTA total	***590.49***	***30.44***	***620.92***	***605.86***	***15.06***
Cumulative	*9,828*	*189*	*10,016*	*9,577*	*439*

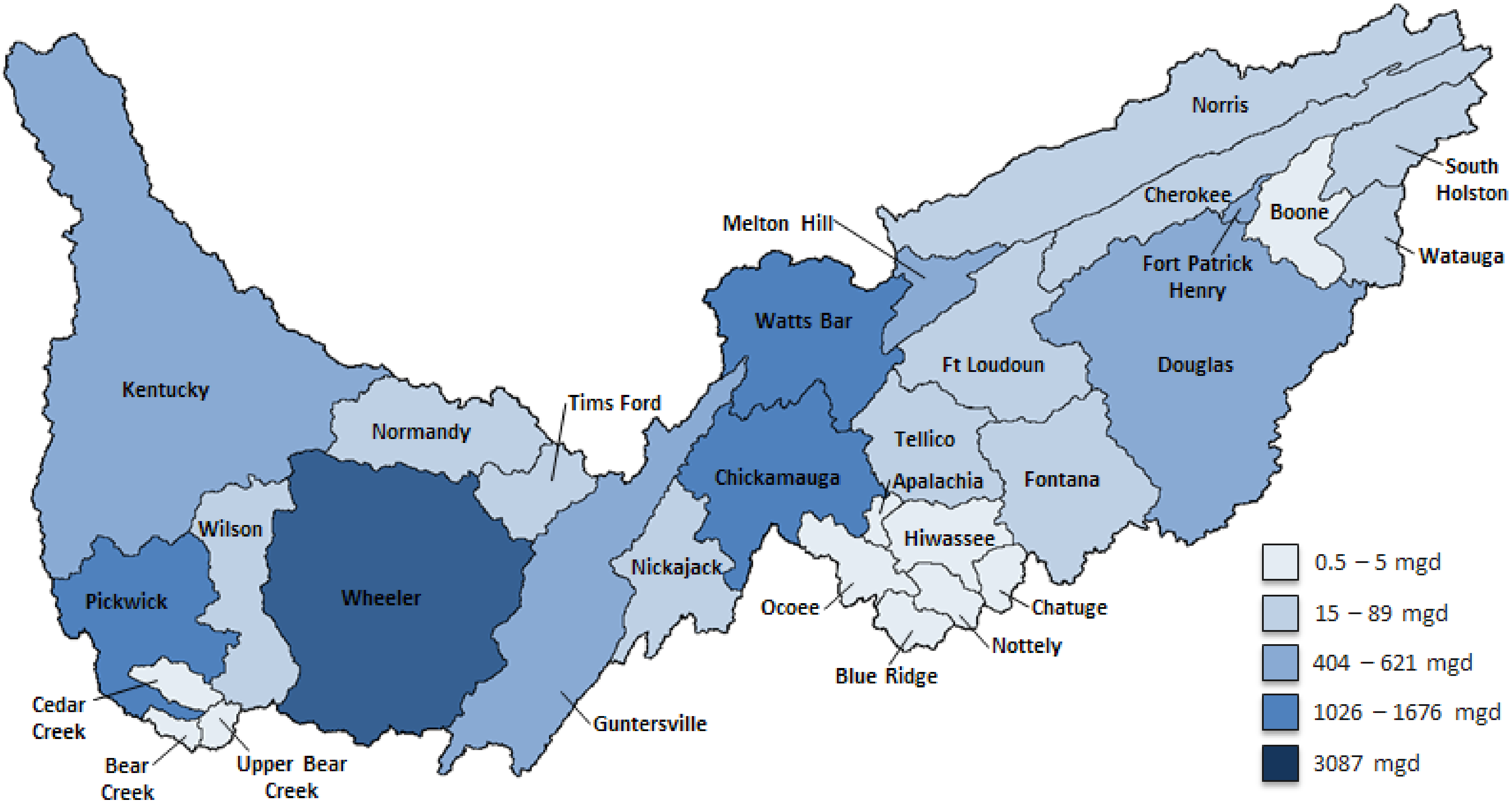

Figure 2-2: Total Withdrawal by RCA in 2015

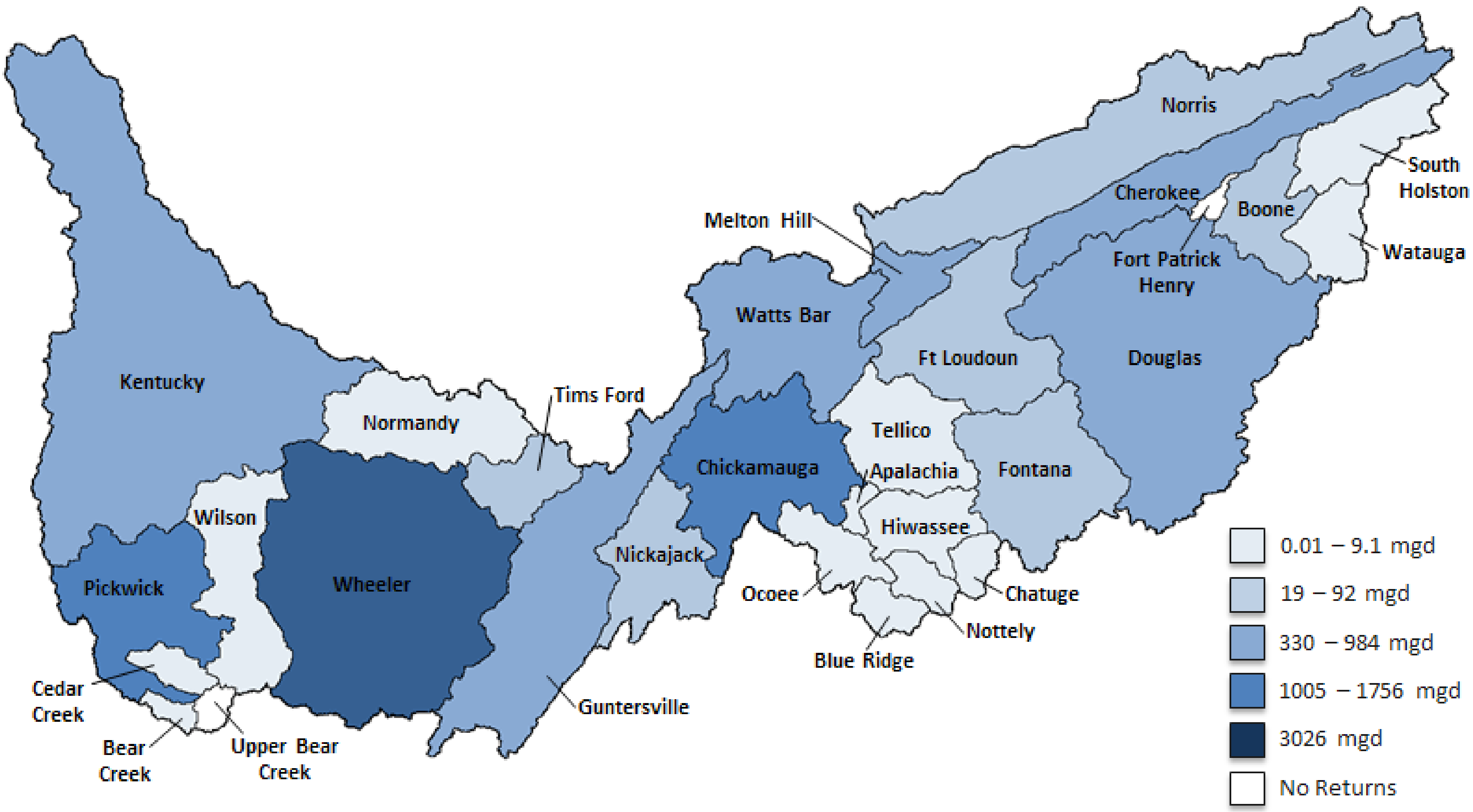

Figure 2-3. Total Returns by RCA in 2015

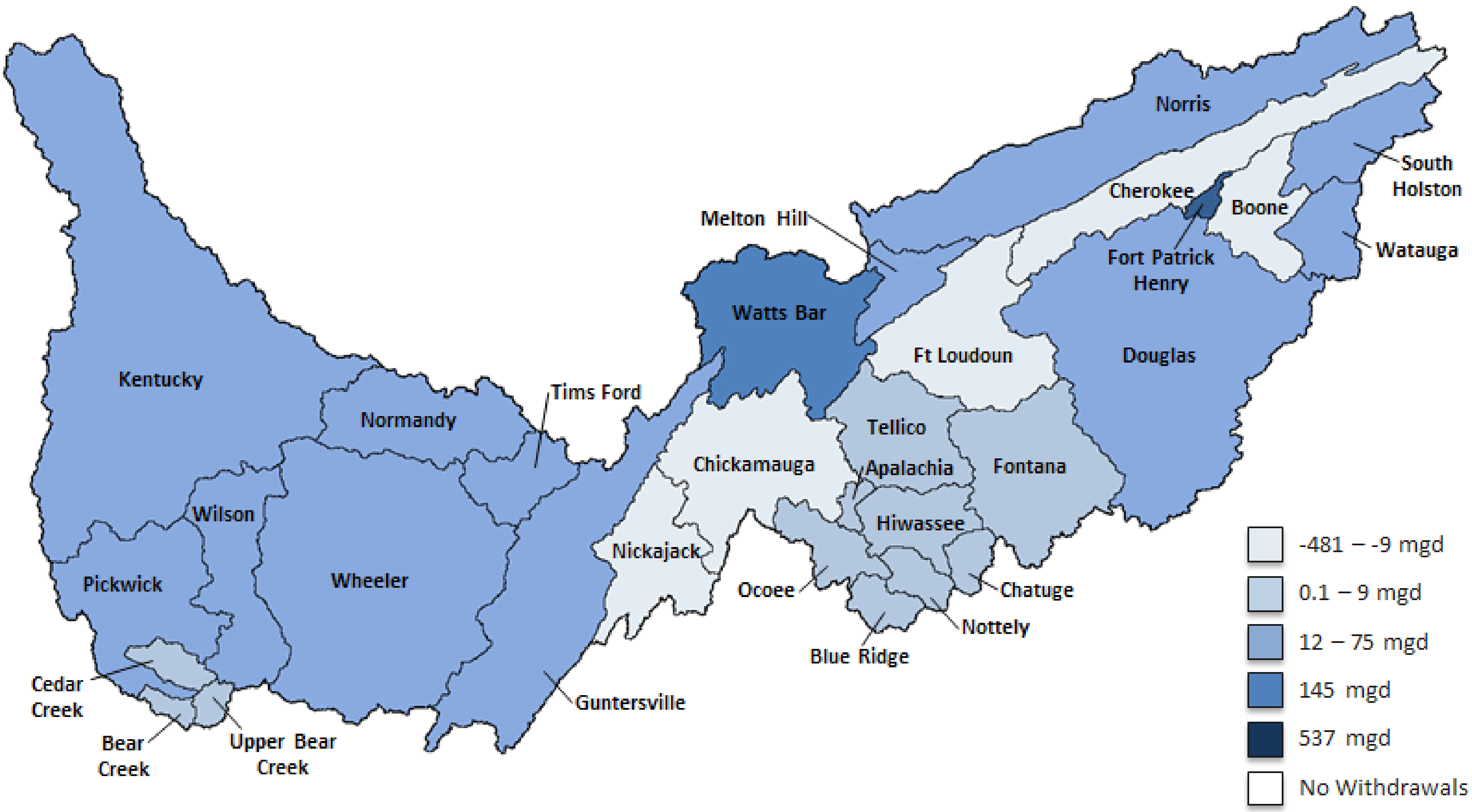

Figure 2-4: Total Net Demand by RCA in 2015

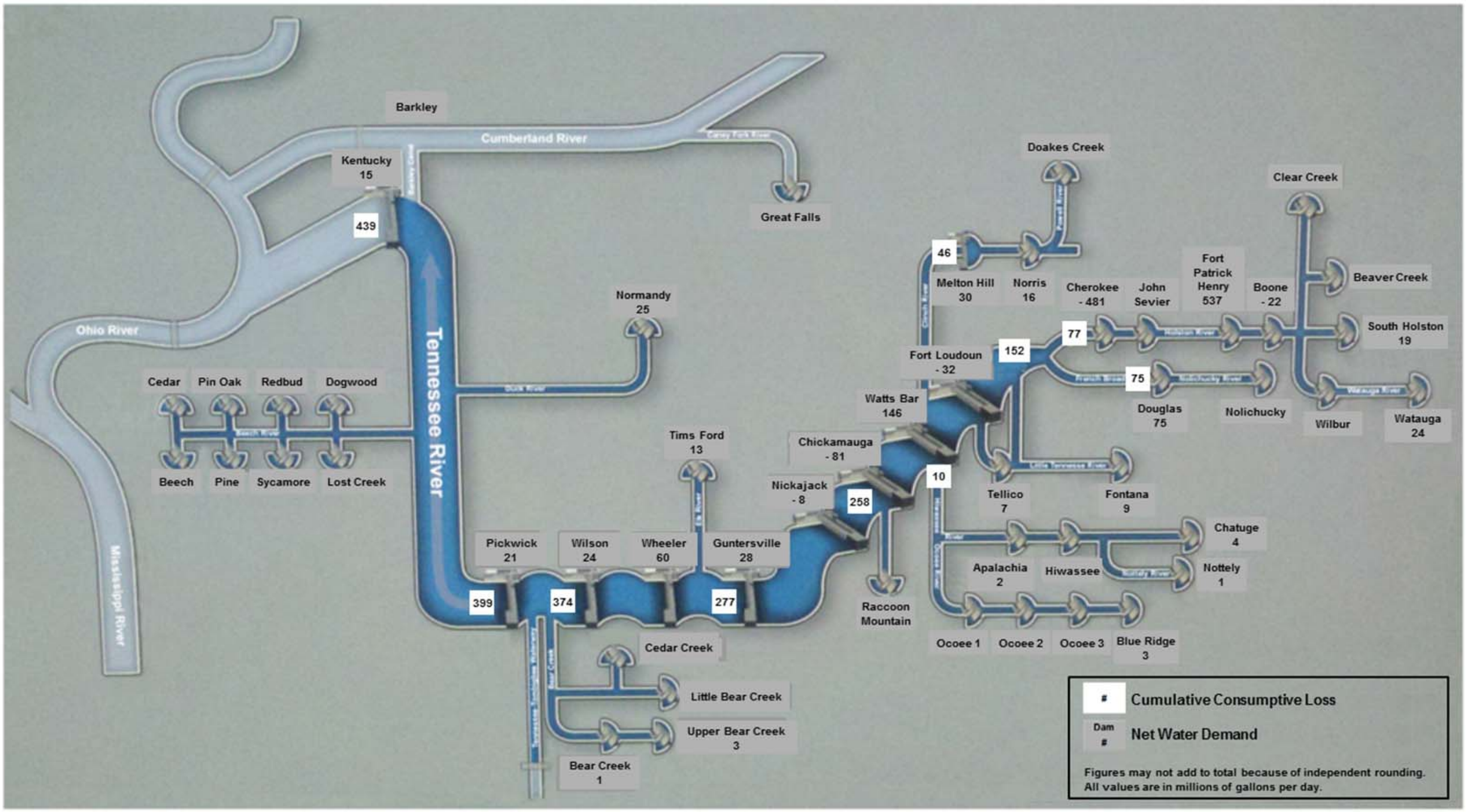

Figure 2-5: Cumulative Net Water Demand for RCAs and WUTAs

Table 2-2. Total water use by category and WUTA in 2015

[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
Cherokee									
Watauga			0.12	0.04	24.28	1.70	1.44	25.85	1.74
South Holston			3.31	2.03	22.52	5.16	0.61	26.44	7.19
Boone			0.16		2.70	25.00	0.33	3.19	25.00
Ft Patrick Henry			520.57		16.44			537.02	0.00
Cherokee			65.82	551.51	20.93	17.72	1.38	88.13	569.23
WUTA total			***589.98***	***553.57***	***86.88***	***49.59***	***3.76***	***680.61***	***603.16***
Cumulative	*0*	*0*	*590*	*554*	*87*	*50*	*4*	*681*	*603*
Douglas									
Douglas	237.92	233.80	65.84	50.90	91.57	45.30	9.24	404.56	330.00
WUTA total	***237.92***	***233.80***	***65.84***	***50.90***	***91.57***	***45.30***	***9.24***	***404.56***	***330.00***
Cumulative	*238*	*234*	*656*	*604*	*178*	*95*	*13*	*1,085*	*933*
Fort Loudoun									
Fort Loudoun			3.44	27.47	55.02	63.68	0.74	59.19	91.15
WUTA total			***3.44***	***27.47***	***55.02***	***63.68***	***0.74***	***59.19***	***91.15***
Cumulative	*238*	*234*	*659*	*632*	*233*	*159*	*14*	*1,144*	*1,024*
Fontana-Tellico									
Fontana			17.98	16.78	10.01	3.78	1.66	29.66	20.55
Tellico			6.60	6.60	8.60	1.82	0.52	15.72	8.42
WUTA total			***24.59***	***23.38***	***18.61***	***5.59***	***2.18***	***45.38***	***28.97***
Cumulative	*238*	*234*	*684*	*655*	*252*	*164*	*16*	*1,190*	*1,053*
Norris									
Norris	10.35	1.42	4.23	3.53	19.16	14.28	1.16	34.90	19.23
Melton Hill	528.62	506.59	0.33	6.53	27.71	14.17	0.67	557.33	527.29
WUTA total	***538.97***	***508.01***	***4.56***	***10.07***	***46.87***	***28.45***	***1.84***	***592.23***	***546.52***
Cumulative	*777*	*742*	*688*	*665*	*299*	*193*	*18*	*1,782*	*1,600*
Hiwassee-Ocoee									
Chatuge					3.83	0.24	0.35	4.19	0.24
Nottely					1.39	0.34	0.43	1.81	0.34
Hiwassee			0.12		1.67	1.93	0.50	2.28	1.93
Apalachia					2.10	0.01		2.10	0.01
Blue Ridge			1.95	1.95	2.91	0.42	0.15	5.01	2.37
Ocoee					0.48	0.45	0.04	0.53	0.45
WUTA total			***2.07***	***1.95***	***12.38***	***3.41***	***1.47***	***15.92***	***5.36***
Cumulative	*777*	*742*	*690*	*667*	*311*	*196*	*19*	*1,798*	*1,605*
Watts Bar-Chickamauga									
Watts Bar	1,095.65	955.74	6.30	5.00	26.36	23.32	1.34	1,129.64	984.06
Chickamauga	1,572.94	1,694.56	44.49	41.28	55.97	20.36	2.30	1,675.70	1,756.20
WUTA total	***2,668.59***	***2,650.30***	***50.79***	***46.29***	***82.33***	***43.68***	***3.63***	***2,805.34***	***2,740.26***
Cumulative	*3,445*	*3,392*	*741*	*714*	*394*	*240*	*23*	*4,603*	*4,345*
Nickajack									
Nickajack			10.72	11.89	37.06	46.03	1.65	49.44	57.92
WUTA total			***10.72***	***11.89***	***37.06***	***46.03***	***1.65***	***49.44***	***57.92***
Cumulative	*3,445*	*3,392*	*752*	*726*	*431*	*286*	*25*	*4,653*	*4,403*

Table 2-2 Continued.

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

WUTA RCA	Thermoelectric Withdrawal	Thermoelectric Return	Industrial Withdrawal	Industrial Return	Public Supply Withdrawal	Public Supply Return	Irrigation Withdrawal	Total Withdrawal	Total Return
Guntersville									
Guntersville	470.69	470.02	9.18	6.73	44.19	21.68	2.45	526.51	498.42
WUTA total	***470.69***	***470.02***	***9.18***	***6.73***	***44.19***	***21.68***	***2.45***	***526.51***	***498.42***
Cumulative	*3,916*	*3,862*	*761*	*732*	*475*	*307*	*27*	*5,179*	*4,902*
Tims Ford									
Tims Ford			28.07	17.14	4.49	5.20	2.57	35.13	22.33
WUTA total			***28.07***	***17.14***	***4.49***	***5.20***	***2.57***	***35.13***	***22.33***
Cumulative	*3,916*	*3,862*	*789*	*749*	*479*	*313*	*30*	*5,214*	*4,924*
Wheeler-Wilson									
Wheeler	2,852.59	2,840.23	98.24	104.43	117.84	81.74	17.90	3,086.57	3,026.40
Wilson			10.55	5.24	19.35	3.81	3.14	33.05	9.05
WUTA total	***2,852.59***	***2,840.23***	***108.79***	***109.67***	***137.19***	***85.55***	***21.04***	***3,119.62***	***3,035.45***
Cumulative	*6,769*	*6,702*	*898*	*859*	*617*	*398*	*51*	*8,334*	*7,960*
Pickwick									
Pickwick	963.90	963.10	46.98	25.28	12.98	16.82	2.18	1,026.04	1,005.20
Cedar Creek					3.99	3.55		3.99	3.55
Upper Bear Creek					2.85			2.85	0.00
Bear Creek					0.66	0.13		0.66	0.13
WUTA total	***963.90***	***963.10***	***46.98***	***25.28***	***20.47***	***20.50***	***2.18***	***1,033.53***	***1,008.88***
Cumulative	*7,733*	*7,665*	*945*	*884*	*637*	*419*	*53*	*9,367*	*8,968*
Normandy									
Normandy			0.62		25.94	3.05	1.41	27.97	3.05
WUTA total			***0.62***		***25.94***	***3.05***	***1.41***	***27.97***	***3.05***
Cumulative	*7,733*	*7,665*	*946*	*884*	*663*	*422*	*54*	*9,395*	*8,971*
Kentucky									
Kentucky	491.26	490.89	89.00	87.05	32.29	27.93	8.37	620.92	605.86
WUTA total	***491.26***	***490.89***	***89.00***	***87.05***	***32.29***	***27.93***	***8.37***	***620.92***	***605.86***
Cumulative	*8,224*	*8,156*	*1,035*	*971*	*695*	*450*	*63*	*10,016*	*9,577*

Table 2-3. Surface water withdrawals by category and WUTA in 2015

[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 water withdrawals
Cherokee					
Watauga		0.12	15.85	1.11	17.09
South Holston		3.31	16.54	0.39	20.24
Boone		0.02		0.16	0.18
Ft Patrick Henry		520.57	16.44		537.02
Cherokee		65.81	17.39	1.23	84.44
WUTA total		***589.84***	***66.23***	***2.90***	***658.96***
Cumulative	*0*	*590*	*66*	*3*	*659*
Douglas					
Douglas	237.92	62.49	75.05	7.47	382.94
WUTA total	***237.92***	***62.49***	***75.05***	***7.47***	***382.94***
Cumulative	*238*	*652*	*141*	*10*	*1,042*
Fort Loudoun					
Fort Loudoun		1.32	54.99	0.32	56.63
WUTA total		***1.32***	***54.99***	***0.32***	***56.63***
Cumulative	*238*	*654*	*196*	*11*	*1,099*
Fontana-Tellico					
Fontana		17.88	5.42	1.66	24.96
Tellico		6.60	7.62	0.41	14.64
WUTA total		***24.48***	***13.05***	***2.07***	***39.60***
Cumulative	*238*	*678*	*209*	*13*	*1,138*
Norris					
Norris	10.35	3.65	16.42	1.12	31.54
Melton Hill	528.62	0.32	26.35	0.65	555.95
WUTA total	***538.97***	***3.97***	***42.77***	***1.77***	***587.49***
Cumulative	*777*	*682*	*252*	*15*	*1,726*
Hiwassee-Ocoee					
Chatuge			2.41	0.30	2.71
Nottely			0.96	0.43	1.39
Hiwassee		0.08	0.75	0.41	1.23
Apalachia			2.10		2.10
Blue Ridge		1.95	2.01	0.12	4.08
Ocoee				0.04	0.04
WUTA total		***2.03***	***8.23***	***1.30***	***11.55***
Cumulative	*777*	*684*	*260*	*16*	*1,737*
Watts Bar-Chickamauga					
Watts Bar	1,095.65	6.30	24.16	1.30	1,127.41
Chickamauga	1,572.94	43.68	28.41	1.81	1,646.84
WUTA total	***2,668.59***	***49.98***	***52.58***	***3.10***	***2,774.25***
Cumulative	*3,445*	*734*	*313*	*19*	*4,511*
Nickajack					
Nickajack		6.54	37.03	0.83	44.40
WUTA total		***6.54***	***37.03***	***0.83***	***44.40***
Cumulative	*3,445*	*741*	*350*	*20*	*4,556*

Table 2-3 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 water withdrawals**
Guntersville					
Guntersville	470.69	9.10	37.22	1.83	518.84
WUTA total	***470.69***	***9.10***	***37.22***	***1.83***	***518.84***
Cumulative	*3,916*	*750*	*387*	*22*	*5,075*
Tims Ford					
Tims Ford		27.66	2.26	2.17	32.09
WUTA total		***27.66***	***2.26***	***2.17***	***32.09***
Cumulative	*3,916*	*777*	*389*	*24*	*5,107*
Wheeler-Wilson					
Wheeler	2,852.59	98.23	82.25	13.68	3,046.76
Wilson		10.55	16.45	1.98	28.98
WUTA total	***2,852.59***	***108.79***	***98.71***	***15.65***	***3,075.74***
Cumulative	*6,769*	*886*	*488*	*39*	*8,182*
Pickwick					
Pickwick	963.90	46.96	7.85	1.28	1,019.99
Cedar Creek			3.73		3.73
Upper Bear Creek			2.85		2.85
Bear Creek			0.66		0.66
WUTA total	***963.90***	***46.96***	***15.09***	***1.28***	***1,027.23***
Cumulative	*7,733*	*933*	*503*	*41*	*9,210*
Normandy					
Normandy		0.37	25.75	1.19	27.32
WUTA total		***0.37***	***25.75***	***1.19***	***27.32***
Cumulative	*7,733*	*934*	*529*	*42*	*9,237*
Kentucky					
Kentucky	491.26	78.52	13.05	7.66	590.49
WUTA total	***491.26***	***78.52***	***13.05***	***7.66***	***590.49***
Cumulative	*8,224*	*1,012*	*542*	*50*	*9,828*

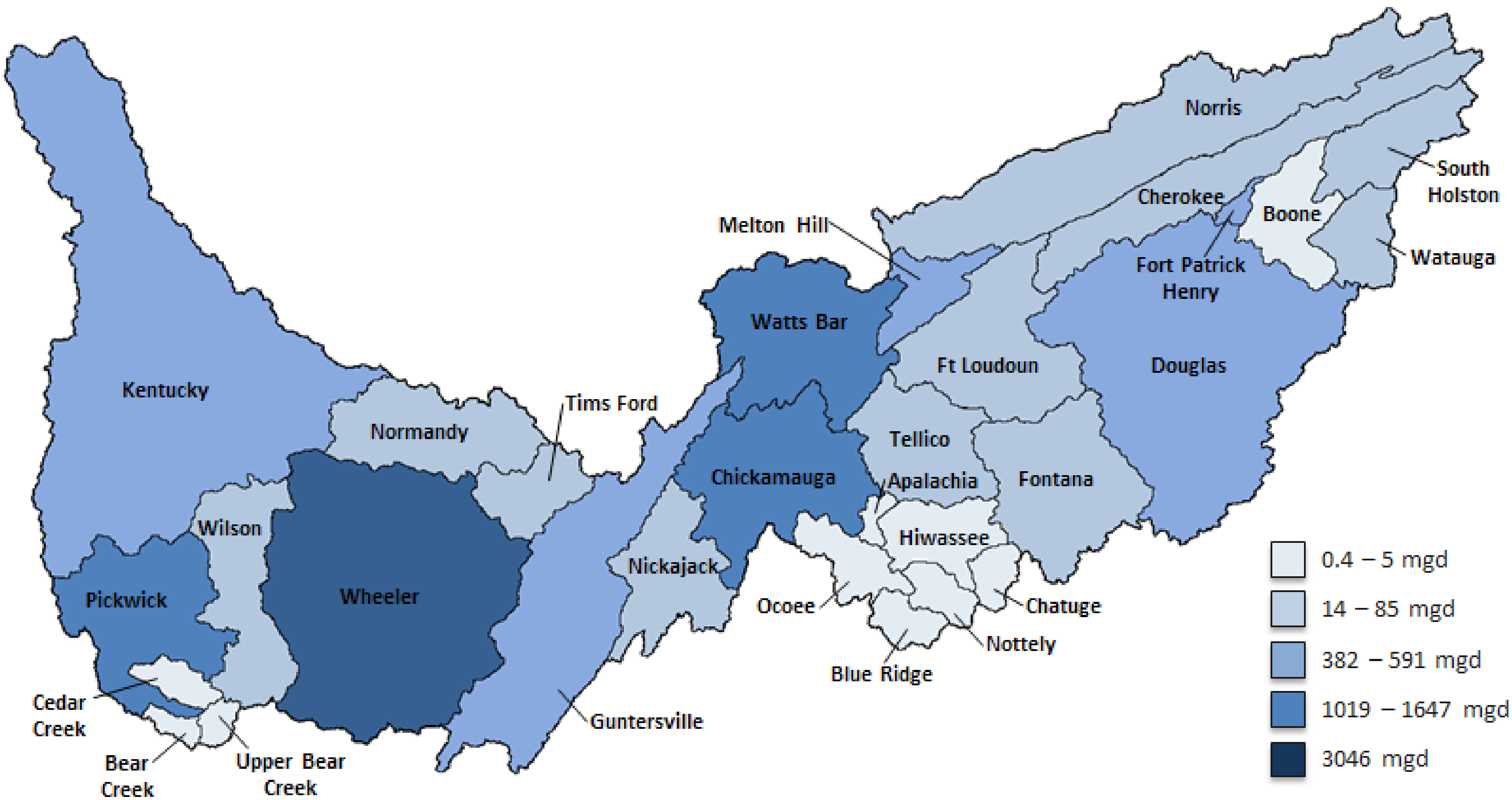

Figure 2-6: Total Surface Water Withdrawal by RCA for 2015

Table 2-4. Groundwater withdrawals by category and WUTA in 2015

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

WUTA RCA	**Industrial**	**Public**	**Irrigation**	**Total water withdrawals**
Cherokee				
Watauga		8.42	0.33	8.76
South Holston		5.98	0.21	6.20
Boone	0.14	2.70	0.16	3.01
Ft Patrick Henry				0.00
Cherokee	0.00	3.54	0.15	3.69
WUTA total	***0.14***	***20.65***	***0.86***	***21.65***
Cumulative	*0*	*21*	*1*	*22*
Douglas				
Douglas	3.34	16.51	1.77	21.62
WUTA total	***3.34***	***16.51***	***1.77***	***21.62***
Cumulative	*3*	*37*	*3*	*43*
Fort Loudoun				
Fort Loudoun	2.11	0.03	0.42	2.56
WUTA total	***2.11***	***0.03***	***0.42***	***2.56***
Cumulative	*6*	*37*	*3*	*46*
Fontana-Tellico				
Fontana	0.10	4.59	0.00	4.69
Tellico		0.97	0.11	1.09
WUTA total	***0.10***	***5.56***	***0.11***	***5.78***
Cumulative	*6*	*43*	*3*	*52*
Norris				
Norris	0.58	2.74	0.04	3.36
Melton Hill	0.00	1.36	0.02	1.38
WUTA total	***0.58***	***4.10***	***0.06***	***4.74***
Cumulative	*6*	*47*	*3*	*56*
Hiwassee-Ocoee				
Chatuge		1.43	0.05	1.48
Nottely		0.43		0.43
Hiwassee	0.04	0.92	0.09	1.05
Apalachia				0.00
Blue Ridge		0.89	0.03	0.93
Ocoee		0.48	0.00	0.49
WUTA total	***0.04***	***4.15***	***0.18***	***4.37***
Cumulative	*6*	*51*	*3*	*61*
Watts Bar-Chickamauga				
Watts Bar		2.19	0.04	2.23
Chickamauga	0.81	27.56	0.49	28.86
WUTA total	***0.81***	***29.75***	***0.53***	***31.09***
Cumulative	*7*	*81*	*4*	*92*
Nickajack				
Nickajack	4.18	0.03	0.82	5.03
WUTA total	***4.18***	***0.03***	***0.82***	***5.03***
Cumulative	*11*	*81*	*5*	*97*

Table 2-4 Continued.

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

WUTA RCA	**Industrial**	**Public**	**Irrigation**	**Total water withdrawals**
Guntersville				
Guntersville	0.08	6.97	0.62	7.67
WUTA total	***0.08***	***6.97***	***0.62***	***7.67***
Cumulative	*11*	*88*	*5*	*105*
Tims Ford				
Tims Ford	0.40	2.23	0.40	3.03
WUTA total	***0.40***	***2.23***	***0.40***	***3.03***
Cumulative	*12*	*90*	*6*	*108*
Wheeler-Wilson				
Wheeler	0.01	35.59	4.22	39.82
Wilson	0.00	2.90	1.17	4.07
WUTA total	***0.01***	***38.48***	***5.39***	***43.88***
Cumulative	*12*	*128*	*11*	*151*
Pickwick				
Pickwick	0.02	5.13	0.90	6.05
Cedar Creek		0.26		0.26
Upper Bear Creek				0.00
Bear Creek				0.00
WUTA total	***0.02***	***5.38***	***0.90***	***6.30***
Cumulative	*12*	*134*	*12*	*158*
Normandy				
Normandy	0.24	0.19	0.22	0.66
WUTA total	***0.24***	***0.19***	***0.22***	***0.66***
Cumulative	*12*	*134*	*12*	*158*
Kentucky				
Kentucky	10.48	19.25	0.71	30.44
WUTA total	***10.48***	***19.25***	***0.71***	***30.44***
Cumulative	*23*	*153*	*13*	*189*

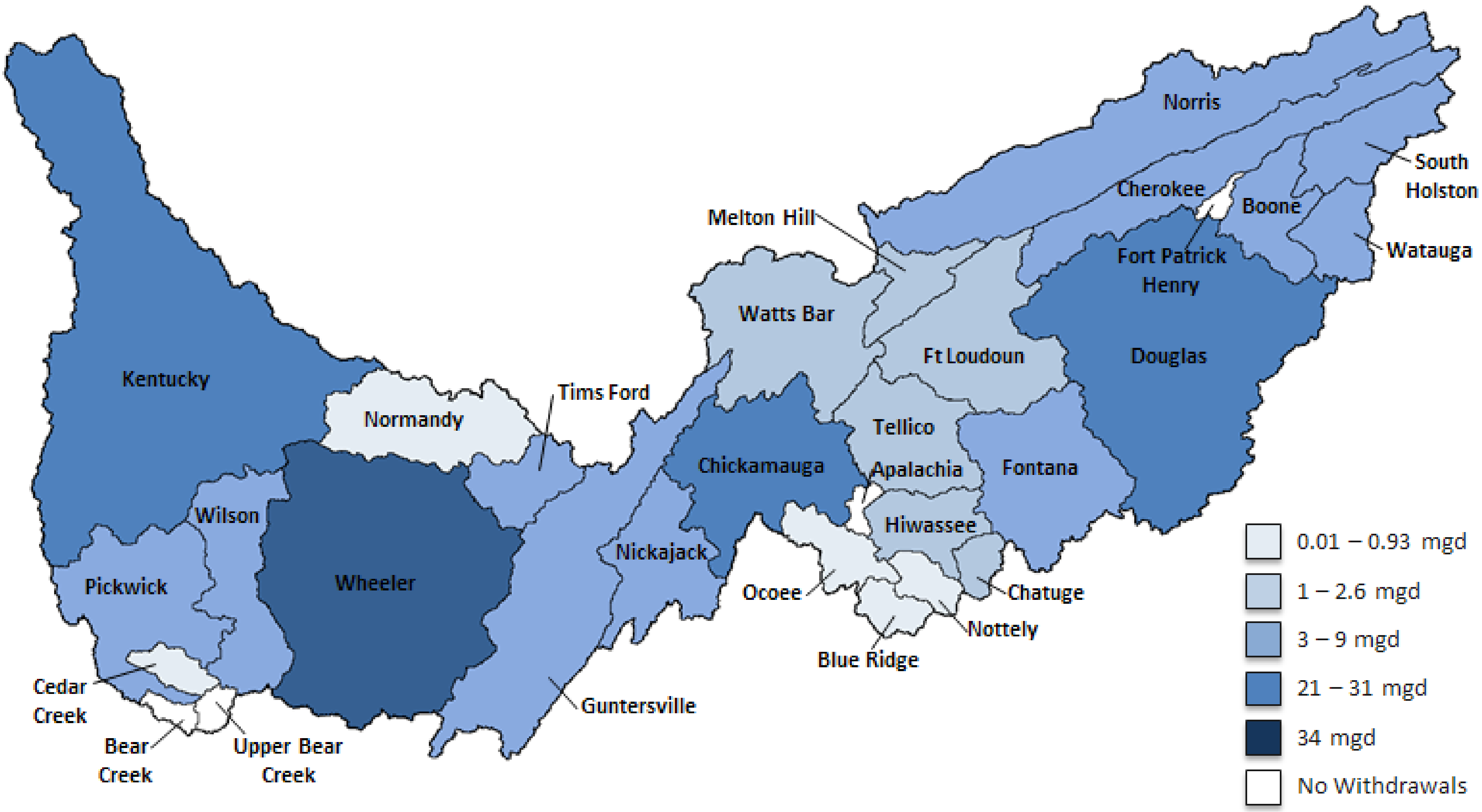

Figure 2-7: Total Groundwater Withdrawal by RCA in 2015

Table 2-5. Thermoelectric power withdrawals by WUTA in 2015

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

WUTA RCA	**Surface-water withdrawals**	**Return flow**	**Net water demand**	**Power generated, in million KWh**
Douglas				
Douglas	237.92	233.80	4.12	1,591
WUTA total	***237.92***	***233.80***	***4.12***	**1,591**
Cumulative	*238*	*234*	*4*	1,591
Norris				
Norris	10.35	1.42	8.93	462
Melton Hill	528.62	506.59	22.03	2,494
WUTA total	***538.97***	***508.01***	***30.96***	**2,956**
Cumulative	*777*	*742*	*35*	4,547
Watts Bar-Chickamauga				
Watts Bar	1,095.65	955.74	139.91	12,312
Chickamauga	1,572.94	1,694.56	-121.62	16,511
WUTA total	***2,668.59***	***2,650.30***	***18.29***	**28,823**
Cumulative	*3,445*	*3,392*	*53*	33,370
Guntersville				
Guntersville	470.69	470.02	0.67	1,627
WUTA total	***470.69***	***470.02***	***0.67***	**1,627**
Cumulative	*3,916*	*3,862*	*54*	34,997
Wheeler-Wilson				
Wheeler	2,852.59	2,840.23	12.36	30,914
WUTA total	***2,852.59***	***2,840.23***	***12.36***	**30,914**
Cumulative	*6,769*	*6,702*	*66*	65,911
Pickwick				
Pickwick	963.90	963.10	0.80	2,492
WUTA total	***963.90***	***963.10***	***0.80***	**2,492**
Cumulative	*7,733*	*7,665*	*67*	68,403
Kentucky				
Kentucky	491.26	490.89	0.37	1,964
WUTA total	***491.26***	***490.89***	***0.37***	**1,964**
Cumulative	*8,224*	*8,156*	*68*	70,367

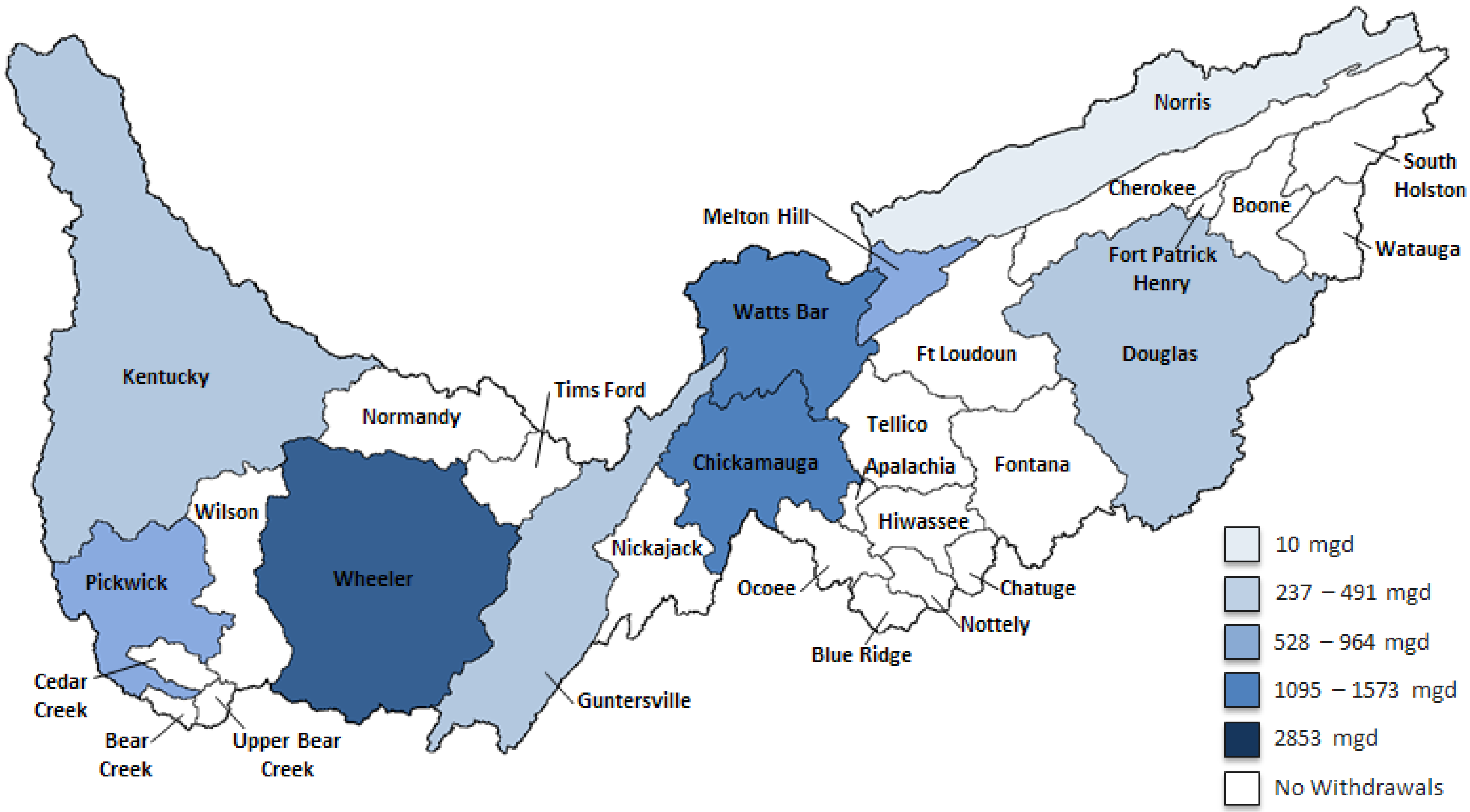

Figure 2-8: Thermoelectric Withdrawal by RCA in 2015

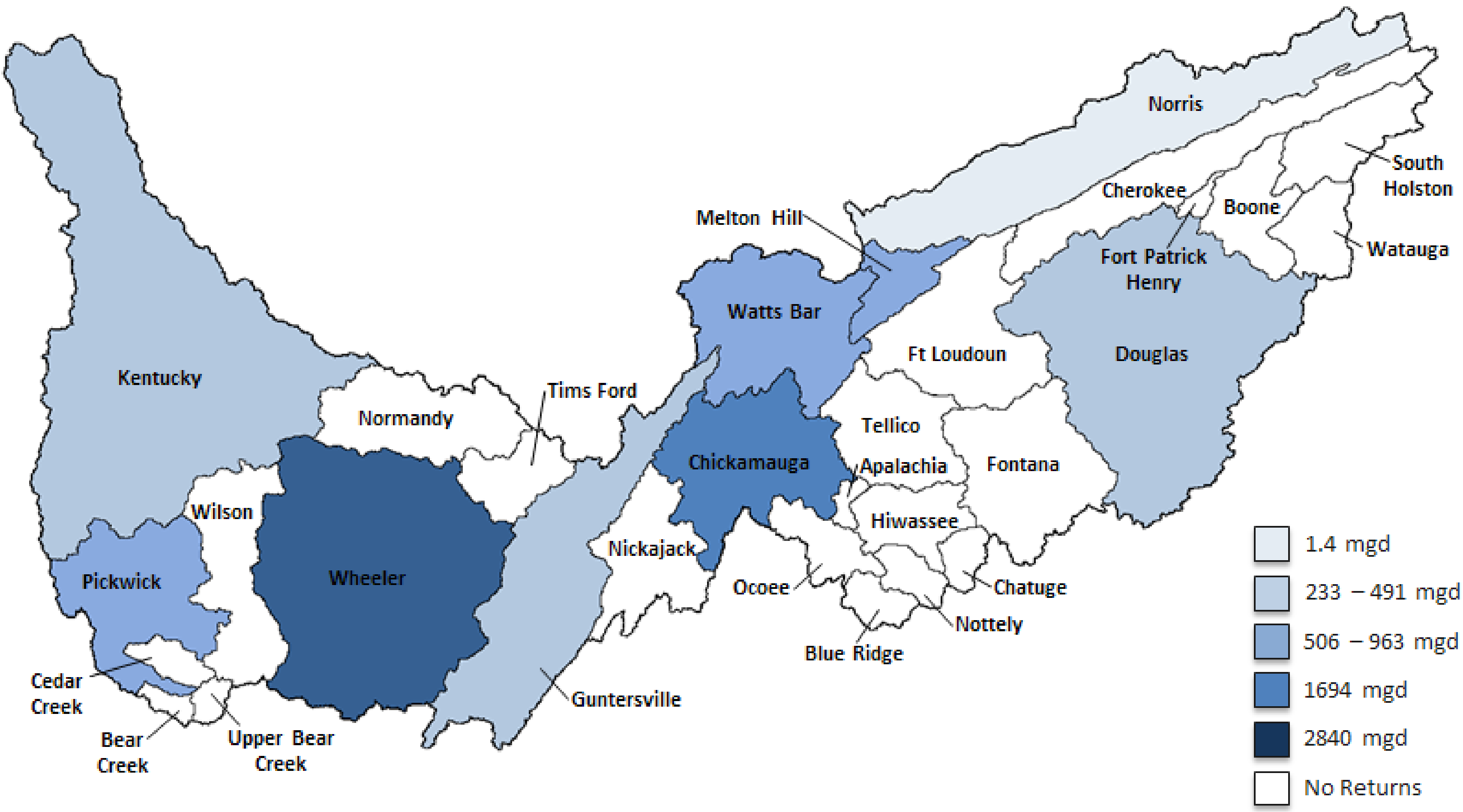

Figure 2-9: Thermoelectric Returns by RCA in 2015

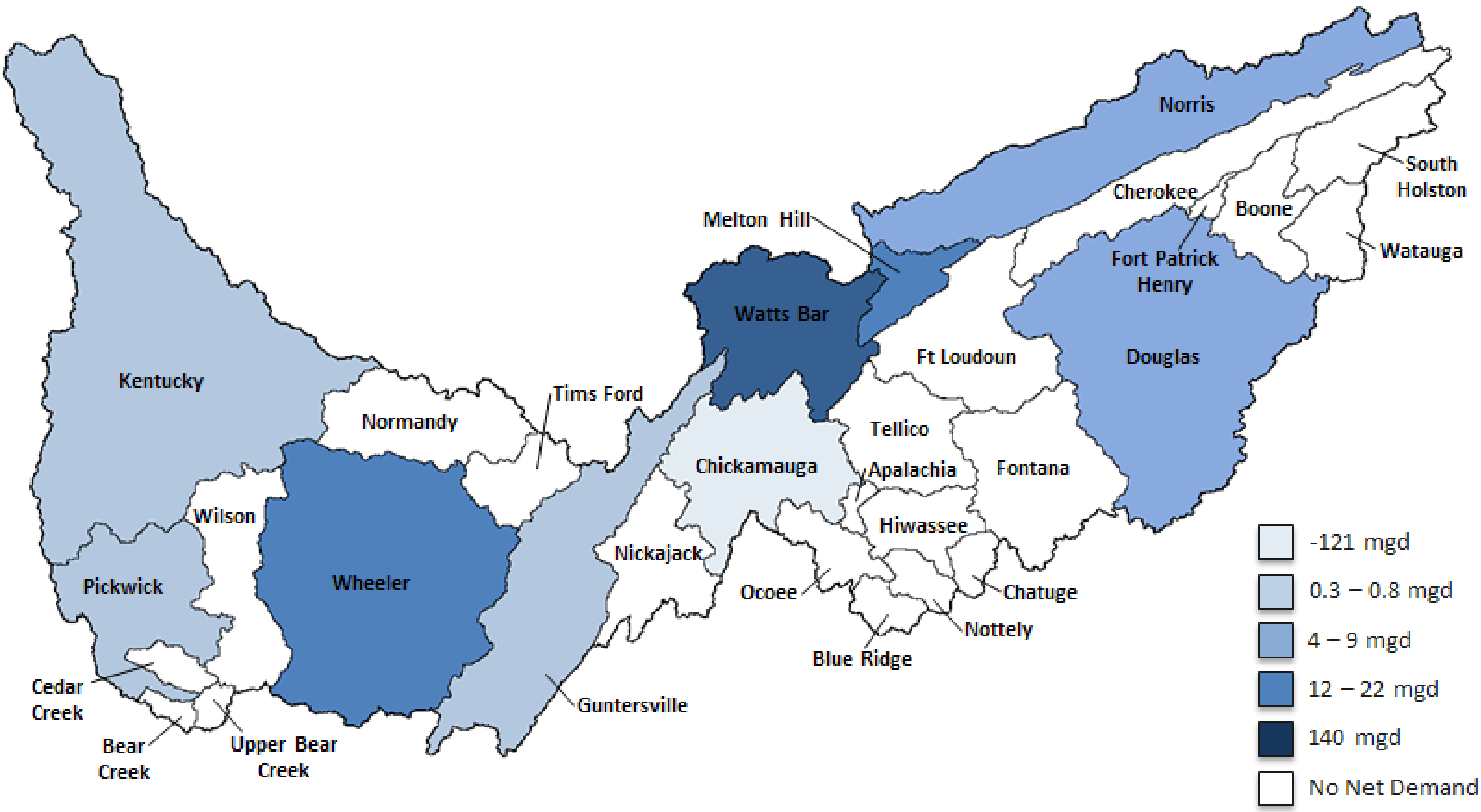

Figure 2-10: Thermoelectric Net Demand by RCA for 2015

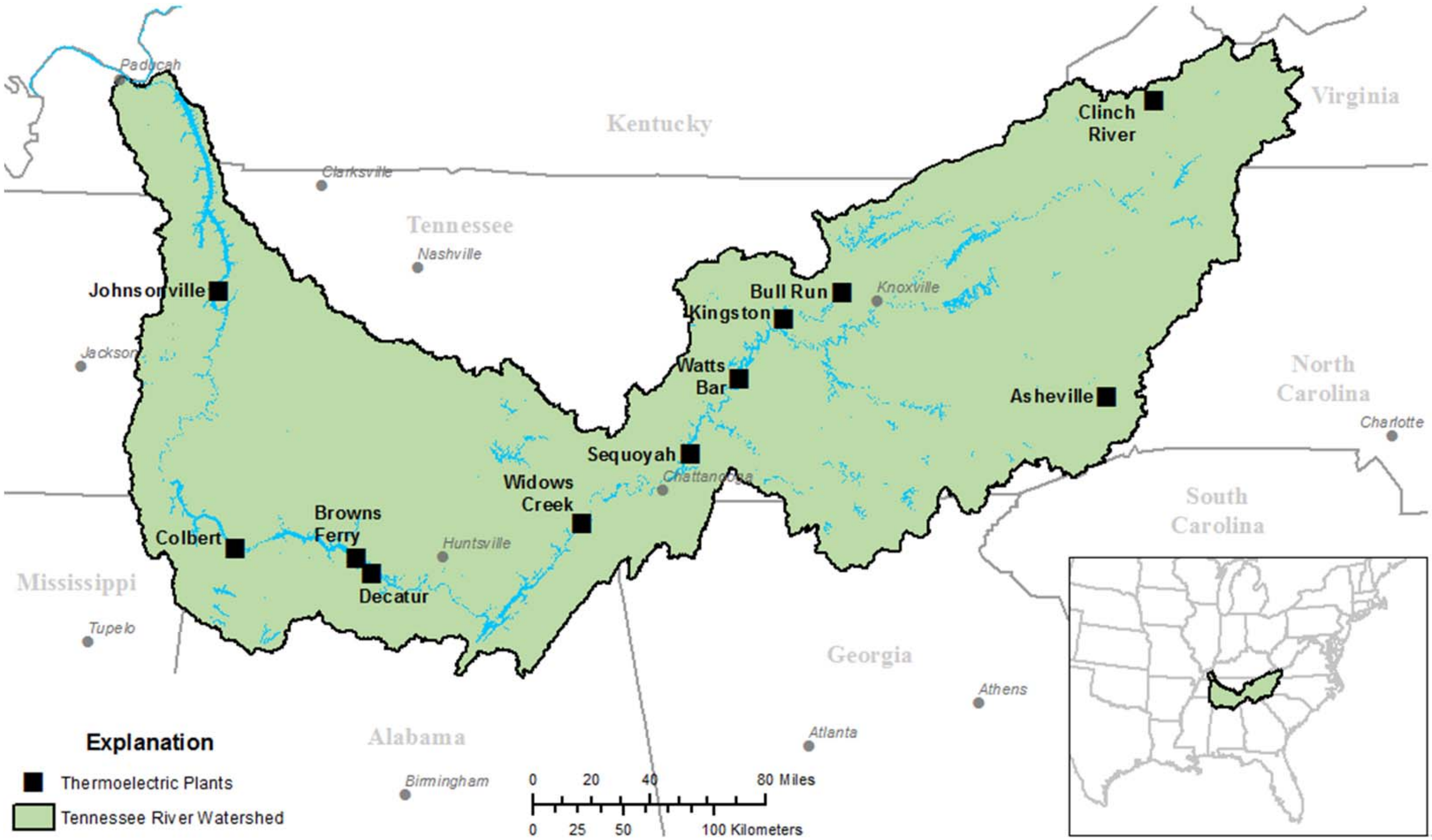

Figure 2-11: Location of Thermoelectric Power Plants in the Tennessee River Watershed

Table 2-6. Industrial withdrawals by source and by WUTA in 2015

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

WUTA RCA	**Ground**	Withdrawals **Surface**	**Total**	**Return**	**Net water demand**
Cherokee					
Watauga		0.12	0.12	0.04	0.09
South Holston		3.31	3.31	2.03	1.28
Boone	0.14	0.02	0.16		0.16
Ft Patrick Henry		520.57	520.57		520.57
Cherokee	0.00	65.81	65.82	551.51	-485.69
WUTA total	***0.14***	***589.84***	***589.98***	***553.57***	***36.41***
Cumulative	*0*	*590*	*590*	*554*	*36*
Douglas					
Douglas	3.34	62.49	65.84	50.90	14.94
WUTA total	***3.34***	***62.49***	***65.84***	***50.90***	***14.94***
Cumulative	*3*	*652*	*656*	*604*	*51*
Fort Loudoun					
Fort Loudoun	2.11	1.32	3.44	27.47	-24.03
WUTA total	***2.11***	***1.32***	***3.44***	***27.47***	***-24.03***
Cumulative	*6*	*654*	*659*	*632*	*27*
Fontana-Tellico					
Fontana	0.10	17.88	17.98	16.78	1.21
Tellico		6.60	6.60	6.60	0.00
WUTA total	***0.10***	***24.48***	***24.59***	***23.38***	***1.21***
Cumulative	*6*	*678*	*684*	*655*	*29*
Norris					
Norris	0.58	3.65	4.23	3.53	0.70
Melton Hill	0.00	0.32	0.33	6.53	-6.21
WUTA total	***0.58***	***3.97***	***4.56***	***10.07***	***-5.51***
Cumulative	*6*	*682*	*688*	*665*	*23*
Hiwassee-Ocoee					
Chatuge			0.00		0.00
Nottely			0.00		0.00
Hiwassee	0.04	0.08	0.12		0.12
Apalachia			0.00		0.00
Blue Ridge		1.95	1.95	1.95	0.00
Ocoee			0.00		0.00
WUTA total	***0.04***	***2.03***	***2.07***	***1.95***	***0.12***
Cumulative	*6*	*684*	*690*	*667*	*23*
Watts Bar-Chickamauga					
Watts Bar		6.30	6.30	5.00	1.29
Chickamauga	0.81	43.68	44.49	41.28	3.21
WUTA total	***0.81***	***49.98***	***50.79***	***46.29***	***4.50***
Cumulative	*7*	*734*	*741*	*714*	*28*
Nickajack					
Nickajack	4.18	6.54	10.72	11.89	-1.17
WUTA total	***4.18***	***6.54***	***10.72***	***11.89***	***-1.17***
Cumulative	*11*	*741*	*752*	*726*	*26*

Table 2-6 Continued.

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

WUTA RCA	Withdrawals **Ground**	**Surface**	**Total**	**Return**	**Net water demand**
Guntersville					
Guntersville	0.08	9.10	9.18	6.73	2.45
WUTA total	***0.08***	***9.10***	***9.18***	***6.73***	***2.45***
Cumulative	*11*	*750*	*761*	*732*	*29*
Tims Ford					
Tims Ford	0.40	27.66	28.07	17.14	10.93
WUTA total	***0.40***	***27.66***	***28.07***	***17.14***	***10.93***
Cumulative	*12*	*777*	*789*	*749*	*40*
Wheeler-Wilson					
Wheeler	0.01	98.23	98.24	104.43	-6.19
Wilson	0.00	10.55	10.55	5.24	5.32
WUTA total	***0.01***	***108.79***	***108.79***	***109.67***	***-0.87***
Cumulative	*12*	*886*	*898*	*859*	*39*
Pickwick					
Pickwick	0.02	46.96	46.98	25.28	21.71
Cedar Creek			0.00		0.00
Upper Bear Creek			0.00		0.00
Bear Creek			0.00		0.00
WUTA total	***0.02***	***46.96***	***46.98***	***25.28***	***21.71***
Cumulative	*12*	*933*	*945*	*884*	*61*
Normandy					
Normandy	0.24	0.37	0.62		0.62
WUTA total	***0.24***	***0.37***	***0.62***		***0.62***
Cumulative	*12*	*934*	*946*	*884*	*61*
Kentucky					
Kentucky	10.48	78.52	89.00	87.05	1.95
WUTA total	***10.48***	***78.52***	***89.00***	***87.05***	***1.95***
Cumulative	*23*	*1,012*	*1,035*	*971*	*63*

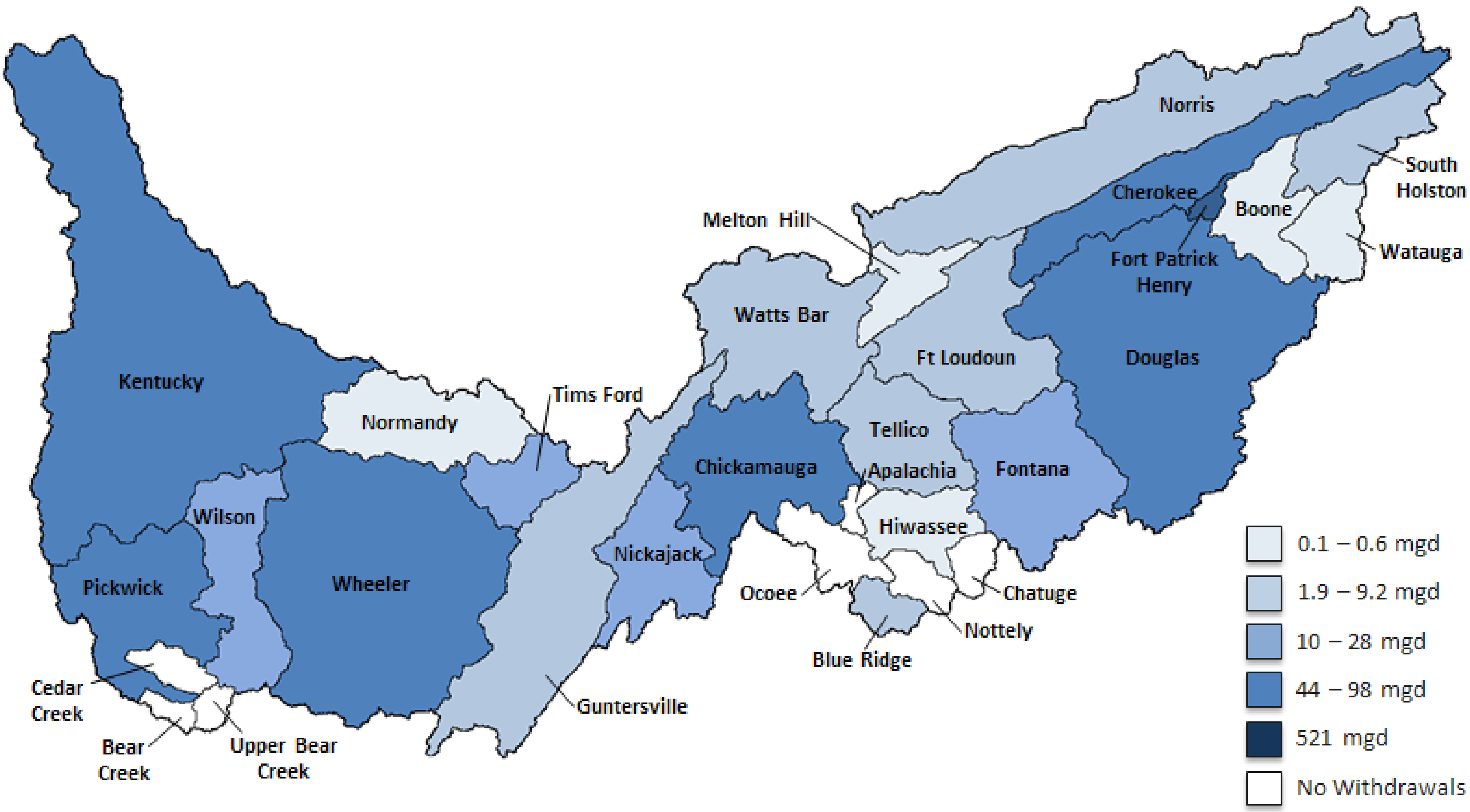

Figure 2-12: Industrial Withdrawal by RCA in 2015

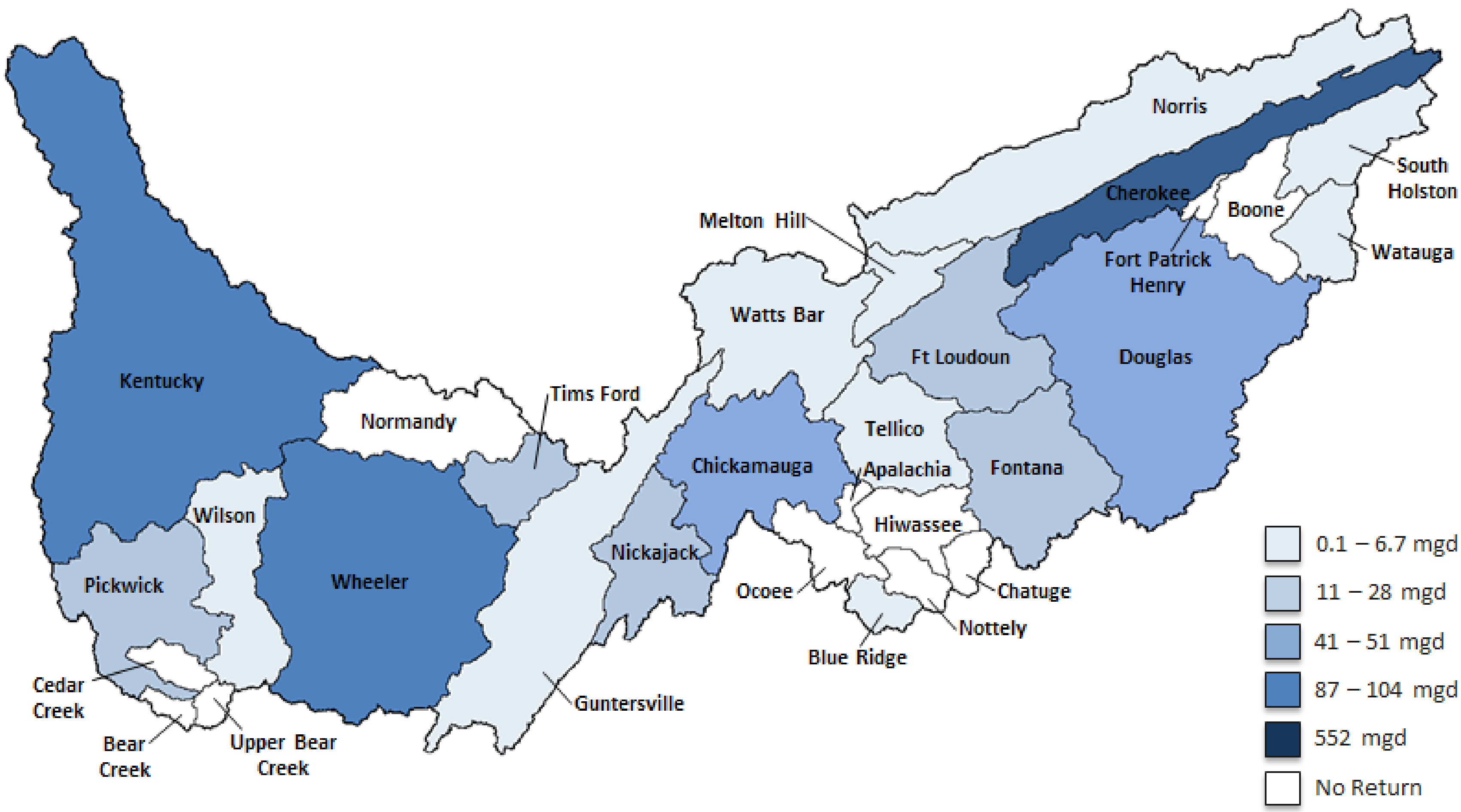

Figure 2-13: Industrial Return by RCA in 2015

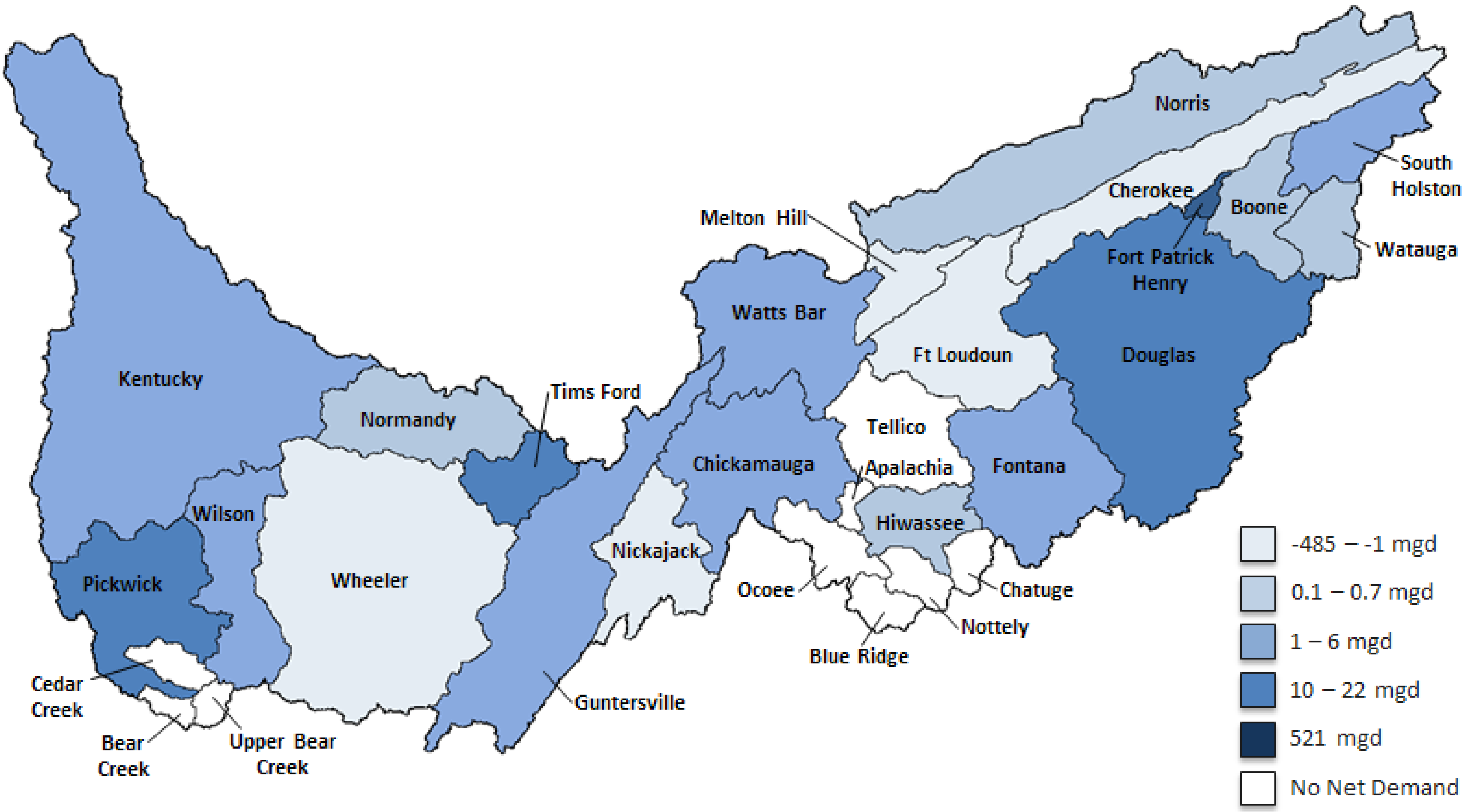

Figure 2-14: Industrial Net Demand by RCA in 2015

Table 2-7. Public supply water use by source and WUTA in 2015

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

WUTA RCA	**Ground**	Withdrawals **Surface**	**Total**	**Return**	**Net water demand**
Cherokee					
Watauga	8.42	15.85	24.28	1.70	22.58
South Holston	5.98	16.54	22.52	5.16	17.36
Boone	2.70		2.70	25.00	-22.30
Ft Patrick Henry		16.44	16.44		16.44
Cherokee	3.54	17.39	20.93	17.72	3.21
WUTA total	***20.65***	***66.23***	***86.88***	***49.59***	***37.29***
Cumulative	*21*	*66*	*87*	*50*	*37*
Douglas					
Douglas	16.51	75.05	91.57	45.30	46.26
WUTA total	***16.51***	***75.05***	***91.57***	***45.30***	***46.26***
Cumulative	*37*	*141*	*178*	*95*	*84*
Fort Loudoun					
Fort Loudoun	0.03	54.99	55.02	63.68	-8.66
WUTA total	***0.03***	***54.99***	***55.02***	***63.68***	***-8.66***
Cumulative	*37*	*196*	*233*	*159*	*75*
Fontana-Tellico					
Fontana	4.59	5.42	10.01	3.78	6.24
Tellico	0.97	7.62	8.60	1.82	6.78
WUTA total	***5.56***	***13.05***	***18.61***	***5.59***	***13.02***
Cumulative	*43*	*209*	*252*	*164*	*88*
Norris					
Norris	2.74	16.42	19.16	14.28	4.88
Melton Hill	1.36	26.35	27.71	14.17	13.54
WUTA total	***4.10***	***42.77***	***46.87***	***28.45***	***18.42***
Cumulative	*47*	*252*	*299*	*193*	*106*
Hiwassee-Ocoee					
Chatuge	1.43	2.41	3.83	0.24	3.59
Nottely	0.43	0.96	1.39	0.34	1.04
Hiwassee	0.92	0.75	1.67	1.93	-0.27
Apalachia		2.10	2.10	0.01	2.09
Blue Ridge	0.89	2.01	2.91	0.42	2.49
Ocoee	0.48		0.48	0.45	0.03
WUTA total	***4.15***	***8.23***	***12.38***	***3.41***	***8.97***
Cumulative	*51*	*260*	*311*	*196*	*115*
Watts Bar-Chickamauga					
Watts Bar	2.19	24.16	26.36	23.32	3.04
Chickamauga	27.56	28.41	55.97	20.36	35.61
WUTA total	***29.75***	***52.58***	***82.33***	***43.68***	***38.65***
Cumulative	*81*	*313*	*394*	*240*	*154*
Nickajack					
Nickajack	0.03	37.03	37.06	46.03	-8.96
WUTA total	***0.03***	***37.03***	***37.06***	***46.03***	***-8.96***
Cumulative	*81*	*350*	*431*	*286*	*145*

Table 2-7 Continued.

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

WUTA RCA	**Ground**	Withdrawals **Surface**	**Total**	**Return**	**Net water demand**
Guntersville					
Guntersville	6.97	37.22	44.19	21.68	22.52
WUTA total	***6.97***	***37.22***	***44.19***	***21.68***	***22.52***
Cumulative	*88*	*387*	*475*	*307*	*168*
Tims Ford					
Tims Ford	2.23	2.26	4.49	5.20	-0.71
WUTA total	***2.23***	***2.26***	***4.49***	***5.20***	***-0.71***
Cumulative	*90*	*389*	*479*	*313*	*167*
Wheeler-Wilson					
Wheeler	35.59	82.25	117.84	81.74	36.10
Wilson	2.90	16.45	19.35	3.81	15.54
WUTA total	***38.48***	***98.71***	***137.19***	***85.55***	***51.64***
Cumulative	*128*	*488*	*617*	*398*	*218*
Pickwick					
Pickwick	5.13	7.85	12.98	16.82	-3.85
Cedar Creek	0.26	3.73	3.99	3.55	0.43
Upper Bear Creek		2.85	2.85		2.85
Bear Creek		0.66	0.66	0.13	0.54
WUTA total	***5.38***	***15.09***	***20.47***	***20.50***	***-0.03***
Cumulative	*134*	*503*	*637*	*419*	*218*
Normandy					
Normandy	0.19	25.75	25.94	3.05	22.89
WUTA total	***0.19***	***25.75***	***25.94***	***3.05***	***22.89***
Cumulative	*134*	*529*	*663*	*422*	*241*
Kentucky					
Kentucky	19.25	13.05	32.29	27.93	4.37
WUTA total	***19.25***	***13.05***	***32.29***	***27.93***	***4.37***
Cumulative	*153*	*542*	*695*	*450*	*246*

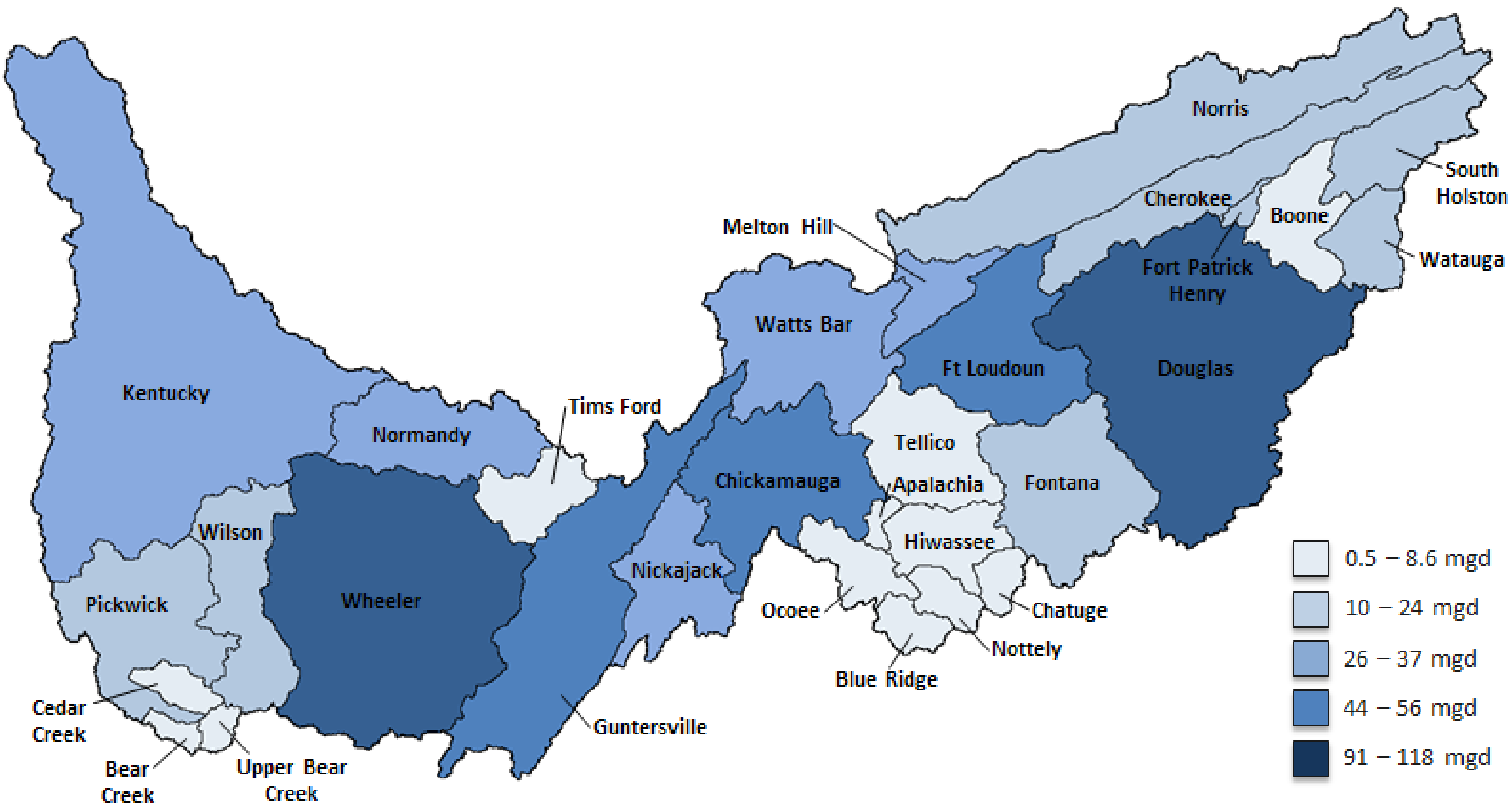

Figure 2-15: Public Supply Withdrawal by RCA in 2015

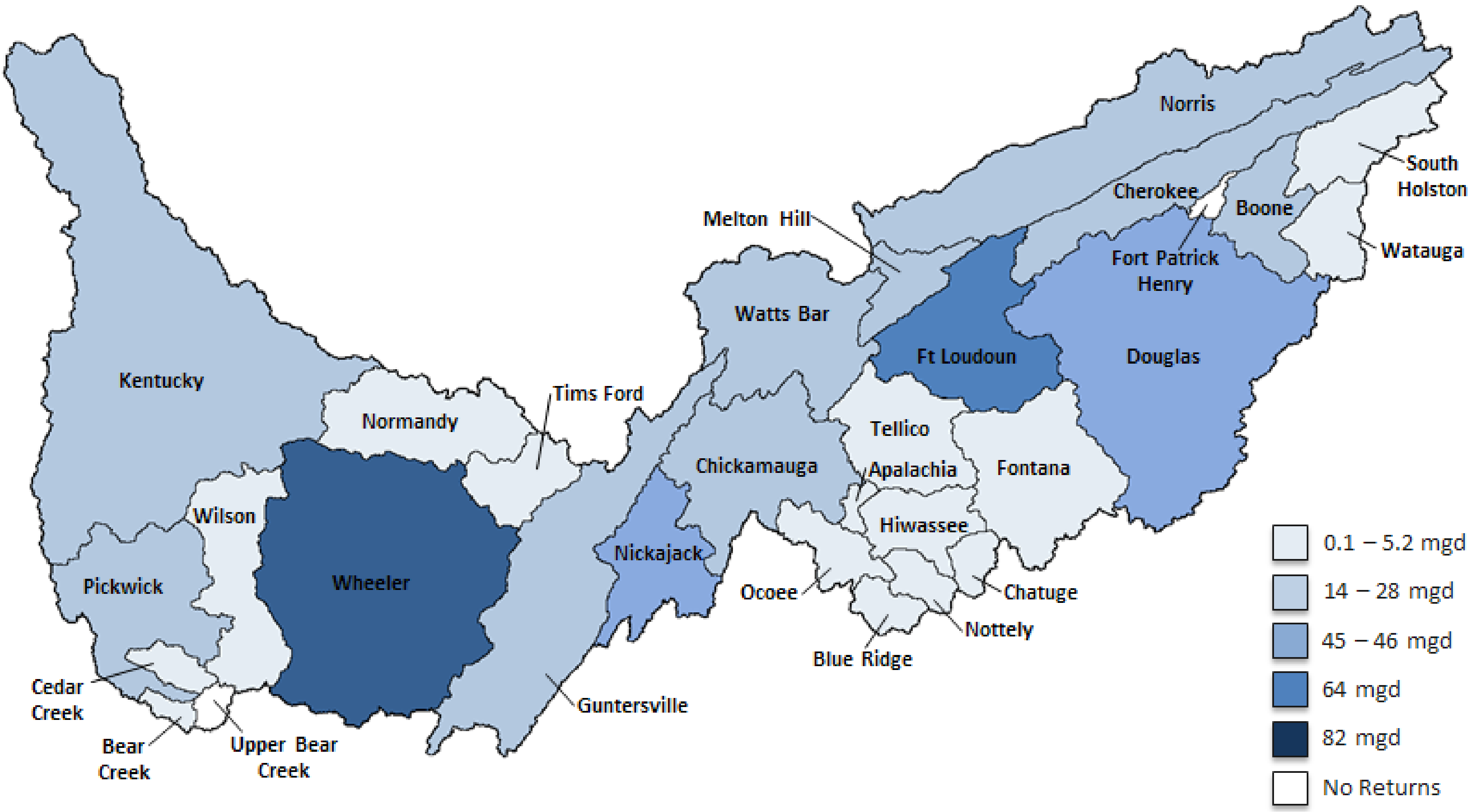

Figure 2-16: Public Supply Return by RCA in 2015

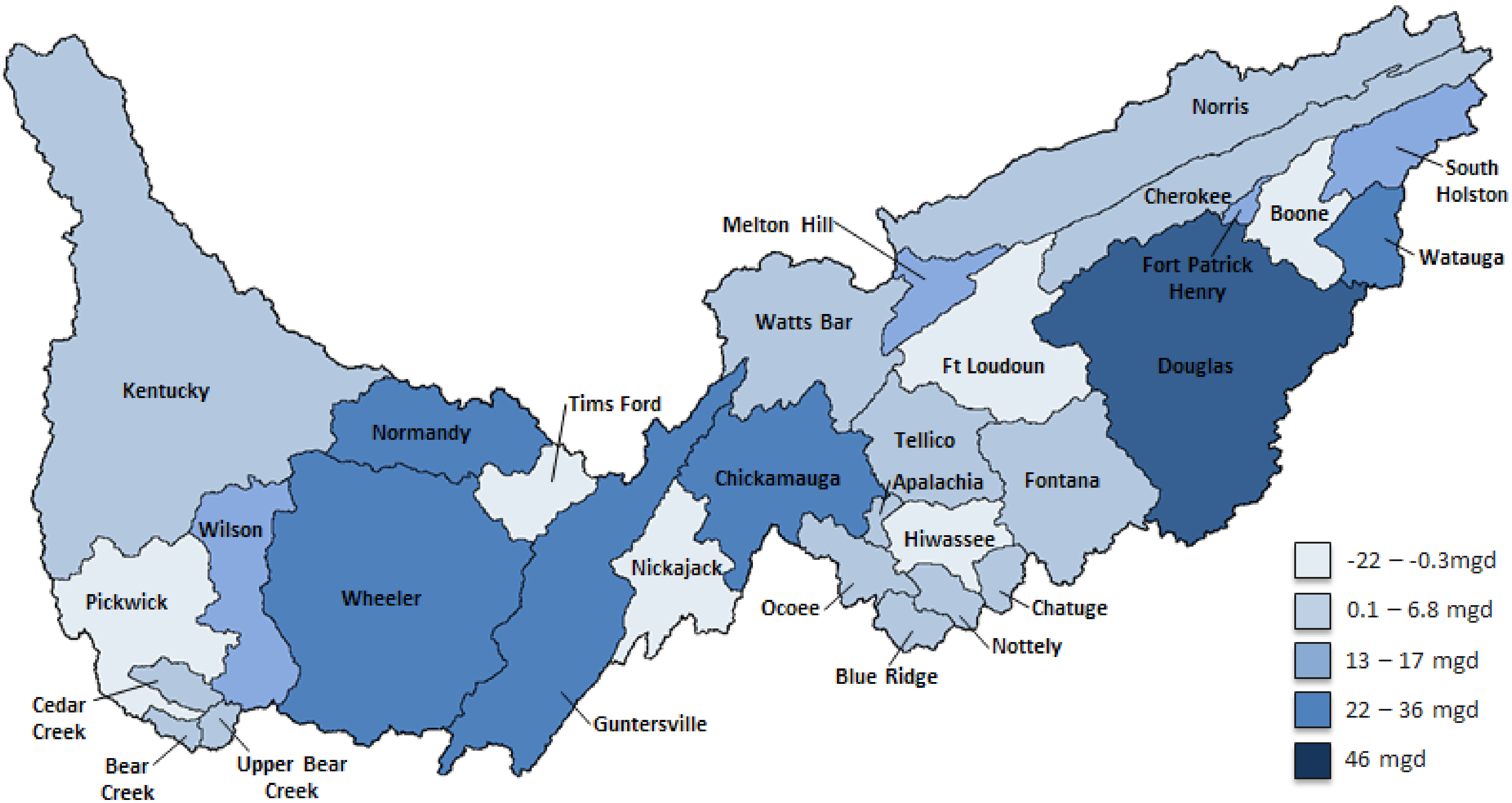

Figure 2-17: Public Supply Net Demand by RCA in 2015

Table 2-8. Irrigation withdrawals by source and WUTA in 2015

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

WUTA RCA	**Groundwater**	**Surface water**	**Total**
Cherokee			
Watauga	0.33	1.11	1.44
South Holston	0.21	0.39	0.61
Boone	0.16	0.16	0.33
Ft Patrick Henry			0.00
Cherokee	0.15	1.23	1.38
WUTA total	***0.86***	***2.90***	***3.76***
Cumulative	*1*	*3*	*4*
Douglas			
Douglas	1.77	7.47	9.24
WUTA total	***1.77***	***7.47***	***9.24***
Cumulative	*3*	*10*	*13*
Fort Loudoun			
Fort Loudoun	0.42	0.32	0.74
WUTA total	***0.42***	***0.32***	***0.74***
Cumulative	*3*	*11*	*14*
Fontana-Tellico			
Fontana	0.00	1.66	1.66
Tellico	0.11	0.41	0.52
WUTA total	***0.11***	***2.07***	***2.18***
Cumulative	*3*	*13*	*16*
Norris			
Norris	0.04	1.12	1.16
Melton Hill	0.02	0.65	0.67
WUTA total	***0.06***	***1.77***	***1.84***
Cumulative	*3*	*15*	*18*
Hiwassee-Ocoee			
Chatuge	0.05	0.30	0.35
Nottely		0.43	0.43
Hiwassee	0.09	0.41	0.50
Apalachia			0.00
Blue Ridge	0.03	0.12	0.15
Ocoee	0.00	0.04	0.04
WUTA total	***0.18***	***1.30***	***1.47***
Cumulative	*3*	*16*	*19*
Watts Bar-Chickamauga			
Watts Bar	0.04	1.30	1.34
Chickamauga	0.49	1.81	2.30
WUTA total	***0.53***	***3.10***	***3.63***
Cumulative	*4*	*19*	*23*
Nickajack			
Nickajack	0.82	0.83	1.65
WUTA total	***0.82***	***0.83***	***1.65***
Cumulative	*5*	*20*	*25*

Table 2-8 Continued.

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

WUTA RCA	**Groundwater**	**Surface water**	**Total**
Guntersville			
Guntersville	0.62	1.83	2.45
WUTA total	***0.62***	***1.83***	***2.45***
Cumulative	*5*	*22*	*27*
Tims Ford			
Tims Ford	0.40	2.17	2.57
WUTA total	***0.40***	***2.17***	***2.57***
Cumulative	*6*	*24*	*30*
Wheeler-Wilson			
Wheeler	4.22	13.68	17.90
Wilson	1.17	1.98	3.14
WUTA total	***5.39***	***15.65***	***21.04***
Cumulative	*11*	*39*	*51*
Pickwick			
Pickwick	0.90	1.28	2.18
Cedar Creek			0.00
Upper Bear Creek			0.00
Bear Creek			0.00
WUTA total	***0.90***	***1.28***	***2.18***
Cumulative	*12*	*41*	*53*
Normandy			
Normandy	0.22	1.19	1.41
WUTA total	***0.22***	***1.19***	***1.41***
Cumulative	*12*	*42*	*54*
Kentucky			
Kentucky	0.71	7.66	8.37
WUTA total	***0.71***	***7.66***	***8.37***
Cumulative	*13*	*50*	*63*

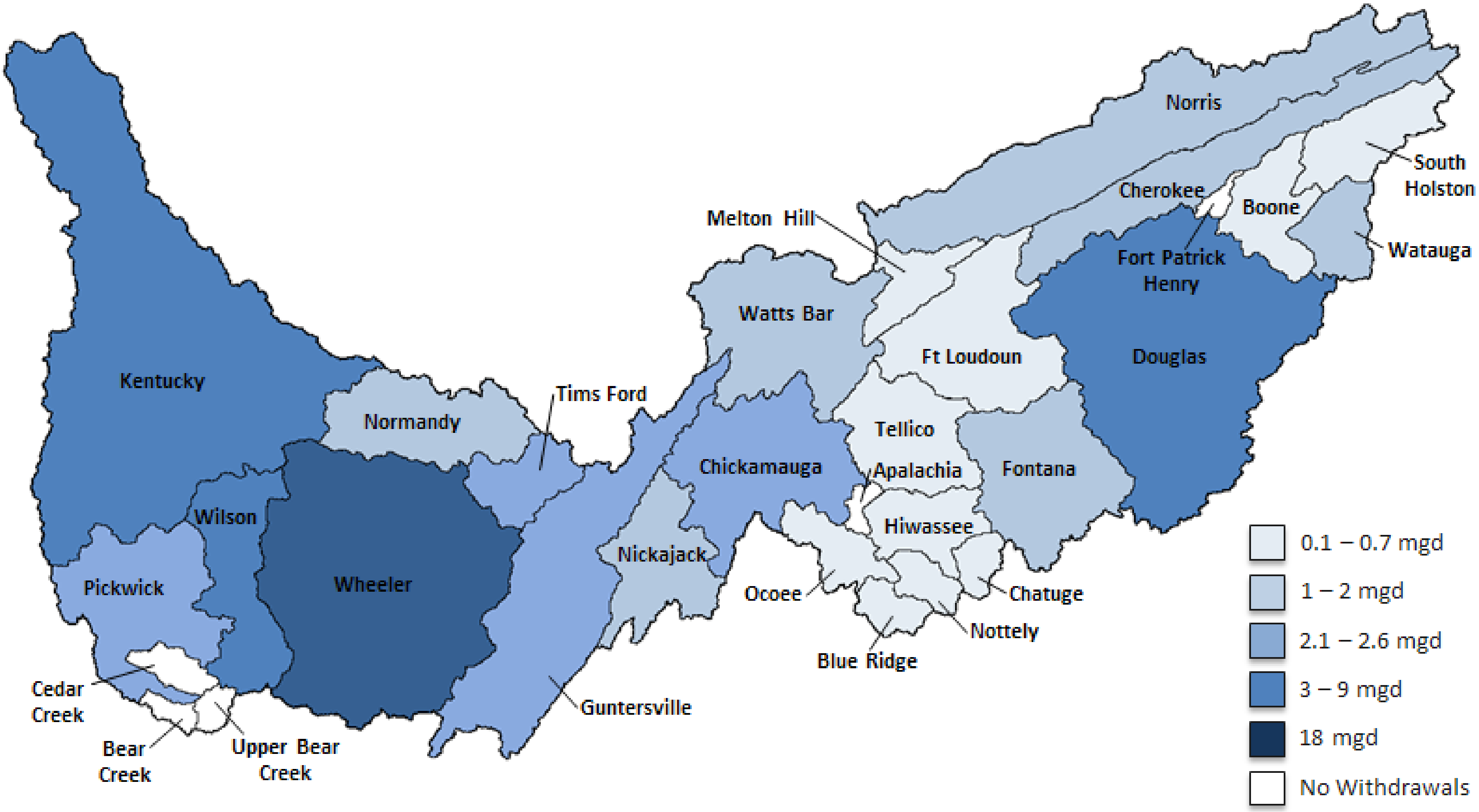

Figure 2-18: Irrigation Withdrawals by RCA in 2015

3 COMPARISON TO PREVIOUS UPDATES, INTER-BASIN TRANSFERS, AND DIVERSIONS

COMPARISON TO PREVIOUS UPDATES

The Tennessee River watershed is the only watershed in the nation that has continuous trend data since 1995. Table 3-1 compares water use in 2015 to 2010, 2005, 2000 and 1995. All of the line numbers in the following discussion refer to Table 3-1. The 1995 data were provided by the USGS and are contained in the 2000 water use report (Hutson and others, 2004).

Total withdrawal grew by 22 percent from 1995 to 2000 as the result of major power plant additions in the watershed, peaking in 2005. 2015 total withdrawal was 16.2 percent below 2010 total withdrawal (line 2). This was largely the result of a reduction in thermoelectric withdrawal of 1,822 mgd (line 11), which was caused by less power generation in 2015 compared to 2010 (line 20). Industrial use was also down 113 mgd in 2015 compared to 2010 (line 29). For the first time since 1995, public supply use saw a slight decrease in 2015 compared to 2010 (line 38). Irrigation increased 85.3 percent to 63 mgd (lines 49 and 47). Total withdrawal excluding thermoelectric was 113 mgd less in 2010 than it was in 2005 (line 23).

The largest percent growth was Irrigation (line 49). TVA was not provided county irrigation aggregate data in 2015 and TVA chose the largest of the previously provided data to be conservative in their estimates. This accounted for a small increase from 2010, but the big contributions were three new irrigation intakes that were permitted between 2010 and 2015. There was 24.3 mgd of new irrigation use from a wildlife refuge and two new farms that was added during that time frame that account for the large growth.

Although there was a decreasing trend in groundwater use from 1995 to 2005, 2010 showed an increase in groundwater use, but the 2015 use was back down to pre-2005 levels (line 5). Of course, surface water continued to supply the majority of the water used in the watershed in 2015 (98.1 percent, line 4).

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 with 95.6 percent of the withdrawal returned in 2015 (line 8).

Net water demand decreased about 7 percent from 2010 to 2015 (line 9), but increased from 3.9 to 4.4 percent of total withdrawal from 2010 to 2015 (line 10). The reduction in net water demand between 2010 and 2015 was due to reported reductions in several large industrial withdrawals while reported returns for those industries increased. There were also several public supply municipalities that installed new flowmeters at withdrawal and discharge locations and reported more precise numbers in 2015.

The average percent of total withdrawal for thermoelectric use between 2000 and 2010 was 84.3 percent (line 13). Thermoelectric withdrawal in 2015 was 18.1 percent lower than it was in 2010 (line 12), and the percent of total withdrawal in 2015 dropped to 82.1 percent (line 13). As in the past, more than 99 percent of the water withdrawn for thermoelectric use is returned (line 15). In 2015 thermoelectric net water demand was 15.5 percent of total net water demand (line19).

In 2000 and 2005, the thermoelectric unit water requirement for power generation was 39 gal/KWh. It rose in 2010 to 42 gal/KWh and remained nearly the same at 43 gal/KWh in 2015 (line 21). While about 12 percent less energy was generated in 2010 than in 2005 (line 20), the reduction in thermoelectric withdrawal between 2000 and 2010 was only 4.6 percent (line 12). In 2015, the reduction in power generated was 19.6 percent (line 20) and there was also a reduction in water withdrawal proportionally at 18.1 percent (line 12). Changes in cooling technology between 2005 and 2010, along with the closures of some fossil plants, led to the increase in the thermoelectric unit water requirement. Between 2010 and 2015 additional plants shut down, but the thermoelectric unit water requirement did not change because the existing cooling technology from 2010 was still adequate.

Industrial withdrawal in 2015 was 9.8 percent lower than in 2010 (line 31), but its percent of total withdrawal increased to 10.3 percent (line 30). Industrial net water demand was 14.4 percent of total net water demand, which was lower than it was in 2000, 2005, and 2010 (line 37).

For the first time since 1995, public supply withdrawal dropped (line 38). The population between 2010 and 2015 only increased 2.0 percent, whereas previously it has steadily increased about 5.5 percent every 5 years. Some of the decrease in public supply withdrawal can be attributed to a wetter than normal 2015. In 2000, 2005, and 2010, the watershed received 76 percent, 79 percent, and 80 percent, of average rainfall respectively. The rainfall in 2015 was 59 inches or 115 percent of average. The decrease in public supply withdrawal can also 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. 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 had increased from 39.9 percent in 2000 to 42.8 percent in 2010, but in 2015 the net water demand as a percent of public supply withdrawal was down to 35.4 percent (line 45).

Irrigation declined from 69 mgd in 2000 to 43 mgd in 2005 to 34 mgd in 2010, but was back up to 63 mgd in 2015 (line 29). Irrigation's contribution to total net water demand nearly doubled from 7.2 percent in 2010 to 14.1 percent in 2015 (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.

In 2010, surface water supplied 100 percent of the thermoelectric withdrawal, 97.8 percent of the industrial withdrawal, 78.0 percent of the public supply withdrawal, and 79.4 percent of the irrigation withdrawal (lines 69, 71, 73, and 75). These percentages have remained basically constant over the 2000 to 2015 period.

The watershed population has increased by 17.4 percent from 1995 to 2015 (line 84).

Table 3-1. Comparing 2015 Water Use with Previous Years

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

Table 3-1. Continued

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

Table 3-1. Continued

	Units are mgd or as noted	1995	2000	2005	2010	2015
	Net water demand by WUTA, lines 52-66					
52	Cherokee		88	90	79	78
53	Douglas		65	53	70	75
54	Fort Loudoun		23	1	8	-32
55	Fontana-Tellico		7	7	9	16
56	Norris		45	28	21	45
57	Hiwassee-Ocoee		16	10	8	11
58	Watts Bar-Chickamauga		45	40	57	65
59	Nickajack		12	-3	-13	-9
60	Guntersville		16	30	32	29
61	Tims Ford		21	8	8	13
62	Wheeler-Wilson		196	112	129	85
63	Pickwick		29	-13	-2	25
64	Normandy		26	25	26	25
65	Kentucky		60	43	41	15
66	Total net water demand, lines 53-66		649	431	473	439
67	**Diversions to the Tennessee-Tombigbee Waterway**		200	190	200	195
	Surface water withdrawal, lines 70-77					
68	Thermoelectric		10,276	10,531	10,046	8,224
69	Percent of total thermoelectric		100	100	100	100
70	Industrial		1,134	1,149	1,116	1,012
71	Percent of total industrial		94.1	97.5	97.2	97.8
72	Public supply		526	534	558	542
73	Percent of total public supply		79.5	78.1	77.2	78
74	Irrigation		61	32	27	50
75	Percent of total irrigation		88.4	74.4	79.4	79.4
	Groundwater withdrawal, lines 79-86					
76	Thermoelectric		0	0	0	0
77	Percent of total thermoelectric		0	0	0	0
78	Industrial		71	30	32	23
79	Percent of total industrial		5.9	2.5	2.8	2.2
80	Public supply		136	150	165	153
81	Percent of total public supply		20.5	21.9	22.8	22.0
82	Irrigation		7.6	11	7	13
83	Percent of total irrigation		11	25.6	20.6	20.6
84	**Watershed population (1000s)**	4,198	4,506	4,705	4,982	5,084

INTER-BASIN TRANSFERS

An inter-basin transfer (IBT), in the context of this report, is a transfer of water across the Tennessee River watershed boundary. 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 such as for 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 2015 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 2015 was 5.9 mgd. Three IBTs were not active in 2015, but were previously permitted or existing in 2010. These include Spring City Water System (permitted for 1.0 mgd), Crossville (permitted for 5.0 mgd), and Franklin County Water Service Authority[1]. Water transfer data on four other IBTs were not available for 2015. These include Ocoee Utility District, Selmer Water System, Tazewell County Public Service Authority, and Tennessee-American Water Company.

The estimated values (Est) 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. Inter-basin transfers from the Tennessee River in 2015

Transfer From			Transfer To			2015
System	State	Basin	System	State	Basin	mgd
Albertville Municipal Utilities Board	AL	Tennessee	Albertville Service Area and Boaz	AL	Black Warrior	3.19
Arab Water Works	AL	Tennessee	Joppa	AL	Black Warrior	0.28
Fort Payne Water Works	AL	Tennessee	Fort Payne Water Works Service Area	AL	Coosa	0.13
Upper Bear Creek Water Authority	AL	Tennessee	Haleyville	AL	Tombigbee	1.6
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	2.28
Highlands	NC	Tennessee	Highlands Service Area	NC	Savannah	0.1
Hendersonville Water and Sewer	NC	Tennessee	Saluda	NC	Broad	0.15
Tennessee-American Water Company	TN	Tennessee	Walker County	GA	Coosa	No Data
Cleveland Utilities	TN	Tennessee	Ocoee UD	TN	Coosa	0.16
Eastside Utility District	TN	Tennessee	Dalton Utilities	GA	Coosa	0.76
Lexington Water System	TN	Tennessee	Jackson Energy Authority	TN	Mississippi	0.1 Est
Spring City Water System	TN	Tennessee		TN	Cumberland	0
Ocoee Utility District	TN	Tennessee	Ocoee UD Service Area	TN	Coosa	0.02
Cumberland Utility District	TN	Tennessee	Sunbright	TN	Cumberland	0.087
Plateau Utility District	TN	Tennessee	Sunbright	TN	Cumberland	0.18
Duck River Utility Commission	TN	Tennessee	Hillsville UD	TN	Cumberland	0.089
Crossville	TN	Tennessee	Crossville Service Area	TN	Cumberland	0

Table 3-3. Inter-basin transfers into the Tennessee River in 2015

Transfer From			Transfer To			2015
System	State	Basin	System	State	Basin	mgd
Rabun County Water and Sewer Authority	GA	Savannah	Rabun County W&SA Service Area	GA	Tennessee	0.1 Est
Cleveland Utilities	TN	Coosa	Cleveland Utilities Service Area	TN	Tennessee	0.5
Huntsville Utility District	TN	Cumberland	Sunbright Service Area	TN	Tennessee	0.05
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	0.25 Est
Crossville	TN	Cumberland	Crossville Service Area	TN	Tennessee	2.33
Tazewell County Public Service Authority	VA	New	Tazewell County PSA Service Area	VA	Tennessee	No Data

DIVERSIONS

Under agreement with the U.S. Army Corps of Engineers (USACE), an average of 195 mgd in 2015 was diverted from Pickwick Reservoir on the Tennessee River to the Tennessee-Tombigbee Waterway to support its operations.

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. However, in 2015, the flow was reversed and resulted in a net flow of Cumberland River water through the Barkley Canal into the Tennessee River averaging 1,534 mgd from Barkley Reservoir to Kentucky Reservoir.

4 PROJECTED WATER USE

INTRODUCTION

Projections of water use for 2040 were prepared for the four use categories of thermoelectric, industrial, public supply, and irrigation. The projection methods used for each category of use are described below.

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 generation within the Tennessee River watershed for 2000 - 2015. The percent of TVA's generation that comes from Coal-Fired and Nuclear generation within the Tennessee River watershed has steadily decreased from 2000 through 2015.

Table 4-1. Power Generation from TVA-operated Generation Facilities

	2000	**2005**	**2010**	**2015**
Total Generation*	153,394	161,057	147,421	143,046
Coal-Fired and Nuclear Generation from Tennessee River Watershed*	99,343	99,519	87,529	70,367
Percent of Coal-Fired and Nuclear Generation from Tennessee River Watershed	64.8%	61.8%	59.4%	49.2%

*Units are in GWh

Thermoelectric water use for 2040 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, and not just those owned or leased by TVA.

After more than two years of development, TVA completed its Integrated Resource Plan in 2011. This plan and the associated Environmental Impact Statement are the result of extensive analysis and collaboration with TVA partners and stakeholders. 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 the ordinary people, whose lives and livelihoods depend on the electricity supplied by Tennessee Valley Authority (2011). Table 4-2 shows recommendations developed by the Integrated Resource Plan to help guide TVA's future generation portfolio.

Table 4-2. Recommendations from the Integrated Resource Plan

Recommendation	Component	Guideline MW[2] range	Window of time
Expand energy efficiency	EEDR[1]	3,600 - 5,100	By 2020
Pursue cost effective renewable energy	Renewable additions	1,500 - 2,500	By 2020
Consider idling coal-fired capacity	Coal-fired capacity idled	2,400 - 4,700	By 2017
Add pumped-storage capacity	Energy storage	840	2020 - 2024
Increase contribution of nuclear generation	Nuclear additions	1,150 - 5,900	2012 - 2029
Preserve option of generation with carbon capture	Coal additions	0 - 900	2025 - 2029
Utilize natural gas as an intermediate supply source	Natural gas additions	900 - 9,300	2012 - 2029

[1]Energy Efficiency and Demand Response, or measures to reduce overall electricity consumption without degrading the services provided (energy efficiency) or to shift the use of electricity from high demand to low demand times (demand response).
[2]Megawatts

The implications of the Integrated Resource Plan recommendations are that EEDR and renewables such as wind power will slow the need for new water for thermoelectric use. Idling of coal-fired plants will substantially reduce thermoelectric withdrawal 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 if the cooling mode was open-cycle. 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 2015 water use estimates serve as the basis for the 2040 projections. Economic and demographic data at the county level projected to 2040 (Woods and Poole Economics Inc., 2015) were used to project water use to

2040. 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 2015 water use database to produce estimates of 2040 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, 2012).

TRANSFERS FROM THE WATERSHED

In 2015, 26 public supply IBTs resulted in a net loss of 5.9 mgd from the Tennessee River watershed. The projection for 2040 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 2040 range from 300 to 500 mgd with a midpoint of 400 mgd.

Water transfer from Kentucky Reservoir to Barkley Reservoir in 2040 is assumed to be the long-term average of 3,900 mgd.

PROJECTED WATER USE IN 2040

Total withdrawal for 2040 is projected to be 8,108 mgd with net water demand projected as 543 mgd, as shown in Table 4-3. The projected 2040 withdrawal will decrease by 19 percent compared to 2015. This is the result of a 27 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 24 percent because of increased withdrawal for industrial, public supply, and irrigation.

Table 4-3: Estimated Water Use in the Tennessee River watershed 1995 to 2040

Off-stream use (mgd)	1995	2000	2005	2010	2015	2040	Percent change 2015-2040
Withdrawal							
Total withdrawals	10,008	12,211	12,437	11,951	10,016	8,108	-19%
Thermoelectric	8,010	10,276	10,531	10,046	8,224	5,981	-27%
Industrial	1,030	1,205	1,179	1,148	1,035	1,197	16%
Public supply	574	662	684	723	695	842	21%
Irrigation	48	69	43	34	63	88	40%
Source of water							
Surface	9,750	11,996	12,237	11,747	9,828		
Ground	258	215	200	204	189		
Net water demand (consumptive use)		**649**	**432**	**471**	**439**	**543**	**24%**
Transfers							
To the Tennessee-Tombigbee		200	190	200	195	400	
To Barkley Reservoir*		4,524	4,246	1,636	-1,534	3,900	

5 SUMMARY AND CONCLUSIONS

WATER USE IN 2015

Water withdrawals during 2015 were estimated to average 10,016 mgd for off-stream uses or 16.2 percent less than the 2010 withdrawals. Return flow was estimated to be 9,577 mgd or 95.6 percent of the water withdrawn in 2010. Net water demand, which is an estimate of consumptive use, was 439 mgd, and accounted for the remaining 4.4 percent of withdrawal.

In 2015, thermoelectric withdrawals were 8,224 mgd, which was 82.1 percent of total withdrawal. As a percentage of total withdrawal, this was down slightly from its 2010 value of 84.1 percent. Thermoelectric withdrawal has been declining since peaking in 2005, resulting from an 11 percent decline of electrical power generation over the same period. Thermoelectric net water demand in 2015 was only 68 mgd, which was 0.8 percent of thermoelectric withdrawal (99.2 percent of the withdrawal was returned), but it was 15.5 percent of the total net water demand.

The total of all other withdrawals, excluding thermoelectric, was 1,792 mgd, which is a 5.9 percent decline from 2010 (1,905 mgd). The total of all other withdrawals in 2010 had been little changed from 2005 (1,906 mgd), 2000 (1935 mgd), and 1995 (1,998 mgd). Total returns excluding thermoelectric were 1,421 mgd in 2015 or about 4.4 percent lower than they were in 2010, when the returns totaled 1,486 mgd.

Withdrawals for industrial use in 2015 were 1,035 mgd, which was reduced from the withdrawals in 2010 (1,148 mgd), 2005 (1,179 mgd) and 2000 (1,205 mgd). From 2000 to 2015, industrial withdrawals have ranged from 9.5 to 10.3 percent of total withdrawal. Industrial net water demand was 63 mgd in 2015 or 6.1 percent of total industrial withdrawal. This was a little lower than in 2010 when it was 6.5 percent of total withdrawal. Industrial net water demand in 2010 was 14.4 percent of the total net water demand.

Public supply withdrawals in 2015 totaled 695 mgd, which was the first decline in withdrawal for public supply since reporting began in 1995. Public supply withdrawals had a 3.9 percent decline from 2010 (723 mgd), but were not as low as 2005 withdrawals (684 mgd). 2015 public supply withdrawal was 6.9 percent of total withdrawal, which was up slightly from 2010 (6.0 percent). Public supply net water demand was 246 mgd in 2015, 56.0 percent of total net water demand, and was the largest component of total net water demand. This was much lower than in 2010 when it was 65.7 percent of total net water demand.

Irrigation withdrawal was 63 mgd in 2015, or 0.6 percent of total withdrawal. From 1995 through 2015, irrigation has always been below one percent of total withdrawal. However, because there is no return flow from irrigation, irrigation’s 2015 net water demand was 14.1 percent of the total net water demand, nearly double irrigation’s net water demand in 2010 (7.2 percent).

Once again, almost all the water was surface-supplied. In 2015, 98.1 percent of the total withdrawal came from surface water, which was about the same percentage as it was in 2010 (98.3 percent), 2005 (98.5 percent) and in 2000 (98.2 percent). As has always been the case, all the water for thermoelectric use came from surface water. In 2015 surface water supplied 97.8 percent of the industrial withdrawal (97.2 percent in 2010), 78.0 percent of the public supply withdrawal (77.2 percent in 2010), and 79.4 percent of the irrigation withdrawal (79.4 percent in 2010).

Diversions to the Tennessee-Tombigbee Waterway were 195 mgd in 2015, essentially unchanged for the past 20 years. The diversions through the Barkley Canal were 1,534 mgd into the Kentucky Reservoir 2015. These diversions had previously averaged 3,900 mgd into the Barkley Reservoir.

PROJECTED WATER USE FOR 2040

Total water withdrawals in 2040 are projected to decrease by 1,908 mgd, which is a 19 percent decrease from the 2015 withdrawal. This is the result of the anticipated decrease of 2,243 mgd in thermoelectric withdrawal brought about by the retirement of old power plants, which utilize once-through cooling, and the introduction of new plants using closed-cycle cooling. Water use by industry is projected to increase by 16 percent or 162 mgd, to 1,197 mgd. Public supply use is projected to increase by 21 percent or 147 mgd, to 842 mgd. A 40 percent increase in irrigation is anticipated, which increases irrigation from 62 mgd to 88 mgd. Although a large reduction in total withdrawal will occur, net water demand is projected to increase by 24 percent, or 104 mgd to 543 mgd.

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APPENDIX

2015 WATER USE DATA SOURCES FOR THE TENNESSEE RIVER WATERSHED

State/Agency	Source	Department/Organization	Data Type	Date
Alabama	Tom Littlepage	Office of Water Resources	WD	3/31/2017
Alabama	Michael Harper	Office of Water Resources	WD	3/31/2017
Georgia	Vicki Trent	Environmental Protection Division	WD	6/7/2016
Kentucky	Bill Caldwell	Energy and Environment Cabinet	WD	5/13/2016
Mississippi	Wayne Williams	Department of Environmental Quality	WD	5/9/2016
North Carolina	Linwood Peele	Department of Environmental Quality	WD	6/2/2016
Tennessee	Wayne Muirhead	Department of Environment and Conservation	WD	6/28/2016
Virginia	Curt Thomas	Department of Environmental Quality	WD	7/26/2016
Virginia	Allen Newman	Department of Environmental Quality	RT	8/26/2016
Virginia	Steve Artrip	Department of Environmental Quality	RT	8/30/2016
Environmental Protection Agency	Jennifer Pearce	Region 4	RT	7/28/2016
Tennessee Valley Authority	Mandy Anderson	Fuel Accounting	WD, RT	6/12/2017
U.S. Department of Energy	Online	Energy Information Administration (EIA)	TH	6/2/2017
Woods and Poole Economics Inc	CD-ROM	Complete Economic and Demographic Data Source	PROJ	1/19/2016

Data Abbreviations:
WD - Withdrawal
RT - Return (discharge)
TH - Thermoelectric (generation, fuel consumption, operational cooling water data)
PROJ - Projection Data (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.
Inter-basin 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 sufficient for the daily public supply needs of 6,900 people in the Tennessee River watershed
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	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	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