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Budgeting North Carolina Water through Watershed Trading Quotas

Adam C. Mottershead[1], Western Carolina University

Water is one of life's most essential natural resources. As the population increases in urban areas of North Carolina (NC), a new water policy is needed to ensure there is an adequate supply of water for all. While the overall use of water in the United States has declined by nine percent from 2010 to 2015[2], several geographic regions of North Carolina have increased their water use. For example, from 2010 to 2015 the United States Geological Surveyors (USGS) reported that Wake County, NC increased water use by 33 million gallons[3]. Because water can be considered a localized resource, local conservation efforts are necessary in places of urban growth and urban water demand.

Due to the diverse geography and climate in the United States (US), two different sets of water laws have emerged: the Riparian Doctrine and the Water Rights Doctrine. In the eastern US in states such as NC, a Riparian Doctrine is common. Under the Riparian Doctrine, the owner of land adjacent to a waterbody (lake, river, stream) has the right to use the water that they physically hold, meaning it has no marginal cost[4]. This legal structure is common in the eastern US due to the current abundance of water, because all downstream demand is met. One drawback to this system is because the right requires physical allocation to claim a right, water is not used at the highest value. Moreover, this system assumes the available water will always be greater than the amount demanded.

In more arid regions of the US, such as the west coast and mountain west, water scarcity is an issue, and, in response, a Water Rights Doctrine developed. Unlike a Riparian System, Water Rights Doctrines do not require physical holding of water to lay claim to it. Water is owned by past agreements that are entirely separate from land ownership. Water is sold or leased in the form of a right to an allotment of water. The ability to lease and sell water is beneficial to conservation as the action of trading promotes water conservation through personal net benefit. Unfortunately, these rights were established in perpetuity during an extremely wet decade in the west, resulting in an overallocation of water than what is typically present in the region. Setting water claims in perpetuity fails to ensure that water will continue to be allocated to its highest current use value.

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[1] Adam Mottershead: adam12mottershead@bellsouth.net, 3025 Sylvania Drive Raleigh NC 27607. This study would not have been possible without Sean Mulholland who originally got me excited about the concept of merging Natural Resource Management with Economics. I could not have completed the project without the support and encouragement of Keith Gibbs, Jerry Miller, D. Mark Durway, J. Curtis Weaver, Sean Heuser, Bob Payne, Bryan Jarvis, and Angela K. Dills. I received valuable guidance from Michelle Gess, of the Wyoming State Engineering Office, Sara Leonard of the Colorado Water Conservation Board, and Barry B. Lawrence of the Wyoming Water Development Office. I would also like to thank the participants at the Issues in Political Economy's annual meetings in 2022 for helpful comments. This project has been kindly supported by the Academic Project Grants Committee at Western Carolina and the Gimelstob-Landry Distinguished Professor in Regional Economic Development at Western Carolina University. Any errors or mistakes are mine.

[2] "Total Water Use in the United States" *United States Geological Surveyors.* https://www.usgs.gov/special-topics/water-science-school/science/total-water-use-united-states

[3] https://waterdata.usgs.gov/nc/nwis/water_use?format=html_table&rdb_compression=file&wu_area=County&wu_year=ALL&wu_county=ALL&wu_county_nms=--ALL%2BCounties--

[4] Weber, et. al. "Introduction to Riparian Doctrine" *Cases and Materials on Water Law.* 9th edition, 2014.

Both systems for water appropriation have their benefits and drawbacks. The benefit of a Riparian Doctrine is that water has an almost zero marginal cost associated with it. For example, the only cost for well users is the construction cost of the well itself, electricity, and operational maintenance. Once those conditions are met any water physically captured is the right of the user. However, the drawback is the policy assumes an abundant supply of water to meet all the local demands, an assumption not likely to hold true in the coming decades with the increase in population. The benefit of a Water Rights Doctrine is that users have a claim to water without having to physically hold it and, in some locations, that claim can be leased or sold. The drawback is that the claims are written in perpetuity, so water is valued at its historic highest value, not its current highest value. In addition, because the contracts assume a constant, annual availability of water, shortages may occur if water availability declines.

For water conservation to be successful a new approach is needed that accounts for changing climate, demand, and population. One potential dynamic process that meets the needs of current and future use is a Watershed Trading Quota (WTQ), a derivative of a Cap-and-Trade or the fishing industry's Individual Trade Quota (ITQ) system.[5] As with an ITQ, under a WTQ, individuals or groups are granted ownership of a share of available water at the watershed level. Natural resource managers would periodically measure water withdraw and availability, and grant each rights holder the right to use, trade, or sell their share. Only a dynamic market process of reevaluated tradable permits can account for changes in real time so that water continues to be available in each watershed.

The WTQ model offers a market-based solution to water conservation that looks to be a long-term viable option to meet local water conservation needs. Market-based water conservation efforts succeed where Riparian Law and Water Doctrines often fail because these two established systems rarely allow users to exchange water rights so that water can be used at its current highest value. Through price signals, water rights holders will respond to changes in climate and demand to ensure water is used as its current highest value. Voluntarily trading though a market-based cap and trade system will not only encourage water conservation, but also promote innovation water saving technology through potential financial benefit.

Another potential benefit is the development of water infrastructure and new wealth in rural parts of the state as well user trading increases. The key is to implement a new WTQ state policy before large shortages emerge. Under water surplus, users would be able to continue to have access to the same amount as before but are now able to sell or lease this right, likely making residents more open to the change. The vital aspect is that users need a predefined area, such as a watershed, to determine how much they are allotted, and, a way to measure within that watershed the amount they are selling, leasing, or buying.

Using water estimates defined below, two out of the fifty-three watersheds are not in surplus. Due to the fact that the majority of NC is still in surplus it is an excellent time to switch to a WTQ market based conservation system as most users can still consume at their current amount. The watersheds not in surplus must have a collective reduction in water withdrawals for that watershed but can buy water from rights holders in other watersheds that are in surplus.

[5] https://fishionary.fisheries.org/tag/itq/#:~:text=An%20ITQ%20is%20an%20Individual,can%20be%20bought%20and%20sold.

II. METHODS

Watersheds can be defined on different spatial scales known as Hydrologic Unit Codes (HUC), where smaller HUCs are delineations within larger ones, like Russian nesting dolls. The HUC classification is assigned numbers based on a decrease in area. For example, a HUC 10 sized watershed contains multiple HUC 12 watersheds inside of it. For statewide water planning a mid-sized watershed known as a HUC 8 works well. One way to think of watershed spatial scales is through local drainage patterns. Imagine the peak of a mountain range during a precipitation event. The rain can fall on one side of the mountain range or another, like two side by side bowls. Within a bowl (watershed) there are several smaller local maximum and minimum elevations. Another way of thinking about HUC spatial scales is to think of the Southeastern US as a children's swimming pool, within the pool are several mixing bowls, within each mixing bowl are several cereal bowls, and within each cereal bowl are several shot glasses. Each item has a lower local maximum than the scale above it, with several lower local maximums within it. The USGS has spatially classified all the watersheds in the US, seen below[6]. In Figure 1, the South Atlantic Gulf of the US (indicated in dark green) is a large HUC 2 meaning all the water that falls inside the boarder of the green area drains into the South Atlantic Gulf. Within the green section of the US there are several smaller HUC 4s as indicated by Figure 2. Within those, Figure 3 shows two HUC 6s in NC followed by HUC 8s encompassed in those. Each HUC contains hydrologic inputs and outputs. Together the watersheds inputs minus its outputs make up the available water for human use.

Understanding, analyzing, and budgeting water is no easy task as the water cycle contains multiple factors that must be considered. Humans are a driver in altering the water budget with both direct and indirect impacts. Human use has direct impacts on the water cycle by the amount of withdraw on the system. In more rural regions a well that pumps from the water table is a common water supply for both domestic and agricultural use known as the groundwater out rate. It is important to monitor the rate at which humans use groundwater, as an overdraw in groundwater leads to a shift in stream baseflow levels[7]. When water is overdrawn the groundwater falls below the base of the streambed, causing the stream to recharge the groundwater as opposed to the groundwater recharging the stream. If a landowner borders a stream, they can also pump directly from the surface water itself, which effects the total amount of water flowing in a river, also known as streamflow[8]. This interaction of groundwater and surface water is dependent on several factors including human use.

[6] https://water.usgs.gov/wsc/map_index.html

[7] https://www.usgs.gov/centers/utah-water-science-center/science/baseflow

[8] https://www.usgs.gov/special-topics/water-science-school/science/streamflow-and-water-cycle

Figure 1: USGS "Science in your Watershed" HUC 2 National Map

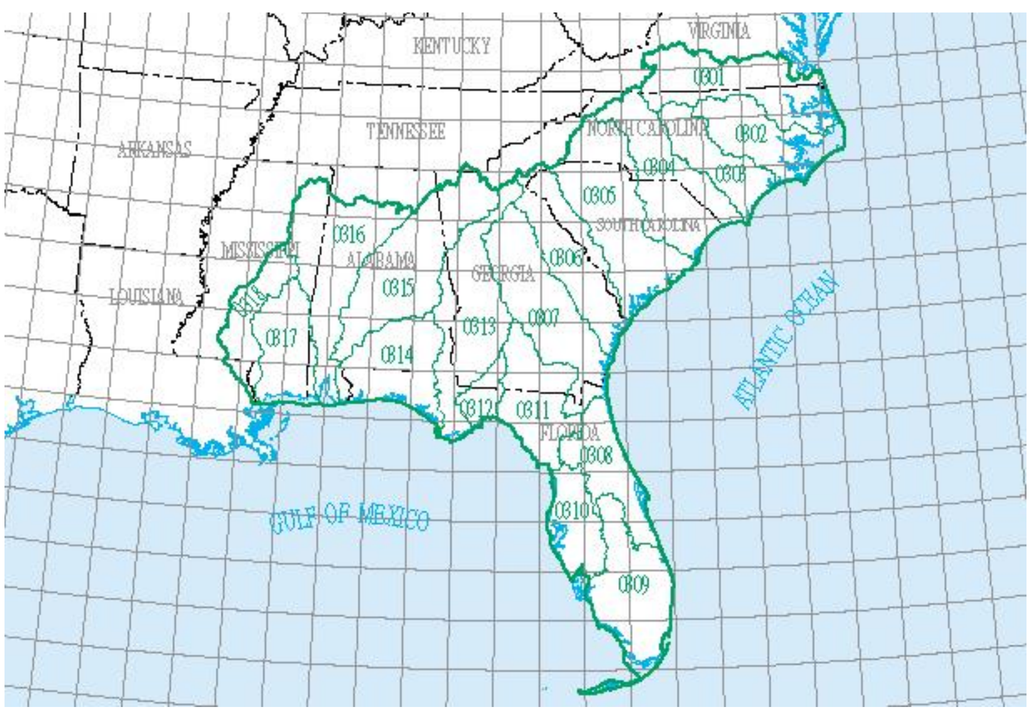

Figure 2: USGS "Science in your Watershed" HUC 4 South Atlantic Gulf Map

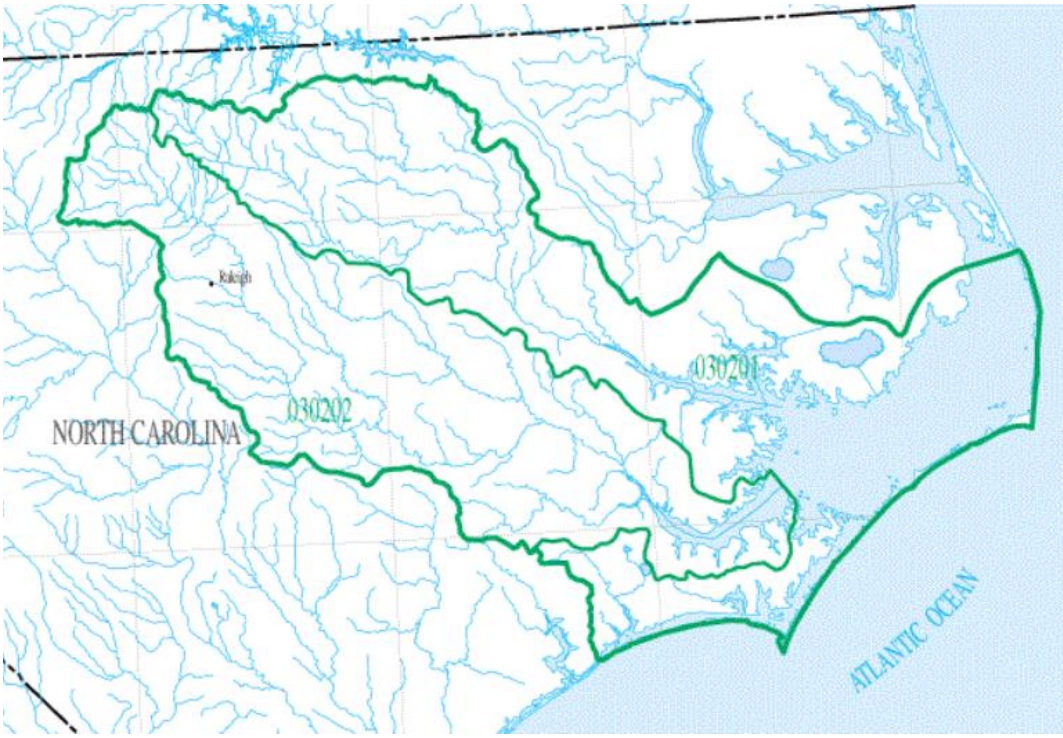

Figure 3: USGS "Science in your Watershed" HUC 6 North Carolina Map

Figure 4: USGS "Science in your Watershed" HUC 8 North Carolina Map

Indirectly, human activities have altered natural hydrologic processes over time such as increasing the carbon dioxide concentration in the atmosphere. This results of an increase in average temperatures across various regions is leading to more water evaporating from the land surface as well as increased transpiration from plants. Together this is known as evapotranspiration[9]. A shift in climate can also alter the amount of precipitation[10] the region receives, a key input of evapotranspiration levels. The water budget can be derived from the variables above using the equation below:

(1) **AVAILABLE WATER** = STREAMFLOW-SURFACE WATER OUT-GROUNDWATER OUT- EVAPOTRANSPIRATION

With enough data it is possible to estimate the available water for these natural containment areas (in this case at the HUC 8 spatial scale) and assign permits to individuals. A permit would allot each user a set number of Gallons of water per year over a fixed time interval that is a percent of total available water. The use of the allotted Gallons is up to the user, they can use or sell part or all of their WTQ. For example, if a HUC 8 has 100 users and there are 200,000 Gallons of water available for WTQ permits, each user could be allotted one percent of the total available water where one percent is equal to two thousand Gallons. Or, they could be allotted the amount they consumed the previous year, or the previous year's consumption plus a slight surplus to promote public by in to the policy.

Ideally, the eastern US could switch from riparian law to a WTQ system while there is still a surplus of water in each HUC 8. This would allow the WTQ to be implemented under nonbinding conditions, making WTQs a much easier political task to implement because each user could initially use, or claim, the same amount as they did previously. Claimants could either use the allotted amount or implement conservation measures such as buying low flow showerheads to reduce their consumption and sell the surplus. The WTQ system would rely on decentralized individual transactions to determine when water is purchased from one person to another, how it is physically moved, and who would pay for it. The development of rural infrastructure from trading presents the ability for water in these areas to be a part of a two-way renewable energy style grid, with the ability to sell surplus into the grid.

Every 5 years an ecological reassessment of all HUC 8s in NC would be conducted by the state and reallot the number of annual Gallons per permit. Unlike a Water Rights Doctrine, this system allows the total water budget to reflect the altering needs of the state keeping water at the current highest value. One benefit to the reallotment of total available water is the development of a futures market in water. At the time of reassessment if decision makers are concerned about going above the maximum sustainable yield (MSY) a smaller number of Gallons per year can be assigned per percent to catalyze conservation measures. The only way to ensure this however is to calculate available water to see the current standings.

Unfortunately, there is currently no official measure of available water at the HUC 8 level. Therefore, the first part of this study focuses on using available North Carolina data and NC

[9] https://www.usgs.gov/special-topics/water-science-school/science/evapotranspiration-and-water-cycle
[10] https://www.usgs.gov/special-topics/water-science-school/science/precipitation-and-water-cycle

HUC 8 scale watershed information to estimate the availability of water. Each variable in the fundamental water equation below had to be collected and cleaned to fit the study's temporal scale of 1995- 2015, in five-year intervals. Prior to 1995 publicly available environmental data records are limited. See Appendix A for formula explanation and additional calculation information for each variable in Equation (1).

(1) **AVAILABLE WATER** = STREAMFLOW-SURFACE WATER OUT-GROUNDWATER OUT- EVAPOTRANSPIRATION

Streamflow measurements are estimated using annual discharge values within each HUC 8. Data can be found through the USGS Water Information System[11] at the HUC 8 scale and discharge is not available at the mouth (entire area) of each HUC 8. While streamflow rates are not available for entire HUC 8s, they are available at different points within each HUC 8 for each of the sampling years. All available NC measurements are taken and sorted into four geographic regions including Coastal, Piedmont Rural, Piedmont Urban, and Mountain geographic areas. Each HUC 8 are assigned to the respective region using climate and geographical maps from the office of the NC Secretary of State[12], seen in Figure 5. Areas of the Piedmont were classified as urban according to US Census thresholds of population values exceeding 50,000 people[13]. A linear regression is estimated for each of the four geographic regions based off collected HUC 8 data and a line of best fit was applied, seen below. The total watershed area was then applied to the line of best fit equation to estimate the streamflow for each year of study, resulting in an estimate of the annual Cubic Feet per Second streamflow. See Figure 6, Figure 7, Figure 8, and Figure 9 below for linear approximations. To convert from Cubic Feet per Second to Gallons per Year the following equation was used:

(2) **STREAMFLOW GAL/YEAR** = ((VALUE*646190.43922943)*365)

[11] https://waterdata.usgs.gov/nwis
[12] https://www.sosnc.gov/divisions/publications/kids_page_geography
[13] https://www.census.gov/programs-surveys/geography/guidance/geo-areas/urban-rural.html

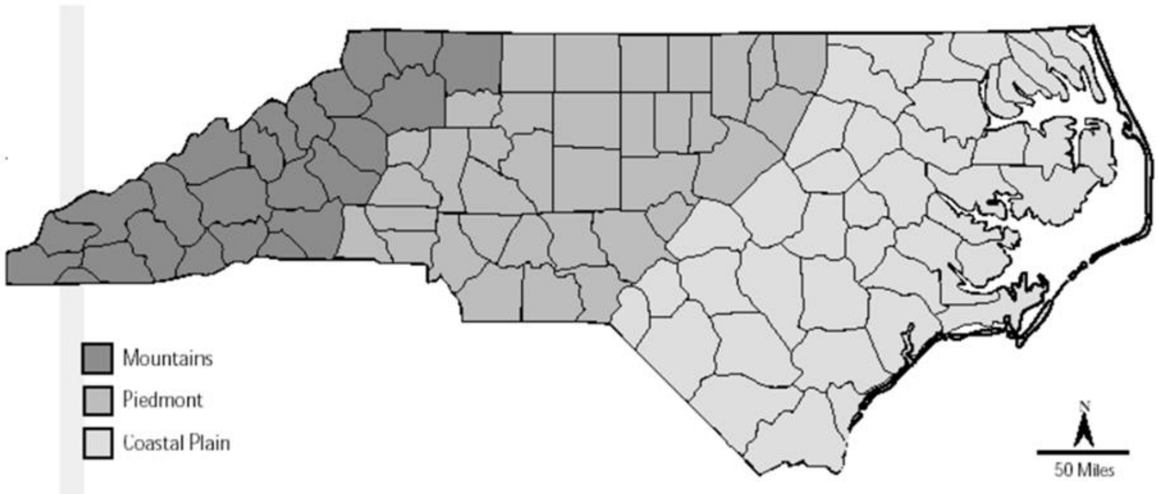

Figure 5: North Carolina climate zones

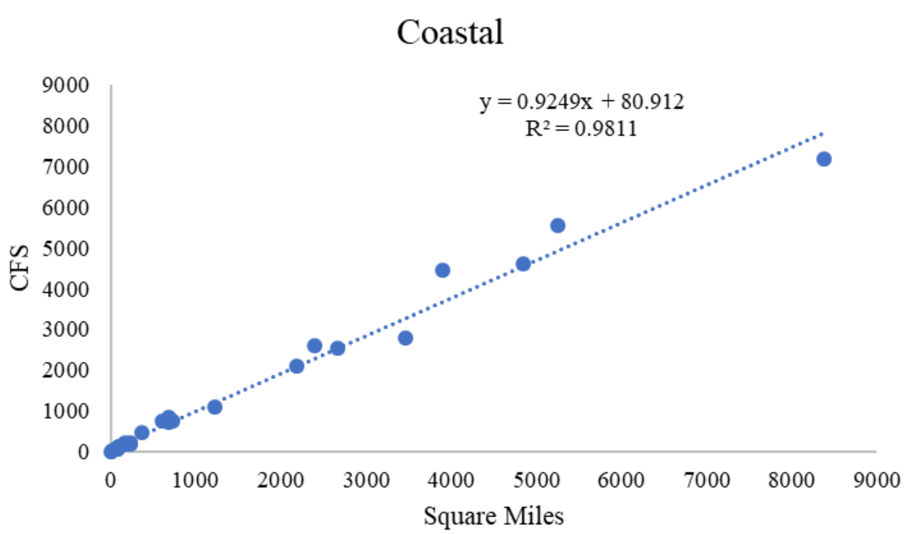

Figure 6: NC Coastal streamflow estimates from USGS stations

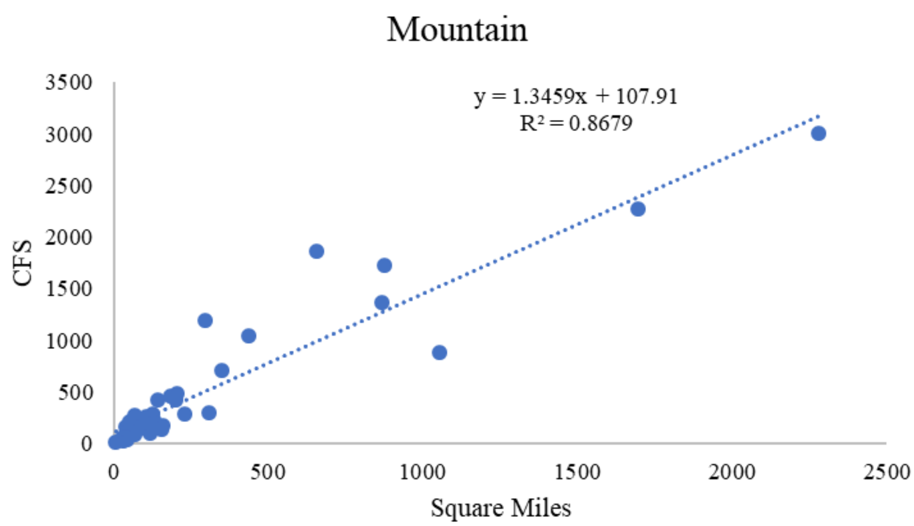

Figure 7: NC Mountain streamflow estimates from USGS stations

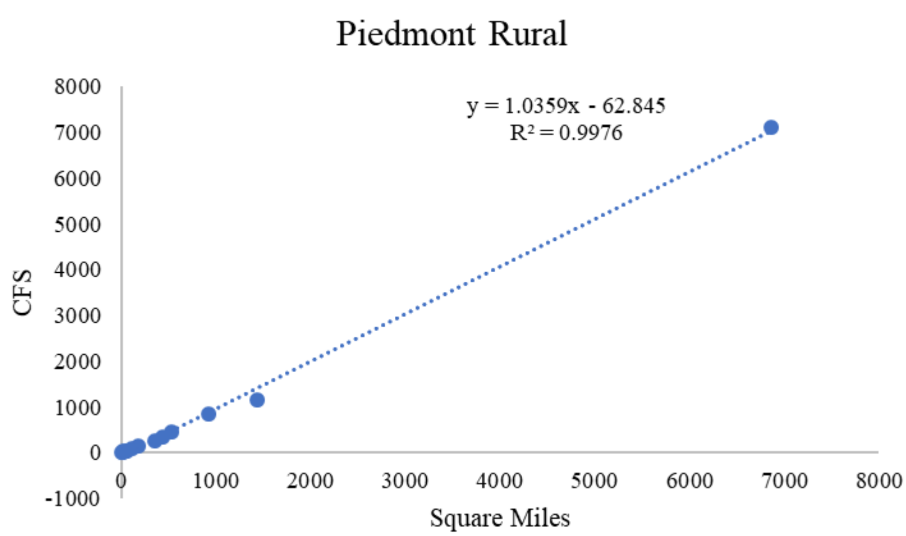

Figure 8: NC Piedmont Rural streamflow estimates from USGS stations

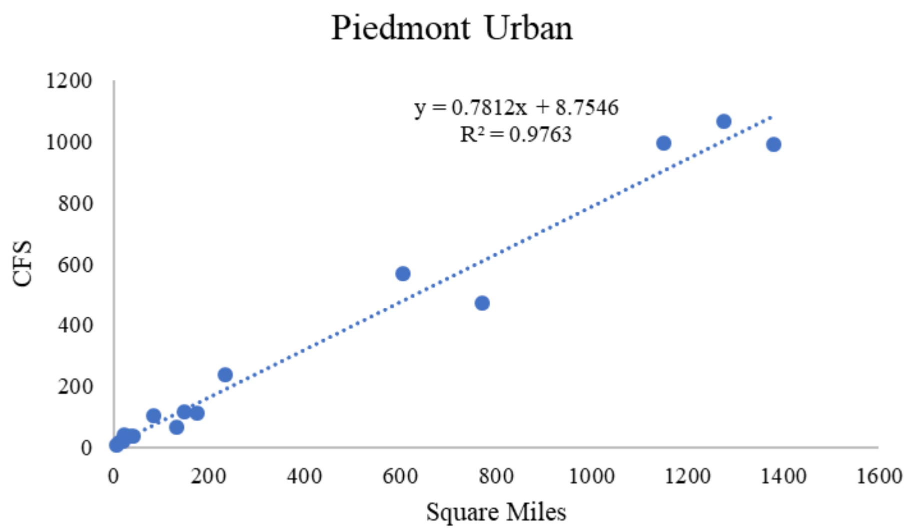

Figure 9: NC Piedmont Urban streamflow estimates from USGS stations

Surface water Out data was gathered at the NC county level using the USGS Water Information System. Data is available for all NC counties for every study year; 1995, 2000, 2005, 2010, 2015. ESRI ArcGIS Pro software was used to overlay HUC 8 borders and NC county borders. The ArcGIS intersect tool was used to determine the percent of each county in a HUC 8. With the percent of each county per watershed it could then be determined from total county estimates how much of a variable fell inside the corresponding HUC 8. Surface water out data was originally recorded in millions of Gallons per day. To convert to Gallons per year the following equation was used:

(3) **SURFACE WATER OUT GAL/YEAR**= (VALUE*1000000)*365

Groundwater Out data was gathered at the NC county level using the USGS Water Information System. Data is available for all NC counties for every study year; 1995, 2000, 2005, 2010, 2015. ESRI ArcGIS Pro software was used to overlay HUC 8 borders and NC county borders. The ArcGIS intersect tool was used to determine the percent of each county in a HUC 8. With the percent of each county per watershed it could then be determined from total county estimates how much of a variable fell inside the corresponding HUC 8. Groundwater out data was originally recorded in millions of Gallons per day. To convert to Gallons per year the following equation was used:

(4) **GROUNDWATER OUT GAL/YEAR**= (VALUE*1000000)*365

Evapotranspiration data at the HUC 8 level is available through the North Carolina State University (NCSU) Climate Office webpage. The data was accessed through the NCSU Cardinal Data Retrieval Center online[14]. Evapotranspiration was gathered at the HUC 8 level in inches per year with sensors of a nine square inch capture area. Using the geographic regions from Figure 5 the median evapotranspiration levels at each year of study were taken and applied per region. The median estimates were then applied to all HUC 8s in the region for evapotranspiration data. To convert to Gallons per year the following equation was used:

(5) **EVAPOTRANSPIRATION GAL/YEAR**= ((EVAPOTRANSPIRATION IN/YEAR *456,054,400)/231)

A. FUNDAMENTAL ASSUMPTIONS

The overall fundamental assumption is that Equation (1) gives an accurate representation of the surplus/ deficit of available water in each basin:

(1) **AVAILABLE WATER** = STREAMFLOW-SURFACE WATER OUT-GROUNDWATER OUT- EVAPOTRANSPIRATION

It is also assumed that NC water data from 1995 to 2015 is an accurate representation of long-term estimates, and that this time period is not an abnormally wet/dry period.

It is assumed that the regression equations used to estimate streamflow is the most accurate method of defining long term stream flow measurements. It is also assumed that in reality watershed streamflow does scale with the linear approximations.

All counties contained complete data for Groundwater Out and Surface water Out as reported by the USGS Water Information System. When a value of “0” occurred, it is treated as a value of Null as opposed to missing. Although a value of “0” does not seem likely in some counties, the source where data was gathered does indicate “NA” in some columns. Since the value “NA” was present, it is fundamentally assumed that the value “0” truly means “0”. It is assumed that the formulas used are an accurate representation of Groundwater and Surface Water out in NC.

Evapotranspiration data is not available before 2005. For the year 2000, 2010 data was used; for 1995, 2005 data was used. The rationale behind this assumption and not using 2005 data for both 2000 and 1995 is the trend for evapotranspiration appears to fluctuate as seen in Figure 10. The fundamental assumption is made by the author that the sine wave trend continues for 1995-2005. Thirty of the fifty-three HUC 8s do not have evapotranspiration data. Because only the median of known evapotranspiration values was used per region of Figure 5, the individual HUC 8s

[14] https://climate.ncsu.edu/

missing evapotranspiration were not needed to be estimated. Using regional evapotranspiration medians does assume that evapotranspiration levels are relatively uniform across each region.

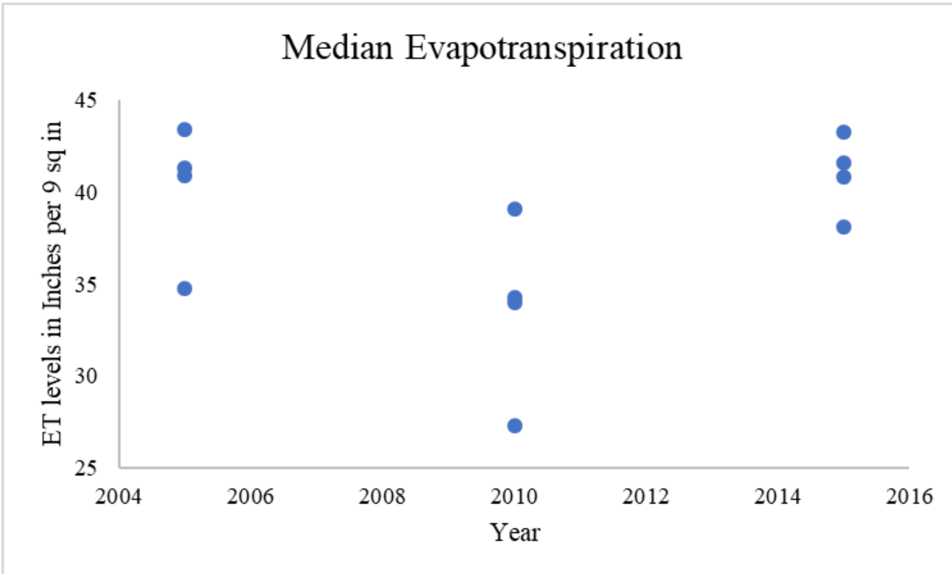

Figure 10: Evapotranspiration levels per year recorded in inches in a 9^2 in area

III. RESULTS

The results for the entire state of North Carolina indicate a surplus in ever year of data observed as indicated by Table 1.

Table 1: Statewide water surplus in Gal/ year

Year	Statewide Net (Gal./Year)
1995	1.47E+13
2000	1.58E+13
2005	1.46E+13
2010	1.58E+13
2015	1.45E+13

While overall NC experiences an annual surplus of water in years observed, delineation on the HUC 8 scale results in most basins with a surplus and a few in deficit. Figure 11 and Figure 12 on the page below indicate what HUC 8s are in surplus (indicated in green) and what HUC 8s are in deficit (red).

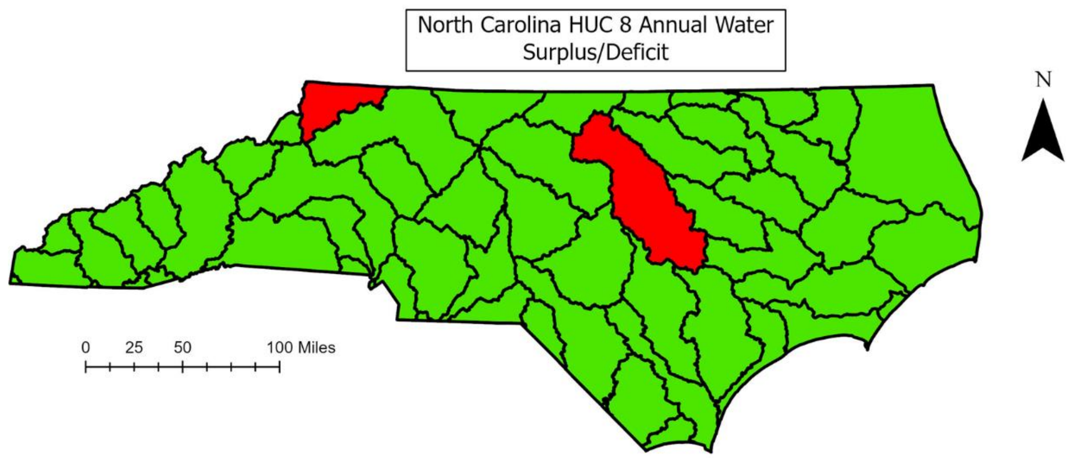

Figure 11: North Carolina HUC 8's in surplus (green) and deficit (red) for 1995, 2005, 2015

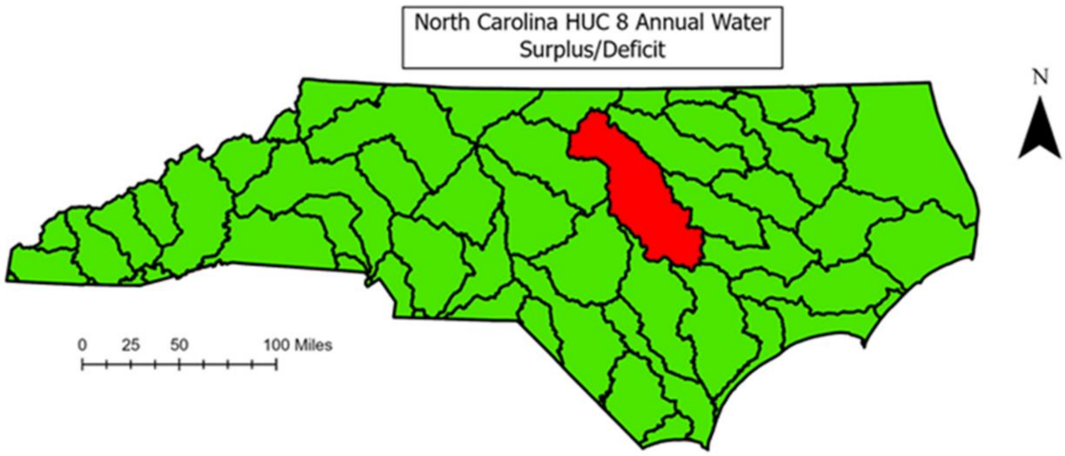

Figure 12: North Carolina HUC 8's in surplus (green) and deficit (red) for 2000, 2010.

The Upper Neuse HUC 8 (Table 2) experienced a water shortage every year of the study and the Upper New HUC 8 (Table 3) experienced a shortage in 1995, 2005, and 2015. All other NC HUC 8's were in a surplus for the entire study. The annual mean surplus and median surplus can be found in Table 4 and Table 5 below. Complete results for HUC 8 data can be found in Appendix B.

Table 2: Upper Neuse HUC 8 deficit

Year	HUC 8 Upper Neuse
1995	-6.4E+10
2000	-5.4E+10
2005	-6.4E+10
2010	-5.4E+10
2015	-6.6E+10

Table 3: Upper New HUC 8 deficit/ surplus

Year	HUC 8 Upper New
995	-1.5E+09
000	2.5E+09
005	-1.5E+09
010	3.17E+09
015	-2E+10

Table 4: Mean of all HUC 8 surpluses per year

Year	HUC 8 Annual Surplus Mean
995	2.77E+11
000	2.98E+11
005	2.76E+11
010	2.98E+11
015	2.73E+11

Table 5: Median of all HUC 8 surpluses per year

Year	HUC 8 Annual Surplus Median
995	2.12E+11
000	2.36E+11
005	2.12E+11
010	2.36E+11

	2.13E+11
015	

IV. DISCUSSION

The results above imply that the state of North Carolina is in a unique position. As a whole NC can handle the increased water demand as notated by Table 1. However, a few HUC 8s are running a deficit. Under a WTQ, deficit running HUC 8s can buy water from HUC 8s that have a surplus.

The Upper Neuse HUC 8 contains the greater Raleigh area, a region that in 1995 had a population of 413,000 and a population of 1.1 million in 2015[15]. The Upper New HUC 8 is home to the city of Boone which grew from 39,000 in 1995 to 53,000 in 2015[16]. The deficit in these HUC 8s supports earlier claims that areas with urban growth are going to place continued strain on local water resources. For the two HUC 8s in deficit, trade is key for all to have reliable access to water. To create a WTQ system that provides a sustainable water supply for future water demand in these HUC 8s requires a variety of legal components from both the private and public sector.

The State Department of Environmental Quality (DEQ)[17] would be responsible for assessing and publishing the 5-year water reports, setting technological standards for trading devices, and the development of the WTQ contracts. It is critical that the government role in the WTQ model is seen as the collectively agreed upon enforcer of a contract. While the contracts would be recognized and enforced through the courts, the exchange of water itself would be on a private exchange.

For HUC 8s currently in deficit, a collectively allocated reduction is needed to ensure a sustainable water future. This reduction only needs to occur on the HUC 8 level, meaning every individual would not need to reduce by the same amount if the net usage for the HUC 8 is reduced. The benefit of the WTQ system is that it allows users in these deficit HUCs to invest in conservation measures to reduce their water intake, buy or lease from those within their HUC 8 with a surplus, or buy or lease from another HUC 8 with a surplus. For individuals in a surplus HUC 8 as determined by Figure 11 and Appendix B, users could each be allotted a percent increase above their normal use rate. This increase would be defined at a percent that still maintains instream flow minimums for wildlife corridors and does not provide so many tradable Gallons the market collapses from a surplus of Gallons per permit. The reason for allotting a surplus and not what users last consumed is twofold. Initial overreporting of Gallons of annual use by users should be less likely to occur if they are told they can use more than they currently are consuming. Secondly, the switch from Riparian to WTQ must be enticing enough to get zero marginal cost users to enter into a trading market. I believe the precent of entry into the market will be higher if allotted additional Gallons of use.

[15] "Raleigh Metro Area Population 1950-2022" *MacroTrends* https://www.macrotrends.net/cities/23110/raleigh/population
[16] https://www.biggestuscities.com/city/boone-north-carolina
[17] https://deq.nc.gov/

The WTQ model is only viable if the trading has collective buy in from users, which requires both technologies to monitor trading activity and enforcement that users are not going beyond the percent allotted. In urban settings, municipalities hold the upfront benefit of having water infrastructure already in place. The water used is already metered meaning it is relatively straight forward to ensure users are not going over their percent allotted. With urban conservation measures such as rain barrels the municipal water infrastructure could become a two-way grid. This system would be like the electrical grid on urban homes where water is constantly flowing both in and out of homes and other users or municipalities can buy back water.

Many portions of NC are areas in which individuals rely on well water, a non-municipal system for obtaining water. For these well owners to engage in buying, selling, and leasing these new water rights, they would need a water meter that captures and transmits flow rates. This would enable well users to measure water sales and, charge for those sales. DEQ would not require current well users to use these new meters, but users would only be able to sell or lease their rights if they used these new, more sophisticated smart meters. New well users would also need to buy the rights to consume water and also use the new meter. Lastly, whenever there is a deed transfer it would be required that the new owner to install a device with a trading monitor on it. All of these mechanisms help ensure that other parties in the trading process are getting the value of the percent water traded.

In regard to enforcement of trading, there are many possibilities for both municipalities and well users. If a well user or municipality is caught over pumping via meter, the user would have violated the collective of the HUC 8 and could be forced to pay a fine to the members of the HUC 8 and possibly DEQ or the exchange. Since personal financial gain has been introduced to water consumption, a certain level of peer-to-peer accountability is introduced as users want to make sure their bottom line is accurate.

IV.A. FURTHER RESEARCH

Further research on the WTQ system includes determining the percent allotment per HUC 8 for each individual within the watershed. This allotment cannot just use basic algebra based on the surplus for two main reasons. Ecologically, streams need an inflow-minimums to support the movement and stability of aquatic ecological organisms. Also, the percent allotment cannot use the total surplus per HUC 8 because there would be no incentive to trade. The WTQ credits must hold enough scarcity that trading looks like a viable option for water.

The transfer of water itself will need a digital network of smart meters and corresponding billing applications to verify when an amount of water is traded, like several cash apps such as Venmo or Chime. A social science study is needed to see what the best approach is to persuade potential users that this option is worthwhile for them, considering the fact they currently obtain water at zero marginal cost. For WTQ implantation, a copy of the findings so far would be sent to the State of North Carolina for their consideration. Once approved a small sample project of a few HUC 8s would be used to study the real-world trading network of WTQs, eventually scaling up to the entire state of NC.

V. CONCLUSION

A dynamic WTQ policy is an innovative, market-based water conservation policy to ensure water availability. By assessing water availability every 5 years, ensuring water rights holders a percentage from each assessment, and recognizing the ability of right owners to trade water, the WTQ provides a market-based solution to conservation. Through price signals, water rights holders will respond to changes in climate and demand to ensure water is used as its current highest value. Results from the model show that overall, the state of North Carolina can handle current water demand, but a few local areas of urban growth are running a deficit. This indicates now is the key time for NC to switch to a WTQ policy, while people's daily water usage would be largely unaffected by the change in water rights policy. Moreover, voluntarily trading though a water-based cap and trade system will not only encourage water conservation, but also promote innovation of water saving technology through potential financial benefit. Another benefit of HUC 8s in surplus is the possible development of water infrastructure and new wealth in rural parts of the state as well user trading increases. Overall, the WTQ model represents a new approach to water conservation at the local level that would ensure water needs are met in each HUC 8.

VI. APPENDIX A

There were several equations used when developing the final water budget estimates. Below is an example table with mock data to illustrate the process used to obtain the results.

<u>Overall Water Budget Equation</u>:

(A1) AVAILABLE WATER = STREAMFLOW-SURFACE WATER OUT-GROUNDWATER OUT- EVAPOTRANSPIRATION

The goal was to convert every variable to Gal/year

<u>Key to Excel Table</u>:

Variable	Meaning
year	The year the data was gathered
huc	The name of the watershed (HUC 8 scale)
hucareasqmi	The square milage of the HUC 8
evap_comp_med_gal	The amount of evapotranspiration in Gallons per year
streamflow_gal	This estimates the total discharge for each HUC 8 in Gallons per year for the area of the HUC 8.
gwout	This estimates the human withdraw from groundwater (wells) in Gallons per year for the area of each NC county. The percent of each county in the HUC was applied to the total groundwater out levels for each county. All counties' percent in the HUC 8 were summed to get the Gallons per year for each HUC 8.
swout	This estimates the human withdraw from surface water (stream irrigation) in Gallons per year for the area of each NC county. The percent of each county in the HUC 8 was applied to the total surface water out levels for each county. All counties' percent in the HUC 8 were summed to get the Gallons per year for each HUC 8.
net_test	This estimates the results of the overall available water using the fundamental water equation (1) Available water= streamflow- surface water out- groundwater out- evapotranspiration. Answer is expressed in Gallons/year.

Mock Data and Formulas:

Groundwater Out					
Data Source: https://waterdata.usgs.gov/nc/nwis/water_use?format=html_table&rdb_compression=file&wu_area=County&wu_year=ALL&wu_county=ALL&wu_county_nms=--ALL%2BCounties--					
Year	Name	Area (sq_mi)	Raw data	Conversion formula	Data for equation
2000	Pamlico HUC	100 sq mi Note: because the 2 counties make up the entire watershed, the HUC area is not needed in calculations	County 1: 100 Million gal/Day Assume 95% of County 1 is in Pamlico. County 2: 200 Million Gal/day. Assume 50 % of County 2 is in Pamlico.	(100*.95)+(200*.5)= 195 MGal/day (195*1000000)*365	195000000 gal/year

Surface Water Out					
Data Source: https://waterdata.usgs.gov/nc/nwis/water_use?format=html_table&rdb_compression=file&wu_area=County&wu_year=ALL&wu_county=ALL&wu_county_nms=--ALL%2BCounties--					
Year	Name	Area (sq_mi)	Raw data	Conversion formula	Data for equation
2005	Upper French Broad HUC	100 sq mi Note: because the 2 counties make up the entire watershed, the HUC area is not needed in calculations	County 1: 100 Million gal/Day Assume 95% of County 1 is in Upper French Broad. County 2: 200 Million Gal/day. Assume 50 % of County 2 is in Upper French Broad.	(100*.95)+(200*.5)= 195 MGal/day (195*1000000)*365	195000000 gal/year

Evapotranspiration					
Data Source: https://products.climate.ncsu.edu/cardinal/user/					
Year	Name	Area (sq_mi)	Raw data	Conversion formula	Data for equation
2000	Pamlico HUC	100 sq mi	43 inches per 9 square inches as the Coastal median value.	(4,014,489,600 sq in/mile)/9 sq in= 456054400 456054400*100= 4.56E+10 456054400*43inches= 1.96E+12 /231	8489324329 gal/ year

Streamflow					
Data Source: https://maps.waterdata.usgs.gov/mapper/index.html					
Year	Name	Area (sq_mi)	Raw data	Conversion formula	Data for equation
2000	Pamlico HUC	1500 sq mi	Streamflow data was derived from a series of regressions based off land density and geography of each HUC where "x" represents the area in sq miles to calculate "y" the CFS. Equations are used with Coastal regression estimates.	y = 0.9249x + 80.912 Area = 1500 0.9249(1500)+80.912 =1468.262 Gal/year= (1468.262*646190.43922943)*365	3.46E+11 gal/ year

VII. APPENDIX B

year	Huc	Hucarea sqmi	evap_comp_med _gal	streamflow_ gal	gwout	swout	net_test
1995	Albemarle	4323	3.63E+11	9.62E+11	3.47E+08	0	5.99E+11
2000	Albemarle	4323	2.28E+11	9.62E+11	3.07E+08	0	7.34E+11
2005	Albemarle	4323	3.63E+11	9.62E+11	4.09E+08	0	5.99E+11
2010	Albemarle	4323	2.28E+11	9.62E+11	3.87E+08	0	7.34E+11
2015	Albemarle	4323	3.61E+11	9.62E+11	3.94E+08	0	6.01E+11
1995	Black	1574	1.32E+11	3.63E+11	9.44E+08	6.05E+08	2.29E+11
2000	Black	1574	8.3E+10	3.63E+11	8.87E+08	2.78E+09	2.76E+11
2005	Black	1574	1.32E+11	3.63E+11	8.78E+08	2.38E+09	2.27E+11
2010	Black	1574	8.3E+10	3.63E+11	8.2E+08	5.37E+09	2.73E+11
2015	Black	1574	1.31E+11	3.63E+11	9.9E+08	6.45E+09	2.24E+11
1995	Chowan	898	7.53E+10	2.15E+11	3.89E+08	0	1.39E+11
2000	Chowan	898	4.74E+10	2.15E+11	4.18E+08	0	1.67E+11
2005	Chowan	898	7.53E+10	2.15E+11	4.55E+08	0	1.39E+11
2010	Chowan	898	4.74E+10	2.15E+11	5.53E+08	0	1.67E+11
2015	Chowan	898	7.5E+10	2.15E+11	4.56E+08	0	1.40E+11
1995	Coastal Carolina	679	5.7E+10	1.67E+11	6.13E+08	25550000	1.10E+11
2000	Coastal Carolina	679	3.58E+10	1.67E+11	4.38E+08	0	1.31E+11
2005	Coastal Carolina	679	5.7E+10	1.67E+11	1.42E+09	0	1.09E+11
2010	Coastal Carolina	679	3.58E+10	1.67E+11	1.75E+09	0	1.30E+11
2015	Coastal Carolina	679	5.67E+10	1.67E+11	1.02E+09	0	1.10E+11
1995	Contentnea	1009	8.46E+10	2.39E+11	6.14E+08	1.63E+09	1.52E+11
2000	Contentnea	1009	5.32E+10	2.39E+11	6.21E+08	2.16E+09	1.83E+11
2005	Contentnea	1009	8.46E+10	2.39E+11	5.93E+08	2.73E+09	1.51E+11
2010	Contentnea	1009	5.32E+10	2.39E+11	5.64E+08	3.25E+09	1.82E+11
2015	Contentnea	1009	8.43E+10	2.39E+11	3.53E+08	2.88E+09	1.52E+11
1995	Deep	1450	1.14E+11	3.18E+11	1.87E+08	1.96E+09	2.01E+11
2000	Deep	1450	9.6E+10	3.18E+11	1.67E+08	4.53E+09	2.17E+11
2005	Deep	1450	1.14E+11	3.18E+11	1.09E+08	2.79E+09	2.00E+11
2010	Deep	1450	9.6E+10	3.18E+11	91500000	4.65E+09	2.17E+11
2015	Deep	1450	1.14E+11	3.18E+11	80300000	4.33E+09	1.99E+11
1995	Fishing	894	7.06E+10	2.64E+11	2.19E+08	1.08E+09	1.92E+11
2000	Fishing	894	5.92E+10	2.64E+11	1.97E+08	1.1E+09	2.03E+11
2005	Fishing	894	7.06E+10	2.64E+11	1.17E+08	8.58E+08	1.92E+11
2010	Fishing	894	5.92E+10	2.64E+11	76650000	9.93E+08	2.03E+11

2015	Fishing	894	7.05E+10	2.64E+11	32850000	1.04E+09	1.92E+11
1995	Haw	1708	1.36E+11	3.64E+11	1.33E+08	6.36E+09	2.22E+11
2000	Haw	1708	1.29E+11	3.64E+11	1.57E+08	6.55E+09	2.29E+11
2005	Haw	1708	1.36E+11	3.64E+11	1.02E+08	6.81E+09	2.21E+11
2010	Haw	1708	1.29E+11	3.64E+11	1.08E+08	7.64E+09	2.28E+11
2015	Haw	1708	1.37E+11	3.64E+11	93075000	7.62E+09	2.20E+11
1995	Hiwassee	2056	1.38E+11	3.05E+11	49275000	2.89E+08	1.67E+11
2000	Hiwassee	2056	1.35E+11	3.05E+11	65700000	3.83E+08	1.70E+11
2005	Hiwassee	2056	1.38E+11	3.05E+11	60225000	1.95E+08	1.67E+11
2010	Hiwassee	2056	1.35E+11	3.05E+11	51100000	3.84E+08	1.70E+11
2015	Hiwassee	2056	1.51E+11	3.05E+11	67525000	3.91E+08	1.53E+11
1995	Little Pee Dee	1368	1.15E+11	2.29E+11	3.93E+08	1.46E+09	1.12E+11
2000	Little Pee Dee	1368	7.21E+10	2.29E+11	1.31E+09	1.45E+09	1.54E+11
2005	Little Pee Dee	1368	1.15E+11	2.29E+11	1.01E+09	1.21E+09	1.12E+11
2010	Little Pee Dee	1368	7.21E+10	2.29E+11	1.03E+09	7.3E+08	1.55E+11
2015	Little Pee Dee	1368	1.14E+11	2.29E+11	9.34E+08	9.55E+08	1.12E+11
1995	Lower Cape Fear	1121	9.4E+10	4.02E+11	7.23E+08	12775000	3.07E+11
2000	Lower Cape Fear	1121	5.91E+10	4.02E+11	8.95E+08	1.12E+08	3.41E+11
2005	Lower Cape Fear	1121	9.4E+10	4.02E+11	1.15E+09	0	3.06E+11
2010	Lower Cape Fear	1121	5.91E+10	4.02E+11	1.02E+09	0	3.41E+11
2015	Lower Cape Fear	1121	9.36E+10	4.02E+11	9.65E+08	2.17E+08	3.07E+11
1995	Lower Catawba	1334	1.06E+11	3.71E+11	1.84E+08	1.49E+10	2.49E+11
2000	Lower Catawba	1334	1.01E+11	3.71E+11	4.29E+08	2.04E+10	2.49E+11
2005	Lower Catawba	1334	1.06E+11	3.71E+11	1.19E+08	2.34E+10	2.41E+11
2010	Lower Catawba	1334	1.01E+11	3.71E+11	2.1E+08	2.33E+10	2.47E+11
2015	Lower Catawba	1334	1.07E+11	3.71E+11	1.55E+08	2.15E+10	2.42E+11
1995	Lower Dan	1284	1.01E+11	2.51E+11	60225000	2.66E+09	1.47E+11
2000	Lower Dan	1284	8.5E+10	2.51E+11	71175000	2.93E+09	1.63E+11
2005	Lower Dan	1284	1.01E+11	2.51E+11	43800000	3.05E+09	1.47E+11
2010	Lower Dan	1284	8.5E+10	2.51E+11	47450000	2.28E+09	1.64E+11
2015	Lower Dan	1284	1.01E+11	2.51E+11	41975000	9.98E+08	1.49E+11
1995	Lower Little Tennessee	1055	7.07E+10	2.13E+11	7300000	1.21E+08	1.43E+11
2000	Lower Little Tennessee	1055	6.92E+10	2.13E+11	14600000	2.74E+08	1.44E+11
2005	Lower Little	1055	7.07E+10	2.13E+11	14600000	2.26E+08	1.43E+11

	Tennessee						
2010	Lower Little Tennessee	1055	6.92E+10	2.13E+11	40150000	2.41E+08	1.44E+11
2015	Lower Little Tennessee	1055	7.76E+10	2.13E+11	18250000	2.34E+08	1.36E+11
1995	Lower Neuse	1583	1.33E+11	3.99E+11	2.05E+09	0	2.64E+11
2000	Lower Neuse	1583	8.35E+10	3.99E+11	1.84E+09	0	3.14E+11
2005	Lower Neuse	1583	1.33E+11	3.99E+11	1.82E+09	0	2.64E+11
2010	Lower Neuse	1583	8.35E+10	3.99E+11	1.76E+09	0	3.14E+11
2015	Lower Neuse	1583	1.32E+11	3.99E+11	1.71E+09	0	2.65E+11
1995	Lower Pee Dee	2532	2.00E+11	3.04E+11	14600000	2.05E+09	1.02E+11
2000	Lower Pee Dee	2532	1.68E+11	3.04E+11	10950000	2.48E+09	1.34E+11
2005	Lower Pee Dee	2532	2.00E+11	3.04E+11	7300000	2.53E+09	1.02E+11
2010	Lower Pee Dee	2532	1.68E+11	3.04E+11	9125000	2.4E+09	1.34E+11
2015	Lower Pee Dee	2532	2.00E+11	3.04E+11	7300000	2.8E+09	1.02E+11
1995	Lower Roanoke	1310	1.10E+11	4.45E+11	4.09E+08	0	3.35E+11
2000	Lower Roanoke	1310	6.91E+10	4.45E+11	3.76E+08	0	3.76E+11
2005	Lower Roanoke	1310	1.10E+11	4.45E+11	4.53E+08	0	3.35E+11
2010	Lower Roanoke	1310	6.91E+10	4.45E+11	5.62E+08	0	3.75E+11
2015	Lower Roanoke	1310	1.09E+11	4.45E+11	2.88E+08	0	3.35E+11
1995	Lower Tar	960	8.05E+10	3.75E+11	3.58E+08	1.9E+09	2.92E+11
2000	Lower Tar	960	5.06E+10	3.75E+11	5.72E+08	2.07E+09	3.21E+11
2005	Lower Tar	960	8.05E+10	3.75E+11	6.52E+08	2.11E+09	2.91E+11
2010	Lower Tar	960	5.06E+10	3.75E+11	4.27E+08	2.15E+09	3.22E+11
2015	Lower Tar	960	8.02E+10	3.75E+11	1.81E+08	2.11E+09	2.92E+11
1995	Lower Yadkin	1190	9.49E+10	3.79E+11	1.94E+08	3.15E+09	2.81E+11
2000	Lower Yadkin	1190	8.97E+10	3.79E+11	2.12E+08	4.84E+09	2.85E+11
2005	Lower Yadkin	1190	9.49E+10	3.79E+11	1.31E+08	2.9E+09	2.81E+11
2010	Lower Yadkin	1190	8.97E+10	3.79E+11	1.1E+08	3.88E+09	2.86E+11
2015	Lower Yadkin	1190	9.56E+10	3.79E+11	94900000	5.2E+09	2.78E+11
1995	Lumber	1753	1.47E+11	2.23E+11	7.45E+08	9.49E+08	7.39E+10
2000	Lumber	1753	9.24E+10	2.23E+11	9.75E+08	1.42E+09	1.28E+11
2005	Lumber	1753	1.47E+11	2.23E+11	9.38E+08	1.65E+09	7.3E+10
2010	Lumber	1753	9.24E+10	2.23E+11	1.09E+09	1.35E+09	1.28E+11

2015	Lumber	1753	1.46E+11	2.23E+11	9.97E+08	1.48E+09	7.38E+10
1995	Lynches	1413	1.12E+11	6.78E+11	14600000	3.52E+09	5.63E+11
2000	Lynches	1413	9.35E+10	6.78E+11	21900000	2.88E+09	5.82E+11
2005	Lynches	1413	1.12E+11	6.78E+11	14600000	2.94E+09	5.64E+11
2010	Lynches	1413	9.35E+10	6.78E+11	18250000	2.21E+09	5.83E+11
2015	Lynches	1413	1.11E+11	6.78E+11	14600000	2.38E+09	5.64E+11
1995	Meherrin	1612	1.35E+11	3.60E+11	4.42E+08	0	2.25E+11
2000	Meherrin	1612	8.5E+10	3.60E+11	5.37E+08	0	2.75E+11
2005	Meherrin	1612	1.35E+11	3.60E+11	5.84E+08	0	2.25E+11
2010	Meherrin	1612	8.5E+10	3.60E+11	8.75E+08	0	2.75E+11
2015	Meherrin	1612	1.35E+11	3.60E+11	5.84E+08	0	2.25E+11
1995	Middle Neuse	1065	8.93E+10	5.84E+11	1.74E+09	0	4.93E+11
2000	Middle Neuse	1065	5.62E+10	5.84E+11	1.73E+09	0	5.26E+11
2005	Middle Neuse	1065	8.93E+10	5.84E+11	1.95E+09	0	4.92E+11
2010	Middle Neuse	1065	5.62E+10	5.84E+11	1.48E+09	0	5.26E+11
2015	Middle Neuse	1065	8.89E+10	5.84E+11	1.41E+09	0	4.93E+11
1995	Middle Roanoke	1738	1.37E+11	2.28E+11	16425000	1.13E+09	9E+10
2000	Middle Roanoke	1738	1.15E+11	2.28E+11	29200000	1.13E+09	1.12E+11
2005	Middle Roanoke	1738	1.37E+11	2.28E+11	14600000	1.47E+09	8.97E+10
2010	Middle Roanoke	1738	1.15E+11	2.28E+11	16425000	1.13E+09	1.12E+11
2015	Middle Roanoke	1738	1.37E+11	2.28E+11	16425000	9.98E+08	9.02E+10
1995	New River	891	7.47E+10	2.44E+11	6.9E+08	0	1.69E+11
2000	New River	891	4.7E+10	2.44E+11	1.28E+09	0	1.96E+11
2005	New River	891	7.47E+10	2.44E+11	1.53E+09	0	1.68E+11
2010	New River	891	4.7E+10	2.44E+11	1.75E+09	0	1.95E+11
2015	New River	891	7.44E+10	2.44E+11	1.44E+09	0	1.68E+11
1995	Nolichucky	1758	1.18E+11	8.27E+11	1.62E+08	2.38E+08	7.09E+11
2000	Nolichucky	1758	1.15E+11	8.27E+11	2.21E+08	3.34E+08	7.11E+11
2005	Nolichucky	1758	1.18E+11	8.27E+11	1.81E+08	2.65E+08	7.09E+11
2010	Nolichucky	1758	1.15E+11	8.27E+11	1.96E+08	2.87E+08	7.11E+11
2015	Nolichucky	1758	1.29E+11	8.27E+11	1.86E+08	2.85E+08	6.97E+11
1995	Northeast Cape Fear	1741	1.46E+11	3.52E+11	1.28E+09	0	2.05E+11
2000	Northeast Cape Fear	1741	9.18E+10	3.52E+11	1.73E+09	0	2.58E+11
2005	Northeast Cape Fear	1741	1.46E+11	3.52E+11	1.95E+09	0	2.04E+11
2010	Northeast Cape Fear	1741	9.18E+10	3.52E+11	1.62E+09	0	2.58E+11
2015	Northeast Cape Fear	1741	1.45E+11	3.52E+11	1.59E+09	0	2.05E+11
1995	Ocoee	639	4.28E+10	2.35E+11	43800000	5.04E+08	1.92E+11

2000	Ocoee	639	4.19E+10	2.35E+11	73000000	5.99E+08	1.93E+11
2005	Ocoee	639	4.28E+10	2.35E+11	62050000	2.26E+08	1.92E+11
2010	Ocoee	639	4.19E+10	2.35E+11	40150000	5.26E+08	1.93E+11
2015	Ocoee	639	4.7E+10	2.35E+11	58400000	5.73E+08	1.88E+11
1995	Pamlico	1307	1.10E+11	3.13E+11	4.09E+08	0	2.03E+11
2000	Pamlico	1307	6.89E+10	3.13E+11	3.76E+08	0	2.44E+11
2005	Pamlico	1307	1.10E+11	3.13E+11	4.38E+08	0	2.03E+11
2010	Pamlico	1307	6.89E+10	3.13E+11	4.45E+08	0	2.44E+11
2015	Pamlico	1307	1.09E+11	3.13E+11	3.94E+08	0	2.04E+11
1995	Pamlico Sound	1952	1.64E+11	2.59E+11	5.64E+08	0	9.42E+10
2000	Pamlico Sound	1952	1.03E+11	2.59E+11	9.63E+08	0	1.55E+11
2005	Pamlico Sound	1952	1.64E+11	2.59E+11	1.22E+09	0	9.36E+10
2010	Pamlico Sound	1952	1.03E+11	2.59E+11	1.48E+09	0	1.54E+11
2015	Pamlico Sound	1952	1.63E+11	2.59E+11	1.5E+09	0	9.4E+10
1995	Pigeon	689	4.62E+10	3.39E+11	1.35E+08	2.41E+08	2.93E+11
2000	Pigeon	689	4.52E+10	3.39E+11	1.28E+08	3.64E+08	2.94E+11
2005	Pigeon	689	4.62E+10	3.39E+11	82375000	4.36E+08	2.93E+11
2010	Pigeon	689	4.52E+10	3.39E+11	1.9E+08	4.69E+08	2.94E+11
2015	Pigeon	689	5.07E+10	3.39E+11	2.21E+08	5.37E+08	2.88E+11
1995	Roanoke Rapids	592	4.67E+10	8.12E+11	80125000	9.35E+08	7.64E+11
2000	Roanoke Rapids	592	3.92E+10	8.12E+11	1.15E+08	9.6E+08	7.72E+11
2005	Roanoke Rapids	592	4.67E+10	8.12E+11	67625000	1.17E+09	7.64E+11
2010	Roanoke Rapids	592	3.92E+10	8.12E+11	47450000	1.13E+09	7.72E+11
2015	Roanoke Rapids	592	4.67E+10	8.12E+11	18250000	1.08E+09	7.64E+11
1995	Rocky	1417	1.13E+11	7.74E+11	1.94E+08	3.15E+09	6.57E+11
2000	Rocky	1417	1.07E+11	7.74E+11	3.65E+08	2.88E+09	6.64E+11
2005	Rocky	1417	1.13E+11	7.74E+11	1.46E+08	2.94E+09	6.58E+11
2010	Rocky	1417	1.07E+11	7.74E+11	1.57E+08	2.78E+09	6.64E+11
2015	Rocky	1417	1.14E+11	7.74E+11	1.57E+08	3.26E+09	6.57E+11
1995	Saluda	2525	1.69E+11	6.78E+11	1.79E+08	3.61E+08	5.08E+11
2000	Saluda	2525	1.66E+11	6.78E+11	1.42E+08	4.09E+08	5.12E+11
2005	Saluda	2525	1.69E+11	6.78E+11	1.24E+08	3.83E+08	5.08E+11
2010	Saluda	2525	1.66E+11	6.78E+11	1.42E+08	4.82E+08	5.12E+11
2015	Saluda	2525	1.86E+11	6.78E+11	1.35E+08	4.27E+08	4.92E+11
1995	Seneca	1028	6.89E+10	6.22E+11	2.28E+08	1.84E+08	5.53E+11
2000	Seneca	1028	6.75E+10	6.22E+11	1.63E+08	3.64E+08	5.54E+11
2005	Seneca	1028	6.89E+10	6.22E+11	94875000	4.36E+08	5.53E+11
2010	Seneca	1028	6.75E+10	6.22E+11	2.23E+08	4.69E+08	5.54E+11
2015	Seneca	1028	7.56E+10	6.22E+11	2.43E+08	4.42E+08	5.46E+11

1995	South Fork Catawba	661	4.43E+10	2.91E+11	1.41E+08	5.19E+09	2.42E+11
2000	South Fork Catawba	661	4.34E+10	2.91E+11	1.15E+08	5.62E+09	2.42E+11
2005	South Fork Catawba	661	4.43E+10	2.91E+11	49275000	4.4E+09	2.42E+11
2010	South Fork Catawba	661	4.34E+10	2.91E+11	76750000	3.35E+09	2.44E+11
2015	South Fork Catawba	661	4.86E+10	2.91E+11	75100000	3.57E+09	2.39E+11
1995	South Yadkin	907	6.08E+10	9.60E+11	2.41E+08	1.68E+09	8.97E+11
2000	South Yadkin	907	5.95E+10	9.60E+11	80225000	1.84E+09	8.98E+11
2005	South Yadkin	907	6.08E+10	9.60E+11	56575000	2.18E+09	8.97E+11
2010	South Yadkin	907	5.95E+10	9.60E+11	51100000	1.92E+09	8.98E+11
2015	South Yadkin	907	6.67E+10	9.60E+11	51100000	1.86E+09	8.91E+11
1995	Tuckase-gee	734	4.92E+10	8.05E+11	69350000	3.61E+08	7.55E+11
2000	Tuckase-gee	734	4.82E+10	8.05E+11	62050000	4.09E+08	7.56E+11
2005	Tuckase-gee	734	4.92E+10	8.05E+11	54750000	4.89E+08	7.55E+11
2010	Tuckase-gee	734	4.82E+10	8.05E+11	1.13E+08	4.82E+08	7.56E+11
2015	Tuckase-gee	734	5.4E+10	8.05E+11	1.39E+08	4.56E+08	7.50E+11
1995	Tugaloo	989	6.63E+10	3.01E+11	69350000	7300000	2.35E+11
2000	Tugaloo	989	6.49E+10	3.01E+11	69350000	3.18E+08	2.36E+11
2005	Tugaloo	989	6.63E+10	3.01E+11	58400000	4.89E+08	2.34E+11
2010	Tugaloo	989	6.49E+10	3.01E+11	1.13E+08	4.56E+08	2.36E+11
2015	Tugaloo	989	7.28E+10	3.01E+11	1.39E+08	4.56E+08	2.28E+11
1995	Upper Broad	2478	1.66E+11	3.40E+11	1.63E+08	2.83E+09	1.70E+11
2000	Upper Broad	2478	1.63E+11	3.40E+11	1.5E+08	3.53E+09	1.73E+11
2005	Upper Broad	2478	1.66E+11	3.40E+11	1.06E+08	2.94E+09	1.70E+11
2010	Upper Broad	2478	1.63E+11	3.40E+11	1.3E+08	3.35E+09	1.73E+11
2015	Upper Broad	2478	1.82E+11	3.40E+11	1.28E+08	3.32E+09	1.54E+11
1995	Upper Cape Fear	1630	1.37E+11	2.04E+11	8.93E+08	1.99E+09	6.4E+10
2000	Upper Cape Fear	1630	8.59E+10	2.04E+11	8.39E+08	3.38E+09	1.13E+11
2005	Upper Cape Fear	1630	1.37E+11	2.04E+11	1.02E+09	2.36E+09	6.35E+10
2010	Upper Cape Fear	1630	8.59E+10	2.04E+11	1.18E+09	4.66E+09	1.12E+11
2015	Upper Cape Fear	1630	1.36E+11	2.04E+11	1.03E+09	5.09E+09	6.14E+10
1995	Upper Catawba	2357	1.58E+11	2.99E+11	1.46E+08	2.5E+09	1.38E+11
2000	Upper Catawba	2357	1.55E+11	2.99E+11	1.57E+08	2.78E+09	1.41E+11

2005	Upper Catawba	2357	1.58E+11	2.99E+11	1.31E+08	2.87E+09	1.38E+11
2010	Upper Catawba	2357	1.55E+11	2.99E+11	1.17E+08	2.6E+09	1.42E+11
2015	Upper Catawba	2357	1.73E+11	2.99E+11	1.21E+08	2.41E+09	1.23E+11
1995	Upper Dan	2055	1.38E+11	6.04E+11	94900000	5.19E+09	4.61E+11
2000	Upper Dan	2055	1.35E+11	6.04E+11	1.08E+08	4.61E+09	4.64E+11
2005	Upper Dan	2055	1.38E+11	6.04E+11	93150000	4.89E+09	4.61E+11
2010	Upper Dan	2055	1.35E+11	6.04E+11	1.06E+08	2.84E+09	4.66E+11
2015	Upper Dan	2055	1.51E+11	6.04E+11	94900000	2.81E+09	4.50E+11
1995	Upper French Broad	1879	1.26E+11	3.30E+11	1.39E+08	5.04E+08	2.04E+11
2000	Upper French Broad	1879	1.23E+11	3.30E+11	1.63E+08	5.66E+08	2.06E+11
2005	Upper French Broad	1879	1.26E+11	3.30E+11	98800000	5.22E+08	2.04E+11
2010	Upper French Broad	1879	1.23E+11	3.30E+11	1.9E+08	5.17E+08	2.06E+11
2015	Upper French Broad	1879	1.38E+11	3.30E+11	1.86E+08	5.37E+08	1.92E+11
1995	Upper Little Tennessee	837	5.61E+10	4.10E+11	49275000	1.16E+08	3.54E+11
2000	Upper Little Tennessee	837	5.49E+10	4.10E+11	65700000	2.96E+08	3.55E+11
2005	Upper Little Tennessee	837	5.61E+10	4.10E+11	56575000	2.41E+08	3.53E+11
2010	Upper Little Tennessee	837	5.49E+10	4.10E+11	63875000	3.49E+08	3.55E+11
2015	Upper Little Tennessee	837	6.16E+10	4.10E+11	67525000	3.45E+08	3.48E+11
1995	Upper Neuse	2406	1.92E+11	1.30E+11	2.91E+08	1.77E+09	-6.4E+10
2000	Upper Neuse	2406	1.81E+11	1.30E+11	1.99E+08	2.16E+09	-5.4E+10
2005	Upper Neuse	2406	1.92E+11	1.30E+11	2.14E+08	2.04E+09	-6.4E+10
2010	Upper Neuse	2406	1.81E+11	1.30E+11	2.1E+08	2.52E+09	-5.4E+10
2015	Upper Neuse	2406	1.93E+11	1.30E+11	2.25E+08	2.45E+09	-6.6E+10
1995	Upper New	2942	1.97E+11	1.98E+11	87600000	1.68E+09	-1.5E+09
2000	Upper New	2942	1.93E+11	1.98E+11	1.1E+08	1.82E+09	2.5E+09
2005	Upper New	2942	1.97E+11	1.98E+11	1.06E+08	1.65E+09	-1.5E+09
2010	Upper New	2942	1.93E+11	1.98E+11	1.76E+08	1.09E+09	3.17E+09
2015	Upper New	2942	2.16E+11	1.98E+11	1.04E+08	1.28E+09	-2E+10

1995	Upper Pee Dee	869	6.86E+10	3.04E+11	63800000	2.11E+09	2.33E+11
2000	Upper Pee Dee	869	5.75E+10	3.04E+11	21900000	2.6E+09	2.44E+11
2005	Upper Pee Dee	869	6.86E+10	3.04E+11	7300000	2.58E+09	2.33E+11
2010	Upper Pee Dee	869	5.75E+10	3.04E+11	10950000	2.4E+09	2.44E+11
2015	Upper Pee Dee	869	6.86E+10	3.04E+11	9125000	2.8E+09	2.33E+11
1995	Upper Tar	1305	1.03E+11	3.17E+11	1.2E+08	1.29E+09	2.12E+11
2000	Upper Tar	1305	8.64E+10	3.17E+11	74725000	1.21E+09	2.29E+11
2005	Upper Tar	1305	1.03E+11	3.17E+11	29200000	1.47E+09	2.12E+11
2010	Upper Tar	1305	8.64E+10	3.17E+11	29200000	1.14E+09	2.29E+11
2015	Upper Tar	1305	1.03E+11	3.17E+11	25550000	1.06E+09	2.13E+11
1995	Upper Yadkin	2455	1.65E+11	2.48E+11	94900000	1.22E+09	8.2E+10
2000	Upper Yadkin	2455	1.61E+11	2.48E+11	1.1E+08	1.15E+09	8.55E+10
2005	Upper Yadkin	2455	1.65E+11	2.48E+11	98550000	2.2E+09	8.1E+10
2010	Upper Yadkin	2455	1.61E+11	2.48E+11	1.02E+08	1.14E+09	8.55E+10
2015	Upper Yadkin	2455	1.81E+11	2.48E+11	94900000	1.31E+09	6.59E+10
1995	Waccam-aw	1651	1.38E+11	2.21E+11	6.79E+08	0	8.22E+10
2000	Waccam-aw	1651	8.71E+10	2.21E+11	8.14E+08	2.23E+08	1.33E+11
2005	Waccam-aw	1651	1.38E+11	2.21E+11	9.38E+08	0	8.19E+10
2010	Waccam-aw	1651	8.71E+10	2.21E+11	9.45E+08	0	1.33E+11
2015	Waccam-aw	1651	1.38E+11	2.21E+11	9.09E+08	0	8.26E+10
1995	Watauga	868	5.82E+10	2.63E+11	1.94E+08	1.22E+09	2.04E+11
2000	Watauga	868	5.7E+10	2.63E+11	1.39E+08	1.11E+09	2.05E+11
2005	Watauga	868	5.82E+10	2.63E+11	1.31E+08	1.1E+09	2.04E+11
2010	Watauga	868	5.7E+10	2.63E+11	1.72E+08	1.03E+09	2.05E+11
2015	Watauga	868	6.39E+10	2.63E+11	1.61E+08	1.04E+09	1.98E+11
1995	White Oak River	933	7.83E+10	4.45E+11	2.31E+09	0	3.65E+11
2000	White Oak River	933	4.92E+10	4.45E+11	3.06E+09	0	3.93E+11
2005	White Oak River	933	7.83E+10	4.45E+11	3.1E+09	0	3.64E+11
2010	White Oak River	933	4.92E+10	4.45E+11	3.43E+09	0	3.93E+11
2015	White Oak River	933	7.79E+10	4.45E+11	3.24E+09	0	3.64E+11

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