# GREEN BUILDING WITH ONSITE WASTEWATER SYSTEMS

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## ABSTRACT

Concern is growing globally over natural resource consumption and climate change. Many governments, companies, and industries are taking action to reduce the environmental footprint associated with manufacturing, processing, and building. Meanwhile, much of the world is working through an economic downturn that has left governments and individuals in debt and trying to stay afloat. It is therefore imperative that all aspects of building and development are conducted both sustainably and economically, including wastewater management.

The environmental and economic benefits provided through the manufacture and construction of onsite (decentralized) wastewater systems versus centralized wastewater treatment plants (WWTP) were quantitatively examined through an analysis of embodied energy, embodied carbon, and the cost of each system type. Average values per sewer connection were calculated by analyzing the material and construction costs for 40 sewer extension plans from the 2005 Southwest Virginia Regional Wastewater Study. The total system and per sewer connection values of embodied energy, embodied carbon, and costs were then compared to the resource consumption of materials and construction for the same number of onsite wastewater systems.

The average embodied energy, embodied carbon, and cost per connection for the materials and construction of a sewer extension were found to be 157,563 MJ, 7,006 kg $CO_2$, and $18,590, respectively. In comparison, the embodied energy, embodied carbon, and cost of the materials and construction of an average septic system were found to be 40,025 MJ, 1,908 kg $CO_2$, and $5,954, respectively. This relates to a savings of 117,538 MJ, 5,099 kg $CO_2$, and $12,636 per system. Looking from a broader prospective, a shift from 25% to 50% of homes served by decentralized systems through increased federal funding and consumer awareness would lead to a savings of 63 billion MJ, 2.7 billion kg $CO_2$, and 6.7 billion dollars each year. The energy savings alone are equivalent to 5.25 years of Washington D.C.'s motor gasoline supply or a 26-day supply of motor gasoline for all of Washington DC, Maryland, Delaware, and Virginia combined (7% of yearly supply).

With the clear environmental and economic benefits associated with decentralized wastewater treatment systems, it is imperative that local, state, and national regulators shift the focus of wastewater treatment from centralized sewer systems to the more sustainable decentralized model. Doing so will greatly aid in the efforts to reduce the carbon footprint associated with development as well as reduce the cost of development for both government entities and end users.

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## INTRODUCTION

### *Centralized vs Decentralized Wastewater Management*

Concern is growing globally over natural resource consumption and climate change. Many governments, companies, and industries are taking action to reduce the environmental footprint associated with manufacturing, processing, and building. Meanwhile, much of the world is working through an economic downturn that has left governments and individuals in debt and trying to stay afloat. It is therefore imperative that all aspects of building and development are done both sustainably and economically, including wastewater management.

The environmental benefits of operating decentralized over centralized wastewater management have long been cited. Decentralized management is most often passive, allowing for groundwater recharge with little to no operational energy consumption. Decentralized systems require little maintenance and, with proper care and design, perform equally to centralized treatment processes (U.S. EPA, 1997; U.S. EPA, 2003).

Centralized systems, on the other hand, often require pumping stations in conveying the sewage to the wastewater treatment plant (WWTP), where it undergoes energy- and chemical-intensive treatment processes prior to discharging into local water bodies. In addition, gathering all the wastewater into one localized area is often disastrous during inclement weather. The United States Environmental Protection Agency (U.S. EPA, 2001) has estimated that approximately 1.26 trillion gallons of untreated wastewater flows into surface waters nation-wide each year due to combined sewage overflow (CSO) discharges. In comparison, it is estimated that only 200,000 replacement onsite wastewater systems are installed each year in the United States (Permit Data, 2005).

Despite these operational environmental benefits, centralized sewer replacement, expansion, and separation continue to be the focus of federal funding and new development. The funds distributed through the Clean Water Act State Revolving Fund are largely biased toward centralized wastewater management programs; a mere 0.2% of the allocations are used toward decentralized wastewater treatment, despite approximately 25% of all homes currently using decentralized wastewater management schemes (NOWRA, 2011).

While there are areas where decentralized wastewater treatment is not a viable option due to lot size or geologic conditions, the first reaction to sewage problems is usually to connect the area to an existing WWTP through centralized sewer line extensions. However, before reaching this conclusion, the environmental, economic, and cost impacts of each project should be more clearly assessed to ensure it is the best solution.

### *The Southwest Virginia Regional Wastewater Study (SVRWS)*

The SVRWS was developed in 2005 in attempts to manage wastewater in Southwest Virginia. The project focused largely on extending centralized sewer lines to areas with antiquated septic systems and considered some decentralized managed wastewater systems due to remote location, topographic situations, small size, or soil conditions. In all, over 136 sites were examined under the following criteria: degree of health hazard, severity of environmental problems, number of customers served, construction cost per connection, construction feasibility, as well as

residential, commercial and industrial growth potential. The top 44 centralized projects, 12 decentralized projects, and 3 hybrid projects were then recommended for implementation. Of the 44 centralized projects, 40 were sewer extensions to existing WWTPs (Thompson & Little, Inc. et al., 2005).

In attempts to quantify the economic and environmental implications of centralized and decentralized wastewater treatment models, material consumption and construction of 40 sewer extension plans from the SVRWS were quantitatively analyzed to determine the environmental and economic impacts per connection for each project.

## METHODS AND CALCULATIONS

### *Overview*

An analysis was performed to quantitatively determine the embodied carbon, embodied energy, and fiscal resource consumption of the materials and construction associated with 40 sewer extension projects and equivalent decentralized wastewater treatment systems.

Unit values for embodied carbon and energy were taken from the Inventory of Carbon and Energy (ICE) compiled by the University of Bath. This is a highly cited source of information and has been used in many life cycle and carbon footprint analyses. This document defines embodied energy (carbon) as, "…the total primary energy consumed (carbon released) over its life cycle… includ[ing] extraction, manufacturing and transportation." (Hammond et al., 2008)

The sewer extension projects were identified and individually defined through the SVRWS report. The construction cost of each project was delineated within the report by a breakdown of material and construction costs. The breakdown of materials was used to determine the embodied carbon and embodied energy of the materials in the project, as well as the construction embodied carbon and embodied energy. The construction equipment used in the construction process and the related fuel efficiencies and production rates were estimated through literature review. These values were then used to determine the average resource consumption per connection and compare it to the average resource consumption of a typical decentralized wastewater treatment system (Thompson & Little, Inc. et al., 2005; HOLT CAT, 2012; Methvin, 2014; Georg Fischer Harvel, 2014b; JM Eagle, 2008; Supple, 2010).

A 3-bedroom septic system was used as the model for the decentralized systems, as it is the most common form of decentralized wastewater treatment in Southwest Virginia. The septic tank and drainfield were designed using the State of Virginia's Sewage Handling and Disposal Regulations, 12VAC5-610 (Regulations). The drainfield size and construction equipment typically used were chosen based on industry knowledge and a brief survey of designers and installers in Southwest Virginia. Fuel efficiencies and production rates were based on literature review (Georg Fischer Harvel, 2014a; HOLT CAT, 2012; Methvin, 2014; State of Virginia, 2012; Supple, 2010).

### *Materials and Processes*

The materials included under the sewer extension project are PVC sewer piping, manholes, pumps and pumping stations (where indicated in the SVWRS), gravel bedding for the sewer pipe, and asphalt for repaving the excavated areas. While entire roads are often repaved after sewer construction, it was assumed that only the excavated areas were repaved to be conservative. Virginia Department of Transportation paving codes were used to determine the amount of pavement required over the excavated areas. The centralized sewer also did not include infiltration and inflow (I/I) improvements, clean-outs, or any special railroad or road crossings, as these measures are much more difficult to quantify from a larger point of view (Virginia Asphalt Association, 2011).

From the Regulations, the conventional septic tank was defined as a 900-gallon precast concrete septic tank. The associated drainfield was sized using a 65 mpi percolation rate, for a total of 1488 sf of stone and pipe (washed septic gravel and PVC piping) filled absorption trenches. An estimate of PVC piping from the home to tank and tank to drainfield was also included.

The construction practices included in this study are excavation, backfill, compaction, and paving. Additional processes were not included due to the number of unknowns associated with each project. For instance, hauling excavated material was not included for either the centralized or decentralized models, as fuel consumption relies heavily upon an unknown travel distance.

### *Outputs*

The resource consumption for each of the 40 sewer extension projects was analyzed both in total resource consumption and resource consumption per connection. The average septic system consumption was then multiplied by the number of sewer connections for each project to find the associated environmental and fiscal costs of the septic systems being updated rather than extending the sewer line. An average consumption rate per connection was determined by averaging the per connection results from each of the projects; this was used to correlate the potential resource savings by utilizing decentralized systems over centralized WWTPs throughout the nation.

## RESULTS

### *Sewer Extension Projects*

A summary of the total and average embodied energy, embodied carbon, and costs for the 40 projects are shown in Table 1; the full results are provided in Appendix 1. As shown, the average project resource consumption is 58.5 million MJ, 2.5 million kg $CO_2$, and 6.7 million dollars for an average of 363 connections. The total resource consumption of the 40 sewer extensions is 2,340.8 million MJ, 99.2 million kg $CO_2$, and 266.5 million dollars for 14,507 connections.

Table 1. Total and average embodied energy, embodied carbon, and costs for sewer extensions.

| | Number of Connections | Embodied Energy (million MJ) | Embodied Carbon (million kg $CO_2$) | Cost (million USD) |
|---|---|---|---|---|
| Total of 40 projects | 14,507 | 2,340.8 | 99.2 | $266.5 |
| Average | 363 | 58.5 | 2.5 | $6.7 |
| Median | 299 | 38.9 | 1.9 | $5.1 |
| Max | 1160 | 355.5 | 7.8 | $24.3 |
| Min | 85 | 7.3 | 0.4 | $1.5 |

Average per connection embodied energy, embodied carbon, and costs for the 40 projects are shown in Table 2. As shown, the average per connection resource consumption is 157.6 thousand MJ, 7.0 thousand kg $CO_2$, and 18.6 thousand dollars.

Table 2. Per connection average embodied energy, embodied carbon, and costs for sewer extensions.

| | Embodied Energy (thousand MJ) | Embodied Carbon (thousand kg $CO_2$) | Cost (thousand USD) |
|---|---|---|---|
| Average | 157.6 | 7.0 | $18.6 |
| Median | 139.6 | 6.7 | $17.1 |
| Max | 766.3 | 16.5 | $34.7 |
| Min | 50.8 | 2.5 | $7.2 |

The median, maximum and minimum values are also shown for both the total project consumption and the per connection values. In all cases, the median value is lower than the average value, showing there are a few higher consumption cases that are raising the average higher than the most common range. These values were left in the study as they represent an actual distribution of cases – some sewer projects are extremely high consumers and some are on the lower end. The frequency of resource consumption values is shown in Figures 1-3.

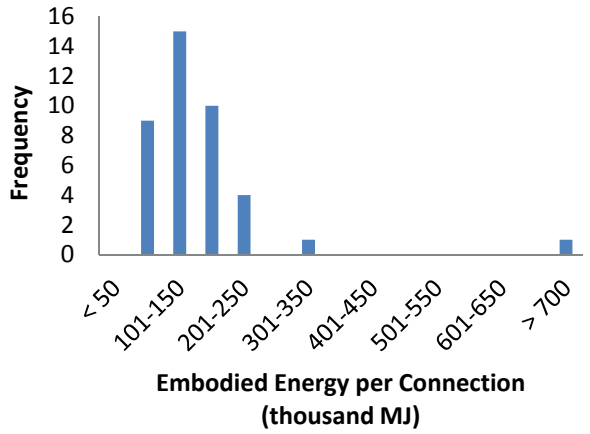


Figure 1. Frequency of Embodied Energy per Connection

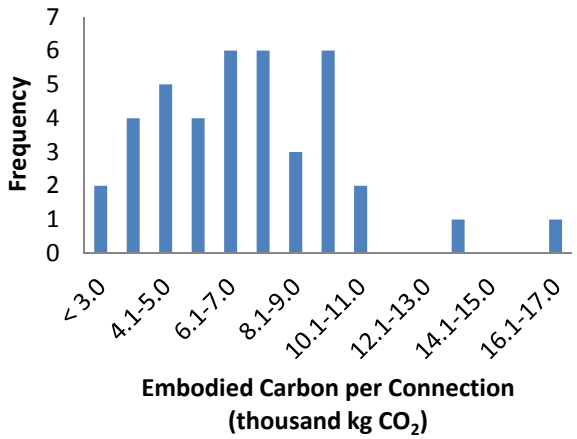


Figure 2. Frequency of Embodied Carbon per Connection

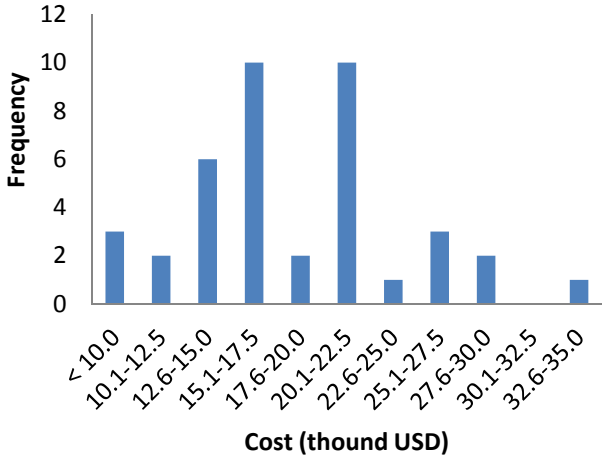


Figure 3. Frequency of Cost per Connection

The sewer extension projects were analyzed for a correlation between the number of connections and both the resource consumption per connection and total resource consumption. There was no correlation found between the number of connections and the embodied carbon per connection and a moderate correlation found between the number of connections and the project total embodied carbon, as would be expected. These results are shown in Appendix 2.

***Decentralized Project Equivalents***

The average Regulation septic system was analyzed for material and construction resource consumption. The embodied energy, embodied carbon, and costs for each installed decentralized wastewater treatment system was calculated to be 40 thousand MJ, 1.9 thousand kg $CO_2$, and 5.9 thousand dollars, respectively. Since a typical system was used in the equivalency generation, there are no statistics to show for the per connection resource consumption values.

A summary of the total and average embodied energy, embodied carbon, and costs for the decentralized equivalency of the 40 sewer extension projects are shown in Table 3; the full results are provided in Appendix 1. As shown, the average project resource consumption for the decentralized model is 14.5 million MJ, 0.7 million kg $CO_2$, and 2.2 million dollars for an average of 363 connections. The total resource consumption of the 40 sewer extensions is 580.6 million MJ, 27.7 million kg $CO_2$, and 86.4 million dollars for 14,507 connections.

Table 3. Total and average embodied energy, embodied carbon, and costs for decentralized wastewater management.

| | Number of Connections | Embodied Energy (million MJ) | Embodied Carbon (million kg $CO_2$) | Cost (million USD) |
|---|---|---|---|---|
| Total of 40 projects | 14,507 | 580.6 | 27.7 | $86.4 |
| Average | 363 | 14.5 | 0.7 | $2.2 |
| Median | 299 | 11.9 | 0.6 | $1.8 |
| Max | 1160 | 46.4 | 2.2 | $6.9 |
| Min | 85 | 3.4 | 0.2 | $0.5 |

## DISCUSSION

### *Resource Savings per Connection*

The average per connection resource savings are shown in Table 4 and Figure 4. As shown, there's a 75% savings in embodied energy, 73% savings in embodied carbon, and 68% cost savings on average through the construction of decentralized wastewater systems over the centralized sewer extensions.

Table 4. Comparison of average per connection resource consumption for centralized and decentralized wastewater management.

| | Centralized Per Connection | Decentralized Per Connection | Difference | Percent Difference |
|---|---|---|---|---|
| Embodied Energy (MJ) | 157,563 | 40,025 | 117,538 | 75% |
| Embodied Carbon (kg $CO_2$) | 7,006 | 1,908 | 5,099 | 73% |
| Cost (USD) | $18,590 | $5,954 | $12,636 | 68% |

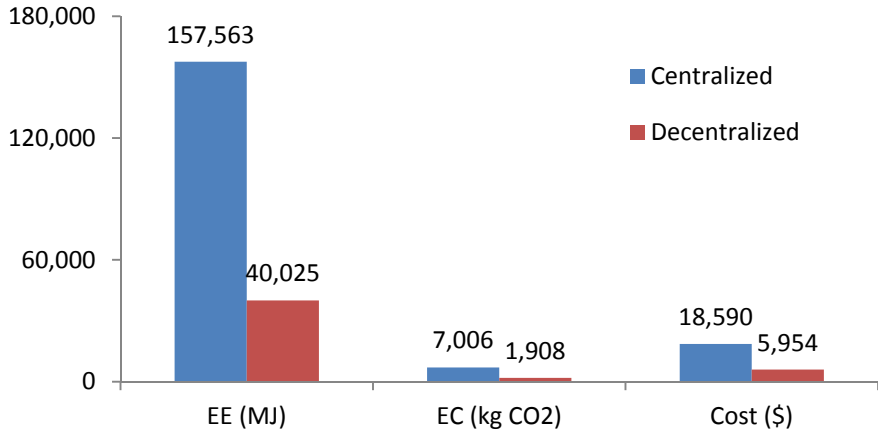


Figure 4. Comparison of Average per Connection Resource Consumption for Centralized and Decentralized Wastewater Management

The savings associated with each decentralized system is significant; the energy savings of 117,538 MJ is equivalent to the energy content of 969 gallons of gasoline – enough to take 2093 cars off the roads in DC for a day (Supple, 2010; U.S. DOE, 2011).

### *Resource Savings per Project*

These per connection savings add up quickly in relation to sewer extension projects; the average number of connections per project was calculated to be 363 connections. Multiplying the average savings by the average number of connections, the savings for utilizing a decentralized scheme over a centralized sewer extension is shown in Table 5.

Table 5. Summary of resource savings from using decentralized over the average sewer extension project.

| | Decentralized Savings Per Connection | Average Number of Decentralized Connections | Total Decentralized Savings |
|---|---|---|---|
| Embodied Energy (MJ) | 117,538 | 363 | 42,666,294 |
| Embodied Carbon (kg $CO_2$) | 5,099 | 363 | 1,850,937 |
| Cost (USD) | $12,636 | 363 | $4,586,868 |

For just one project switching to decentralized wastewater management, the embodied energy savings is 42.7 million MJ (11.8 millon kWh); this is equivalent to taking nearly 2100 people off the Virginia residential electricity grid for an entire year (U.S. DOE, 2011). The carbon savings of 1.85 million kg $CO_2$ is equivalent to 480 yearly round-trip commutes of 50 miles per day; in other words, the emissions saved by taking 480 people off the roads for the entire year of daily commutes (Amtrak, 2014).

***Resource Savings per Year***

When multiplied by a mere percentage of the homes being installed each year, the savings have the potential to be astronomical. The U.S. Census Bureau's 30-year average for single-family starts is 1,064 thousand homes (U.S. Census, 2013). Of these, approximately 25% (266,025) of the permits were for decentralized systems. The resource savings from this 25% of homes is estimated in Table 6.

Table 6. Summary of resource savings through current use of decentralized wastewater management.

| | Decentralized Savings Per Connection | Number of Decentralized Connections | Total Decentralized Savings |
|---|---|---|---|
| Embodied Energy (MJ) | 117,538 | 266,025 | 31,267,931,402 |
| Embodied Carbon (kg $CO_2$) | 5,099 | 266,025 | 1,356,336,964 |
| Cost (USD) | $12,636 | 266,025 | $3,361,360,285 |

As shown, the total energy savings are nearly 31 billion MJ each year; this equates to the equivalent amount of energy in motor gasoline consumed in Washington DC, Maryland, Delaware, and Virginia combined for nearly two weeks (4% of the yearly motor gasoline consumed in these states) (U.S. EIA, 2014).

The embodied carbon savings of 1.4 billion kg$CO_2$ each year equates to 351,019 people (56% of Washington DC's population) with an average commuting distance of 50 miles round trip choosing to carpool to work every day for an entire year (Amtrak, 2014).

With this in mind, greater efforts should be made toward designing sustainable wastewater management systems. With more balanced funding from the U.S. Environmental Protection Agency (U.S. EPA), this could become reality. For every 1% of new homes permitted that switch to using a decentralized wastewater treatment approach, an additional 54 million kg $CO_2$, 1.3 billion MJ, and 134 billion dollars could be saved each year. If the percentage of homes served by decentralized systems increased to 50%, the total energy savings alone would be equivalent to 5.25 years of Washington DC's motor gasoline supply (U.S. EIA, 2014).

## CONCLUSIONS

### *Benefits and Resource Savings of Decentralized Wastewater Management*

Decentralized wastewater management provides both environmental and economic benefits for new communities and those looking to update their current wastewater management systems. They are often passive systems, requiring little to no operational costs, and can provide similar treatment levels to centralized systems when properly designed, sited, and maintained. Where individual onsite wastewater systems are not always feasible due to lot size, soil conditions, or limiting subsurface layers, community decentralized systems can usually be designed, similar to the 14 decentralized projects in the SVRWS. These projects often consist of a septic tank at each connection that lead to an off-site recirculating sand filter and can provide a low-cost, low-maintenance alternative to centralized sewer extensions.

The materials and construction associated with decentralized wastewater managements consume far less embodied energy, embodied carbon, and capital than centralized systems. The average resource savings per connection was calculated to be 117,538 MJ (75%), 5,099 kg $CO_2$ (73%), and $12,636 (68%). These savings have the potential to add up quickly with the large number of sewer extensions and new developments being installed each year.

### *Limitations*

While this report provides a starting place for the comparison of centralized and decentralized wastewater management, it is based on data from Southwest Virginia that may not be applicable to all areas of the nation. While the embodied energy and carbon of materials remains the same, the cost of both sewer extensions and septic systems changes drastically from location to location, as well as the construction practices and equipment used. Special note should also be taken to the type of centralized wastewater system being proposed; this study covers only sewer extensions from existing wastewater treatment plants and does not include the construction and materials required for new plant construction.

In addition, this study assumes the sewer extension can be replaced entirely with conventional septic systems; this is may not be the case in some places. The typical conventional system was chosen for averaging purposes and to make the study as widely applicable as possible; when looking at a specific project, an average mixture of the onsite wastewater systems permitted in the area at hand should be obtained and used to determine the resource consumption of the decentralized systems.

It should be noted that septic systems require a level of personal responsibility from each homeowner to ensure long term function. Public awareness and education is essential to the proper function and longevity of any wastewater treatment system. Improper use or lack of maintenance can lead to clogging of the infiltrative surface, back-up of sewage into the home, and contamination of water bodies.

However, a greater public awareness is also needed for centralized sewers, as WWTPs are not set up to treat and remove all chemicals that are found in households. Centralizing all of the waste that homeowners and businesses discharge into the sewer system can lead to a high concentration of untreated chemicals and compounds that are then released directly into public surface waters. Homeowner awareness is crucial to protection of public health and the environment, regardless of centralized or decentralized management.

Finally, this report also does not include any operational or longevity data from either decentralized or centralized systems. Future reports should include pumping and processing sewage and the effects of inflow and infiltration (I&I) for the centralized sewer, tank pumping and any non-passive systems that are used for the decentralized version, as well as the expected life span and repair frequency expected for both centralized and decentralized systems.

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# APPENDIX 1

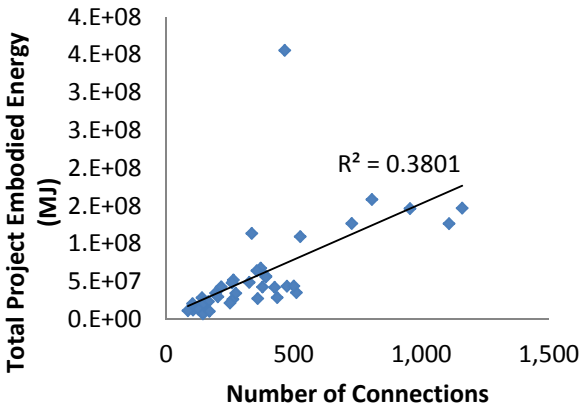
| Project Number | County | Planning District | Project Name | Number of Connections | Sewer EE (MJ) | | | | | | Septic EE (MJ) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Total | Materials | Construction | Total Per Connection | Materials Per Connection | Construction Per Connection | Total | Materials | Construction | Total Per Connection | Materials Per Connection | Construction Per Connection |
| 1 | Lee | LEN | Woodway | 510 | 35336307 | 34782539 | 553768 | 69287 | 68201 | 1086 | 20412850 | 20019141 | 393709 | 40025 | 39253 | 772 |
| 2 | Washington | MTR | West Central (Beaver Creek) | 1160 | 147065190 | 144546507 | 2518683 | 126780 | 124609 | 2171 | 46429228 | 45533732 | 895496 | 40025 | 39253 | 772 |
| 3 | Grayson | MTR | Fairview | 335 | 113603116 | 111760314 | 1842802 | 339114 | 333613 | 5501 | 13408441 | 13149828 | 258613 | 40025 | 39253 | 772 |
| 4 | Lee | LEN | Sandy Ridge/N. Jonesville | 261 | 26604727 | 26175094 | 429633 | 101934 | 100288 | 1646 | 10446576 | 10245090 | 201487 | 40025 | 39253 | 772 |
| 6 | Smyth | MTR | Groseclose | 215 | 43038288 | 42428911 | 609377 | 200178 | 197344 | 2834 | 8605417 | 8439442 | 165976 | 40025 | 39253 | 772 |
| 7 | Tazewell | CP | Baptist Valley East | 955 | 146446093 | 145572195 | 873898 | 153347 | 152432 | 915 | 38224063 | 37486823 | 737240 | 40025 | 39253 | 772 |
| 8 | Tazewell | CP | Baptist Valley West | 1108 | 126463155 | 124255143 | 2208012 | 114136 | 112144 | 1993 | 44347918 | 43492565 | 855353 | 40025 | 39253 | 772 |
| 9 | Wise | LEN | East Stone Gap/Cracker Neck | 473 | 43853946 | 43145759 | 708187 | 92714 | 91217 | 1497 | 18931918 | 18566772 | 365146 | 40025 | 39253 | 772 |
| 10 | Buchanan | CP | Leemaster/Lovers Gap | 272 | 34634405 | 34075102 | 559303 | 127332 | 125276 | 2056 | 10886854 | 10676875 | 209978 | 40025 | 39253 | 772 |
| 11 | Lee | LEN | Dryden Hts/Cross Creek | 250 | 21742469 | 21260384 | 482085 | 86970 | 85042 | 1928 | 10006299 | 9813304 | 192995 | 40025 | 39253 | 772 |
| 12 | Lee | LEN | Rose Hill | 358 | 27634889 | 27192510 | 442380 | 77192 | 75957 | 1236 | 14329020 | 14052652 | 276369 | 40025 | 39253 | 772 |
| 13 | Russell | CP | Hansonville | 525 | 109391494 | 107156310 | 2235185 | 208365 | 204107 | 4257 | 21013228 | 20607939 | 405289 | 40025 | 39253 | 772 |
| 14 | Smyth | MTR | Pleasant Heights | 153 | 20259630 | 19925770 | 333860 | 132416 | 130234 | 2182 | 6123855 | 6005742 | 118113 | 40025 | 39253 | 772 |
| 15 | Tazewell | CP | Gratton | 425 | 42404416 | 41628415 | 776001 | 99775 | 97949 | 1826 | 17010709 | 16682617 | 328091 | 40025 | 39253 | 772 |
| 16 | Washington | MTR | Benhams Road | 325 | 48958827 | 48118145 | 840682 | 150643 | 148056 | 2587 | 13008189 | 12757296 | 250893 | 40025 | 39253 | 772 |
| 17 | Washington | MTR | Spring Creek | 727 | 126790276 | 124737314 | 2052962 | 174402 | 171578 | 2824 | 29098318 | 28537089 | 561229 | 40025 | 39253 | 772 |
| 18 | Wise | LEN | Wildcat/Irondale | 377 | 42748764 | 41909533 | 839231 | 113392 | 111166 | 2226 | 15089499 | 14798463 | 291036 | 40025 | 39253 | 772 |
| 19 | Scott | LEN | Daniel Boone | 370 | 67874830 | 66584347 | 1290483 | 183445 | 179958 | 3488 | 14809323 | 14523691 | 285632 | 40025 | 39253 | 772 |
| 20 | Scott | LEN | Yuma | 390 | 57197996 | 56275780 | 922216 | 146662 | 144297 | 2365 | 15609827 | 15308755 | 301072 | 40025 | 39253 | 772 |
| 21 | Dickenson | CP | Rt 83/Georges Fork | 140 | 28750412 | 28227040 | 523373 | 205360 | 201622 | 3738 | 5603528 | 5495450 | 108077 | 40025 | 39253 | 772 |
| 22 | Buchanan | CP | Poplar Creek | 142 | 22096932 | 21740094 | 356838 | 155612 | 153099 | 2513 | 5683578 | 5573957 | 109621 | 40025 | 39253 | 772 |
| 23 | Smyth | MTR | Watson Gap | 193 | 34786738 | 34217575 | 569163 | 180242 | 177293 | 2949 | 7724863 | 7575871 | 148992 | 40025 | 39253 | 772 |
| 24 | Tazewell | CP | Tazewell to Divides | 165 | 23507908 | 23022338 | 485571 | 142472 | 139529 | 2943 | 6604157 | 6476781 | 127377 | 40025 | 39253 | 772 |
| 25 | Tazewell | CP | Tazewell to Claypool Alt I | 464 | 355544749 | 353492749 | 2052000 | 766260 | 761838 | 4422 | 18571691 | 18213493 | 358198 | 40025 | 39253 | 772 |
| 26 | Tazewell | CP | Abbs Valley | 435 | 28836989 | 28191310 | 645679 | 66292 | 64808 | 1484 | 17410961 | 17075150 | 335811 | 40025 | 39253 | 772 |
| 27 | Washington | MTR | East Central | 806 | 158507303 | 155924512 | 2582791 | 196659 | 193455 | 3204 | 32260309 | 31638093 | 622215 | 40025 | 39253 | 772 |
| 28 | Wise | LEN | Coeburn Mountain | 500 | 44027766 | 43321086 | 706679 | 88056 | 86642 | 1413 | 20012598 | 19626609 | 385990 | 40025 | 39253 | 772 |
| 29 | Wise | LEN | Powell Valley | 355 | 64356686 | 63331124 | 1025561 | 181286 | 178398 | 2889 | 14208945 | 13934892 | 274053 | 40025 | 39253 | 772 |
| 30 | Scott | LEN | Hiltons | 263 | 52203910 | 50932914 | 1270997 | 198494 | 193661 | 4833 | 10526627 | 10323596 | 203031 | 40025 | 39253 | 772 |
| 31 | Tazewell | CP | Birmingham | 390 | 56179744 | 55113457 | 1066286 | 144051 | 141317 | 2734 | 15609827 | 15308755 | 301072 | 40025 | 39253 | 772 |
| 32 | Buchanan | CP | Lower Mill Branch | 103 | 20825518 | 20489212 | 336306 | 202189 | 198924 | 3265 | 4122595 | 4043081 | 79514 | 40025 | 39253 | 772 |
| 33 | Buchanan | CP | Lynn Camp/Looney Creek | 132 | 17541578 | 17258303 | 283275 | 132891 | 130745 | 2146 | 5283326 | 5181425 | 101901 | 40025 | 39253 | 772 |
| 34 | Grayson | MTR | Providence | 258 | 48363150 | 47419558 | 943592 | 187454 | 183797 | 3657 | 10326501 | 10127330 | 199171 | 40025 | 39253 | 772 |
| 35 | Grayson | MTR | Stevens Creek | 202 | 29820683 | 29339116 | 481567 | 147627 | 145243 | 2384 | 8085090 | 7929150 | 155940 | 40025 | 39253 | 772 |
| 36 | Lee | LEN | Red Hill/Poor Valley | 141 | 19286326 | 18950446 | 335881 | 136782 | 134400 | 2382 | 5643553 | 5534704 | 108849 | 40025 | 39253 | 772 |
| 37 | Tazewell | CP | Red Ash | 105 | 12415072 | 12214584 | 200488 | 118239 | 116329 | 1909 | 4202646 | 4121588 | 81058 | 40025 | 39253 | 772 |
| 38 | Washington | MTR | Larwood | 126 | 13373369 | 13148819 | 224551 | 106138 | 104356 | 1782 | 5043175 | 4945905 | 97269 | 40025 | 39253 | 772 |
| 39 | Wise | LEN | Tacoma | 144 | 7308991 | 7190960 | 118031 | 50757 | 49937 | 820 | 5763628 | 5652463 | 111165 | 40025 | 39253 | 772 |
| 40 | Wise | LEN | Banner | 169 | 10592931 | 10421868 | 171063 | 62680 | 61668 | 1012 | 6764258 | 6633794 | 130464 | 40025 | 39253 | 772 |
| 41 | Scott | LEN | Route 871 | 85 | 11465152 | 11267736 | 197416 | 134884 | 132562 | 2323 | 3402142 | 3336523 | 65618 | 40025 | 39253 | 772 |
| | | | Total | 14507 | 2341840726 | 2306744871 | 35095856 | 6302511 | 6203088 | 99422 | 580645531 | 569446428 | 11199103 | 1601008 | 1570129 | 30879 |
| | | | Average | 363 | 58546018 | 57668622 | 877396 | 157563 | 155077 | 2486 | 14516138 | 14236161 | 279978 | 40025 | 39253 | 772 |
| | | | Median | 299 | 38870362 | 38205477 | 627528 | 139627 | 136965 | 2344 | 11947521 | 11717085 | 230436 | 40025 | 39253 | 772 |
| | | | Max | 1160 | 355544749 | 353492749 | 2582791 | 766260 | 761838 | 5501 | 46429228 | 45533732 | 895496 | 40025 | 39253 | 772 |
| | | | Min | 85 | 7308991 | 7190960 | 118031 | 50757 | 49937 | 820 | 3402142 | 3336523 | 65618 | 40025 | 39253 | 772 |
| | | | Std. Dev Population | 262 | 62803006 | 62267674 | 683853 | 111186 | 110477 | 1057 | 10472436 | 10270450 | 201985 | 0 | 0 | 0 |
| | | | Std. Dev Sample | 265 | 63603076 | 63060925 | 692564 | 112603 | 111884 | 1070 | 10605848 | 10401289 | 204559 | 0 | 0 | 0 |

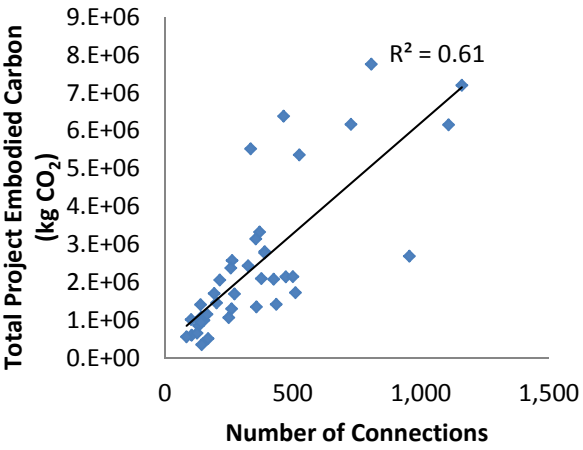
| Project Number | County | Planning District | Project Name | Number of Connections | Sewer EC (kg CO2) | | | | | | Septic EC (kg CO2) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Total | Materials | Construction | Total Per Connection | Materials Per Connection | Construction Per Connection | Total | Materials | Construction | Total Per Connection | Materials Per Connection | Construction Per Connection |
| 1 | Lee | LEN | Woodway | 510 | 1727467 | 1685980 | 41487 | 3387 | 3306 | 81 | 972949 | 943453 | 29496 | 1908 | 1850 | 58 |
| 2 | Washington | MTR | West Central (Beaver Creek) | 1160 | 7199464 | 7010769 | 188695 | 6206 | 6044 | 163 | 2212983 | 2145894 | 67089 | 1908 | 1850 | 58 |
| 3 | Grayson | MTR | Fairview | 335 | 5522782 | 5384723 | 138059 | 16486 | 16074 | 412 | 639094 | 619719 | 19375 | 1908 | 1850 | 58 |
| 4 | Lee | LEN | Sandy Ridge/N. Jonesville | 261 | 1301463 | 1269276 | 32187 | 4986 | 4863 | 123 | 497921 | 482826 | 15095 | 1908 | 1850 | 58 |
| 6 | Smyth | MTR | Groseclose | 215 | 2059878 | 2012730 | 47148 | 9581 | 9362 | 219 | 410165 | 397730 | 12435 | 1908 | 1850 | 58 |
| 7 | Tazewell | CP | Baptist Valley East | 955 | 2691320 | 2625849 | 65471 | 2818 | 2750 | 69 | 1821895 | 1766662 | 55233 | 1908 | 1850 | 58 |
| 8 | Tazewell | CP | Baptist Valley West | 1108 | 6158666 | 5993246 | 165420 | 5558 | 5409 | 149 | 2113780 | 2049698 | 64081 | 1908 | 1850 | 58 |
| 9 | Wise | LEN | East Stone Gap/Cracker Neck | 473 | 2145269 | 2092213 | 53056 | 4535 | 4423 | 112 | 902363 | 875007 | 27356 | 1908 | 1850 | 58 |
| 10 | Buchanan | CP | Leemaster/Lovers Gap | 272 | 1694153 | 1652251 | 41902 | 6229 | 6074 | 154 | 518906 | 503175 | 15731 | 1908 | 1850 | 58 |
| 11 | Lee | LEN | Dryden Hts/Cross Creek | 250 | 1071597 | 1035480 | 36117 | 4286 | 4142 | 144 | 476936 | 462477 | 14459 | 1908 | 1850 | 58 |
| 12 | Lee | LEN | Rose Hill | 358 | 1353673 | 1320531 | 33142 | 3781 | 3689 | 93 | 682972 | 662267 | 20705 | 1908 | 1850 | 58 |
| 13 | Russell | CP | Hansonville | 525 | 5365190 | 5197735 | 167456 | 10219 | 9900 | 319 | 1001565 | 971202 | 30363 | 1908 | 1850 | 58 |
| 14 | Smyth | MTR | Pleasant Heights | 153 | 995818 | 970806 | 25012 | 6509 | 6345 | 163 | 291885 | 283036 | 8849 | 1908 | 1850 | 58 |
| 15 | Tazewell | CP | Gratton | 425 | 2081923 | 2023787 | 58136 | 4899 | 4762 | 137 | 810791 | 786211 | 24580 | 1908 | 1850 | 58 |
| 16 | Washington | MTR | Benhams Road | 325 | 2437270 | 2374288 | 62982 | 7499 | 7306 | 194 | 620017 | 601220 | 18796 | 1908 | 1850 | 58 |
| 17 | Washington | MTR | Spring Creek | 727 | 6167484 | 6013043 | 154441 | 8483 | 8271 | 212 | 1386930 | 1344883 | 42046 | 1908 | 1850 | 58 |
| 18 | Wise | LEN | Wildcat/Irondale | 377 | 2099847 | 2036974 | 62874 | 5570 | 5403 | 167 | 719219 | 697415 | 21804 | 1908 | 1850 | 58 |
| 19 | Scott | LEN | Daniel Boone | 370 | 3330302 | 3233622 | 96681 | 9001 | 8740 | 261 | 705865 | 684466 | 21399 | 1908 | 1850 | 58 |
| 20 | Scott | LEN | Yuma | 390 | 2810545 | 2738697 | 71848 | 7207 | 7022 | 184 | 744020 | 721464 | 22556 | 1908 | 1850 | 58 |
| 21 | Dickenson | CP | Rt 83/Georges Fork | 140 | 1410778 | 1371568 | 39210 | 10077 | 9797 | 280 | 267084 | 258987 | 8097 | 1908 | 1850 | 58 |
| 22 | Buchanan | CP | Poplar Creek | 142 | 1080811 | 1054078 | 26734 | 7611 | 7423 | 188 | 270900 | 262687 | 8213 | 1908 | 1850 | 58 |
| 23 | Smyth | MTR | Watson Gap | 193 | 1706971 | 1664330 | 42641 | 8844 | 8623 | 221 | 368195 | 357032 | 11162 | 1908 | 1850 | 58 |
| 24 | Tazewell | CP | Tazewell to Divides | 165 | 1158186 | 1121808 | 36378 | 7019 | 6799 | 220 | 314778 | 305235 | 9543 | 1908 | 1850 | 58 |
| 25 | Tazewell | CP | Tazewell to Claypool Alt I | 464 | 6384212 | 6230480 | 153732 | 13759 | 13428 | 331 | 885193 | 858357 | 26836 | 1908 | 1850 | 58 |
| 26 | Tazewell | CP | Abbs Valley | 435 | 1420922 | 1372549 | 48373 | 3266 | 3155 | 111 | 829868 | 804710 | 25158 | 1908 | 1850 | 58 |
| 27 | Washington | MTR | East Central | 806 | 7757906 | 7526489 | 231418 | 9625 | 9338 | 287 | 1537641 | 1491026 | 46615 | 1908 | 1850 | 58 |
| 28 | Wise | LEN | Coeburn Mountain | 500 | 2150824 | 2097881 | 52943 | 4302 | 4196 | 106 | 953872 | 924954 | 28918 | 1908 | 1850 | 58 |
| 29 | Wise | LEN | Powell Valley | 355 | 3146434 | 3069601 | 76833 | 8863 | 8647 | 216 | 677249 | 656717 | 20531 | 1908 | 1850 | 58 |
| 30 | Scott | LEN | Hiltons | 263 | 2575312 | 2480091 | 95221 | 9792 | 9430 | 362 | 501737 | 486526 | 15211 | 1908 | 1850 | 58 |
| 31 | Tazewell | CP | Birmingham | 390 | 2774788 | 2690234 | 84554 | 7115 | 6898 | 217 | 744020 | 721464 | 22556 | 1908 | 1850 | 58 |
| 32 | Buchanan | CP | Lower Mill Branch | 103 | 1018698 | 993503 | 25195 | 9890 | 9646 | 245 | 196498 | 190541 | 5957 | 1908 | 1850 | 58 |
| 33 | Buchanan | CP | Lynn Camp/Looney Creek | 132 | 858108 | 836885 | 21222 | 6501 | 6340 | 161 | 251822 | 244188 | 7634 | 1908 | 1850 | 58 |
| 34 | Grayson | MTR | Providence | 258 | 2376487 | 2305795 | 70692 | 9211 | 8937 | 274 | 492198 | 477276 | 14921 | 1908 | 1850 | 58 |
| 35 | Grayson | MTR | Stevens Creek | 202 | 1458783 | 1422705 | 36078 | 7222 | 7043 | 179 | 385364 | 373681 | 11683 | 1908 | 1850 | 58 |
| 36 | Lee | LEN | Red Hill/Poor Valley | 141 | 946565 | 921401 | 25164 | 6713 | 6535 | 178 | 268992 | 260837 | 8155 | 1908 | 1850 | 58 |
| 37 | Tazewell | CP | Red Ash | 105 | 607217 | 592197 | 15020 | 5783 | 5640 | 143 | 200313 | 194240 | 6073 | 1908 | 1850 | 58 |
| 38 | Washington | MTR | Larwood | 126 | 659072 | 642250 | 16823 | 5231 | 5097 | 134 | 240376 | 233088 | 7287 | 1908 | 1850 | 58 |
| 39 | Wise | LEN | Tacoma | 144 | 357545 | 348702 | 8843 | 2483 | 2422 | 61 | 274715 | 266387 | 8328 | 1908 | 1850 | 58 |
| 40 | Wise | LEN | Banner | 169 | 518135 | 505320 | 12816 | 3066 | 2990 | 76 | 322409 | 312635 | 9774 | 1908 | 1850 | 58 |
| 41 | Scott | LEN | Route 871 | 85 | 563987 | 549197 | 14790 | 6635 | 6461 | 174 | 162158 | 157242 | 4916 | 1908 | 1850 | 58 |
| | | | Total | 14507 | 99145854 | 96469061 | 2676792 | 280251 | 272729 | 7522 | 27675636 | 26836620 | 839015 | 76310 | 73996 | 2313 |
| | | | Average | 363 | 2478646 | 2411727 | 66920 | 7006 | 6818 | 188 | 691891 | 670916 | 20975 | 1908 | 1850 | 58 |
| | | | Median | 299 | 1893673 | 1849355 | 47761 | 6674 | 6498 | 176 | 569461 | 552198 | 17264 | 1908 | 1850 | 58 |
| | | | Max | 1160 | 7757906 | 7526489 | 231418 | 16486 | 16074 | 412 | 2212983 | 2145894 | 67089 | 1908 | 1850 | 58 |
| | | | Min | 85 | 357545 | 348702 | 8843 | 2483 | 2422 | 61 | 162158 | 157242 | 4916 | 1908 | 1850 | 58 |
| | | | Std. Dev Population | 262 | 1960983 | 1907800 | 53921 | 2892 | 2815 | 80 | 499154 | 484021 | 15132 | 0 | 0 | 0 |
| | | | Std. Dev Sample | 265 | 1985965 | 1932104 | 54608 | 2929 | 2851 | 81 | 505513 | 490187 | 15325 | 0 | 0 | 0 |

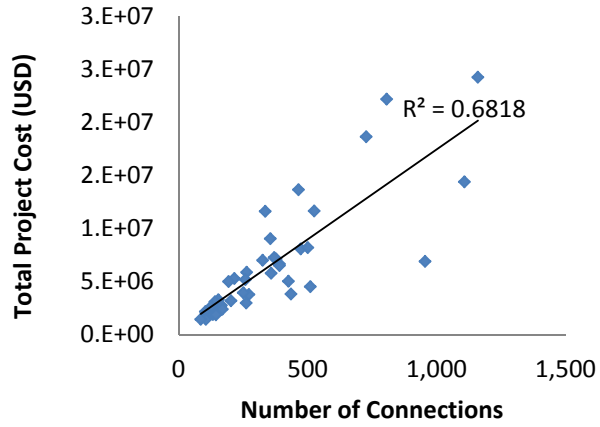
| Project Number | County | Planning District | Project Name | Number of Connections | Sewer Cost ($) | | | | | | Septic Cost ($) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Total | Materials | Construction | Total Per Connection | Materials Per Connection | Construction Per Connection | Total | Materials | Construction | Total Per Connection | Materials Per Connection | Construction Per Connection |
| 1 | Lee | LEN | Woodway | 510 | $ 4,524,780 | $ 3,480,600 | $ 1,044,180 | $ 8,872 | $ 6,825 | $ 2,047 | $ 3,036,540 | $ 2,335,800 | $ 700,740 | $ 5,954 | $ 4,580 | $ 1,374 |
| 2 | Washington | MTR | West Central (Beaver Creek) | 1160 | $ 24,273,288 | $ 18,671,760 | $ 5,601,528 | $ 20,925 | $ 16,096 | $ 4,829 | $ 6,906,640 | $ 5,312,800 | $ 1,593,840 | $ 5,954 | $ 4,580 | $ 1,374 |
| 3 | Grayson | MTR | Fairview | 335 | $ 11,637,080 | $ 8,951,600 | $ 2,685,480 | $ 34,738 | $ 26,721 | $ 8,016 | $ 1,994,590 | $ 1,534,300 | $ 460,290 | $ 5,954 | $ 4,580 | $ 1,374 |
| 4 | Lee | LEN | Sandy Ridge/N. Jonesville | 261 | $ 2,996,370 | $ 2,304,900 | $ 691,470 | $ 11,480 | $ 8,831 | $ 2,649 | $ 1,553,994 | $ 1,195,380 | $ 358,614 | $ 5,954 | $ 4,580 | $ 1,374 |
| 6 | Smyth | MTR | Groseclose | 215 | $ 5,294,020 | $ 4,072,323 | $ 1,221,697 | $ 24,623 | $ 18,941 | $ 5,682 | $ 1,280,110 | $ 984,700 | $ 295,410 | $ 5,954 | $ 4,580 | $ 1,374 |
| 7 | Tazewell | CP | Baptist Valley East | 955 | $ 6,910,020 | $ 5,315,400 | $ 1,594,620 | $ 7,236 | $ 5,566 | $ 1,670 | $ 5,686,070 | $ 4,373,900 | $ 1,312,170 | $ 5,954 | $ 4,580 | $ 1,374 |
| 8 | Tazewell | CP | Baptist Valley West | 1108 | $ 14,408,849 | $ 11,083,730 | $ 3,325,119 | $ 13,004 | $ 10,003 | $ 3,001 | $ 6,597,032 | $ 5,074,640 | $ 1,522,392 | $ 5,954 | $ 4,580 | $ 1,374 |
| 9 | Wise | LEN | East Stone Gap/Cracker Neck | 473 | $ 8,085,870 | $ 6,219,900 | $ 1,865,970 | $ 17,095 | $ 13,150 | $ 3,945 | $ 2,816,242 | $ 2,166,340 | $ 649,902 | $ 5,954 | $ 4,580 | $ 1,374 |
| 10 | Buchanan | CP | Leemaster/Lovers Gap | 272 | $ 3,787,160 | $ 2,913,200 | $ 873,960 | $ 13,923 | $ 10,710 | $ 3,213 | $ 1,619,488 | $ 1,245,760 | $ 373,728 | $ 5,954 | $ 4,580 | $ 1,374 |
| 11 | Lee | LEN | Dryden Hts/Cross Creek | 250 | $ 3,952,442 | $ 3,040,340 | $ 912,102 | $ 15,810 | $ 12,161 | $ 3,648 | $ 1,488,500 | $ 1,145,000 | $ 343,500 | $ 5,954 | $ 4,580 | $ 1,374 |
| 12 | Lee | LEN | Rose Hill | 358 | $ 5,804,765 | $ 4,465,204 | $ 1,339,561 | $ 16,214 | $ 12,473 | $ 3,742 | $ 2,131,532 | $ 1,639,640 | $ 491,892 | $ 5,954 | $ 4,580 | $ 1,374 |
| 13 | Russell | CP | Hansonville | 525 | $ 11,670,620 | $ 8,977,400 | $ 2,693,220 | $ 22,230 | $ 17,100 | $ 5,130 | $ 3,125,850 | $ 2,404,500 | $ 721,350 | $ 5,954 | $ 4,580 | $ 1,374 |
| 14 | Smyth | MTR | Pleasant Heights | 153 | $ 3,291,600 | $ 2,532,000 | $ 759,600 | $ 21,514 | $ 16,549 | $ 4,965 | $ 910,962 | $ 700,740 | $ 210,222 | $ 5,954 | $ 4,580 | $ 1,374 |
| 15 | Tazewell | CP | Gratton | 425 | $ 5,041,972 | $ 3,878,440 | $ 1,163,532 | $ 11,863 | $ 9,126 | $ 2,738 | $ 2,530,450 | $ 1,946,500 | $ 583,950 | $ 5,954 | $ 4,580 | $ 1,374 |
| 16 | Washington | MTR | Benhams Road | 325 | $ 7,014,280 | $ 5,395,600 | $ 1,618,680 | $ 21,582 | $ 16,602 | $ 4,981 | $ 1,935,050 | $ 1,488,500 | $ 446,550 | $ 5,954 | $ 4,580 | $ 1,374 |
| 17 | Washington | MTR | Spring Creek | 727 | $ 18,659,056 | $ 14,353,120 | $ 4,305,936 | $ 25,666 | $ 19,743 | $ 5,923 | $ 4,328,558 | $ 3,329,660 | $ 998,898 | $ 5,954 | $ 4,580 | $ 1,374 |
| 18 | Wise | LEN | Wildcat/Irondale | 377 | $ 7,141,030 | $ 5,493,100 | $ 1,647,930 | $ 18,942 | $ 14,571 | $ 4,371 | $ 2,244,658 | $ 1,726,660 | $ 517,998 | $ 5,954 | $ 4,580 | $ 1,374 |
| 19 | Scott | LEN | Daniel Boone | 370 | $ 7,271,680 | $ 5,593,600 | $ 1,678,080 | $ 19,653 | $ 15,118 | $ 4,535 | $ 2,202,980 | $ 1,694,600 | $ 508,380 | $ 5,954 | $ 4,580 | $ 1,374 |
| 20 | Scott | LEN | Yuma | 390 | $ 6,671,197 | $ 5,131,690 | $ 1,539,507 | $ 17,106 | $ 13,158 | $ 3,947 | $ 2,322,060 | $ 1,786,200 | $ 535,860 | $ 5,954 | $ 4,580 | $ 1,374 |
| 21 | Dickenson | CP | Rt 83/Georges Fork | 140 | $ 3,094,260 | $ 2,380,200 | $ 714,060 | $ 22,102 | $ 17,001 | $ 5,100 | $ 833,560 | $ 641,200 | $ 192,360 | $ 5,954 | $ 4,580 | $ 1,374 |
| 22 | Buchanan | CP | Poplar Creek | 142 | $ 2,363,530 | $ 1,818,100 | $ 545,430 | $ 16,645 | $ 12,804 | $ 3,841 | $ 845,468 | $ 650,360 | $ 195,108 | $ 5,954 | $ 4,580 | $ 1,374 |
| 23 | Smyth | MTR | Watson Gap | 193 | $ 5,017,350 | $ 3,859,500 | $ 1,157,850 | $ 25,997 | $ 19,997 | $ 5,999 | $ 1,149,122 | $ 883,940 | $ 265,182 | $ 5,954 | $ 4,580 | $ 1,374 |
| 24 | Tazewell | CP | Tazewell to Divides | 165 | $ 2,767,310 | $ 2,128,700 | $ 638,610 | $ 16,772 | $ 12,901 | $ 3,870 | $ 982,410 | $ 755,700 | $ 226,710 | $ 5,954 | $ 4,580 | $ 1,374 |
| 25 | Tazewell | CP | Tazewell to Claypool Alt I | 464 | $ 13,670,800 | $ 10,516,000 | $ 3,154,800 | $ 29,463 | $ 22,664 | $ 6,799 | $ 2,762,656 | $ 2,125,120 | $ 637,536 | $ 5,954 | $ 4,580 | $ 1,374 |
| 26 | Tazewell | CP | Abbs Valley | 435 | $ 3,838,583 | $ 2,952,756 | $ 885,827 | $ 8,824 | $ 6,788 | $ 2,036 | $ 2,589,990 | $ 1,992,300 | $ 597,690 | $ 5,954 | $ 4,580 | $ 1,374 |
| 27 | Washington | MTR | East Central | 806 | $ 22,208,004 | $ 17,083,080 | $ 5,124,924 | $ 27,553 | $ 21,195 | $ 6,358 | $ 4,798,924 | $ 3,691,480 | $ 1,107,444 | $ 5,954 | $ 4,580 | $ 1,374 |
| 28 | Wise | LEN | Coeburn Mountain | 500 | $ 8,217,300 | $ 6,321,000 | $ 1,896,300 | $ 16,435 | $ 12,642 | $ 3,793 | $ 2,977,000 | $ 2,290,000 | $ 687,000 | $ 5,954 | $ 4,580 | $ 1,374 |
| 29 | Wise | LEN | Powell Valley | 355 | $ 9,055,150 | $ 6,965,500 | $ 2,089,650 | $ 25,507 | $ 19,621 | $ 5,886 | $ 2,113,670 | $ 1,625,900 | $ 487,770 | $ 5,954 | $ 4,580 | $ 1,374 |
| 30 | Scott | LEN | Hiltons | 263 | $ 5,895,110 | $ 4,534,700 | $ 1,360,410 | $ 22,415 | $ 17,242 | $ 5,173 | $ 1,565,902 | $ 1,204,540 | $ 361,362 | $ 5,954 | $ 4,580 | $ 1,374 |
| 31 | Tazewell | CP | Birmingham | 390 | $ 6,515,197 | $ 5,011,690 | $ 1,503,507 | $ 16,706 | $ 12,850 | $ 3,855 | $ 2,322,060 | $ 1,786,200 | $ 535,860 | $ 5,954 | $ 4,580 | $ 1,374 |
| 32 | Buchanan | CP | Lower Mill Branch | 103 | $ 2,174,770 | $ 1,672,900 | $ 501,870 | $ 21,114 | $ 16,242 | $ 4,873 | $ 613,262 | $ 471,740 | $ 141,522 | $ 5,954 | $ 4,580 | $ 1,374 |
| 33 | Buchanan | CP | Lynn Camp/Looney Creek | 132 | $ 1,907,880 | $ 1,467,600 | $ 440,280 | $ 14,454 | $ 11,118 | $ 3,335 | $ 785,928 | $ 604,560 | $ 181,368 | $ 5,954 | $ 4,580 | $ 1,374 |
| 34 | Grayson | MTR | Providence | 258 | $ 5,191,940 | $ 3,993,800 | $ 1,198,140 | $ 20,124 | $ 15,480 | $ 4,644 | $ 1,536,132 | $ 1,181,640 | $ 354,492 | $ 5,954 | $ 4,580 | $ 1,374 |
| 35 | Grayson | MTR | Stevens Creek | 202 | $ 3,205,540 | $ 2,465,800 | $ 739,740 | $ 15,869 | $ 12,207 | $ 3,662 | $ 1,202,708 | $ 925,160 | $ 277,548 | $ 5,954 | $ 4,580 | $ 1,374 |
| 36 | Lee | LEN | Red Hill/Poor Valley | 141 | $ 3,084,094 | $ 2,372,380 | $ 711,714 | $ 21,873 | $ 16,825 | $ 5,048 | $ 839,514 | $ 645,780 | $ 193,734 | $ 5,954 | $ 4,580 | $ 1,374 |
| 37 | Tazewell | CP | Red Ash | 105 | $ 1,448,850 | $ 1,114,500 | $ 334,350 | $ 13,799 | $ 10,614 | $ 3,184 | $ 625,170 | $ 480,900 | $ 144,270 | $ 5,954 | $ 4,580 | $ 1,374 |
| 38 | Washington | MTR | Larwood | 126 | $ 2,665,689 | $ 2,050,530 | $ 615,159 | $ 21,156 | $ 16,274 | $ 4,882 | $ 750,204 | $ 577,080 | $ 173,124 | $ 5,954 | $ 4,580 | $ 1,374 |
| 39 | Wise | LEN | Tacoma | 144 | $ 1,881,360 | $ 1,447,200 | $ 434,160 | $ 13,065 | $ 10,050 | $ 3,015 | $ 857,376 | $ 659,520 | $ 197,856 | $ 5,954 | $ 4,580 | $ 1,374 |
| 40 | Wise | LEN | Banner | 169 | $ 2,402,010 | $ 1,847,700 | $ 554,310 | $ 14,213 | $ 10,933 | $ 3,280 | $ 1,006,226 | $ 774,020 | $ 232,206 | $ 5,954 | $ 4,580 | $ 1,374 |
| 41 | Scott | LEN | Route 871 | 85 | $ 1,446,614 | $ 1,112,780 | $ 333,834 | $ 17,019 | $ 13,092 | $ 3,927 | $ 506,090 | $ 389,300 | $ 116,790 | $ 5,954 | $ 4,580 | $ 1,374 |
| | | | Total | 14507 | $266,487,420 | $204,990,323 | $ 61,497,097 | $ 743,580 | $ 571,985 | $ 171,595 | $ 86,374,678 | $ 66,442,060 | $ 19,932,618 | $ 238,160 | $ 183,200 | $ 54,960 |
| | | | Average | 363 | $ 6,662,185 | $ 5,124,758 | $ 1,537,427 | $ 18,590 | $ 14,300 | $ 4,290 | $ 2,159,367 | $ 1,661,052 | $ 498,315 | $ 5,954 | $ 4,580 | $ 1,374 |
| | | | Median | 299 | $ 5,116,956 | $ 3,936,120 | $ 1,180,836 | $ 17,100 | $ 13,154 | $ 3,946 | $ 1,777,269 | $ 1,367,130 | $ 410,139 | $ 5,954 | $ 4,580 | $ 1,374 |
| | | | Max | 1160 | $ 24,273,288 | $ 18,671,760 | $ 5,601,528 | $ 34,738 | $ 26,721 | $ 8,016 | $ 6,906,640 | $ 5,312,800 | $ 1,593,840 | $ 5,954 | $ 4,580 | $ 1,374 |
| | | | Min | 85 | $ 1,446,614 | $ 1,112,780 | $ 333,834 | $ 7,236 | $ 5,566 | $ 1,670 | $ 506,090 | $ 389,300 | $ 116,790 | $ 5,954 | $ 4,580 | $ 1,374 |
| | | | Std. Dev Population | 262 | $ 5,372,518 | $ 4,132,706 | $ 1,239,812 | $ 5,786 | $ 4,451 | $ 1,335 | $ 1,557,841 | $ 1,198,339 | $ 359,502 | $ - | $ - | $ - |
| | | | Std. Dev Sample | 265 | $ 5,440,961 | $ 4,185,354 | $ 1,255,606 | $ 5,860 | $ 4,508 | $ 1,352 | $ 1,577,687 | $ 1,213,605 | $ 364,082 | $ - | $ - | $ - |

# APPENDIX 2

**Total Resource Consumption**




**Resource Consumption per Connection**