**COMMONWEALTH OF KENTUCKY**

**BEFORE THE PUBLIC SERVICE COMMISSION**

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| **IN THE MATTER OF:** | **)** | |
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| **THE APPLICATION OF KENTUCKY-AMERICAN** | **)** | **CASE NO. 2017-00313** |
| **WATER COMPANY FOR A QUALIFIED** | **)** | |
| **INFRASTRUCTURE PROGRAM RIDER** | **)** | |

# DIRECT TESTIMONY OF BRENT E. O'NEILL, P.E.

**Q. Please state your name and business address.**

A. My name is Brent E. O'Neill and my business address is 2300 Richmond Road, Lexington, Kentucky 40502.

**Q. By whom are you employed and in what capacity?**

A. I am employed by the American Water Works Service Company ("Service Company") as Director of Engineering for Kentucky-American Water Company ("KAWC" or "Company") and Tennessee-American Water Company ("TAWC").

**Q. Have you previously filed testimony before this Commission?**

A. Yes. I have provided written testimony in Case No. 2015-00418, the Application of KAWC for an adjustment of rates. In addition, I have provided written testimony in Case No. 2014-00258, the Application of KAWC for a Certificate of Convenience and Necessity Authorizing the Construction of Richmond Road Station Filter Improvements.

**Q. Please describe your educational and professional background.**

A. I received a B.S. degree in Civil Engineering from the University of Illinois in Urbana, Illinois in 1991. I completed a Masters of Business Administration from Eastern Illinois University in Charleston, Illinois in 2002. I am a registered Professional Engineer in the State of Illinois, State of Iowa, State of Tennessee, and Commonwealth of Kentucky.

I began my career with American Water Works Company, Inc. ("AWW" or "American Water") in 1996, as a Staff Engineer for Northern Illinois Water Company until 1999 when I was promoted to Engineering Manager for Illinois American Water Company ("ILAWC"). In July 2004, I accepted the position of Network Operations Manager for the Champaign County District of ILAWC. In June 2005, I accepted the position of

Senior Asset Manager with AWW and worked in Reading, England in a joint project with Thames Water. In 2006, I became the ILAWC Project Manager for the construction of a new 15 million gallons per day ("MGD") ground water softening treatment plant, wells, and transmission main in Champaign, Illinois. In March 2008, I became the Engineering Manager Capital Delivery with ILAWC with responsibilities for the delivery of capital projects for the Central and Southern portions Illinois. In April 2013, I accepted my current position as Director of Engineering for KAWC and TAWC. I am an active member of the American Water Works Association ("AWWA").

**Q. What are your duties as Director of Engineering?**

A. I am responsible for the coordination of the Engineering Departments for both KAWC and TAWC, which includes the planning, development, and implementation of all aspects of construction projects. This includes main extensions and developers, replacement mains, water treatment plant upgrades, new construction and network facilities improvements. I coordinate technical assistance to all other Company departments as needed and oversee the capital budget development and implementation. I report to the Presidents of KAWC and TAWC.

**Q. What is the purpose of your direct testimony?**

A. My testimony describes the critical infrastructure issues facing KAWC, and the need for the Qualified Infrastructure Program ("QIP") Rider that will support KAWC's plan to accelerate replacement of aging infrastructure.

**Q. What is the critical infrastructure issue facing KAWC?**

A. Utilities, customers, and regulators across the country are facing the reality of infrastructure nearing the end of its useful life, especially buried pipes. Over the past 15 years, several studies have been published[1] that have documented the pending financial investments that the water and wastewater industries face based on the anticipated service life of the original mains. The preeminent reports are, "Dawn of the Replacement Era," and "Buried No Longer: Confronting America's Infrastructure Challenge," both published by AWWA.[2]

**Q. Why is infrastructure replacement such an important issue?**

A. In the summary of the "Buried No Longer" study, AWWA indicates that "the United States is reaching a crossroads and faces a difficult choice. We can incur the haphazard and growing costs of living with aging and failing drinking water infrastructure. Or, we can carefully prioritize and undertake drinking water infrastructure renewal investments to ensure that our water utilities can continue to reliably and cost-effectively support the public health, safety, and economic vitality of our communities."[3] The tariff KAWC is proposing in this case supports the careful prioritization as AWWA recommends.

[1] E.g., Studies by American Water Works Association, the Water Research Foundation ("WRF"), the American Society of Civil Engineers, and the US Environmental Protection Agency.

[2] AWWA, 2001. *Dawn of the Replacement Era: Reinvesting in Drinking Water Infrastructure*. AWWA, Denver. www.scribd.com/document/39675402/AWWA-Dawn-of-the-Replacement-Era.

[3] AWWA, 2012. *Buried No Longer: Confronting America's Water Infrastructure Challenge*. AWWA, Denver. www.awwa.org/Portals/0/files/legreg/documents/BuriedNoLonger.pdf.

**Q. How did AWWA determine the importance of addressing the current state of water and wastewater infrastructure?**

A. AWWA has performed significant research on the issue of infrastructure replacement and published the two landmark studies. "Dawn of the Replacement Era" (May 2001) drew attention to the issue by benchmarking 20 utility systems from across the United States (Louisville Water, Cincinnati Water Works and West Virginia American Water were 3 of the 20 systems). This study looked at the factors that impacted infrastructure replacement as well as the financial impacts of the infrastructure that was constructed in waves and will fail in waves. The study developed "Nessie Curves" that illustrated the pending financial liabilities that the industry faces based on the anticipated service life of the original main.

Ultimately, "Dawn of the Replacement Era" served as the initial call to action that our generation would need to rebuild the infrastructure that was built and provided to us by the previous generations. In a follow-up study "Buried No Longer" (2012), AWWA expanded on the previous study and took a detailed look at the distribution network and the factors that lead to failure. The study took a closer look at how demographics, material types, regions, and other factors affect the current system conditions that each utility faces. The study was nationwide in scope and was clear that each utility needed to determine their own needs based on the criteria provided in the study, but provided a tremendous amount of data and understanding of the factors affecting the infrastructure that was not available prior to the study.

The "Buried No Longer" study provided important findings regarding the water infrastructure including:

- The Needs Are Large – investment needs for buried drinking water infrastructure total more than $1 trillion over the next 25 years;

- Household Water Bills Will Go Up – The level of the rate increases will depend on each system's composition, demographics and needs but significant increases should be maintain the current level of service;

- There Are Important Regional Differences – The needs of infrastructure replacement affects different regions in different ways. Population growth in a community or population shift from one region to another along with the composition and configuration of a systems network are variables that impact each region and utility differently. In growing systems, new lines must be balanced with replacements to assure continuity of service. However, in declining population areas, the aging infrastructure still needs to be replaced even though there are fewer customers to support the effort;

- There are Important Differences Based on System Size - Small systems face different variables than larger systems but the overall impact to both is considerable;

- The Costs Keep Coming – based on the Nessie Curves, it should be expected that buried infrastructure replacement needs will continue to increase for the coming decades; and

- Postponing The Problem Only Makes It Worse – not making investment now only steepens the slope of investment required later as more distribution lines exceed their life expectancy, increasing leaks and breaks and eventually reducing the level of service to customer.

**Q. What are the current assets that make up the Company's distribution system?**

A. The Company's distribution system contains approximately 2,017 miles of pipe ranging in sizes from 1.5 to 42 inches. The distribution system also contains 23 water storage tanks, 17,919 main line valves, 7,921 public hydrants, and 17 distribution pump stations.

**Q. Have you evaluated the condition of KAWC's infrastructure?**

A. Yes. Over the past several years, the Company completed a multiple method review of its pipeline asset replacement needs. The Company began its review with the recently published AWWA software analytics tool named "Buried No Longer Pipe Replacement Modeling Tool." The software uses system specific pipe asset characteristics of pipe material type, decade of pipe installation, and pipe diameter to develop a multi-decade projection of pipe asset replacement needs. The Company further enhanced its analysis by conducting additional review of its distribution system and producing the "Aging Infrastructure; A Review of the Water Distribution System" report, that is attached as BEO Exhibit 1 ("KAWC Report").[4] As discussed further below, KAWC's efforts have revealed critical information that will allow the Company to prioritize necessary replacements. KAWC has detailed plans for the types of projects that will constitute the majority of the work performed under the first years of the QIP Rider, realizing that the Company's distribution system is not static, and adjustments will likely occur as actual system conditions evolve.

[4] The original KAWC report was prepared in 2015. The report has been updated during the first part of 2017 to account for improvements carried out in 2016 and for improved data being utilized by the GIS maps.

**Q. Does KAWC control when, and which, mains in the distribution system are replaced?**

A. Frequently, no. While KAWC can target segments of its distribution system for replacement due to the age of the facilities or the type of material involved, replacements are often driven by main breaks, infrastructure relocation, and municipality paving programs.

**Q. Please explain what you mean by "infrastructure relocation."**

A. Most of KAWC's buried infrastructure is located within public rights-of-way. The governmental entities in control of these rights-of-way, such as the Kentucky Transportation Cabinet, various municipal governments, county highway departments, etc. require KAWC to relocate its water infrastructure to accommodate projects such as road widening, sewer installation, storm drainage improvements, traffic signals, streetscapes, etc. Because the timing of these relocations is controlled by the governmental entities and not KAWC, the Company proposes to use the QIP mechanism to provide timely regulatory recognition of these relocation costs and, as discussed in Ms. Bridwell's testimony, could potentially extend the period between rate filings.

**Q. Is KAWC able to predict when these relocations projects will occur?**

A. Often, no. As such, it can be difficult for KAWC to accurately predict, and consequently budget for, the relocation of buried assets necessary to accommodate government projects. The total capital investment for such relocations varies significantly from year to year. For example, recent annual capital expenditures for relocations have ranged from $0.6 million in 2014, to $2.6 million in 2015, to $1.9 million in 2016. During these three years, the total capital investment that resulted in the relocation of buried assets necessary to accommodate government projects accounted for 47% of the investment in the removal of cast iron main from the distribution system and removed 22.1% of the 11.2 miles of cast iron main removed during this period.

**Q. In addition to infrastructure relocations, you also mentioned that KAWC cannot always predict when main breaks will occur. Did the Company's analysis provide key information regarding the types of materials that have an increased susceptibility for breaks?**

A. Yes, it did. The Company analyzed main break history from January 2012 to December 2016. During this period, the Company experienced 837 main breaks, averaging about 167 breaks per year. Review of the reported breaks from January 2012 to December 2016 indicated that main breaks on cast iron main represented 60% of all breaks. Since cast iron main (lined and unlined) material only represents 15.9% of the total inventory of mains in the ground, the break rate on this type of material is significantly higher than the other material in the system. The break rate per mile of main shows that cast iron main had a break rate of 1.1 breaks per mile of main compared to ductile iron, which saw a break rate of 0.04 breaks per mile of main from January 2012 to December 2016. The worst performing material was galvanized steel, which had a break rate of 3.24 breaks per mile of main.

**Q. What is the current pipeline replacement rate for the Company's distribution system?**

A. Since 2009, the Company has replaced 21.9 miles of cast iron main primarily with ductile iron main. This represents a replacement rate for cast iron main of 2.7 miles per year during the 7-year period including the accelerated rate of 3.7 miles per year from 2014 through 2016. This translates to an average pipeline replacement rate of only 0.2%. At this rate of pipe replacement, it will take approximately 86.4 years to replace just the cast iron main in the Company's distribution system and nearly 500 years to replace all mains in the system. If the current pace merely continues, by the time the cast iron main has been replaced, a meaningful portion of the other components of the distribution system would be well past the end of its useful life.

**Q. What consequences may result from maintaining KAWC'S current rate of pipe replacement?**

A. Buried pipes are a critical part of the infrastructure necessary for a utility to deliver reliable service to customers. In fact, for many water utilities, buried pipes are the largest infrastructure category as a percentage of total infrastructure on an asset cost basis. This is because pipes are required to extend along every block of every street in every neighborhood throughout the service area to deliver water to each address served. KAWC will always make the needed investments to maintain or replace infrastructure. In other words, we continue to make necessary investments for adequate sources of supply, treatment, pumping, transmission and distribution facilities, as well as to comply with applicable laws and regulations. But the rate of ongoing infrastructure investment to provide safe and adequate service is not the same as the rate of infrastructure investment that best serves the long term interests of our customers.

To the extent that pipe replacement needs are deferred into the future, service quality will suffer from an increasing number of pipe breaks, service disruptions, health risks from potential drinking water contamination exposure during pipe breaks, property damage, and related community opportunity costs related to community health and economic development. Deferral of pipe replacements year by year has a cumulative tidal wave effect on the future cost to customers for replacing these pipes, leaving future customers with costs of service that reflect significantly increased capital improvements. The phrase "tidal wave" has been used in AWWA studies to present a future picture regarding the effect of how deferring presently needed pipeline replacements will result in dramatic and steep increases in future replacement costs.

**Q. Why is it important to replace water mains?**

A. As the water distribution system begins to reach its useful life, failures in the infrastructure begin to occur that impact the ability to provide safe and reliable service to the community. Neglecting this aging infrastructure will increase the frequency of water main breaks and leaks, leading to the corrosion of surrounding utility pipes, disrupting automobile, pedestrian and public transportation, and stymieing local economic activity.

Although most of these breaks are minor, serious ruptures can and do occur. With these serious breaks the impact can be catastrophic due to flooding of streets and sidewalks, and in some instances flooding of local businesses and basements of local residents. In rare instances, the loss of water can undermine pavement or building foundations that can lead to the failure of pavements or the loss of a building that can result in significant property damage and serious injuries.

The impact of a water main break is mostly a localized impact, with the exception of large main breaks that impact a large portion of the community or the loss of the service to the entire community. The loss of water through leaking pipe as the infrastructure ages is an impact that affects the entire community, most of the time with no one knowing it is occurring. This loss of water typically manifests itself in an increase in "non-revenue water." A high level of non-revenue water affects the financial viability of water utilities through lost revenues and increased operational costs. Although KAWC's non-revenue water is at or below the industry standard, there is concern that over time the ability to manage non-revenue water would be impacted without a systematic approach for replacing aging infrastructure.

**Q. Please discuss some of the customer benefits of accelerating the rate of pipe replacement.**

From the perspective of long-term sustainable customer service and water rates, replacing pipes that are near the end of their useful life in a systematic responsible manner now will result in lower costs to customers over time as compared with deferring needed replacements. This is because planned pipe replacements are much less costly on a unit cost basis than the costs of increasing pipe breaks, service disruptions, health risks from potential drinking water contamination exposure during pipe breaks, property damages, related community opportunity costs related to community health and economic development, and the steep increase in future pipe replacements resulting from prior deferrals of the replacements. Revitalizing the distribution infrastructure installed by earlier generations is essential to maintain the infrastructure that meets the ongoing needs of the communities and customers KAWC serves. In addition, investing in the replacement of the infrastructure enhances the Company's ability to continue to meet customers' service expectations, and may improve fire protection. In addition, the replaced areas of the system will likely be more robust and resilient during periods of high demand.

**Q. Why is the Company proposing a QIP surcharge mechanism?**

A. The Company proposes to accelerate investment in its infrastructure replacement program but would face significant revenue-recognition lag under its current ratemaking structure of periodically filing rate cases. The company is proposing a QIP surcharge mechanism that will provide more timely recovery of its ongoing investments in infrastructure replacement, which are expected to grow in the coming decades. Without a cost recovery mechanism such as the QIP, the ability to sustain the trajectory of the Company's long-term replacement program without impacting other capital needs would be difficult. The QIP is an important component of the Company's efforts to replace its aging infrastructure in a fiscally prudent manner by supporting an accelerating rate of necessary infrastructure replacements, while moderating future rate increases on customers as discussed in greater detail in the testimony of Ms. Bridwell.

The proposed QIP type mechanism is in line with the important role of innovative regulatory policies in facilitating the efforts of water and wastewater utilities to address their significant infrastructure investment challenge that was outlined in the National Association of Regulatory Utility Commissioners (NARUC) resolution passed in 2013.[5]

**Q. How will KAWC's proposed QIP better support the Company's efforts to sustain an accelerated pipe replacement program?**

A. The Company's proposed QIP will support KAWC's multi-decade main replacement program. A long-term commitment is needed to allow both internal and contractor

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[5] National Association of Regulatory Utility Commissioners 2013 Annual Meeting Resolution, "Resolution Endorsing Consideration of Alternative Regulations that Supports Capital Investment in the 21st Century for Water and Wastewater Utilities," November 20, 2013 pubs.naruc.org/pub/53A0858A-2354-D714-5175-3BF53CDDC767

resources to expand their capabilities to meet the increased demand caused by the accelerated pipe replacement. Achieving and sustaining a prudent long-term infrastructure replacement rate will have a positive impact on the cost of the replacement work and repair costs, lowering long-term overall costs for our customers. While it is possible to adjust capital spending on infrastructure replacement to coincide with rate case filings, experience indicates this is likely to result in higher construction costs. In addition, a sustained infrastructure replacement program allows the Company to take full advantage of the favorable weather for construction and a consistent labor supply.

**Q. How does KAWC's current replacement rate compare to the Nessie Curves analysis you previously mentioned?**

A. The Company has completed an evaluation of its existing infrastructure and future long-term spending needs for infrastructure replacement utilizing the "Buried No Longer Pipe Replacement Modeling Tool," which is referred to in the water industry as a "Nessie" analysis. As mentioned, this analysis method was developed by the AWWA and is regarded as the best baseline indicator of long-term infrastructure replacement needs.

Depending on the pipe material, soil conditions, and other factors, a realistic pipe life expectancy is 60 to 100 years. The Nessie analysis provided in BEO Exhibit 1 projects a pipe replacement rate that closely matches the estimated useful life of the respective types of pipe material. The analysis indicates that to keep pace with the aging infrastructure, the replacement rate of KAWC's system will need to be significantly increased from its current level of 0.2% (4 miles per year) to as high as 0.9 percent (18 miles per year) by the year 2034. This replacement rate reflects the age and materials utilized in the original construction of the KAWC distribution system and current estimates of how long these materials will last. Because certain site-specific details such as weather conditions, corrosivity of soils, water alkalinity, pH, operating pressure, and installation practices also impact the useful life of the distribution system components, these projections may change over time and should be updated on a periodic basis. The model also provides an estimate of the annual investment necessary to meet the long-term replacement needs of the system. Without question, a significant gap exists between the Company's current pipeline replacement rate of 0.2% and the optimal projected annual pipe replacement rate of 0.9%. To keep pace with the infrastructure replacement needs predicted by the Nessie Curves analysis, average annual expenditures will need to grow to approximately $15.6 million by 2022, and up to more than $18.5 million by 2037 (in 2016 dollars).

**Q. What are some of the challenges to closing this gap?**

A. One challenge to increasing the Company's pipeline replacement rate is effectively educating all stakeholders about buried pipe infrastructure and its connection to reliable water service. Another challenge is educating stakeholders about the cost of replacing old pipes and its link to the cost of providing water service. A higher investment level is essential to keep pace with the anticipated remaining useful life of water system infrastructure. Another challenge for achieving and sustaining an optimal pipe replacement rate is educating stakeholders about the consequences of delaying replacement of old pipes.

**Q. How is KAWC proposing to address the aging pipe infrastructure and replacement issues that you have identified?**

A. KAWC is proposing the QIP Rider to accelerate replacement needs and allow the Company to recoup these investments in a timely manner. The Company has developed a Main Replacement Model (that is described in the KAWC Report, BEO Exhibit 1) that will be used to prioritize the mains that will be replaced. The Model utilizes eight criteria that are crucial in determining the condition and reliability of the main. These criteria are: Low Pressure; Number of Breaks/Leaks; Fire Flow; Age; Material Type; Size of Main; Water Quality; and Customer Impact. Due to the interrelationships of the eight criteria, the Company established relative weights for each criterion to ensure that the targeted drivers for the main are given greater consideration. Age, material type, low pressure, number of breaks, and water quality were the primary criteria that were used to determine main replacement. These criteria allowed the Model to ensure that underperforming mains were addressed quickly. There are additional external drivers that influence the prioritization schedule. These include roadway paving schedules, weather, and construction considerations. This combination of modeling and subjective considerations allows for a more proactive replacement program that is in concert with the community and allows for efficient use of available resources.

Using this Model, the Company has identified the materials to target for replacement during the first years of the QIP. Specifically, the first materials that need to be replaced in the system are cast iron main and galvanized steel. These two materials represent approximately 15.9% of the distribution system, but account for approximately 60% of all main breaks in a given year. The Company believes that the best course at this time is to target this type of pipe material over the next 25 years for replacement. Through a 25-year replacement period, the 320 miles of cast iron main will be replaced at a rate of 10 to 13 miles per year at an expected cost of $6.9 to 12.6 million per year. The replacement of this type of material allows the Company to address underperforming mains and reduce the impact of main breaks in the areas served by this type of material.

**Q. Will the scope and associated capital improvements under the QIP remain constant from year to year?**

A. No, it will not. Based on the KAWC Report that reviews system characteristics, such as installation periods, expected life of pipe material, main break history, non-revenue water and current replacement efforts, the rate of replacement will vary based on the type and number of targeted materials and projected projects in a given year. For example, KAWC plans to emphasize replacement of galvanized steel and cast iron in the QIP's first years. These materials, while susceptible to an increased chance of breaks, are not the only infrastructure that needs to replaced.

Once the Company and its customers have familiarity with the QIP Rider, KAWC expects to increase the replacement trajectory to close the gap between the current replacement rate and the 0.9% necessary to achieve an optimal level of replacement of the system as indicated by the Nessie Curve analysis conducted in KAWC's Report (BEO Exhibit 1). As an example, the Company plans to begin replacing asbestos cement pipe, which is another material type targeted for replacement, while the replacement of galvanized steel and cast iron main is ongoing. Asbestos cement pipe comprises 16.8% of the KAWC's distribution system. KAWC's planned replacement trajectory will allow the Company to address underperforming mains and reduce the impact of main breaks in the areas served by these types of materials. The Company plans to identify and analyze main breaks and other system data on an ongoing basis in order to continue prioritizing replacements appropriately. In addition, as discussed above, the QIP Rider amount may also change from year to year depending on the number of relocation projects the Company is required to complete during any particular period.

**Q. Will the infrastructure replacement projects have any impact on operation and maintenance costs?**

A. In the absence of an increase in buried infrastructure replacement, the number of main breaks, leaks, and associated repair costs will increase and operational and maintenance costs will increase accordingly. While weather, system demands and pumping pressures, ground movement and other factors all contribute to main breaks, the age of water mains is typically the single largest root cause factor in the failure of main. As water mains and other distribution system components age, they deteriorate and become less durable to outside conditions that make them more susceptible to failure. An increase in the infrastructure replacement program will address the aging infrastructure and help to mitigate the increase in failures the Company would otherwise expect as the system continues to age and deteriorate.

**Q. Are there additional savings to operations and maintenance costs that can be experienced by infrastructure replacement projects?**

A. As metal water mains age, their inside roughness tends to increase and their cross sectional area tends to decrease due to encrustation and tuberculation of corrosion products on the pipe walls. This increase in hydraulic roughness and decrease in effective diameter will increase the resistance to flow and reduce the hydraulic capacity of the aging mains. This constrains the system's ability to respond to fire flow demands and lowers the pressure available to the customers served by the aging main.

The reduction in the hydraulic capacity can lead to a subsequent unwanted reduction in system pressure due to the higher head loss. In order to meet demand in such systems, higher pumping rates are needed to overcome the higher head losses of tuberculated mains. This can result in a significant increase in energy consumption and operational and maintenance costs as the pumps and system compensate for the loss of capacity in the mains in order to maintain pressure for the area served by the main. The additional pumping can over-pressurize certain portions of the distribution system, thereby increasing leaks and breaks and increasing operational and maintenance costs.

**Q. In addition to potential savings on operations and maintenance costs, are there additional benefits to the replacement of cast iron and galvanized water main?**

A. Yes, the aging infrastructure also impacts the ability to continue to provide adequate service to our customers and the system's ability to meet fire flow requirements. A majority of this older infrastructure was installed during a period when the expectations or requirements for fire service and household appliances were not as great as they are today. In some cases, deposits within the pipes have also reduced the water flow for customer uses and fire service.

Currently, approximately 48% of the 320 miles of cast iron and galvanized water main have a diameter of 6 inches or less. As this main is replaced, the area that the main serves is reviewed and the properly sized main is installed to provide adequate service to the surrounding area. Typically, water main equal to and greater than 6 inches is used to replace the older, smaller main. Replacing this aging infrastructure with larger mains allows the Company to provide improved service to the customer and usually improves fire protection. In most cases where hydrants are connected the main, the replacement main is sized equal to or greater than 8 inches as directed by the Lexington Fayette Urban County Government ("LFUCG"), the University of Kentucky, and to support the LFUCG recently obtained Class 1 Fire Protection Rating from the Insurance Service Organization. In addition, the areas of the system that are replaced are made more robust and are more resilient during periods of high demands and reduce the number service disruptions.

**Q. You previously stated that the replacement of cast iron and galvanized steel main would require $6.9 to $12.6 million per year. How was this calculated?**

A. The expected cost of $6.9 to $12.6 million per year was developed by using the replacement rate of 10 to 13 miles per year at average cost per foot for main replacement based on a review of main replacement projects over the past few years.

**Q. What activities are included in the cost for main replacements?**

A. A review of twelve different main replacement projects indicated an average cost of $150 per foot with approximately 44% ($66 per foot) of that cost coming from installing the replacement main via outside contractors. The second largest cost of a main replacement project is the cost to restore pavement and sidewalk following the project. The restoration of pavement is approximately 17% ($25.5 per foot) of the overall project cost. The remaining major costs are material cost at approximately 15% ($22.5 per foot) and Company Labor at 5% ($7.5 per foot).

**Q. How will work be carried out under the QIP?**

A. KAWC will utilize both Company resources and consultant/contractor resources. The use of consultant resources will be used to augment the Company's capabilities of designing and inspecting the proposed main replacements. These services will be acquired through a competitive bid process that will consider proposed costs, available resources, experience and institutional knowledge. The use of contractor resources will be used to augment KAWC's pipe installation efforts and ancillary work. Similar to the consultant services, KAWC will use a competitive bid process for contractor services that will consider proposed costs, safety record, available resources and knowledge of installation procedures.

**Q. What are the anticipated incremental costs of the Company's accelerated infrastructure replacement program?**

A. The Company expects to incur an additional $6 to $10 million each year for the first 5 years of the QIP Rider. As explained, these costs are primarily driven by cast iron and galvanized steel replacements. KAWC expects that by 2037, the annual cost will increase to $18 million as the Company begins replacement of asbestos cement main and PVC as indicated by the Nessie Curve analysis.

**Q. Will alternative solutions to replacement of mains be considered during the QIP?**

A. Yes, KAWC will continue to look at different techniques and processes that will allow for more efficient replacement or rehabilitation of pipe infrastructure. These include consideration of different construction techniques to reduce neighborhood impacts and reduce the amount of pavement and ground repair.

**Q. Will the Company and its customers benefit from timely infrastructure replacement?**

A. Yes, maintaining a steady and prudent long-term infrastructure replacement rate will have a positive effect on the cost of the replacement work and repair costs, meaning lower overall costs for our customers. A significant benefit of a defined replacement plan is that the Company is able to move away from a supply and demand market for the cost of construction to a defined program that allows the Company to take full advantage of favorable construction levels and a consistent labor supply from our contractors.

Using a consistent infrastructure replacement program, contractors are able to establish the right size for their organizations that is beneficial to the Company due to a more talented and reliable work force and a potentially lower overhead being charged by the contractors. In addition, the Company will be able to bundle replacement projects to ensure that competition is consistent on all projects, whether the anticipated construction level by the contractor is considered difficult or easy.

**Q. Are there other positive impacts from timely infrastructure replacement?**

A. Yes, a robust and reliable water system is an important asset to the entire community. It protects the public health and enhances the ability of the communities that KAWC serves to compete for new businesses and industries, which is often an important economic benefit to the community.

The increase in infrastructure replacement will also result in several million dollars of additional construction activity. This work will be completed primarily by consultants and local contractors, and will have a significant impact on the construction related jobs in the area. In Ms. Bridwell's testimony, she provides statistics and explanations regarding increased job creation and economic activity arising from investment in water infrastructure.

**Q. What components of the distribution system are included in the proposed QIP?**

A. The QIP would be limited to the following distribution system components: water mains, hydrants and hydrant isolation valves, distribution system valves, service lines, meters, and distribution pumping equipment. The above would include main extensions to eliminate dead ends and the unreimbursed costs associated with relocations of mains, services, and hydrants occasioned by street or highway construction. Mains installed to provide service to new customers would not be included in the QIP.

**Q. Why is distribution pumping equipment included in the proposed QIP?**

A. Distribution pumping equipment, such as distribution pump stations, is integral to the provision of safe, reliable and affordable service while meeting the demands placed upon the system to provide adequate pressure, fire protection, and limited disruptions in service. KAWC has 17 distribution pump stations that allow it to move water through the distribution system. These pump stations work in concert with the 23 water storage tanks to smooth out the effects of fluctuating demands and provide capacity for fire suppression and other emergencies. Similar to the aging water mains within the distribution system, the distribution pumping equipment is also aging and, if not replaced, will have a significant impact on the ability of the distribution system to provide reliable service and integrity of the system. As an integral part of the distribution system, pumping equipment is appropriate to include in the QIP Rider.

**Q. Will the replacement of the distribution pump stations have any impact on operation and maintenance costs?**

A. Yes. We will be able to replace older motors with motors that are more efficient and employ the use of variable frequency drives to allow the pump stations to more efficiently meet the needs of the distribution system. The use of variable frequency drives allows for more precise control of the water distribution system and allows for more energy savings. Variable frequency drives allow the pump to be operated at varying speeds to meet the pressure needs of the system and allow the pump to be better utilized. Through controlling the speed of the pumps, a reduction in energy use can be realized which leads to electrical cost savings that reduces the pumping related operating costs.

**Q. Are there additional benefits to the replacement of the distribution pump stations?**

A. Yes, several of the distribution pump stations are located below grade in underground vaults. The Company can eliminate the safety concerns associated with entering underground vaults for maintenance purposes through the replacement of these distribution pump stations with above grade pump stations. In addition, by placing the pump station above grade, future maintenance of the stations can be handled more efficiently and the pumps and equipment can be optimally maintained.

**Q. For significant replacement projects, will KAWC continue to request a certificate of public convenience and necessity?**

A. Yes, KAWC will seek a certificate of public convenience and necessity as necessary and request that the project costs be recovered through the QIP.

**Q. Does this conclude your testimony?**

A. Yes.

**VERIFICATION**

**STATE OF TENNESSEE** )
) **SS:**
**COUNTY OF HAMILTON** )

The undersigned, **Brent O'Neill**, being duly sworn, deposes and says he is the Director of Engineering for Kentucky-American Water Company, that he has personal knowledge of the matters set forth in the foregoing testimony, and the answers contained therein are true and correct to the best of his information, knowledge, and belief.

**BRENT O'NEILL**

Subscribed and sworn to before me, a Notary Public in and before said County and State, this 3rd day of August, 2017.

SONAL C. MODI
STATE OF TENNESSEE NOTARY PUBLIC
HAMILTON COUNTY

_______________________________(SEAL)
Notary Public

Sonal C. Modi

My Commission Expires:

Oct 9, 2019

KENTUCKY
AMERICAN WATER

# AGING INFRASTRUCTURE
## A REVIEW OF THE WATER DISTRIBUTION SYSTEM

2017

Kentucky-American Water Company

# Contents

## Introduction

Similar to other water utilities, the water distribution system of Kentucky American Water is beginning to reach its expected life expectancy. Even though the company has made investments in the replacement of the aging infrastructure, the rate at which existing infrastructure is reaching its useful life continues to increase at a quicker pace than the work to replace the outdated mains occurs.

One of the major challenges that water utilities face is that the distribution systems were installed to support the growth of communities that varied over time. The mains installed during the high growth periods reach their life expectancy at the same time, resulting in sections of communities that need all of the mains replaced in a short time period.

In addition, during the periods of system expansions, different pipe materials were used as they were introduced as an alternative to the existing main materials. With each pipe material, the life expectancy of the main is different. Unfortunately, that results in periods where pipes that were installed at different times in the past reach their useful life at the same time as other types of pipe material, increasing the amount of mains that need to be replaced throughout the system in a compressed timeframe.

As the American Water Works Association indicated in their May 2001 publication, “Reinvesting in Drinking Water Infrastructure,” a new era was emerging regarding the operation of our water infrastructure—the replacement era—where water providers would need to replace the water infrastructure that was built for us by earlier generations.

Although Kentucky American has made investments in the replacement of mains over the past decades, the amount of main replaced cannot keep up with the expected amount of main requiring replacement that will occur in the coming decades.

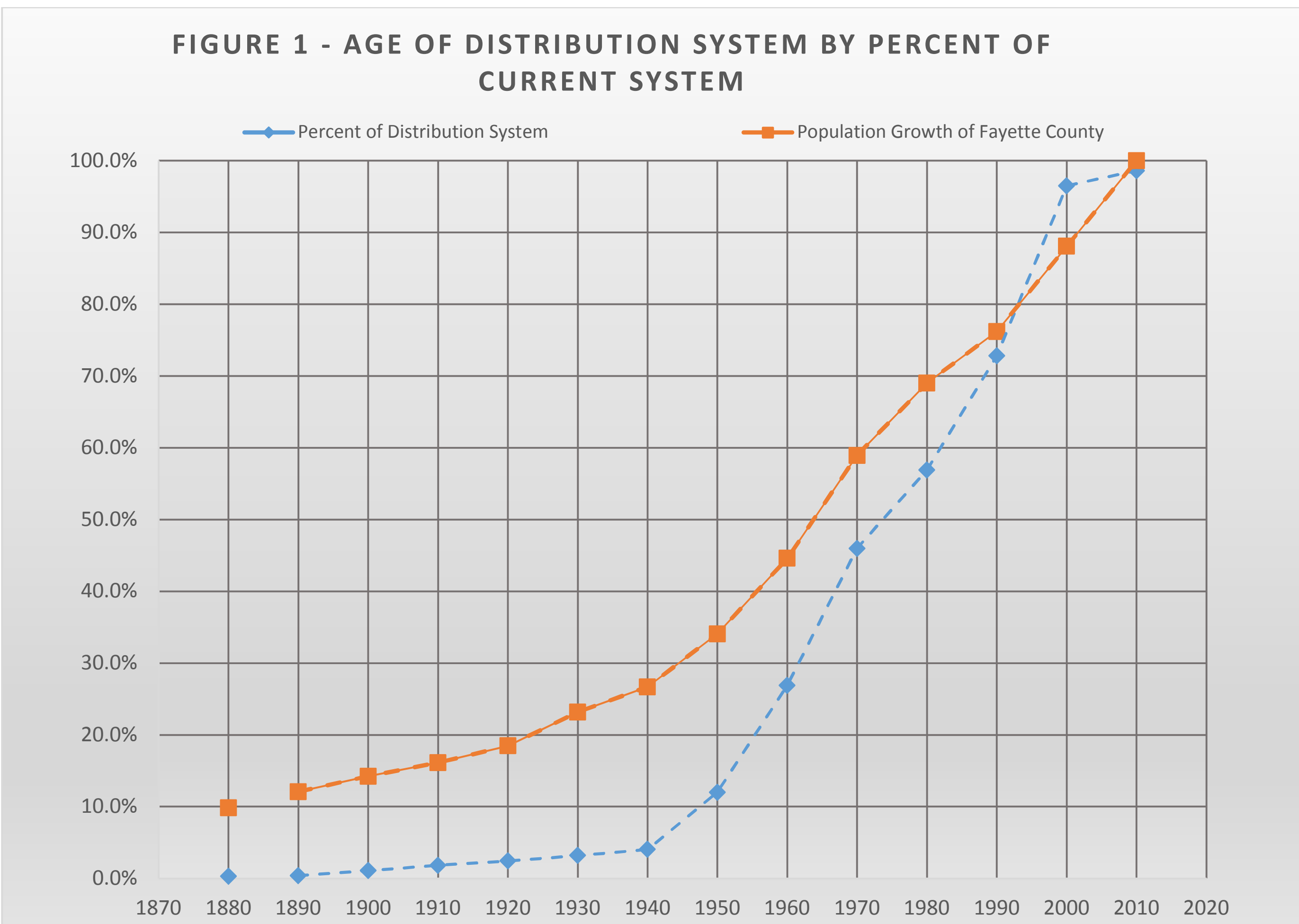
## System Background

Kentucky American Water first began operation as the Lexington Hydraulic and Manufacturing Company providing water to Lexington in 1885. The company was started by three local businessmen who saw a need for a water system to help fight fires and prevent disease. During the early 1970s the name changed from the Lexington Water Company to the current Kentucky American Water Company.

Since 1885 the system has grown from serving approximately 200 customers to about 124,000 customers within 11 counties, including Fayette County. With that growth the distribution system has expanded to include approximately 2,017 miles of water mains of a variety of sizes and material types.

## History of the Growth of the Distribution System

Kentucky American's water distribution system growth mirrors the growth of the City of Lexington and Fayette County. Figure 1 shows the percent of the water distribution system that was installed within each of the decades from 1880 to present.



From the start of the system in 1885 through the 1940's the area was predominately an agricultural based economy and growth was steady. Main installed during that period was cast iron main. Currently there remains approximately 63 miles of cast iron main that was installed during this period that still remains within the distribution system and represents approximately 3% of the current distribution system. This amount used to be a greater amount of the distribution system, however during the 1980s, 1990s and 2010s the Company undertook a concerted effort to replace this era of cast iron main.

Following World War II, Lexington experienced an increased growth rate due to the move away from agriculture and the baby boom. During the 1950's and 60's, the distribution system also grew substantially to keep up with the expansion of Lexington. Main installed during that period was cast iron, both cement lined and unlined. During this period asbestos cement pipe was introduced for the first time into the distribution system. The main installed during this period represents 25% of the current distribution system (514 miles of main).

The Lexington system experienced its greatest growth during the 1970s through the housing boom of the first part of 2000. During this period, Lexington experienced a growth due to industry and service companies locating and growing in Fayette County. In addition, Kentucky American acquired several outlying systems by growing into the counties surrounding Fayette County. Also during this period, the main extension from Kentucky River Station Two to the Lexington distribution system was placed into service during September 2010, which was during the end of this time frame. During this period of time approximately 1,290 miles of main were installed which represents 63% of the current distribution system. Asbestos Cement pipe was the predominate material installed during the start of this period with Ductile Iron pipe and PVC becoming the predominate material during the 1980's.

From 2010 to present, the distribution system has seen a much slower growth rate and represents a little more than 3% of the current distribution system (80 miles). Currently, the predominate material installed is Ductile Iron with some PVC pipe.

## Pipe Materials in Distribution System

The Kentucky American distribution system contains mostly five major material types. Those types are Ductile Iron, PVC, Asbestos Cement, Cast Iron Lined and Cast Iron Unlined. The period that the system was growing determines the areas and the amount of each material type in the system. Table 2 provides a listing of the major material types in the distribution system along with the amount of each material in miles and percentage of that material within the system:

| Table 2 – Distribution System Material Types | | |
|---|---|---|
| | Miles of Material | Percentage of System |
| Ductile Iron | 862.2 | 42.7 |
| PVC | 437.1 | 21.7 |
| Asbestos Cement | 339.3 | 16.8 |
| Cast Iron Unlined | 184.4 | 9.1 |
| Cast Iron Lined | 136.4 | 6.8 |
| Prestressed Concrete | 39.4 | 2.0 |
| Galvanized | 3.4 | 0.2 |
| Other (Brass, Lead, Steel) | 2.4 | 0.1 |
| Unknown | 12.3 | 0.6 |

## Distribution of Pipe Material by Decade

When the material type is compared to the timeline of growth of the distribution system, certain periods of time were dominated by particular pipe materials. During the first part of the system development from 1885 to 1950, cast iron unlined and lined was the predominant material. During 1950 to 1980, asbestos cement pipe was used along with cast iron pipe and the introduction of ductile iron into the system. After 1980, ductile iron pipe dominated the material type being used to meet system growth. PVC pipe use in new water main was not prevalent in the distribution system except for small diameter pipe. During the 1980s, 90s and 2000s with the acquisition of systems, PVC was introduced into the Kentucky American distribution system. Table 3 provides a breakdown by decade of the material types used in the expansion of the distribution system.

| Table 3 – Miles of Existing Material Types Installed by Decade | | | | | | | |
|---|---|---|---|---|---|---|---|
| Decade | Material Types | | | | | | |
| | Cast Iron Unlined | Cast Iron Lined | Asbestos Cement | PVC | Ductile Iron | Galvanized[2] | Other[1] |
| 1881 - 1890 | 5.5 | | | | | | |
| 1891 - 1900 | 1.6 | | | | | | |
| 1901 - 1910 | 15.9 | 0.2 | | | | | |
| 1911 - 1920 | 11.7 | 0.7 | | | | 0.1 | |
| 1921 - 1930 | 11.3 | 2.2 | | | | | |
| 1931 - 1940 | 8.6 | 6.4 | 0.1 | | | | |
| 1941 - 1950 | 3.3 | 5.2 | 13.3 | | | | |
| 1951 - 1960 | 22.8 | 55.4 | 72.1 | 5.0 | 0.5 | 1.2 | 8.5 |
| 1961 - 1970 | 48.5 | 66.3 | 96.9 | 64.9 | 50.6 | 1.2 | 12.8 |
| 1971 - 1980 | | | 122.7 | 134.4 | 164.6 | 0.1 | 22.2 |
| 1981 - 1990 | | | 13.7 | 37.7 | 163.9 | | |
| 1991 - 2000 | | | | 27.9 | 286.0 | 0.1 | |
| 2001 - 2010 | | | | 149.3 | 267.3 | | |
| 2011 - | | | | 12.2 | 58.2 | | |

1 – Other represents Lead Pipe, Reinforced Concrete Pipe and PEP Pipe
2- In most cases the Galvanized Pipe indicated on this table occurred during acquisitions during these periods

## Expected Life of Pipe Material

Based on information developed by American Water Works Association for the "Buried No Longer" report released in February 2012, Table 4 provides an estimated expected service life for pipes of varying material. The expected life was determined based on operating experiences of water utilities and insight from research with typical pipe conditions based on pipe material and varying conditions of age and size.

| Table 4 – Average Expected Life of Pipe Material | | | | | | |
|---|---|---|---|---|---|---|
| Material Types | | | | | | |
| Cast Iron Unlined | Cast Iron Lined | Asbestos Cement | PVC | Ductile Iron | Galvanized | Concrete |
| 110 yrs | 100 yrs | 90 yrs | 55 yrs | 80 yrs | 70 yrs | 105 yrs |

This table is a simplification of reality since the life of the pipe is also impacted by the pipe material, soil properties, installation practices and climate conditions. Kentucky American has experienced that pipe life depends on many variables, such as soil conditions and installation practices, rather than just the age of the pipe itself. The company has had many pipes last longer than the typical service life indicated, but has had other pipes fail sooner than expected. For the purpose of this report and due to the lack of specific data that allows the company to develop an understanding of each condition that affects each pipe segment in the system, the average life expectancy provides a reasonable approximation of the replacement rate.

Using the average expected life for Kentucky American's distribution system indicates that the pipe that has been installed over the past 130 years will need to be replaced over the next 85 years to ensure that the system is maintained within the expected life of the networks pipe material.

## Importance of Replacing Mains

Access to clean reliable water is critical for the communities served and has become an intrinsic responsibility of those who manage the water infrastructure throughout the world. Safe drinking water is important to the health and economic welfare of a community. The ability to obtain clean water, free of contaminants, reduces sickness and related health costs. In addition, the ability to access a sufficient supply creates economic opportunities throughout the community.

As the water distribution system begins to reach its useful life, failures in the infrastructure begin to occur that impact the ability to provide safe and reliable service to the community. Neglecting this aging infrastructure will increase the frequency of water main breaks and leaks, leading to the corrosion of surrounding utility pipes, disrupting automobile, pedestrian and public transportation and stymieing local economic activity.

Although most of these breaks are minor, serious ruptures can and do occur.   With these serious breaks the impact can be catastrophic due to flooding of streets and sidewalks, and in some instances flooding of local businesses and basements of local residents.  In rare instances, the loss of water can undermine pavement or building foundations that can lead to the failure of pavements or the loss of a building that can result in significant property damage and serious injuries.

We have seen numerous examples of serious failures over the past few years that have affected major metropolitan areas.  On June 18, 2015 Louisville Water Company experienced a break on a 60-inch water main that impacted 33,000 customers and caused the road to buckle, breaking apart huge pieces of pavement that floated and damaged vehicles in the area. The break also caused damage in adjacent parking lots and impacted the ability of the local residents to continue with their regular routine.

This break followed a 48-inch water main break during April 24, 2014 near the intersection of Eastern Parkway and Baxter Avenue that caused the intersection to be closed for at least 6 days.  The break sent water cascading down Baxter Avenue, flooding Tyler Parks and nearby yards.  In addition, the break flooded athletic fields on the University of Louisville campus and caused concerns for participants of athletic camps who were on the fields at the time of the break.

One of the most significant breaks of 2015 was a water main break near the University of California in Los Angeles on July 29 that caused massive street flooding and damage on the campus.  The break caused the loss of more than 20 million gallons during the 3 and half hours that it required to turn off the main.  The water flooded into the university and entered numerous buildings and structures causing significant damage. Firefighters saved up to five people that were stuck in underground parking structures and trapped more than 730 cars with half of the vehicles being entirely submerged.

Kentucky American Water has not seen these dramatic of main breaks over the past few years, but it has seen several main breaks that have not only caused impact to the adjacent area that is surrounding the break but has also caused traffic disruptions and inconveniences due to repair activities. Some of these breaks have resulted in business disruptions and economic impact to the community.

The American Society of Civil Engineers study “Failure to Act,” released in 2012 on the economic impact of under-investing in our water and wastewater infrastructure, the authors estimated that remaining on the current track will cost American businesses and households $216 billion in increased costs between now and 2020, and the cumulative loss to our gross domestic product (GDP) will be $400 billion, directly due to deteriorating water infrastructure. Without additional investment in the infrastructure, almost 700,000 jobs will be threatened due to unreliable water delivery and wastewater treatment services.

The impact of a water main break is mostly a localized impact, with the exception of large main breaks that impact a large portion of the community or the loss of the service to the entire community. The loss of water through leaking pipe as the infrastructure ages is an impact that affects the entire community, most of the time with no one knowing it is occurring. This loss of water typically manifests itself in an increase in “non-revenue water.” A high level of non-revenue water affects the financial viability of water utilities through lost revenues and increased operational costs. Although Kentucky American Water’s non-revenue water is at or below the industry standard, there is concern that over time the ability to manage non-revenue water would be impacted without a systematic approach for replacing aging infrastructure.

Other than the impact of pipe failure, the aging infrastructure also impacts the ability to provide adequate service to our customers and the system’s ability to meet fire flow requirements. A majority of this older infrastructure was installed during a period where the expectations or requirements for fire service and household appliances were not as great as we see it today. In some cases, deposits within the pipes have also reduced its ability to provide adequate water flow for customer uses and fire service.

Replacement of the infrastructure enhances the system’s ability to meet the service expectations of the customers. The ability to replace this aging infrastructure allows the company to provide improved service to the customer and usually improves fire protection. In addition, the areas of the system that are replaced are made more robust and are more resilient during periods of high demands and reduces the number service disruptions.

The investment in replacing the infrastructure allows for a more robust system that enhances the ability of the community to compete for new business and industries, which is an important economic benefit to the community. According to the U.S. Conference of Mayors, every dollar invested in water infrastructure adds $6.35 to the national economy.

## Previous Review of Network

During 2009, Kentucky American Water commissioned Gannett Fleming to conduct an Analysis of Non-Revenue Water for the system as ordered by the Commission as part of Case No. 2007-00134. A part of that analysis was a determination if there was a correlation or trend in the occurrence of main breaks and leaks in the Central Division. The analysis was conducted on 1,927 main breaks reported from January 2000 to October 2008.

Review of the main break data indicated that a majority of breaks (82%) in the system during this period were reportedly caused on Ground Shift/Other. Age and Deterioration was reported to be the cause of approximately 10% of the breaks. Pressure Surge, Tree Roots, and Clamp Failure were reported to be collectively the cause of the remaining 8% of the breaks during the period of January 2000 to October 2008.

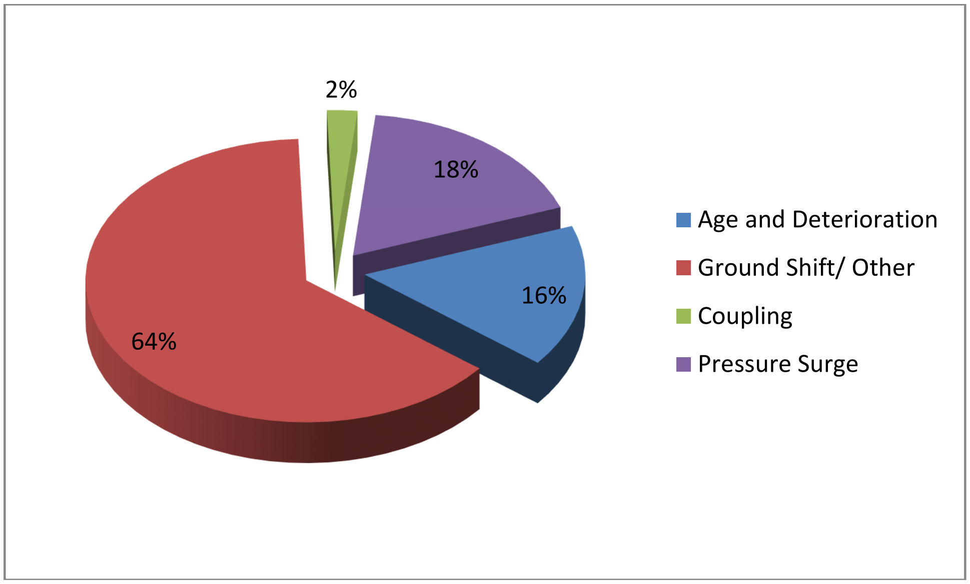
The main breaks that were reportedly caused by Age and Deterioration or Ground Shift/Other occurred on unlined cast iron main 53% of the time and, in particular, a significantly high percentage of reported breaks associated with age and deterioration occurred on unlined cast iron mains 37% of the time. The analysis indicated that the highest percentage of breaks caused by Ground Shift/Other occurred on unlined cast iron main and asbestos cement main (34% and 26%, respectively).

The analysis by Gannett Fleming found that replacing specific main sizes or types of material that exhibit a high concentration of breaks would not have a substantial impact on reducing non-revenue water. Gannett Fleming concluded that other factors should be considered with regard to replacement of problematic main rather than trying to control non-revenue water.

During the review of the main break history, Gannett Fleming found that the highest concentration of reported main breaks occurred on unlined cast iron. The concentration of reported main breaks on galvanized steel main was also significantly higher than the system average of 0.9 breaks per mile of main. Gannett Fleming suggested that a main replacement program targeting unlined cast iron main and galvanized steel main, specifically those less than 4 inches in diameter, should be considered to reduce the occurrence of main breaks.

## Current Review of Network

Review of the main break history from January 2012 to December 2016 indicated that there have been 837 breaks during this period, averaging about 167 per year. Similar to the finding of the 2009 Gannett Fleming report, the current break history indicates that 64% of the main breaks are caused by ground shift. This percentage decreased from 82%, while the age and deterioration breaks increased to 16% compared to 10% during the past review. Although a small increase, it is an indication that the distribution system is aging and we would expect to see an increase in these types of breaks as the age of the mains increases.



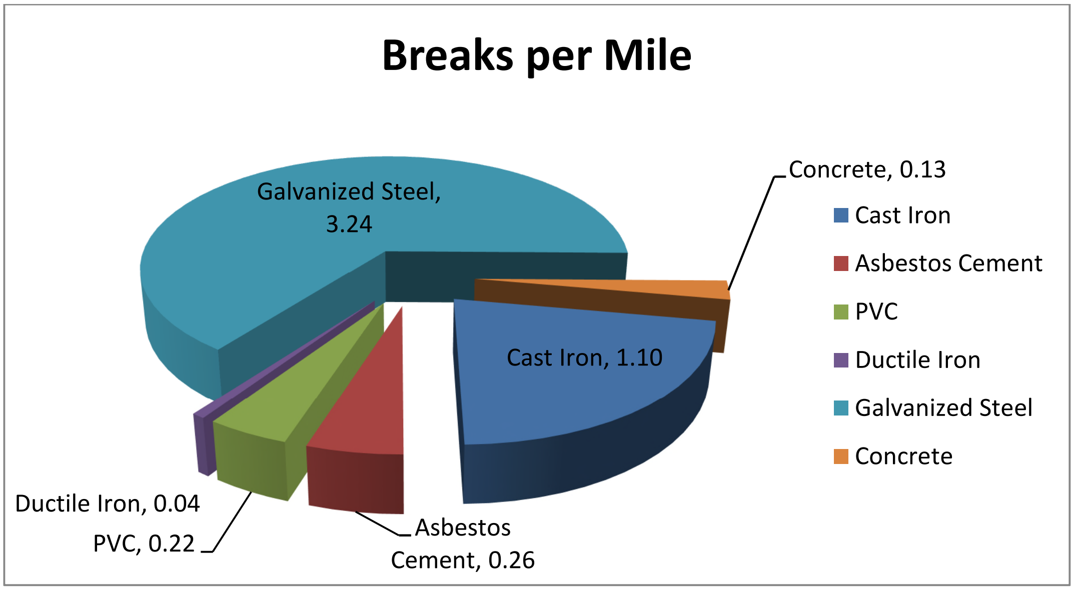

The average number of breaks per year has decreased from 222 per year for the period of January 2000 to October 2008 to 167 per year for January 2012 to December 2016. This reduction is indicative of the main replacement work conducted following 2008 that specifically targeted mains with high break incidents.

Review of the reported breaks from January 2012 to December 2016 indicates that main breaks on cast iron main represented 60% of all of the breaks. Since cast iron main lined and unlined material only represents 15.9% of the total inventory of mains in the ground, the break rate on this type of material is significantly higher than the other material in the system.

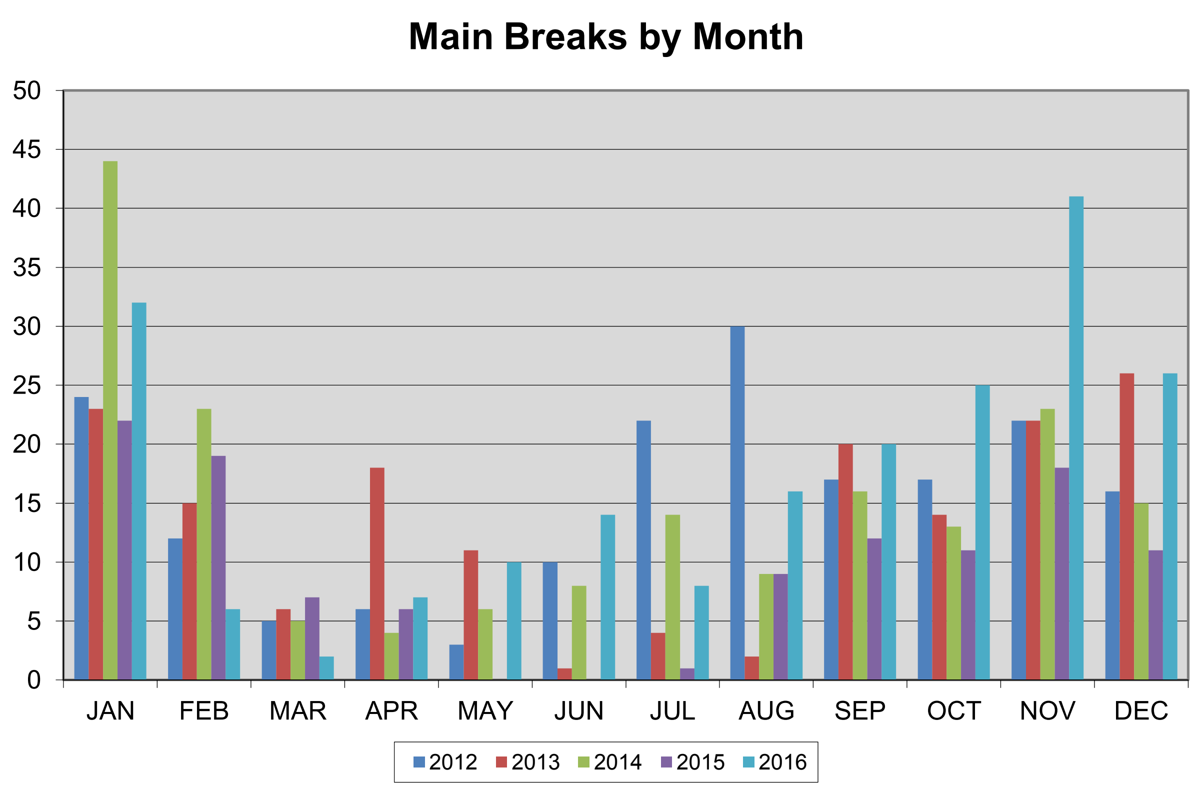
**Table 5 – Breaks by Material**

| Material Types | | | | | |
|---|---|---|---|---|---|
| Cast Iron | Asbestos Cement | PVC | Ductile Iron | Galvanized | Concrete |
| 60.1% | 15.5% | 16.4% | 6.2% | 1.3% | 0.5% |

The break rate per mile of main shows that cast iron main had a break rate of 1.1 breaks per mile of main compared to ductile iron which saw a break rate of 0.04 breaks per mile of main from January 2012 to December 2016. The worst performing material was galvanized steel which had a break rate of 3.24 breaks per mile of main.




Another area reviewed in the main break data from January 2012 to December 2016 indicated that 52% of the breaks occur between November to February of each year with the lowest break period being during May and June. Analysis of the break reports would support that ground shift breaks cause the most failure of the pipe material and we would expect to see the ground shifts occur during the November to February time frame. It should be noted that the high break occurrence that is observed in July and August of 2012 is believed to be caused by ground shift breaks that occurred following high rain events during each of those months.



With ground shift breaks being 64% of the overall breaks that occurred during January 2012 to August 2015, this would correlate with pipe materials that are susceptible to ground movement or shifting being at greater risk than other materials. Cast iron and galvanized steel are not resilient to tension and bending forces that result in ground shifting and contribute to the higher break per mile numbers that the system has experiencing.

Cast iron and galvanized steel are good at controlling internal forces and crushing forces that were generally used during the design stage when this material was placed into service. However, the industry gained the knowledge that cast iron and galvanized steel were susceptible to bending forces and encouraged the introduction of other materials. Materials such as ductile iron and PVC handle these types of forces and as such are more resilient to this type of ground movement. This resulted in the water utility industry standardizing on ductile iron and PVC and moving away from cast iron and galvanized steel.

## Current Replacement Effort

Following the Gannett Fleming report in 2009, the replacement effort was predominantly driven by mains that exhibit high break frequency, relocations and requests by operations to replace mains to address multiple repair trips to the same main. During the period of 2009 to 2013 the average spend on main replacement projects was $2.6 million per year. The main replacement projects replaced all types of material that were experiencing high break frequencies, but the majority of the type of main replaced during this period was cast iron main. With this effort the amount of cast iron main replaced in the system was 10.7 miles with an average of 2.1 miles a year.

In 2014 there was a renewed effort to review the distribution infrastructure and start to address the aging infrastructure needs of the system. During 2014 and through 2016 the average spend on main replacement projects was $3.7 million per year. Based on this current effort the amount of cast iron main replaced in the system from January 2014 through December 2016 was 11.2 miles with an average of 3.7 miles per year.

Since 2009 the main replacement work has replaced 21.9 miles of cast iron main from the system and replaced it primarily with ductile iron main. This represents a replacement rate for cast iron main of 2.7 miles per year during the 8 year period including the accelerated rate of 3.7 miles per year over the past 3 years from 2014 and 2016. While this is making significant progress, it is still not enough to address the rapidity aging distribution system. At the current rate over the past few years it would take approximately 86.4 years to replace the reminaing 320 miles of the cast iron main in the distribution system. At the end of the 86 year period the possible age of a cast iron main could be 220 years old or over twice the life expectancy for this type of material.

## Main Replacement Criteria Development

With the renewed effort to review the distribution system in 2014, Kentucky American Water analyzed the methodology for planning main replacement to ensure that the distribution system could meet the needs of its customers and developed ways to reduce the failure rate of mains. The previous method of determining main replacement was based on break history and requests from the operations group on which mains to replace was determined to be too limited in determining the most critical mains to replace.

With the understanding that continued enhancement of the Kentucky American Water system would require a systematic replacement plan to ensure that the right mains were being replaced at the right time, the company established a goal in 2013 to research and develop tools to assist in developing the plan.

The first step was to develop the criteria that would be used to assess the existing mains and develop a list of mains that were in critical need of being replaced. It was determined that a main replacement assessment standard would require adoption of several criteria to determine which mains would need to be replaced. Development of the assessment standard considered the inclusion of eight criteria that played a major role in providing reliable service and were a good indicator of the condition of the main. These criteria are included in Table 6.

During development of the criteria it was determined that several of the criteria had interrelationships with each other and contributed to the performance of a section of water main. One of the interrelationships was main size and fire flow. In addition, it was determined that leaks can also be related to the age and material of the mains, and material types can be related to the water quality aspect of the main.

Due to the interrelationships of the eight criteria, the team established relative weights for each criterion to ensure that the targeted drivers for the main are given greater consideration. Age, material type, low pressure, number of breaks and water quality were the primary criteria that would be used to determine main replacement. These criteria allowed the main replacement program to ensure that mains that were not meeting the needs of the community and customers were addressed quickly.

Along with the criteria weighting, the assessment contains a rating standards for each of the eight criteria. A numeric rating of between 1 and 5 was used for each criterion – with 1 being the better rating and 5 being the worst rating.

| TABLE 6 - MAIN REPLACEMENT CRITERIA | | | | | | |
|---|---|---|---|---|---|---|
| ***Criteria (Max. Points)*** | ***Weight*** | ***Rating*** | | | | |
| | | ***1*** | ***2*** | ***3*** | ***4*** | ***5*** |
| | | | | | | |
| Low Pressure (75) | 15x | 50 psi or greater | 50 psi to 45 psi | 45 psi to 40 psi | 40 psi to 35 psi | < 35 psi |
| Number of Breaks/Leaks (75) | 15x | 0 breaks/5-year avg. | 1-2 breaks/5-year avg. | 3-4 breaks/5-year avg. | 5-6 breaks/5-year avg. | < 6 breaks/5-year avg. |
| Fire Flow (50) | 10x | Greater than 1,500 gpm (Blue) | 1,500 to 1,000 gpm (Green) | 999 gpm to 500 gpm (Yellow) | Less than 500 gpm (Red) | Known problems |
| Age (75) | 15x | 1995 or later | 1980 to 1994 | 1970 to 1979 | 1960 to 1969 | 1959 and prior |
| Material Type (75) | 15x | DI/RCP | PVC/HDPE | Transite/AC | CI/CLCI | Gal. / Steel |
| Size of Main (50) | 10x | 8 inch and above | 6 inch | 4 inch | 2 inch to 3 inch | Main smaller than 2 inch |
| Water Quality (75) | 15x | Flushing but not routine | Monthly Flushing | Bi weekly Flushing | Weekly (or more frequent) Flushing | Continuous Flushing (w/ discussion) |
| Customer Impact (25) | 5x | less than 2 customers | 2 to 10 customers | 11 to 20 customers | greater than 20 customers | School/Hospital (Critical Customer) |

An electronic database was developed to assist in the assessment and prioritization of the replacement mains and subsequent development of replacement schedules. The database is designed to perform the necessary queries and calculations to determine the main section overall rating and ranking. Initially 62 mains were entered into the database as a pilot to ensure that the assessment tool was capturing the critical needs of the system and identified the more critical sections to replace.

During most of 2013 through 2016 this initial list has provided a schedule for which mains are in need of replacement and provided a schedule that has been used to guide the main replacement program.

As with any tool, there are still external drivers that influence the main replacement program. These external items such as roadway paving schedules, weather or construction considerations are combined with the results of the assessment tool to make adjustments in the replacement program. This combination of tools and subjective considerations allows for a more reactive replacement program that is in concert with the community and allows for efficient use of available resources.

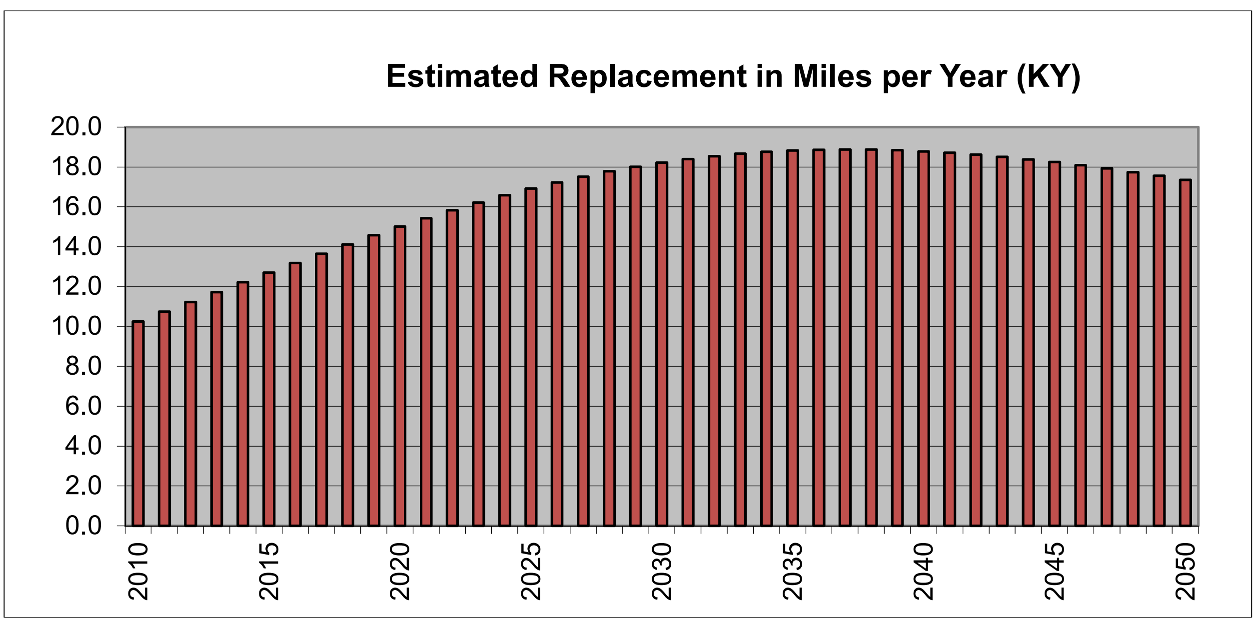
## Nessie Model

While the assessment tool provides a numerical approach of determining the critical mains to replace, the company needed to determine the overall scope and financial impact over a longer planning horizon. The company looked for tools that could provide assistance in determining the capital needs for water main replacement in the coming years that considered the life expectancy of the infrastructure.

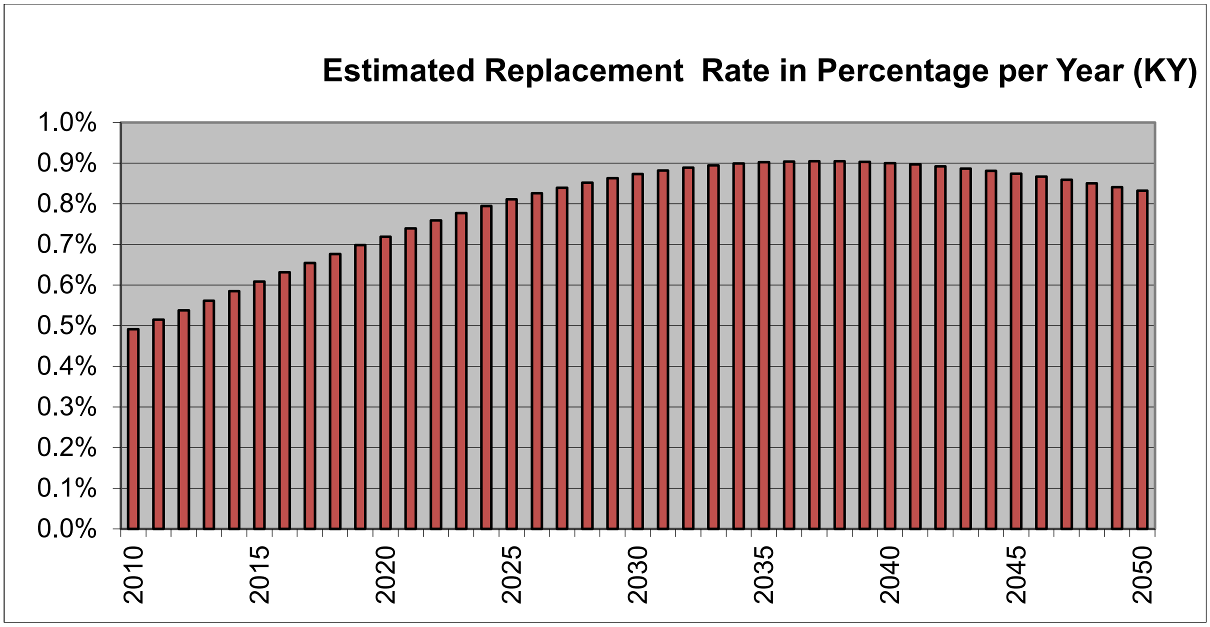
The American Water Works Association report "Dawn of the Replacement Era" developed a process that created a "Nessie Curve" for the 20 systems it reviewed in the report. The Nessie Curve, so called because the graph follows an outline this is likened to a silhouette of the Loch Ness Monster, provided a visual representation of the capital needs during a defined time frame to rebuild the underground infrastructure of the 20 systems. With the report "Buried No Longer," AWWA further developed the analysis of the underground infrastructure and developed the "Nessie Model."

The model uses pipe failure probability distributions based on past research with typical pipe conditions at different ages and sizes coupled with the indicative costs to replace each size and type of pipe, as well as the cost to repair the projected number of pipe breaks over time. The model projects the "typical" useful service life of the infrastructure based on pipe inventories of the system and estimates how much pipe of each type should be replaced in each of the coming 40 years.

Kentucky American Water utilized the model to provide an insight into the replacement rate suggested during the 40 year planning horizon. The chart below provides the estimated replacement in miles of main per year that peaks to 19 miles per year by 2034.

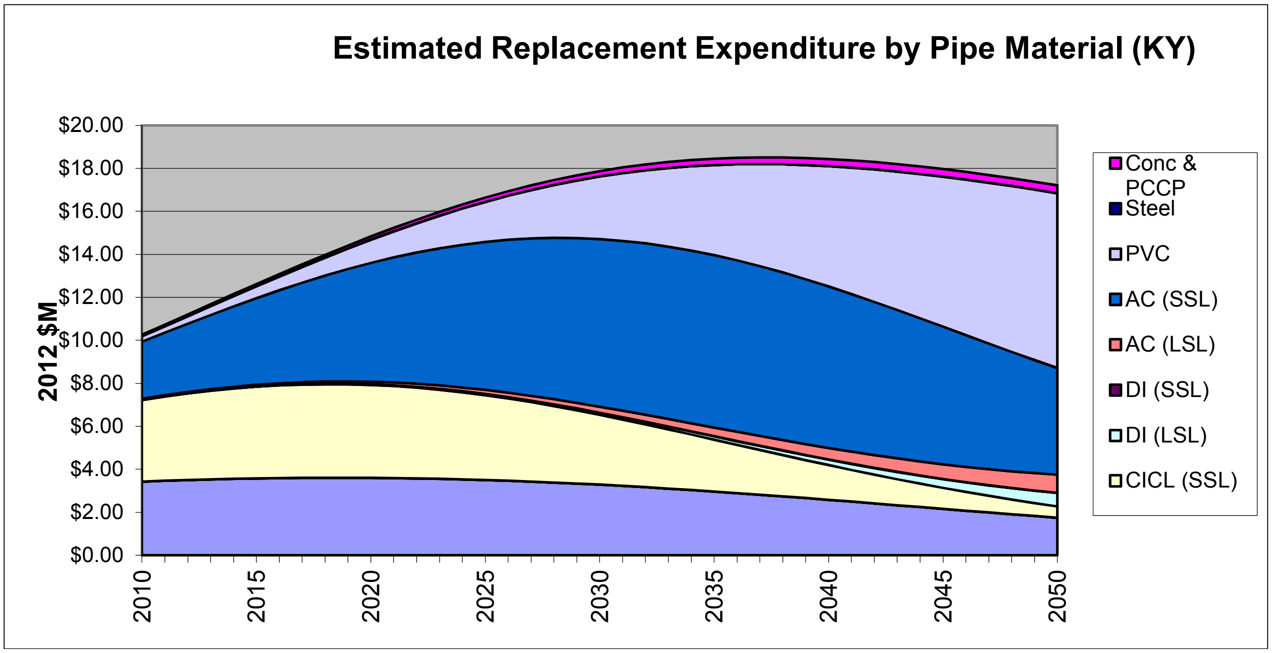


The analysis of the distribution system with the estimated replacement rate of 10 to 19 miles of main per year translates into a replacement rate of 0.49 to 0.90 as percent of the system per year. This estimated replacement rate in percentage of the distribution system per year from 2010 to 2050 is indicated on the chart below.




The model then combines the amount of infrastructure that should be replaced with the typical cost to replace the mains to create an estimate of the total investment cost for the 40 year planning horizon. The model represents this data through a series of Nessie Curves to depict the suggested amount of spending required to replace the main at the optimal life cycle for each material type.

The Nessie Model provides an insight on the amount of capital that is suggested to ensure that the distribution system is being replaced to account for the useful life of the distribution mains. The chart below provides the Nessie Curve developed by the model over a 40 year time frame of the estimated capital needed to replace the appropriate pipe material in the system based on the materials' useful life.




The model identifies that cast iron main is the material that needs to be replaced initially followed by asbestos cement. During the 40 year period the model projects that during the first 20 years approximately $6 to $8 million each year is needed for cast iron main replacement declining to $3 million during the final 20 years. At the same time the model suggests that asbestos cement main be replaced at a rate of $3 to $7 million each year during the 40 year period. In the outer years of the planning horizon, replacement of PVC main and ductile main begin to be shown as a need in order to address the life expectancy of those material types.

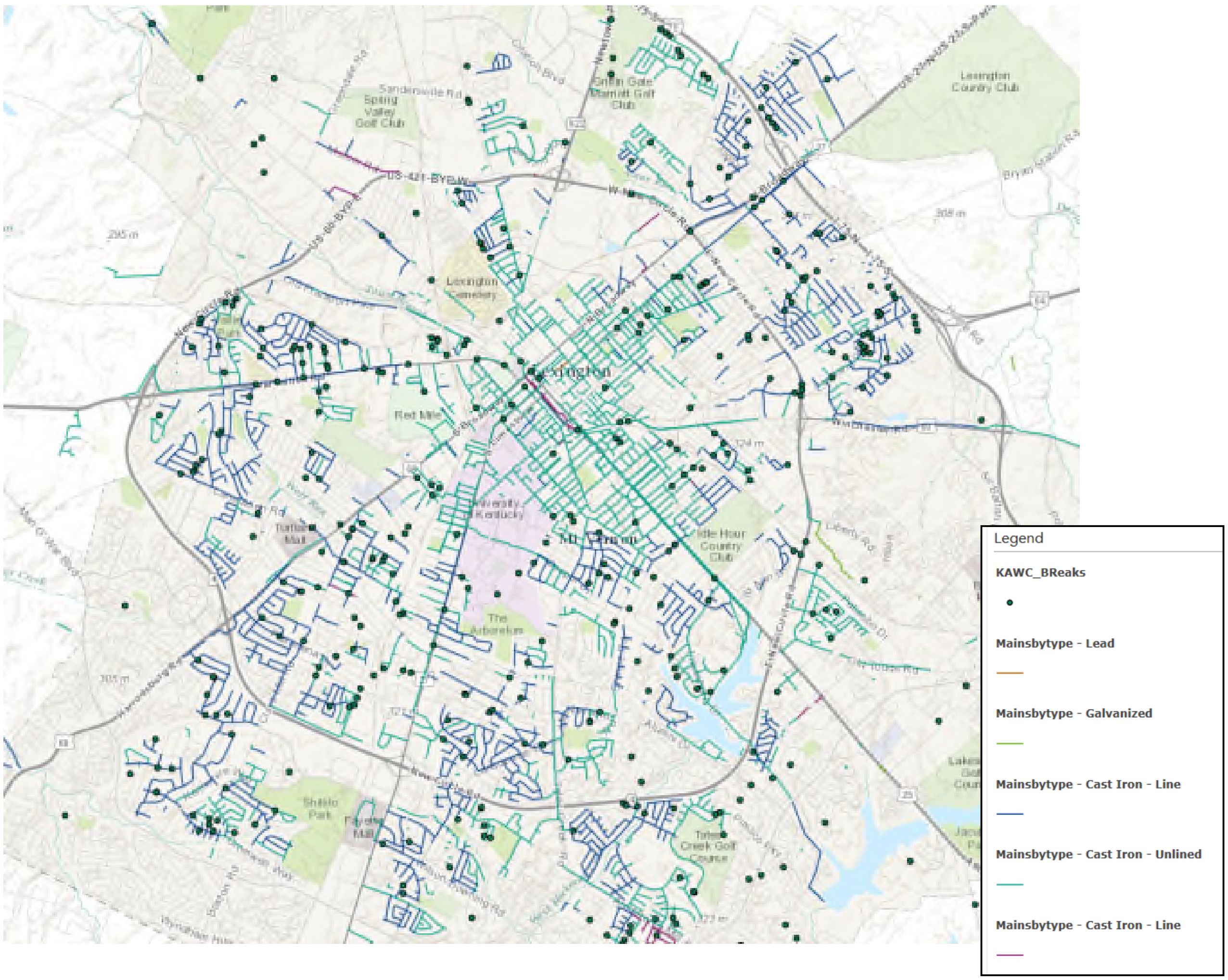
The curve reflects an "echo" of the original trends that shaped the development of the system starting in 1885. The identified capital needs is a reflection of the main installed nearly a century ago that have created a future obligation to replace the mains as they reach their useful life that is now coming due.

## Proposed Accelerated Replacement Plan

Kentucky American recognizes that the past rate of replacement of aging mains the company has employed is not sufficient to address the increased replacement rate that will be required over the coming decades. The need to begin to rebuild the distribution infrastructure that was bequeathed to us by earlier generations is essential to maintain the needs of the community and customers.

Upon review of the distribution system and the material types used in the development of the system, Kentucky American believes that the first materials that need to be replaced in the system are cast iron main and galvanized steel. These two materials represent approximately 16.1% of the distribution system but account for approximately 61.4% of all main breaks in a given year.

The company utilized its Graphical Information System (GIS) to query the main breaks during the period of January 2012 to August 2015 against the main types in the system and found that empirical data from the database is depicted graphically. The following map shows the main breaks during the 2012 to 2015 period against cast iron and galvanized steel main.




The map identifies two items rather definitively. The first is that a majority of the cast iron main was installed during the first half of the development of Lexington. The map clearly shows that a majority of downtown Lexington remains cast iron and to the most extent unlined cast iron. In addition, with the development of the community away from downtown, the map shows those subdivisions during this period that cast iron was used as the predominate material to serve these areas. It is interesting to note that a majority of the development during the time was within the inner circle, with only small pockets of development along the outside of the circle.

The second item that the map shows is the correlation of the main breaks within the areas that are predominately cast iron and galvanized steel. The remaining main breaks shown on the map are scattered throughout the system and have no indication that there are significant trouble spots from the other distribution system material types at this time.

Based on the information reviewed by the company over the past few years and the data developed for this report, a majority of the mains that are susceptible to breaks are cast iron and galvanized steel. Kentucky American believes that the best course at this time is to target this type of pipe material over the next 25 years for replacement. The replacement of this type of material allows the company to address underperforming mains and reduce the impact of main breaks in the areas served by this type of material. A review of several replacement periods was reviewed and illustrated in Table 7, indicating that a 15 year plan would cost $20.2 to $12.6 million annually and a 30 year period would cost $9.6 to $6.3 million per year.

| TABLE 7 - POSSIBLE REPLACEMENT RATES FOR CAST IRON | | | | |
|---|---|---|---|---|
| Period Length | 15 year | 20 year | 25 year | 30 year |
| Miles Replaced per year | 21 - 16 | 16 -12 | 13 - 10 | 10 - 8 |
| Cost per year (million) | $20.3 to $12.6 | $15.5 to $9.5 | $12.6 to $6.9 | $9.6 to $6.3 |

Analysis of the four possible replacement rates lead the company to believe that a 25 year replacement period was more realistic. The 30 year replacement rate would result in a greater overlap of replacement activity between the completion of the cast iron main replacement and the start of the asbestos cement main replacement period.

With the 15 year and the 20 year replacement periods the removal of the cast iron main was removed from the system quicker and allows for the effort to replace asbestos cement to begin sooner. However, the amount of capital required per year was a concern with respect to support from the community. In addition, the level of capital commitment per year for the 15 year and 20 year replacement rates could have a negative impact on Kentucky American’s ability to address other infrastructure replacement needs such as water treatment components at the water treatment plants that are also entering the end of their useful life.

Finally, the amount of mile of replacement main per year of 16 and 12 miles for the 15 year and 20 year replacement rates is a concern for the impact on available resources to complete the construction each year. The 15 year replacement rate is a fourfold increase in the amount of main replaced during 2014 to 2016. This increase would be a significant strain on the available company and contractor resources and would require a substantial increase in labor and equipment creating a concern about sustainability.

Through a 25 year replacement period, the 320 miles of cast iron main will be replaced at a rate of 13 to 10 miles per year at an expected cost of $12.6 to 6.9 million per year. At the conclusion of the 25 year replacement period for cast iron, the company will start to focus on the replacement of the 339 miles of asbestos cement pipe, the earliest of which was installed during 1935, which will mean it will be entering its 105$^{th}$ year of useful life.

## Conclusion

Thanks to the work of past generations that developed and built the water distribution system to support the growth of our community, we have enjoyed access to clean water and economic advantages that it has provided. Because these water mains last a long time, however, we have never had to replace a significant amount of pipe on a large scale. We are on the edge of the period when these mains are reaching their useful life and future generations will need to undertake large scale replacement efforts to ensure that we continue to benefit from our access to clean water.

It is important that instead of entering this period with a careless plan that only address the system as it fails, we undertake a prioritized renewal of the mains to ensure that our water infrastructure can reliably and cost-effectively support the public health, safety, and economic vitality of our community.

Kentucky American believes that with the replacement of cast iron and galvanized steel main through a 25 year replacement period is important to ensure the company can responsibly enter into the period of water infrastructure renewal. Through careful prioritization and looking at emerging technology, the cost of replacing main just prior to failure will be of significant benefit to the community. Through the reduction of the number of failures the system experiences, we can reduce property damage, disruption of businesses and the community, and waste of our water resources. We can help ensure our future generations continue to benefit from access to reliable clean water that will support the economic growth of the community.

## Resources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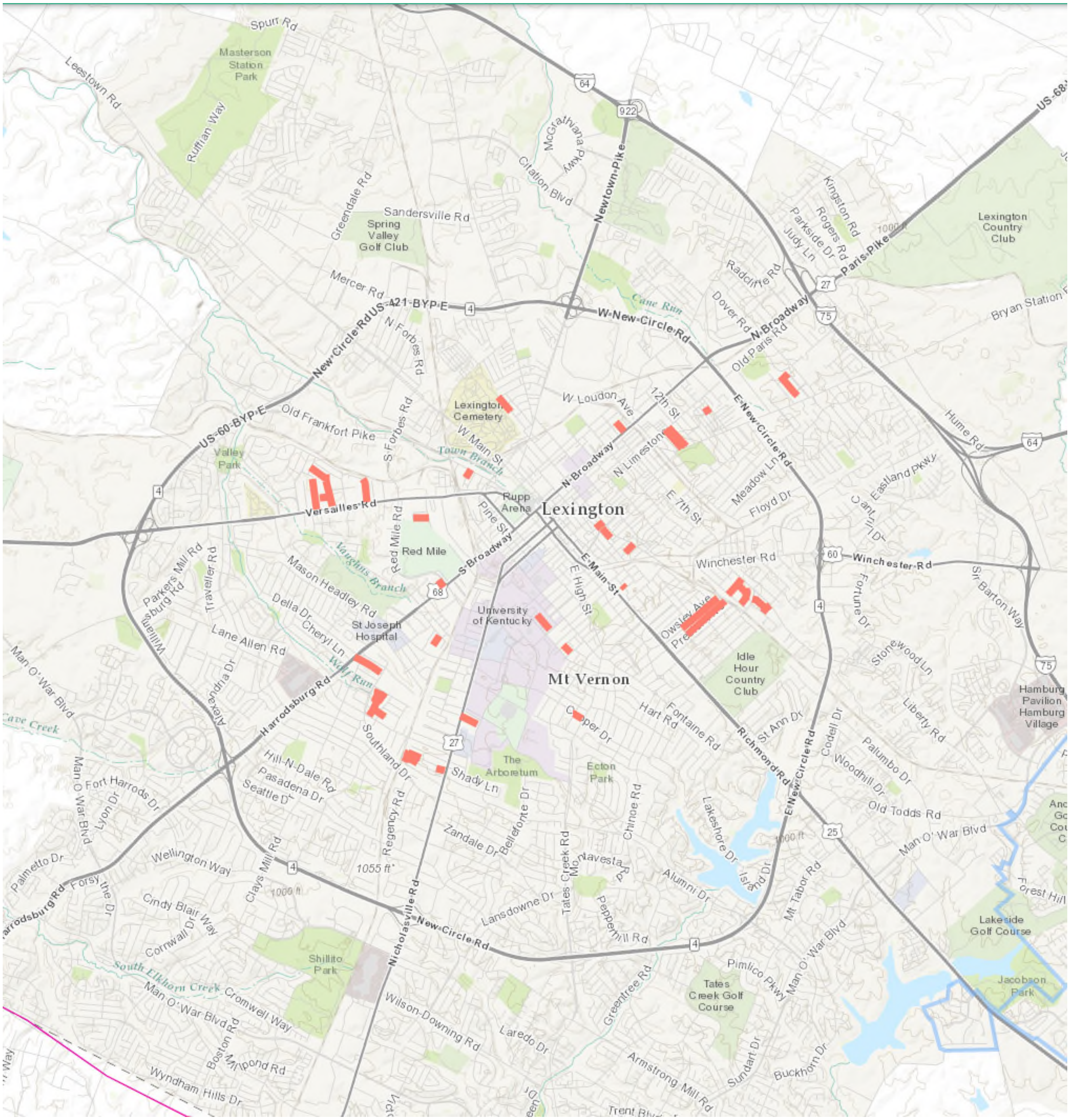
USEPA, 2000. The Infrastructure Investment Gap Facing Drinking Water and Wastewater Systems. Office of Water, Washington.

# APPENDIX

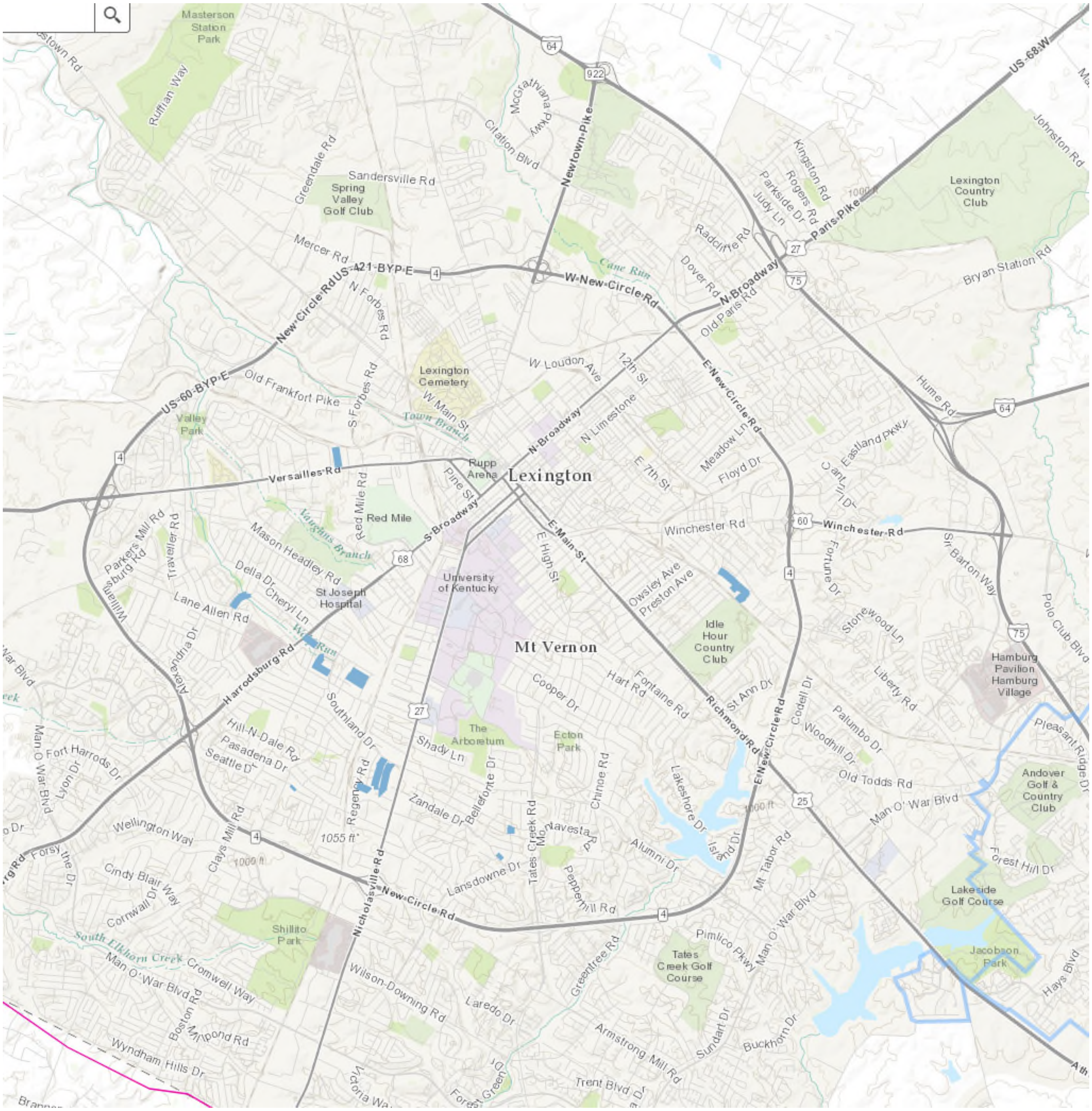
KENTUCKY AMERICAN WATER

# Projected Year One Projects For Main Replacement Program



| PROJECTED YEAR ONE PROJECTS FOR MAIN REPLACEMENT PROGRAM | | | |
|---|---|---|---|
| PROJECT NUMBER | PROJECT LOCATION | AMOUNT OF MAIN TO BE REPLACED (FEET) | ANTICIPATED COST |
| 1 | 600 BLOCK SAYRE AVE | 212 | $31,800 |
| 2 | 900 BLOCK WHITNEY AVE | 1,030 | $154,500 |
| 3 | 200 BLOCK PERRY ST | 466 | $69,900 |
| 4 | 1000 BLOCK KASTLE RD | 512 | $76,800 |
| 5 | 1200 BLOCK EMBRY AVE | 536 | $80,400 |
| 6 | 200 BLOCK SPRUCE ST | 624 | $93,600 |
| 7 | 200 BLOCK HAMILTON PARK | 978 | $146,700 |
| 8 | 300 BLOCK GUNN ST | 184 | $27,600 |
| 9 | 100 BLOCK SHAWNEE PL | 568 | $85,200 |
| 10 | 200 BLOCK WARNOCK ST | 492 | $73,800 |
| 11 | 600 BLOCK ORCHARD AVE | 380 | $57,000 |
| 12 | 100 BLOCK AVON AVE | 1,340 | $201,000 |
| | 100 BLOCK BURNETT AVE | | |
| 13 | 1400 BLOCK CAMDEN AVE | 1,082 | $162,300 |
| 14 | 100 BLOCK WABASH DR | 3,160 | $474,000 |
| | 1800 BLOCK PENSACOLA DR | | |
| | 200 BLOCK LACKAWANNA RD | | |
| | 180 WABASH DR | | |
| | 140 WABASH DR | | |
| 16 | 200 AND 300 BLOCK  LINCOLN AVE | 3,928 | $589,200 |
| 17 | 200 TO 400 BLOCKS OF PRESTON AVE | 2,452 | $367,800 |
| 18 | 300 BLOCK  RICHMOND AVE | 814 | $122,100 |
| | 200 BLOCK WHITE AVE | | |
| 19 | 300 BLOCK PENNSYLVANIA CT | 1,422 | $213,300 |
| 20 | 300 BLOCK  STRATHMORE RD | 1,436 | $215,400 |
| 21 | 100 BLOCK GARRETT AVE | 968 | $145,200 |
| 22 | 200 BLOCK GARRETT AVE | 1,508 | $226,200 |
| 23 | 300 BLOCK N PICADOME PARK | 1,648 | $247,200 |
| 24 | 600 BLOCK COOPER DR | 218 | $32,700 |
| 25 | 1300 BLOCK WILLOWLAWN AVE | 438 | $65,700 |
| 26 | 400 BLOCK UHLAN CT | 768 | $115,200 |
| 27 | 100 DELMONT DR | 1,052 | $157,800 |
| 28 | 200 BLOCK E VISTA ST | 1,260 | $189,000 |
| 29 | 200 BLOCK W VISTA ST | 1,204 | $180,600 |
| 30 | 100 BLOCK E VISTA ST | 1,502 | $225,300 |
| 31 | 400 BLOCK MORRISON AVE | 608 | $91,200 |
| 32 | 200 BLOCK LINWOOD DR | 948 | $142,200 |
| 33 | 500 BLOCK MCCUBBING DR | 2,290 | $343,500 |
| 34 | 1100 BLOCK SPARKS RD | 2,358 | $353,700 |
| 35 | 600 BLOCK LAGONDA AVE | 1,980 | $297,000 |
| 36 | 7OO BLOCK APPLETREE LN | 980 | $147,000 |
| 37 | 1600 BLOCK CLAYTON AVE | 1,644 | $246,600 |
| **ANTICIPATED YEAR TOTAL** | | 42,990 | $6,448,500 |

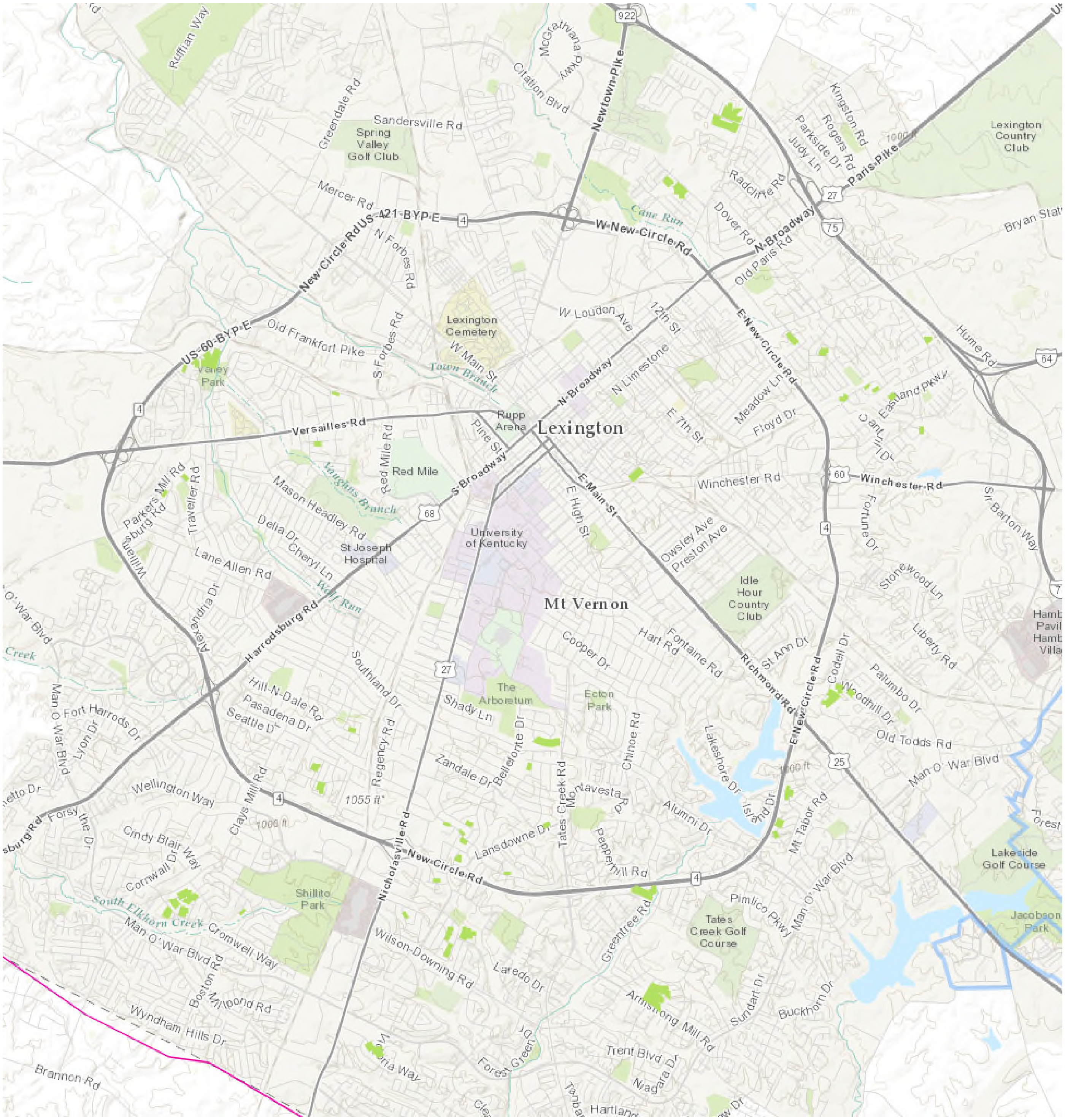
**Projected Year Two Projects**
**For Main Replacement Program**



<table>
<tr><th colspan="4">PROJECTED YEAR TWO PROJECTS FOR MAIN REPLACEMENT PROGRAM</th></tr>
<tr><th>PROJECT NUMBER</th><th>PROJECT LOCATION</th><th>AMOUNT OF MAIN TO BE REPLACED (FEET)</th><th>ANTICIPATED COST</th></tr>
<tr><td>1</td><td>1600 BLOCK COURTNEY AVE</td><td>1,490</td><td>$223,500</td></tr>
<tr><td rowspan="2">2</td><td>EMERY CT</td><td rowspan="2">2,058</td><td rowspan="2">$308,700</td></tr>
<tr><td>1600 BLOCK COURTNEY AVE</td></tr>
<tr><td>3</td><td>600 BLOCK BLUE ASH DR</td><td>940</td><td>$141,000</td></tr>
<tr><td>4</td><td>200 BLOCK KOSTER DR</td><td>1,860</td><td>$279,000</td></tr>
<tr><td>5</td><td>200 BLOCK NORWAY ST</td><td>1,702</td><td>$255,300</td></tr>
<tr><td>6</td><td>100 BLCOK HALLS LANE</td><td>1,626</td><td>$243,900</td></tr>
<tr><td>7</td><td>LONE OAK DR</td><td>3,468</td><td>$520,200</td></tr>
<tr><td rowspan="3">8</td><td>2000 BLOCK RAINBOW RD</td><td rowspan="3">1,508</td><td rowspan="3">$226,200</td></tr>
<tr><td>200 BLOCK DERBY DR</td></tr>
<tr><td>2000 BLOCK REBEL RD</td></tr>
<tr><td>9</td><td>4800 BLOCK BOONE LN</td><td>3,762</td><td>$564,300</td></tr>
<tr><td>10</td><td>1100 BLOCK N CLEVELAND RD</td><td>5,356</td><td>$803,400</td></tr>
<tr><td>11</td><td>5400 BLOCK BRIAR HILL RD</td><td>4,280</td><td>$642,000</td></tr>
<tr><td>12</td><td>4400 BLCOK HALEY RD</td><td>50</td><td>$7,500</td></tr>
<tr><td>13</td><td>4600 BLOCK TODDS RD</td><td>3,496</td><td>$524,400</td></tr>
<tr><td>14</td><td>3500 BLOCK ROLLING HILLS CT</td><td>610</td><td>$91,500</td></tr>
<tr><td>15</td><td>5000 BLOCK SULPHUR LN</td><td>1,462</td><td>$219,300</td></tr>
<tr><td>16</td><td>5200 BLOCK WINCHESTER RD</td><td>5,423</td><td>$813,450</td></tr>
<tr><td>17</td><td>5400 BLOCK WINCHESTER RD</td><td>230</td><td>$34,500</td></tr>
<tr><td>18</td><td>1900 BLOCK BEACON HILL RD</td><td>1,576</td><td>$236,400</td></tr>
<tr><td>19</td><td>3100 BLOCK BRECKENWOOD DR</td><td>356</td><td>$53,400</td></tr>
<tr><td>20</td><td>LAMONT CT</td><td>226</td><td>$33,900</td></tr>
<tr><td>21</td><td>700 BLOCK LANDSDOWNE CIR</td><td>314</td><td>$47,100</td></tr>
<tr><td>22</td><td>3500 BLOCK MADDOX LN</td><td>2,732</td><td>$409,800</td></tr>
<tr><td colspan="2">ANTICIPATED YEAR TOTAL</td><td>44,525</td><td>$6,678,750</td></tr>
</table>

KENTUCKY AMERICAN WATER

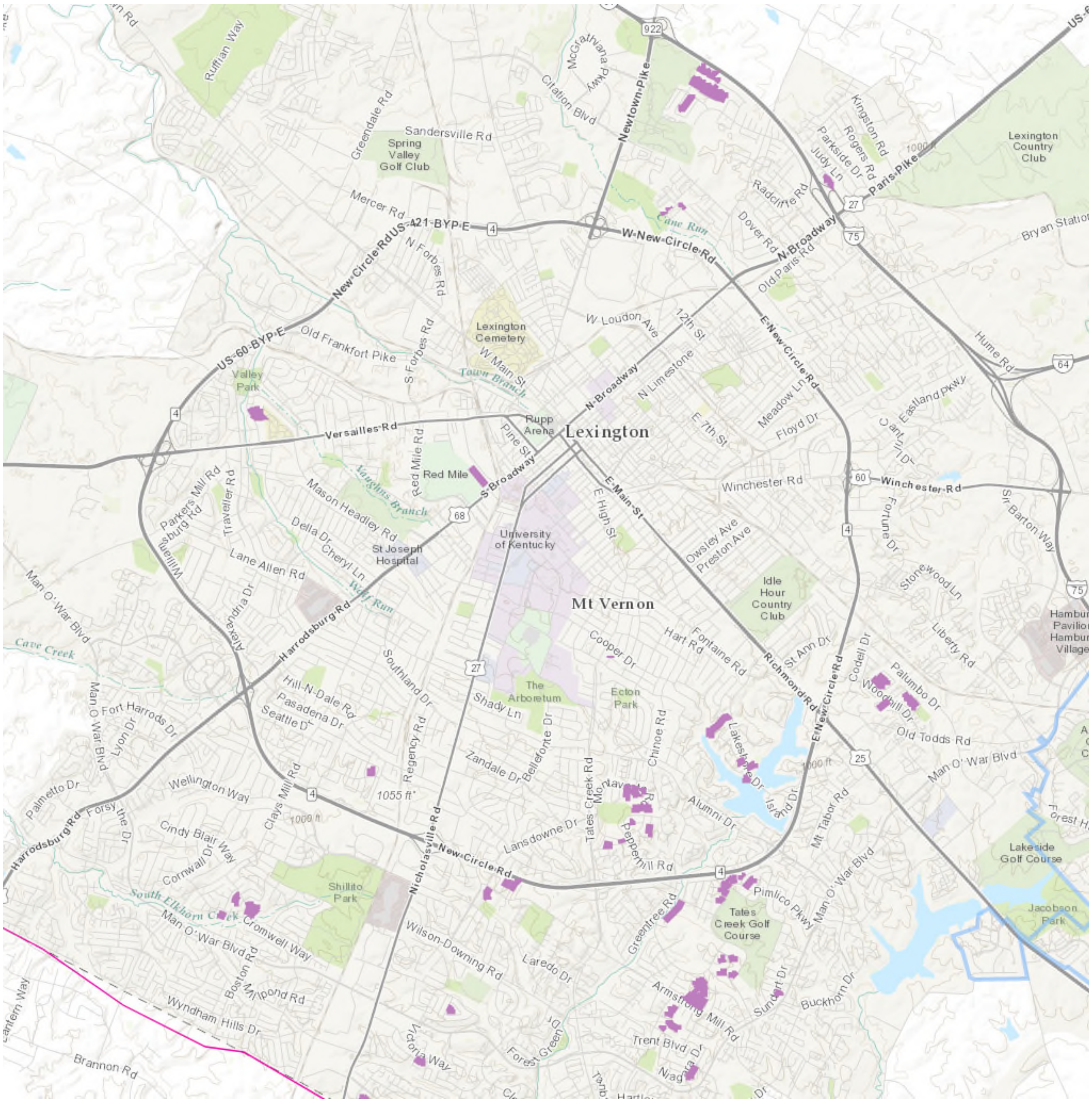
**Projected Year Three Projects**
**For Main Replacement Program**



| PROJECTED YEAR THREE PROJECTS FOR MAIN REPLACEMENT PROGRAM | | | |
|---|---|---|---|
| **PROJECT NUMBER** | **PROJECT LOCATION** | **AMOUNT OF MAIN TO BE REPLACED (FEET)** | **ANTICIPATED COST** |
| 1 | 100 BLOCK NEW ZION RD | 2,302 | $345,300 |
| 2 | SAMUEL LN | 1,156 | $173,400 |
| 3 | TILLYBROOK CT | 624 | $93,600 |
| 4 | 3200 BLOCK RAVEN CIRCLE | 360 | $54,000 |
| 5 | MALABU CT<br>HUNTER CIRCLE<br>HEATHER CT<br>300 BLOCK BELVOIR DR | 1,556 | $233,400 |
| 6 | 200 BLOCK BRADFORD CIR | 352 | $52,800 |
| 7 | SHIRLEE CT | 372 | $55,800 |
| 8 | OLD DOBBIN RD | 482 | $72,300 |
| 9 | DELMONT CT | 168 | $25,200 |
| 10 | 1300 BLOCK HIALEIAH CT<br>1300 BLOCK HOT SPRINGS CT<br>1300 BLOCK KEENELAND CT | 1,682 | $252,300 |
| 11 | CROSS KEYS CT | 490 | $73,500 |
| 12 | 200 BLOCK LEWIS ST | 260 | $39,000 |
| 13 | THISTLETON CIRCLE | 522 | $78,300 |
| 14 | EDINBURGH CT | 258 | $38,700 |
| 15 | CROYDEN CT<br>SHEFFIELD CT | 942 | $141,300 |
| 16 | 100 BLOCK GENTRY RD | 176 | $26,400 |
| 17 | 100 BLOCK N CLEVELAND RD | 238 | $35,700 |
| 18 | 7300 BLOCK OLD RICHMOND RD | 646 | $96,900 |
| 19 | WILLIAMSBURG CT | 368 | $55,200 |
| 20 | WOODSIDE CIRCLE | 304 | $45,600 |
| 21 | 600 BLOCK TATESWOOD DR | 340 | $51,000 |
| 22 | RANGE CT | 672 | $100,800 |
| 23 | GREENLAWN CT<br>JADE CIRCLE<br>KIMBERLITE CT<br>GRANITE CIRCLE | 1,438 | $215,700 |
| 24 | DURHAM CT | 504 | $75,600 |
| 25 | 100 BLOCK COLLEGE ST | 1,098 | $164,700 |
| 26 | GAYLE CIRCLE | 388 | $58,200 |
| 27 | SAYBROOK CT | 282 | $42,300 |
| 28 | WAYCROSSE CIRCLE<br>SHILOH CT | 676 | $101,400 |
| 29 | KELSEY CT<br>KELSEY PL<br>YARMOUTH CT<br>1100 BLOCK KILRUSH DR | 1,694 | $254,100 |
| 30 | CRICKLEWOOD CT | 340 | $51,000 |
| 31 | 1100 BLOCK APPIAN CROSSING WAY | 978 | $146,700 |
| 32 | 600 BLOCK CARDIGAN CT<br>3500 BLOCK BERWIN CT<br>3400 BL0CK IPSWICH CT | 1,416 | $212,400 |
| 33 | 3400 BLOCK FLINTRIDGE CIRCLE | 426 | $63,900 |
| 34 | 500 BLOCK FOLKSTONE DR | 302 | $45,300 |
| 35 | 1100 BLOCK GREENTREE CT<br>GREENTREE PL<br>GREENTREE CIRCLE | 1,252 | $187,800 |

| PROJECTED YEAR THREE PROJECTS FOR MAIN REPLACEMENT PROGRAM | | | |
|---|---|---|---|
| PROJECT NUMBER | PROJECT LOCATION | AMOUNT OF MAIN TO BE REPLACED (FEET) | ANTICIPATED COST |
| 36 | KING ARTHUR CT<br>3400 BLOCK KING ARTHUR DR | 1,272 | $190,800 |
| 37 | PADDOCK CT | 436 | $65,400 |
| 38 | TANNER CT | 438 | $65,700 |
| 39 | PENWAY CT | 438 | $65,700 |
| 40 | 400 BLOCK PLAINVIEW RD | 248 | $37,200 |
| 41 | 100 BLOCK TORONTO DR<br>4000 BLOCK VICTORIA WAY<br>4000 BLOCK VICTORIA WAY<br>200 BLOCK TORONTO RD | 1,286 | $192,900 |
| 42 | 2600 BLOCKI WINBROOKE LN | 408 | $61,200 |
| 43 | 2800 BLOCK MIDDLESEX CT | 778 | $116,700 |
| 44 | 700 BLOCK HILL RISE CT | 542 | $81,300 |
| 45 | 1500 BLOCK HALSTED CT<br>KILDARE CT<br>KIRK CT | 2,420 | $363,000 |
| 46 | 800 BLOCK GENTRY LN | 1,236 | $185,400 |
| 47 | 200 BLOCK MULBERRY RD<br>OSAGE CT<br>2500 BLOCK BUTTERNUT HILL CT | 1,148 | $172,200 |
| 48 | BLACKARROW CT | 730 | $109,500 |
| 49 | BARBADOS LN<br>3100 BLOCK TABAGO CT<br>2700 BLOCK MARTINIQUE LN | 2,508 | $376,200 |
| 50 | 1800 BLOCK COLCHESTER DR<br>FELTNER CT<br>1800 BLOCK BOWEN CT<br>1800 BLOCK BARKSDALE DR<br>1800 BLOCK COLCHESTER DR | 2,484 | $372,600 |
| 51 | HAVELOCK CIR<br>600 BLOCK SAGINAW CT<br>3400 BLOCK ALDERSHOT DR | 1,614 | $242,100 |
| 52 | KILKENNY CT | 932 | $139,800 |
| **ANTICIPATED YEAR TOTAL** | | 43,982 | $6,597,300 |

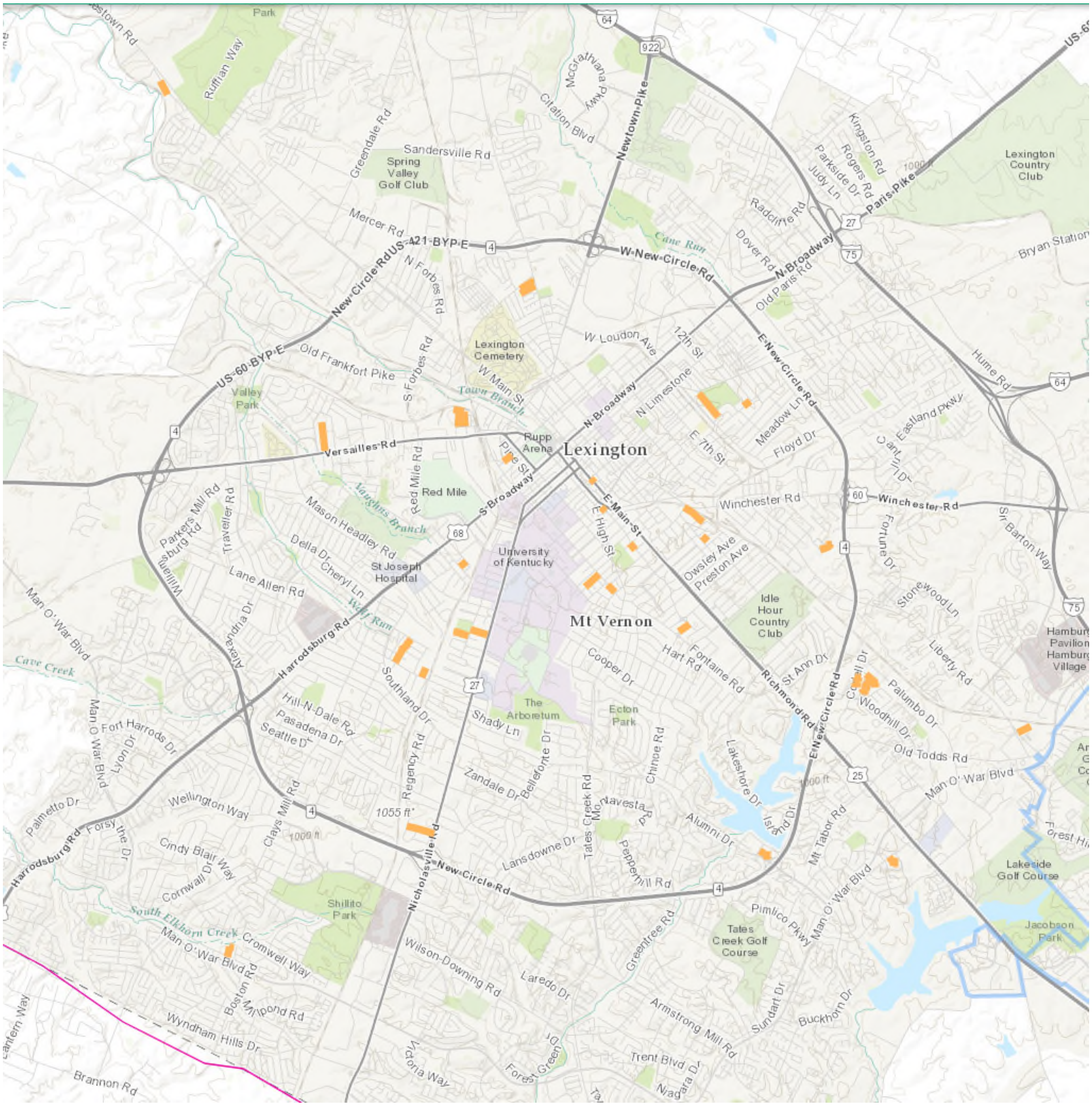
## Projected Year Four Projects
## For Main Replacement Program



| PROJECTED YEAR FOUR PROJECTS FOR MAIN REPLACEMENT PROGRAM | | | |
|---|---|---|---|
| PROJECT NUMBER | PROJECT LOCATION | AMOUNT OF MAIN TO BE REPLACED (FEET) | ANTICIPATED COST |
| 1 | 3100 BLOCK OLD CROW CT<br>3100 BLOCK CLAIR RD<br>MONTAVESTA CT | 1,916 | $287,400 |
| 2 | 2000 BLOCK CUMMINS CT<br>2000 BLOCK DANIEL CT | 758 | $113,700 |
| 3 | 400 BLOCK CURRY AVE | 468 | $70,200 |
| 4 | 4000 BLOCK LILYDALE CT<br>4000 BLOCK WHITEMARK CT | 1,634 | $245,100 |
| 5 | 3500 BLOCK ORMOND CIR | 636 | $95,400 |
| 6 | 1900 BLOCK RITTENHOUSE CT | 328 | $49,200 |
| 7 | 2400 BLOCK PLUMTREE CT<br>2400 BLOCK THORNBERRY CT | 1,236 | $185,400 |
| 8 | 1200 BLOCK MAYWOOD PARK<br>1200 BLOCK OAKLAWN PARK<br>1200 BLOCK TANFORAN DR<br>1200 BLOCK NARRAGANSETT PARK<br>LATONIA PARK<br>3200 BLOCK WATERFORD PARK | 2,744 | $411,600 |
| 9 | 200 BLOCK KELLY CT | 1,352 | $202,800 |
| 10 | 600 BLOCK FOGO CT<br>600 BLOCK CREWE CT<br>3400 BLOCK FRASERDALE CT<br>3400 BLOCK BIRKENHEAD CIR | 2,020 | $303,000 |
| 11 | LOOKOUT CIR<br>2900 BLOCK MONTAVESTA RD | 866 | $129,900 |
| 12 | WEM CT | 562 | $84,300 |
| 13 | 4100 BLOCK WINNIPE CT | 630 | $94,500 |
| 14 | 400 BLOCK WOODLAKE WAY | 250 | $37,500 |
| 15 | 3200 BLOCK WOOD VALLEY CT | 256 | $38,400 |
| 16 | 3500 BLOCK SUTHERLAND DR | 1,020 | $153,000 |
| 17 | 3500 BLOCK NIAGRA DR | 688 | $103,200 |
| 18 | 3300 BLOCK MOUNDVIEW CT | 434 | $65,100 |
| 19 | LISA CIR<br>MONA CT | 912 | $136,800 |
| 20 | MARGO CT<br>KAREN CT | 1,846 | $276,900 |
| 21 | VERSIE CT<br>JANNELLE CT | 1,270 | $190,500 |
| 22 | 200 BLOCK HEDGEWOOD CT | 512 | $76,800 |
| 23 | TAMMY CT<br>LAVERNE CT<br>GREVEY CT<br>HARRIS CT | 2,726 | $408,900 |
| 24 | GRANT CT<br>HOLLOW CREEK CT<br>GRANT PL | 1,034 | $155,100 |
| 25 | GRAIG CT | 626 | $93,900 |
| 26 | LYNNWOOD CT<br>WOODSTON CT<br>CLEARWOOD CT | 1,746 | $261,900 |
| 27 | 3600 BLOCK CAYMAN LN<br>JAMAICA CT | 1,574 | $236,100 |

| PROJECTED YEAR FOUR PROJECTS FOR MAIN REPLACEMENT PROGRAM | | | |
|---|---|---|---|
| **PROJECT NUMBER** | **PROJECT LOCATION** | **AMOUNT OF MAIN TO BE REPLACED (FEET)** | **ANTICIPATED COST** |
| 28 | WATERS EDGE PL<br>2000 BLOCK HARMONY CT<br>2100 BLOCK BRIDGEPORT DR | 1,580 | $237,000 |
| 29 | 1600 BLOCK COSTIGAN DR<br>1900 BLOCK LEITNER CT<br>1900 BLOCK BEDINGER CT<br>1900 BLOCK COBYVILLE CT<br>900 BLOCK VALLEY FARM DR<br>1900 BLOCK CHRIS DR | 3,536 | $530,400 |
| 30 | 3400 BLOCK BELLMEADE RD<br>3400 BLOCK WARWICK CT | 884 | $132,600 |
| 31 | 1300 BLOCK OX HILL DR<br>BASS CT | 758 | $113,700 |
| 32 | 1200 BLOCK ASCOT PARK<br>1200 BLOCK BEULAH PARK<br>1300 BLOCK ATOKAD PARK<br>1300 BLOCK GOLDEN GATE PARK<br>1200 BLOCK AK-SAR-BEN PARK | 1,594 | $239,100 |
| 33 | BRANDON CT | 418 | $62,700 |
| 34 | SWOONALONG CT<br>PERSONALITY CT<br>1300 BLOCK CANONERO DR<br>GUNBOW CT<br>PERSONALITY CT | 2,350 | $352,500 |
| 35 | 3500 BLOCK GINGERTREE CIR | 484 | $72,600 |
| 36 | KENIL CT | 138 | $20,700 |
| 37 | 2000 BLOCK VON LIST WAY | 2,156 | $323,400 |
| **ANTICIPATED YEAR TOTAL** | | 43,942 | $6,591,300 |

Projected Year Five Projects
For Main Replacement Program



| PROJECTED YEAR FIVE PROJECTS FOR MAIN REPLACEMENT PROGRAM | | | |
|---|---|---|---|
| **PROJECT NUMBER** | **PROJECT LOCATION** | **AMOUNT OF MAIN TO BE REPLACED (FEET)** | **ANTICIPATED COST** |
| 1 | TREPASSEY CT | 808 | $121,200 |
| 2 | 100 BLOCK WESTGATE DR | 2,022 | $303,300 |
| 3 | 100 BLOCK MOORE DR | 170 | $25,500 |
| 4 | 3300 BLOCK PITTMAN CREEK CT | 634 | $95,100 |
| 5 | 4700 BLOCK HUFFMAN MILL PIKE | 56 | $8,400 |
| 6 | 300 BLOCK ROBERTSON ST<br>1100 BLOCK MARTIN AVE<br>300 BLOCK FERGUSON ST<br>300 BLOCK ANDERSON ST<br>300 BLOCK ROBERTSON ST | 3,476 | $521,400 |
| 7 | 3200 BLOCK BRACKTOWN RD | 1,946 | $291,900 |
| 8 | 400 BLOCK BRADLEY CT | 1,602 | $240,300 |
| 9 | 100 BLOCK CASTLEWOOD DR | 1,152 | $172,800 |
| 10 | 800 BLOCK CAMPBELL LN | 1,184 | $177,600 |
| 11 | 600 BLOCK CENTRAL AVE | 362 | $54,300 |
| 12 | 100 BLOCK CHELAN CT | 700 | $105,000 |
| 13 | 700 BLOCK E EUCLID AVE | 378 | $56,700 |
| 14 | 200 BLOCK E MAIN ST | 478 | $71,700 |
| 15 | 200 BLOCK SOUTHPORT DR | 2,672 | $400,800 |
| 16 | TIMBERHILL CT<br>ELDERBERRY CT | 858 | $128,700 |
| 17 | HEATON CT<br>2400 BLOCK MIRAHILL DR<br>2400 BLOCK WINDWOOD CT | 1,042 | $156,300 |
| 18 | 1400 BLOCK ELIZABETH ST<br>100 BLOCK FOREST PARK RD | 2,352 | $352,800 |
| 19 | 200 BLOCK WESTWOOD CT | 1,364 | $204,600 |
| 20 | 100 BLOCK WESTWOOD DR | 1,640 | $246,000 |
| 21 | 1100 BLOCK FERN AVE | 1,896 | $284,400 |
| 22 | 1000 BLOCK FLOYD DR | 232 | $34,800 |
| 23 | 400 BLOCK GREENWOOD AVE | 1,280 | $192,000 |
| 24 | 800 BLOCK JOHNSDALE DR | 552 | $82,800 |
| 25 | 3200 BLOCK HALEY RD | 1,616 | $242,400 |
| 26 | 500 BLOCK LONGVIEW DR | 94 | $14,100 |
| 27 | 400 BLOCK MACADAM DR<br>600 BLOCK ROSEMILL DR | 2,604 | $390,600 |
| 28 | 3400 BLOCK MCFARLAND LN | 3,650 | $547,500 |
| 29 | 500 BLOCK MCKINLEY ST | 308 | $46,200 |
| 30 | 500 BLOCK MERINO ST | 542 | $81,300 |
| 31 | 300 BLOCK MEMORY LN | 396 | $59,400 |
| 32 | 600 BLOCK MONTGOMERY AVE | 226 | $33,900 |
| 33 | 700 BLOCK NATIONAL AVE<br>900 BLOCK NATIONAL AVE | 1,242 | $186,300 |
| 34 | 1100 BLOCK OAK HILL DR | 470 | $70,500 |
| 35 | 300 BLOCK OLD VINE ST | 162 | $24,300 |
| 36 | 2100 BLOCK PAIGE CT | 358 | $53,700 |
| 37 | 400 BLOCK PARK AVE | 634 | $95,100 |
| 38 | 500 BLOCK PINE ST | 382 | $57,300 |
| 39 | 200 BLOCK RIDGEWAY RD | 556 | $83,400 |
| 40 | 1400 BLOCK RUSSELL CAVE RD | 210 | $31,500 |
| **ANTICIPATED YEAR TOTAL** | | 42,306 | $6,345,900 |