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September 13, 2019

VIA ELECTRONIC FILING

Brinda Westbrook-Sedgwick
Commission Secretary
Public Service Commission
of the District of Columbia
1325 "G" Street, N.W., 8th Floor
Washington, D.C. 20005

Re: Formal Case Nos. 1142, 1115 and 1154 – Newly Redacted Public CBA - Commitment No. 54

Dear Ms. Westbrook-Sedgwick:

Transmitted for filing is a newly redacted public version of the PROJECTpipes – Cost Benefit Analysis prepared by Jacobs Consultancy.

If you have any questions regarding this matter, please feel free to contact me.

Sincerely,

Cathy Thurston-Seignious
Supervisor, Administrative and
Associate General Counsel

cc: Per Certificate of Service

JACOBS Consultancy

PROJECTpipes – Cost Benefit Analysis

Washington Gas Light

PUBLIC VERSION

Prepared By

Christopher Pioli – Principal Consultant

Lindsay Robson – Principal Consultant

September 12, 2019 | rev1

Study No:	61FFET20
Document Title:	PROJECTpipes Cost Benefit Analysis
Client Name:	Washington Gas Light
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Study Manager:	Christopher Pioli
Approved by:	Lindsay Robson

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Executive Summary

Natural gas delivery systems for domestic and commercial uses and for power generation still and will continue to play a key and central role in powering, heating, and feeding the nation, notwithstanding significant and appropriate efforts to find alternative and renewable sources of energy. While we work diligently toward a clean and sustainable energy future, significant investment will be needed to transform systems, delivery means, and transforming consumer homes and businesses. In the interim, it remains in everyone's interest to ensure the safety and ongoing functionality of the natural gas delivery system. Washington Gas, like all other gas utilities in the country, must do their utmost best to see that consumers remain safe, gas is delivered without interruption, and that the mechanical and operating integrity of the system is managed through replacement and modernization programs, in a manner that reduces the environmental impacts. One such program is PROJECTpipes.

This study's scope was to perform a cost-benefit analysis (CBA) for the acceleration of WGL's PROJECTpipes program and minimization of future Grade 1 leaks not caused by excavation damage, as prescribed in the AltGas Ltd and WGL Holdings, Inc. merger settlement agreement (Order No. 19396 FC 1142), Term No. 54. To this end, this analysis covers the acceleration of replacement programs described in PROJECTpipes 1 Plan for the period from 2020 to 2054.

The CBA is an evaluation framework to assess the economics of an investment. Costs and benefits are broadly defined and are quantified in monetary terms to the extent possible. The overall goal of a CBA is to assess whether the expected benefits of a project support the costs.

Our CBA framework defined a Baseline Case and an Accelerated Asset Replacement (AAR) Case. Two common benefit-cost evaluation measures were applied: net present value and benefit cost ratio. The Baseline Case is built on PROJECTpipes 1 Plan programs. Four baseline scenarios and separate CBA were completed on each one. The scenario resulting in the better B/C ratio, segments ranked by Optimain Project Risk, was further evaluated in the AAR case.

The AAR case added mains and services identified in the proposed PROJECTpipes 2 Plan, which were copper services, vintage mechanical coupled mains and services, and low-pressure service change overs (Programs 3, 5, and 8). A separate CBA was completed based on three program durations: 2054, 2052 (10% reduction), and 2048 (20% reduction).

Table 1 and Table 2 provide a summary of the Baseline Case scenarios and AAR Case program costs, program benefits, reductions in GHG emissions and leaks, and cost benefit measures. The cost benefit measures do not include reductions in GHG emissions.

Table 1 - Baseline Case Scenarios CBA Summary

Baseline 2054 Scenarios	Project Risk	EV Mains Leaks	EV Service Leaks	GRID Break
Program Costs				
Construction (Direct Costs)	**$ 2,164,611,961**	**$ 2,395,905,608**	**$ 2,408,946,663**	**$ 2,393,792,486**
Mains	[redacted]	[redacted]	[redacted]	[redacted]
Services	[redacted]	[redacted]	[redacted]	[redacted]
Contingent Pipe	[redacted]	[redacted]	[redacted]	[redacted]
Program Support	[redacted]	[redacted]	[redacted]	[redacted]
Other Cost	[redacted]	[redacted]	[redacted]	[redacted]
Total (Real, 2020$)	**$ 2,589,125,437**	**$ 2,826,392,059**	**$ 2,832,744,571**	**$ 2,822,429,440**
Escalation	[redacted]	[redacted]	[redacted]	[redacted]
Total (Nominal)	**$ 2,746,865,717**	**$ 2,983,312,939**	**$ 2,985,310,555**	**$ 2,978,594,365**
NPV	**$ 1,623,672,333**	**$ 1,688,689,024**	**$ 1,701,800,027**	**$ 1,699,262,135**
Program Benefits				
Avoided Cost Benefits, NPV	**$ 384,281,290**	**$ 384,281,290**	**$ 384,281,290**	**$ 384,284,441**
Capital Spending	[redacted]	[redacted]	[redacted]	[redacted]
O&M Spending	[redacted]	[redacted]	[redacted]	[redacted]
Transfers Benefits, NPV	**$ 352,067,534**	**$ 352,067,534**	**$ 352,067,534**	**$ 352,068,070**
Excess Flow Valves	[redacted]	[redacted]	[redacted]	[redacted]
Repaved Streets	[redacted]	[redacted]	[redacted]	[redacted]
GHG Reduction, Metric Tons	**97,420**	**97,420**	**97,420**	**97,421**
Equivalent vehicles	20,684	20,684	20,684	20,684
Leak Reduction				
Grade 1	385.8	385.8	385.8	385.8
All Grades	3650	3,650	3,650	3,650
Cost Benefit Measures				
Net Benefits	**$(1,239,391,043)**	**$(1,304,407,734)**	**$(1,317,518,737)**	**$(1,314,977,695)**
B/C Ratio	**0.58**	**0.55**	**0.55**	**0.55**

Note - Based on the Title 40 CFR 98 – Mandatory Greenhouse Gas Reporting, Subpart W

Table 2 - Accelerated Asset Replacement CBA Summary

AAR Case	Duration 2054	Duration 2052	Duration 2048
Project Costs			
Construction (Direct Costs)	**$ 2,360,536,029**	**$ 2,232,524,744**	**$ 2,232,476,372**
Mains	[redacted]	[redacted]	[redacted]
Services	[redacted]	[redacted]	[redacted]
Contingent Pipe	[redacted]	[redacted]	[redacted]
Program Support	[redacted]	[redacted]	[redacted]
Other Cost	[redacted]	[redacted]	[redacted]
Total (Real, 2020$)	**$ 2,820,754,348**	**$ 2,700,969,117**	**$ 2,727,924,523**
Escalation	[redacted]	[redacted]	[redacted]
Total (Nominal)	**$ 2,992,637,148**	**$ 2,884,182,327**	**$ 2,931,031,183**
NPV	**$ 1,764,407,191**	**$ 1,769,244,889**	**$ 1,859,931,074**
Project Benefits	**Accelerated Asset Replacement**	**Duration 2052**	**Duration 2048**
Avoided Cost Benefits, NPV	**$ 390,391,267**	**$ 427,654,233**	**$ 459,911,924**
Capital Spending	[redacted]	[redacted]	[redacted]
O&M Spending	[redacted]	[redacted]	[redacted]
Transfers Benefits, NPV	**$ 362,283,352**	**$ 382,190,575**	**$ 388,654,154**
Excess Flow Valves	[redacted]	[redacted]	[redacted]
Repaved Streets	[redacted]	[redacted]	[redacted]
GHG Reduction, Metric Tons	**100,387**	**100,383**	**100,382**
Equivalent vehicles	21,314	21,313	21,313
Leak Reduction			
Grade 1	413.1	413.0	412.9
All Grades	3,750	3,580	3,176
Cost Benefit Measures	**Accelerated Asset Replacement**	**Duration 2052**	**Duration 2048**
Net Benefits	**$ (1,374,015,924)**	**$ (1,341,590,655)**	**$ (1,400,019,150)**
B/C Ratio	**0.54**	**0.58**	**0.58**

Note - Based on Title 40 CFR 98 – Mandatory Greenhouse Gas Reporting, Subpart W

This Cost Benefit Analysis presented a study/feasibility level estimate of the PROJECTpipes Plan costs, avoided O&M benefits, and subsequent greenhouse gas emission reductions. A societal benefits analysis report was prepared by another consulting firm for WGL, and subsequently included WGL's application for approval of PROJECTpipes 2 Plan as Exhibit WG (A)-4. The economic benefits cited in the societal benefits analysis report are not included in the benefit results shown in this report. As such, the PROJECTpipes benefit cost ratio of less than 1 and a negative net benefits value would be common.

From the data and information available, the results of this cost benefit analysis for the acceleration of PROJECTpipes and minimization of future Grade 1 leaks (not caused by excavation damages), we conclude:

1. Optimain's Project Risk scenario results in a slightly better B/C ratio over PROJECTpipes' remaining 35 years, compared to the other scenarios. The differences in B/C ratios is small.
2. The PROJECTpipes programs productively target mains and services material that result in all Grade leaks, potentially reducing the number of leaks by 3650, of which 385 could be Grade 1 hazardous leaks.
3. PROJECTpipes reduces greenhouse gas emission by 97,000 – 100,000 metric tons, the equivalent of removing 20,600 to 21,300 gasoline vehicles. This estimate is based on Title 40 CFR 98 – Mandatory Greenhouse Gas Reporting, Subpart W.
4. To complete PROJECTpipes by 2054 requires the year-ending 2024 mains replacement rate of 18,000 feet per year to increase to more than 97,000 feet per year, a 5.4-fold plus increase.
5. Adding copper services, vintage mechanical coupled mains and services, and low-pressure services change overs is advisable; a shortened program duration, while improving the cost benefit B/C ratio, is not advisable based on the level of mains replacement to complete PROJECTpipes by 2054.

During this study, our meeting and analysis led to several recommendations and conclusions that WGL and other stakeholders may consider in the future phases of PROJECTpipes.

1. Compulsory use of Accela, the permitting and licensing system, for planning and coordination by all subsurface facility stakeholders has the potential to reduce/share street paving construction expenditures, which represents $300 – $400 million in PROJECTpipes construction costs alone, as well as reduce other economic impacts of infrastructure improvement on consumers, businesses, government, and utilities.

2. A comprehensive resource study can better assess the capital, workforce, material, equipment, and process requirements, as well as work constraints on meeting an accelerated replacement target date.
3. The ability to provide an elevated pressure system to all customers in WGL's network eliminates discrimination against those currently on low-pressure in the form of foregoing consumer appliance choice, and/or suffering inadequate pressures, or water ingress outages. In addition, an elevated pressure system will allow customers to install higher efficiency appliances.

One final observation, by focusing on leaks as the primary safety risk, WGL is defining risk in a way that is out of sync with other North East and Mid Atlantic gas utilities when it comes to the prioritization of small diameter cast iron pipe (CI). Cast iron tends to break, leading to a catastrophic release of gas. WGL records breaks as a leak and prioritizes replacement according to the number of leaks on CI. The result is reflected in the consequence factor of the Optimain model. Other gas operators treat this as an element of the cause, i.e., the break, and actively prioritize the replacement of small diameter (typically 2-8" diameter CI pipe) along with bare and unprotected steel mains and services.

1. Introduction

Natural gas delivery systems for domestic and commercial uses and for power generation still and will continue to play a key and central role in powering, heating and feeding the nation, notwithstanding significant and appropriate efforts to find alternative and renewable sources of energy. While we work diligently toward a clean and sustainable energy future, we cannot wholly predict what that future will bring in continuing political will, future economic drivers and the reliability of alternate sources of supply. Significant investment will be needed to transform systems, delivery means, and transforming consumer homes and businesses. In the interim it remains in everyone's interest to ensure the safety and ongoing functionality of the natural gas delivery system. Given the age of the system and industry advancements, and the future security of supply, it is essential that society invests in programs such as PROJECTpipes.

Because gas pipes are buried under our cities, consumers and the community at large are often not aware of the natural gas delivery system, and it typically takes an event of some nature to get their attention (e.g., getting home to a cold house, no gas to cook dinner, a leak in the neighborhood). Washington Gas, like all other gas utilities in the country, must do their utmost best to see that consumers can remain unconcerned about their gas supply, and system modernization and aging pipe replacement programs help achieve that worthy aim.

1.1 Scope CBA Study

The scope of this study was to perform a cost-benefit analysis (CBA) for the acceleration of WGL's PROJECTpipes program and minimization of future Grade 1 hazardous leaks not caused by excavation damage. The study terms of reference were prescribed in the AltGas Ltd and WGL Holdings, Inc. merger settlement agreement (Order No. 19396 FC 1142), Term No. 54. The CBA covers the acceleration of replacement programs described in PROJECTpipes 1 Plan for the period from 2020 to 2054.

1.2 PROJECTpipes Plan Overview

PROJECTpipes 1 Plan started on or after June 1, 2014, with the aim to reduce risk and enhance safety by replacing aging, corroded or leaking cast iron mains, bare and/or unprotected steel mains and services; and black plastic services in the distribution system. PROJECTpipes 1 Plan consisted of three distribution asset replacement programs:

- **Program 1** – Replacement of unprotected bare and/or unwrapped steel services.

- **Program 2** – Replacement of unprotected bare and targeted unprotected wrapped steel main.
- **Program 4** – Replacement of cast Iron Main

The proposed PROJECTpipes 2 Plan covering the period of October 1, 2019, through December 31, 2024, consists of 13 programs, i.e., eight (8) distribution replacement programs, as well as five (5) transmission replacement programs. The distribution programs under the proposed plan are as follows:

- **Program 1** – Bare Steel Main and Services (including Contingent Main and Affected Services
- **Program 2** – Unprotected Wrapped Steel Main and Services (including Contingent Main and Affected Services)
- **Program 3** – Vintage Mechanically Coupled Main and Services (including Contingent Main and Affected Services)
- **Program 4** – Cast Iron Main (including Contingent Main and Affected Services)
- **Program 5** – Copper Services
- **Program 6** – Distribution Gauge Lines
- **Program 7** – Regulator Station Enhancements
- **Program 8** – Low-Pressure Service Replacements/Transfers

In PROJECTpipes 2 Plan, Washington Gas intends to replace 22 miles of mains and replace or changeover 8,274 services in its distribution system over the five years of the plan.

2. CBA Framework

The Cost Benefit Analysis (CBA) is an evaluation framework to assess the economics of an investment. Costs and benefits are broadly defined and are quantified in monetary terms to the extent possible. The overall goal of a CBA is to assess whether the expected benefits of a project support the costs.

Our CBA framework defined a Baseline Case and an Accelerated Asset Replacement (AAR) Case. The BCA assesses the net benefits, benefit cost ratio, and the incremental difference between the Baseline Case and the AAR Case. CBAs are forward-looking exercises which seek to assess the incremental change over project life. The importance of future program costs and benefit changes are determined through discounting, which is meant to reflect the opportunity cost of capital.

Our methodology included the following general steps:

- Reviewed the current and proposed PROJECTpipes Plans. The current Programs in PROJECTpipes 1 form the foundation of the Baseline Case.
- Reviewed WGL's Cost Memorandums and filings with supporting AMIS, PowerPlant, and other documentation. Using this information, we established construction unit costs. developed for construction.
- Reviewed operational information. WGL provided a dataset of 37,000 pipe segments with Optimain Risk values, and GIS system data. WGL provided a dataset of 4,060 leak history records from which leak rates of mains and services by material and Leak Grades were derived.
- Reviewed WGL operating procedures manual to identify O&M activities likely impacted by mains and services replacement. WGL provided data and information on the units of work, frequency, and operating costs for the O&M activities.
- Identified four Baseline Case scenarios and a separate CBA completed on each one:
    - Project Risk – Optimain's overall segment risk score.
    - EV Mains Leak – the probability of a leak on the mains segment.
    - EV Services Leak – the probability of a leak on services connected to the mains segment.
    - Grid Breaks – cast iron segments were sorted by grid break history, then pipe diameter, and finally operating pressure. The resulting sorts were ranked by Project

Risk. Base and coated unprotected steel mains segments were ranked by Project Risk. Pipe segments larger than 8” were placed at the end.

- Estimated the risk remove by the segments Risk Mains value.
- Developed an Accelerated Asset Replacement Case based on the baseline case scenario with the highest benefit cost ratio. The AAR Case involved the following:
  - Adding the proposed PROJECTpipes 2 Programs 3, 5, 8, which provides replacement of copper, VMC services, and VMC mains and low-pressure service change-overs. The risks these assets pose to safety and system integrity were documented in the 2018 WGL Distribution Integrity Management Plan.
  - Three PROJECTpipes durations with the years ending in 2054, 2052 (10% reduction), and 2048 (20% reduction). A shorter program duration reduces the threat these higher at-risk assets pose to safety and system integrity.
- Prepared detailed schedules of the following:
  - Units of mains and services remove by type of material by year.
  - Capital direct costs for mains and services by major construction elements (materials, installation, paving, traffic control) and indirect costs (permitting, outside engineering, overheads, program management, construction management, contingency).
  - Project cost escalation of materials and labor.
  - Estimate of the number of leaks reduced for all Grade leaks and Grade 1 hazardous leaks.
  - Avoided costs benefits by O&M activity (leak repair, emergency responses, valve maintenance), and transfer benefits (excess flow valves, paving).
  - Estimate of greenhouse gas emission reduction

The appendix contains copies of the program costs and avoided costs.

Table 3 - Baseline and Accelerated Cases: Duration, Mains, Services

	Bare Steel	Coated Unprotected	Cast Iron
Baseline			
Duration	10 years	35 years	35 years
Mains	110,833 ft	110,833 ft	2,161,986 ft
Services	10,094	6,223 bare	41,441
AAR Duration 2054			
Duration	10 years	35	35
Mains	110,833 ft	110,833 ft 58,080 feet VMC	2,161,986 ft
Services	10,094	6,223 bare 6,072 copper 2,132 VMC	41,441 bare 3,586 LP
AAR Duration 2052			
Duration	9 years	33	33
Mains	110,833 ft	110,833 ft 58,080 feet VMC	2,161,986 ft
Services	10,094	6,223 bare 6,072 copper 2,132 VMC	41,441 bare 3,586 LP
AAR Duration 2048			
Duration	8 years	29 years	29 Years
Mains	110,833 ft	110,833 ft 58,080 feet VMC	2,161,986 ft
Services	10,094	6,223 bare 6,072 copper 2,132 VMC	41,441 bare 3,586 LP

VMC – Vintage Mechanical Coupled

2.1 Base Year, Escalation, and Discount Rate

Base Year is used for comparison of costs. For PROJECTpipes investments, dollar figures in this analysis are expressed in constant 2020 dollars. WGL provided us with cost data in constant 2020 dollars.

Escalation is a percentage that is applied to future years to account for changes in the economy and market volatility. The cost and benefit analysis escalate labor and material costs. Labor escalation was based on WGL construction contract terms. Material escalations were obtained from the Department of Labor Producer Price Index (PPI) and based on the most recent five-year rolling average of the Plastic Pipe and Asphalt PPI Indices. Escalations are applied to the cost of construction materials and paving. The Plastic Pipe escalator is applied to the material component of mains and services construction, including contingent pipe. The asphalt escalator is applied to the asphalt component of paving, which varies between 20% – 40% depending on such factors as project size, tolerance, road type. In this analysis, an asphalt component of 35% is used. The balance, 65%, is escalated at the Labor escalator.

Labor Escalation = 3%
Material, Plastic Pipe Escalation = 2.26%
Material, Asphalt Escalation = 0.85%

Discount rate is a percentage that is applied to future benefits and costs to estimate their present value. The nominal discount rate used in this analysis is 6.5%, consistent with an authorized rate of return for WGL in the District of Columbia.

2.2 Evaluation Period

For purposes of this study, the Baseline Case scenarios' cost and benefit analysis cover a 35-year duration from October 1, 2019, through the end of 2054. This period is less than the expected design or, life of the plastic pipe and that of coated, protected steel pipe, resulting in a cautious estimate of benefits. In the AAR Case, our analysis assumes that mains and services replacements are in-service and all program costs incurred before the scenarios' last year.

All costs are assumed to occur at the end of each year, and benefits begin in the calendar year immediately following the final construction year.

The Company provides the Commission an estimated indirect overhead cost factor used on PROJECTpipes. The indirect overhead cost is included in the total project costs, broken down into estimates of overhead, program management, and construction management.

2.3 Project Costs

PROJECTpipes results in the planning and execution of a suite of programs to improve public safety and system integrity and reduce greenhouse gas emissions. The programs comprise direct and indict costs associated with the replacement of mains, services, and contingent pipe.

2.3.1 Direct Cost

Direct costs cover materials, installation, paving and traffic control. Using data and information provided by WGL, we derived unit costs for each of these construction components.

Table 4 summarizes the mains construction unit cost.

Table 4 – Mains Replacement Unit Cost, 2020$

Material cost				
Diameter	PE Pipe ($/ft)	Valves (each)	Other	$/ft
2	[redacted]	[redacted]	[redacted]	[redacted]
4	[redacted]	[redacted]	[redacted]	[redacted]
6	[redacted]	[redacted]	[redacted]	[redacted]
8	[redacted]	[redacted]	[redacted]	[redacted]
12	[redacted]	[redacted]	[redacted]	[redacted]
16	[redacted]	[redacted]	[redacted]	[redacted]

Installation cost		
Diameter	$/ft of PE	$/mile of PE
2	[redacted]	[redacted]
4	[redacted]	[redacted]
6	[redacted]	[redacted]
8	[redacted]	[redacted]
12	[redacted]	[redacted]
16	[redacted]	[redacted]

Paving	[redacted] per sq. ft.

Traffic Control	[redacted] per project

In developing these main construction costs, we made the following assumptions:

- All mains installation is by open cut in street
- Mains Installation in Road typically requiring <6” Break & Remove

- Mains replaced with PE pipe
- Typical project 850 feet of main (range 800 ft - 2,000 ft)
- Critical Valve 0.86 per mile
- Other Material 4% of Installation + Valves
- Average Pave and Mill 40 ft, width of street
- Labor 65%
- Material 35%

To install mains often requires the replacement of adjacent main, referred to as contingent pipe, to execute the projects. In the PROJECTpipes cost, we estimate that contingent pipe represents 4% of mains replacement.

Table 5 summarizes the service construction unit cost.

Table 5 – Services Replacement Unit Cost, 2020$

	Scattered	Within BCA	Change Over
Materials	[redacted]	[redacted]	[redacted]
Installation	[redacted]	[redacted]	[redacted]
Paving	[redacted]	[redacted]	[redacted]
Traffic Control	[redacted]	[redacted]	[redacted]

In developing these service construction costs, we made the following assumptions:

- Commercial services are >= 2" diameter
- Mains Permits cover services or are not required
- Mains replaced with PE pipe

2.3.2 Indirect Costs

Indirect capital costs include support services (e.g., permitting, outsourced engineering/services) and other (e.g., contingency, overhead). Overhead includes administrative and general (A&G), program management, and construction management. Table 6 lists the percentages used to estimate indirect capital costs.

Table 6 – Indirect Costs, Percentages

Indirect Costs		Note
Permitting	1.0%	Applied to Construction Total
Engineering	3.5%	Applied to Construction Mains
Overhead	19.0%	Applied to Construction and Project Support Total
Contingency	25.0%	Applied to Construction and Project Support Total
Program Management	2.0%	Applied to Construction and Project Support Total
Construction Management	1.75%	Applied to Construction Total

2.4 Project Benefits

Project benefits cover quantitative and qualitative operational benefits, as well as societal benefits. While the CBA includes those operational benefits that can be monetized, the other benefits are equally substantive.

2.4.1 Quantitative Benefits

In this CBA study, the quantitative benefits fall into one of two types: avoided costs or transfer costs. Avoided costs are activities expected to either decrease, such as emergency responses, or increase, such as critical valve inspects as a result of PROJECTpipes programs. Avoided cost of leak costs repairs is dependent in part on both the number of Grade 1 (Hazardous) Leaks, as well as all leak Grades (Hazardous and Non-hazardous). Leak repair savings are cumulative, meaning their value increases over the program's duration.

Table 7 lists the avoided cost benefits, categorized as either avoided capital or avoided O&M.

Table 7 – Avoided Costs Benefits

Avoided Capital Spending	
• Leak Repair ST & CU Services	
Avoided O&M Spending	
• Leak Repairs-Unprotected ST Mains	• Inside Leak Survey
• Leak Repairs- Protected ST Mains	• Emergency Response (Below Ground Leak)
• Leak Repairs-Plastic Mains	
• Leak Repairs-CI Mains	• Pressure Regulator Stations
• Leak Repairs-Plastic Services	• Valve Inspection
• Leak Rechecks	• Drips Drained

Transfer costs benefits are costs incurred in the execution of PROJECTpipes programs that benefit others. We identified two transfer benefits associated with PROJECTpipes: excess flow valves installed as a result of change-overs and street restoration where an entire street is paved.

The potential reduction in greenhouse gas emissions (GHG) is quantified based on the Title 40 CFR 98 – Mandatory Greenhouse Gas Reporting, Subpart W – Petroleum and Natural Gas System. However, GHG reductions were not monetized and not included as a quantified benefit. Our estimate considered the sources of methane emissions for the gas distribution system.

- Gas Distribution Mains – bare and unprotected steel, protected steel, plastic, ductile iron, copper, and cast iron; and
- Gas Service Lines – bare and unprotected steel, protected steel, plastic, and copper.

The emission reduction was estimated using the construction schedule presented in the cost estimate. Emission reductions were credited in the year following completion of the work. The methane emission reduction is quantified in metric tons of CO_2 equivalent number of vehicles removed.

2.4.2 Qualitative Benefits

The qualitative benefits rationale of a project such as PROJECTpipes supports the CBA because it illustrates how and where rate payers, and the community as a whole, benefit from this kind of project. The goal is to identify and attempt to measure these benefits to illustrate how an accelerated main replacement program, which is perhaps better called an *accelerated infrastructure improvement program*, delivers a wide range of benefits that might otherwise not be apparent to each stakeholder in the process, or to society at large, such as system safety and reliability and GHG emission reductions, in addition to wider consumer choices.

Accelerated natural gas Infrastructure replacement programs such as PROJECTpipes have become almost commonplace across the United States, and in the wider world, where aging infrastructure is seen to be at or near the end of its viable life. Sometimes this has resulted from catastrophic pipe failures, such as in San Bruno, CA, and Allentown, PA, resulting in serious incidents with significant property damage and loss of life as a consequence. On other occasions, the aging infrastructure has a significant leak rate, above that of more modern systems, leading to inconvenience to the public as the gas operator seeks to locate and stop the leak.

Benefits arising from a program like PROJECTpipes accrue to the following both over the course of the program and beyond, and as a result of the program. Those benefiting directly include customers, communities, the District of Columbia, Washington Gas, as well as the environment.

- Modernized systems
- Longer system life
- Fewer leaks
- Removal of risk of breaks from system failure
- Designed to remove future leak threats
- Modern construction quality control systems
- More efficient higher-pressure delivery
- Wider choice of consumer appliance options, such as commercial style ranges and instant water heaters, without the need for boosters.
- The instillation of Excess Flow Valves (EFVs), allowing greater control to the gas company and first responders, and greater safety to residents.
- New road and sidewalk surfacing, which will not need to be broken open by the gas company due to leaks, other than those caused by third parties.
- Environmental benefits are resulting in GHG reductions from fewer leaks.

Water Ingress. As a direct customer benefit, those on a modernized, elevated-pressure system are unlikely to experience service outages due to water ingress or inadequate pressures. These issues plague low-pressure systems. In 2018, WGL responded to some 56 reports of loss-of-service due to water ingress of low-pressure mains and services. This is typically a winter issue when ground water finds its way into the low-pressure system. Additionally, WGL must carry out periodic drip inspections which, with an elevated-pressure system, will no longer be required.

Latest Gas Equipment. A potentially significant benefit to the customer is greater choice in the type and brands of appliances and gas utilization equipment available to them with elevated pressures. The benefits would include incremental services made possible by the elevated pressure system's ability to accommodate technologies and appliances not available through the current low-pressure system, including access to many high-efficiency appliances. For example, to install a backup electric generator fueled by natural gas, customers on a low-pressure system must install costly electric-driven gas boosters to raise the gas pressure and back-up systems for the pressure boosters as a safeguard against electrical outages. The following higher efficiency appliances require inlet pressures that in many cases would require either a costly customer-installed booster or the provision of an elevated-pressure system:

- Tankless water heaters
- Fan assisted heaters
- Natural gas whole-house generators
- Commercial-grade cooking appliances

Outside Meters. Unlike the low-pressure system, an elevated-pressure meter set will have a pressure regulator with overpressure relief, which functions as an additional overpressure protection device in the event of a district regulator equipment failure or operator error. An above-ground service riser shutoff valve, installed before the meter, enable fire departments and other first responders to shut the gas off quickly to the property from the outside, potentially reducing property damage. Moving meters to the outside of buildings reduces the potential for gas leaks within buildings and theft of gas due to the visibility of the meter location.

Excess Flow Valves (EFVs). Replacing the low-pressure system enables WGL to install approximately excess flow valves on each residential and commercial customer service line, where operationally permissible. An EFV is a device installed on the service line at the point where the service line is connected to the main. If the service is cut, the sudden pressure drop and increased flow rate cause the device to be activated, stopping the further escape of gas. The decrease of vented gas from a hit service line due to the presence of EFVs is not included in this report's estimate of GHG emissions reductions.

Outage Restoration. The use of PE pipe enables WGL crews to isolate gas leaks more quickly for repair, either by closing an existing valve or squeezing the pipe off upstream and downstream of the leak. Squeezing is not advisable with older generation plastics.

Damage Prevention. As replacement facilities are installed, the Company has the opportunity for improved main and service records, with precise as-built drawings resulting in more accurate mark-outs facilitating reduced third-party damage. Also, the provision of new tracer wire and marker balls with the new plastic piping markedly assists with pipe location and mark out.

2.4.3 Societal Benefits

Societal or economic benefits are the third type and are not covered in this CBA. WGL retained a consulting firm to conduct an economic benefits analysis of PROJECTpipes on the District of Columbia economy. The consultant completed the report on November 20, 2018. WGL filed a

copy of the report with the WGL Application for PROJECTpipes 2 Plan.[1] The economic benefits covered in the report include employment, locally value added (e.g., wages, interest, rents, profits-related).

Our study does not duplicate or incorporate these economic benefits. In our opinion, these economic benefits supplement the avoided cost monetized benefits presented in this Cost Benefit Analysis report.

2.5 Cost Benefit Evaluation Measures

The cost benefit analysis converts potential capital expenditure (costs) and avoided spending (benefits) from the Project into monetary units and compares them. The following two common cost-benefit evaluation measures are included in this CBA.

Net Benefits: Net benefits (benefits minus costs) are compared after being discounted to present values using the nominal discount rate assumption. The Net Benefits provides a perspective on the overall dollar magnitude of cash flows over time in 2020-dollar terms.

Benefit Cost (B/C) Ratio: The evaluation also estimates the benefit-cost ratio; the present value of incremental benefits is divided by the present value of incremental costs to yield the benefit-cost ratio. The B/C ratio expresses the relation of discounted benefits to discounted costs as a measure of the extent to which a project's benefits either exceed or fall short of their associated costs.

[1] See FC 1115, the Application of Washington Gas Light Company For Approval of PROJECTpipes 2 Plan, Exhibit WG (A)-4, 12/7/2018

3. Baseline CBA

3.1 Overview

WGL is in the fifth year of the forty-year PROJECTpipes 1 Plan. Table 8 shows the estimated remaining Program units of replacement in PROJECTpipes 1 program. We used these estimates as the starting mains and service inventory in the Baseline Case analysis.

Table 8 – Expected PROJECTpipes Mains & Services, as of September 30, 2019

PROGRAM	Mains (ft)	Services
Program 1 Bare Steel Main and Services (including Contingent Main and Affected Services)	110,833	10,094
Program 2 Unprotected Wrapped Steel Main and Services (including Contingent Main and Affected Services	291,984	6,223
Program 4 Cast Iron Main (including Contingent Main and Affected Services)	2,161,986	41,441
Total	**2,564,803**	**57,758**

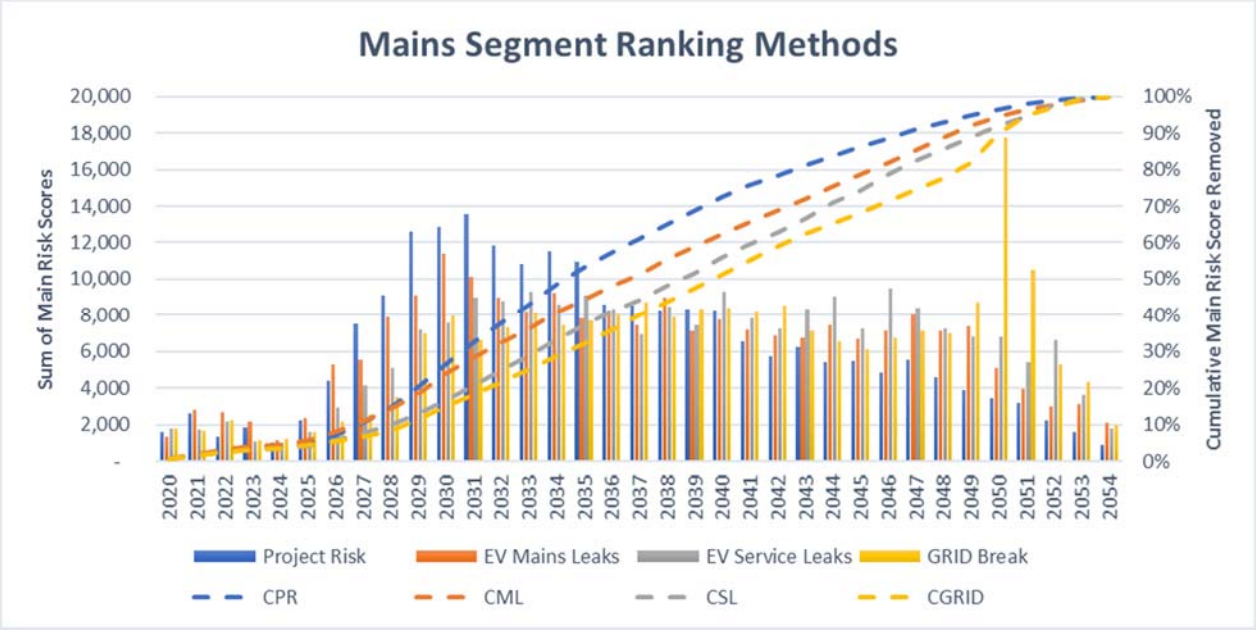
3.2 Program Cost

Our CBA examined the program costs under four replacement scenarios. Each scenario ranked or ordered pipe segment replacement based on different risk measures, as described in Section 2. Using the pipe segment dataset provided by WGL, we estimated the amount of risk removed and the construction cost for each segment. Risk removed was determined by the pipe segments' Optimain RiskMains scores.

The number of segments replaced each year was determined on a fixed annual amount of pipe replacement. This fixed annual amount considered the completion of PROJECTpipes 1, program duration, a five-year ramp up starting in 2024, and five-year ramp-down periods at the end.

Figure 1 shows the effect of the Baseline Case scenarios' method of segment prioritization and annual replacement have on risk removal. The Project Risk scenario removes 80% of mains risks (Optimain RiskMains scores) by 2044, three to six years sooner than the other scenarios.

Figure 1 – Baseline Case Replacement by Risk Removed



In the CBA the highest risk main segment was replaced from highest risk to lowest risk. Location of a segment to one another was not a factor, except for the Grid Break scenario. In the Grid Break scenario, pipe segments were associated with a grid before they were prioritized by diameter, operating pressure, and then Project Risk.

Service replacement, which included scattered, replaced, and change-overs (transfers), was associated with a mains pipe-type and then allocated based on the percentage of mains pipe-type replaced.

Table 9 is a summary of each scenario's the construction, program support, and other costs in real 2020$, cost in total nominal dollars, and the net present value for each scenario.

Table 9 – Baseline PROJECTpipes Costs, 2020$

	Project Risk	EV Mains Leaks	EV Service Leaks	GRID Break
Construction (Direct Costs)	**$ 2,164,611,961**	**$ 2,395,905,608**	**$ 2,408,946,663**	**$ 2,393,792,486**
Mains	[redacted]	[redacted]	[redacted]	[redacted]
Services	[redacted]	[redacted]	[redacted]	[redacted]
Contingent Pipe	[redacted]	[redacted]	[redacted]	[redacted]
Program Support	[redacted]	[redacted]	[redacted]	[redacted]
Other Cost	[redacted]	[redacted]	[redacted]	[redacted]
Total (Real, 2020$)	**$ 2,589,125,437**	**$ 2,826,392,059**	**$ 2,832,744,571**	**$ 2,822,429,440**
Escalation	[redacted]	[redacted]	[redacted]	[redacted]
Total (Nominal)	**$ 2,746,865,717**	**$ 2,983,312,939**	**$ 2,985,310,555**	**$ 2,978,594,365**
NPV	**$ 1,623,672,333**	**$ 1,688,689,024**	**$ 1,701,800,027**	**$ 1,699,262,135**

3.3 Operational Benefits

Our CBA examined the operational benefits. Above in Section 2.4.1, Table 7 showed the list of avoided costs. Avoided costs are a function of the units of mains and services replaced annually, how often an activity occurs, and cost to perform an activity. Table 10 provides the net present value of both avoided cost and transfer benefits for each of the baseline scenarios.

Table 10 – Baseline PROJECTpipes Benefits, 2020$

	Project Risk	EV Mains Leaks	EV Service Leaks	GRID Break
Avoided Cost Benefits, NPV	**$ 384,281,290**	**$ 384,281,290**	**$ 384,281,290**	**$ 384,284,441**
Capital Spending	[redacted]	[redacted]	[redacted]	[redacted]
O&M Spending	[redacted]	[redacted]	[redacted]	[redacted]
Transfers Benefits, NPV	**$ 352,067,534**	**$ 352,067,534**	**$ 352,067,534**	**$ 352,068,070**
Excess Flow Valves	[redacted]	[redacted]	[redacted]	[redacted]
Repaved Streets	[redacted]	[redacted]	[redacted]	[redacted]

As described above in Sections 2.4.2 and 2.4.3, there are tangential benefits by PROJECTpipes that are not included in this study. These benefits contribute to system safety, integrity, and resilience, as well as to customers, community, and stakeholders.

We note that although Federal Regulations (Title 49 CFR §192.723) permits plastic pipe located outside business districts to be leak surveyed every five (5) calendar years, WGL continues to leak survey mains and services every three (3) calendar years. WGL performs leak survey of mains and services located in business districts once every calendar year.

3.4 GHG Emissions and Leak Reduction

The PROJECTpipes Programs 1, 2, and 4 target pipes with the largest natural gas greenhouse emission factors. Unprotected steel and cast iron mains emission factors expressed in scf/hr are 11x and 24x, respectively, that of plastic mains. While the cumulative GHG emissions avoided varies by yearly, the individual scenarios' sum of avoided GHG emissions is the same.

Based on the material-type profiles, the number of avoided Grade 1 leaks on mains represents 3% of the 3,122 total avoided mains leaks of all Grades. The number of avoided Grade 1 services leaks is 56% of the 528 total avoided services leaks of all Grades. Like GHG emissions, the cumulative avoided Leak reduction varies yearly, but the individual scenarios' sum of avoided leaks is the same.

Table 11 summarizes the baseline case reductions of GHG emissions and gas leak.

Table 11 – Baseline GHG Emissions and Leak Reductions

	Project Risk	EV Mains Leaks	EV Service Leaks	GRID Break
GHG Reduction, Metric Tons	**97,420**	**97,420**	**97,420**	**97,421**
Equivalent vehicles	20,684	20,684	20,684	20,684
Leak Reduction				
Grade 1	385.8	385.8	385.8	385.8
All Grades	3,650	3,650	3,650	3,650

Note - Based on Title 40 CFR 98 – Mandatory Greenhouse Gas Reporting, Subpart W

3.5 Summary

The grid breaks ranking has the least favorable net benefits and B/C ratio. This result is principally because replacement of large diameter cast iron mains (>8" diameter) occurs later in the program. Smaller diameter cast iron pipes are more susceptible to breaks, more so in areas where cast iron pipes have broken. Typically, a cast iron break and a leak on a pipe are recorded the same,

like one leak. In analyzing leak frequencies, the leak data treat the severity of a break the same as a leak.

The method of ranking pipe segments by Project Risk, EV Mains Leaks, and EV Services Leaks does not affect program benefits. The primary reason is that the total amount of mains and services removed per year is not affected by the method of ranking. This reason holds for leak reduction as the number of mains and service leaks is based on leaks per mile and leaks per 100-services, respectively.

Ranking segments by Project Risk scenario results in the better net benefits and B/C ratio. This scenario also removes risk as measured by the cumulative Optimain RiskMains scores, as shown in Table 12.

Table 12 – Baseline Cost Benefit Measures

	Project Risk	EV Mains Leaks	EV Service Leaks	GRID Break
Net Benefits	**$(1,239,391,043)**	**$(1,304,407,734)**	**$(1,317,518,737)**	**$(1,314,977,695)**
B/C Ratio	**0.58**	**0.55**	**0.55**	**0.55**

The grid breaks ranking has the second least favorable net benefits and B/C ratio. This result is because replacement of large diameter cast iron mains (>8” diameter) occurs later in the program. Smaller diameter cast iron pipes are more susceptible to breaks, more so in areas where cast iron pipes have broken. Typically, a cast iron break and a leak on a pipe are recorded the same, like one leak. In analyzing leak frequencies, the leak data treat the severity of a break the same as a leak.

4. Project Acceleration

Based on the results of the Baseline Case, we selected the Project Risk method of prioritizing pipe segments in the Acceleration Asset Replacement Case. In this section, the CBA compares the Baseline Case to the AAR case, and PROJECTpipes durations of 2054, 2052, and 2048.

4.1 Overview

WGL proposes additional mains and services in PROJECTpipes 2. The basis for these additional replacements is WGL's Distribution Integrity Management program. The addition of the programs, shown in Table 13, formed the mains and services inventory for the AAR Case.

Table 13 – Project Acceleration: Additional Mains and Services

PROGRAM	Mains, ft	Services
Program 3		
Vintage Mechanically Coupled Main and Services (including Contingent Main and Affected Services)	58,080	2,132
Program 5		
Copper Services		6,072
Program 8		
Low Pressure Services		3,586
Total	**58,080**	**11,790**

Using the AAR Case, the durations of the Programs are reduced by 10% and 20%. Like the Baseline Case, these cases have 5-year ramp up and ramp down periods.

4.2 Program Cost

The addition of 58,080 ft of mains and 11,790 services by the year 2054 increases the amount of assets that must be replaced annually. The additional replacement adds $[redacted] (9%) in construction costs and $[redacted] (9%) in total program costs over the Baseline case.

Shortening the AAR duration by 6 years (2048) could decrease the construction cost by $128 million (5.4%) and total program costs by $93 million (3.3%) over the AAR 2054 scenario.

Tables 14 and 15 provide a breakdown of the AAR construction costs and the effect of PROJECTpipes duration changes.

Table 14 - Accelerated Asset Replacement (AAR), Program Costs

Program Costs	Baseline 2054	AAR Duration 2054
Construction (Direct Costs)	**$ 2,164,611,961**	**$ 2,360,536,029**
Mains	[redacted]	[redacted]
Services	[redacted]	[redacted]
Contingent Pipe	[redacted]	[redacted]
Program Support	[redacted]	[redacted]
Other Cost	[redacted]	[redacted]
Total (Real, 2020$)	**$ 2,589,125,437**	**$ 2,820,754,348**
Escalation	[redacted]	[redacted]
Total (Nominal)	**$ 2,746,865,717**	**$ 2,992,637,148**
NPV	**$ 1,623,672,333**	**$ 1,764,407,191**

Table 15 - AAR Duration Change, Program Costs

Program Costs	Duration 2054	Duration 2052	Duration 2048
Construction (Direct Costs)	**$ 2,360,536,029**	**$ 2,232,524,744**	**$ 2,232,476,372**
Mains	[redacted]	[redacted]	[redacted]
Services	[redacted]	[redacted]	[redacted]
Contingent Pipe	[redacted]	[redacted]	[redacted]
Program Support	[redacted]	[redacted]	[redacted]
Other Cost	[redacted]	[redacted]	[redacted]
Total (Real, 2020$)	**$ 2,820,754,348**	**$ 2,700,969,117**	**$ 2,727,924,523**
Escalation	[redacted]	[redacted]	[redacted]
Total (Nominal)	**$ 2,992,637,148**	**$ 2,884,182,327**	**$ 2,931,031,183**
NPV	**$ 1,764,407,191**	**$ 1,769,244,889**	**$ 1,859,931,074**

4.3 Operational Benefits

The addition mains and services result also avoided O&M costs of $6.1 million and $10.2 million in transfer benefits. Reducing the AAR program by 6 years (2048) increases the avoided O&M costs by $75.6 million.

Tables 16 and 17 summarize the program benefits between the Baseline and AAR 2054 scenario, and the AAR reduction in program duration.

Table 16 - AAR Program Benefits

Program Benefits	Baseline 2054	AAR Duration 2054
Avoided Cost Benefits, NPV	**$ 384,281,290**	**$ 390,391,267**
Capital Spending	[redacted]	[redacted]
O&M Spending	[redacted]	[redacted]
Transfers Benefits, NPV	**$ 352,067,534**	**$ 362,283,352**
Excess Flow Valves	[redacted]	[redacted]
Repaved Streets	[redacted]	[redacted]

Table 17 - AAR Duration Change, Program Benefits

Program Benefits	Duration 2054	Duration 2052	Duration 2048
Avoided Cost Benefits, NPV	**$ 390,391,267**	**$ 427,654,233**	**$ 459,911,924**
Capital Spending	[redacted]	[redacted]	[redacted]
O&M Spending	[redacted]	[redacted]	[redacted]
Transfers Benefits, NPV	**$ 362,283,352**	**$ 382,190,575**	**$ 388,654,154**
Excess Flow Valves	[redacted]	[redacted]	[redacted]
Repaved Streets	[redacted]	[redacted]	[redacted]

4.4 GHG Emissions

The AAR case reduces GHG emission by an additional 2,967 metric tons, the equivalent of removing 630 gasoline vehicles. The number of Grade 1 hazardous leaks avoided increased by 27 and all leak Grades by 101.

Tables 18 and 19 summaries the changes in GHG emission and gas leaks that result from including Programs 3, 5, and 8 into PROJECTpipes.

Table 18 - AAR Greenhouse Gas and Leak Reductions

	Baseline 2054	AAR Duration 2054
GHG Reduction, Metric Tons	**97,420**	**100,387**
Equivalent vehicles	20,684	21,314
Leak Reduction		
Grade 1	385.8	413.1
All Grades	3,650	3,750

Note - Based on Title 40 CFR 98 – Mandatory Greenhouse Gas Reporting, Subpart W

Table 19 - AAR Duration GHG and Leak Reductions

	Duration 2054	Duration 2052	Duration 2048
GHG Reduction, Metric Tons	**100,387**	**100,383**	**100,382**
Equivalent vehicles	21,314	21,313	21,313
Leak Reduction			
Grade 1	413.1	413.0	412.9
All Grades	3,750	3,580	3,176

Note - Based on Title 40 CFR 98 – Mandatory Greenhouse Gas Reporting, Subpart W

4.5 Summary

Adding copper service replacement, VMC mains and services replacements, and low-pressure services (Programs 3, 5, and 8) results in an NPV change of negative $135 million, decreasing the net benefits to negative $1,374 million over the remaining 35 years.

Table 20 - AAR Cost Benefit Measures

Cost Benefit Measures	Baseline 2054	AAR Duration 2054
Net Benefits	**$ (1,239,391,043)**	**$ (1,374,015,924)**
B/C Ratio	**0.58**	**0.54**

Shortening the PROJECTpipes Plan duration to the year 2052 or 2048, results in a net benefit decrease of $102 million and $161 million, respectively, over the Baseline Case. Decreasing the PROJECTpipes duration improves the B/C ratio slightly.

Table 21 - AAR Duration Cost Benefit Measures

	Duration 2054	Duration 2052	Duration 2048
Net Benefits	**$ (1,374,015,924)**	**$ (1,341,590,655)**	**$ (1,400,019,150)**
B/C Ratio	**0.54**	**0.58**	**0.58**

5. Recommendations and Conclusions

This Cost Benefit Analysis presented a study/feasibility level estimate of the PROJECTpipes Plan costs, avoided O&M benefits, and subsequent greenhouse gas emission reductions. The cost benefit measures do not include reductions in GHG emissions. A societal benefits analysis report was prepared by another consulting firm for WGL, and subsequently included WGL's application for approval of PROJECTpipes 2 Plan as Exhibit WG (A)-4. The economic benefits cited in the societal benefits analysis report are not included in the benefit results shown in this report. As such, the PROJECTpipes benefit cost ratio of less than 1 and a negative net benefits value would be common.

From the data and information available, the results of this cost benefit analysis for the acceleration of PROJECTpipes and minimization of future Grade 1 leaks (not caused by excavation damages), we conclude:

- Optimain's Project Risk scenario results in a slightly better B/C ratio over PROJECTpipes' remaining 35 years, compared to the other scenarios. The differences in the B/C ratio are small. The difference between Project Risk and Grid Breaks is $76 million in net benefits on $1.6 billion in program costs. Optimain is one tool in a holistic approach to developing Program replacement projects.
- The PROJECTpipes programs productively target mains and services material that result in all Grade leaks, potentially reducing the number of leaks by 3,650, of which more than 386 could be Grade 1 hazardous leaks.
- PROJECTpipes reduces greenhouse gas emission by 97,000 – 100,000 metric tons, the equivalent of removing 20,600 to 21,300 gasoline vehicles. This estimate is based on Title 40 CFR 98 – Mandatory Greenhouse Gas Reporting, Subpart W.
- WGL's Distribution Integrity Management Plan provides support for the inclusion of Programs 3, 5, and 8 on safety and system integrity grounds. Incorporating copper, and vintage mechanical coupled mains and service increased the number of Grade 1 hazardous leaks and all grade leaks by 27 and 101, respectively, over the remaining 35 years.
- To complete PROJECTpipes by 2054 requires the year-ending 2024 mains replacement rate of 18,000 feet per year to increase to more than 97,000 feet per year, a 5.4-fold plus increase.
- Adding copper services, vintage mechanical coupled mains and services, and low-pressure services change overs is advisable; a shortened program duration, while

improving the cost benefit B/C ratio, is not advisable based on the level of mains replacement to complete PROJECTpipes by 2054.

During this study, our meeting and analysis led to several recommendations and conclusions that WGL and other stakeholders may consider in the future phases of PROJECTpipes.

1. Compulsory use of Accela, the permitting and licensing system, for planning and coordination by all subsurface facility stakeholders has the potential to reduce/share street paving construction expenditures, which represents $300 million – $400 million in PROJECTpipes construction costs alone, as well as reduce other economic impacts of infrastructure improvement on consumers, businesses, government, and utilities.
2. A comprehensive resource study can better assess the capital, workforce, material, equipment, and process requirements, as well as work constraints on meeting an accelerated replacement target date.
3. The ability to provide an elevated pressure system to all customers in WGL's network eliminates discrimination against those currently on low-pressure in the form of foregoing consumer appliance choice, and/or suffering inadequate pressures, or water ingress outages. Also, an elevated pressure system will allow customers to install higher efficiency appliances.

One final observation, by focusing on leaks as the primary safety risk, WGL is defining risk in a way that is out of sync with other North East and Mid Atlantic gas utilities when it comes to the prioritization of small diameter cast iron pipe (CI). Cast iron tends to break, leading to a catastrophic release of gas. WGL records breaks as a leak and prioritizes replacement according to the number of leaks on CI. The result is reflected in the consequence factor of the Optimain model. Other gas operators treat this as an element of the cause, i.e., the break, and actively prioritize the replacement of small diameter (typically 2–8" diameter CI pipe) along with bare and unprotected steel mains and services.

Appendix A – Baseline Case

Project Risk Scenario

- Program Costs, 32
- Avoided Costs, 40
- Mains Replacement, 52
- Services Replacement, 53

EV Mains Leak

- Program Costs, 54
- Avoided Costs, 64
- Mains Replacement, 76
- Services Replacement, 77

EV Services Leak

- Program Costs, 78
- Avoided Costs, 86
- Mains Replacement, 98
- Services Replacement, 99

Grid Break

- Program Costs, 100
- Avoided Costs, 108
- Mains Replacement, 120
- Services Replacement, 121

Appendix B – Accelerated Asset Replacement

AAR 2054 Duration

- Program Costs, 123
- Avoided Costs, 130
- Mains Replacement, 138
- Services Replacement, 139

AAR 2052 Duration

- Program Costs, 140
- Avoided Costs, 148
- Mains Replacement, 156
- Services Replacement, 157

AAR 2048 Duration

- Program Costs, 158
- Avoided Costs, 166
- Mains Replacement, 174
- Services Replacement, 175

Description	PROGRAM TOTAL Units			Percent
Assets				
Mains	[redacted]			
Bare Steel				
Coated Unprotected				
Cast Iron				
Contingent Pipe				
Services				
Scattered				
Replaced				
Transferred				
		$/unit	PROJECTpipes	Percent
Construction (Direct Costs)				
Mains	[redacted]			
Materials				
Installation				
Paving				
Traffic Control				
Services				
Materials				
Installation				
Paving				
Traffic Control				
Contingent Pipe				
Materials				
Installation				
Paving				
Traffic Control				
Subtotal				
Program Support (Indirect Costs)				
Permitting				
Engineering				
Subtotal				
Other Costs				
Contingency				
Overhead				
Program Management				
Construction Management				
Subtotal				
Total (Real Cash Flow, 2020$)				
Escalation				
Labor				
All				
Materials				
Plastic				
Paving				
Total Escalation				
Total (Nominal Cash Flow)				

Description	2020	2021	2022	2023	2024
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains					
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

Description	2025	2026	2027	2028	2029
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains					
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

Description	2030	2031	2032	2033	2034
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains	[redacted]				
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

Description	2035	2036	2037	2038	2039
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains	[redacted]				
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

Description	2040	2041	2042	2043	2044
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains	[redacted]				
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

Description	2045	2046	2047	2048	2049
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains	[redacted]				
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

Description	2050	2051	2052	2053	2054
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains	[redacted]				
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

AVOIDED COST INPUTS				
Program Inventory			Feet of Pipe	
Mains				
Annual Productivity				
Bare Steel (Unprotected)	[redacted]			
Coated Steel (Unprotected)				
Cast Iron				
Coated Steel (Protected)				
Plastic				
Contingent Mains				
Totals				
Year Ending Balance				
Bare Steel (Unprotected)				
Coated Steel (Unprotected)				
Cast Iron				
Coated Steel (Protected)				
Plastic				
Contingent Mains				
Totals				
Services				
Annual Productivity				
Unprotected Steel (Bare Steel)				
Unprotected Steel (Coated Steel)				
Unprotected Steel (Cast Iron)				
Coated Steel (Protected)				
Copper				
Plastic				
Totals				
Year Ending Balance				
Unprotected Steel (Bare Steel)				
Unprotected Steel (Coated Steel)				
Unprotected Steel (Cast Iron)				
Coated Steel (Protected)				
Copper				
Plastic				
Totals				
Meters				
Meter Move outs				
Pressure Regulator Stations				
Less than 100 psig				
Net Program Impact				
Mains - PE				
Services - PE				
Meter Move outs				
Regulator Stations				

AVOIDED COST INPUTS	2020	2021	2022	2023	2024	2025	2026	2027
Program Inventory								
Mains								
Annual Productivity								
Bare Steel (Unprotected)								
Coated Steel (Unprotected)								
Cast Iron								
Coated Steel (Protected)								
Plastic								
Contingent Mains								
Totals								
Year Ending Balance								
Bare Steel (Unprotected)								
Coated Steel (Unprotected)								
Cast Iron								
Coated Steel (Protected)								
Plastic								
Contingent Mains								
Totals								
Services								
Annual Productivity								
Unprotected Steel (Bare Steel)								
Unprotected Steel (Coated Steel)								
Unprotected Steel (Cast Iron)								
Coated Steel (Protected)								
Copper								
Plastic								
Totals								
Year Ending Balance								
Unprotected Steel (Bare Steel)								
Unprotected Steel (Coated Steel)								
Unprotected Steel (Cast Iron)								
Coated Steel (Protected)								
Copper								
Plastic								
Totals								
Meters								
Meter Move outs								
Pressure Regulator Stations								
Less than 100 psig								
Net Program Impact								
Mains - PE								
Services - PE								
Meter Move outs								
Regulator Stations								

AVOIDED COST INPUTS	2028	2029	2030	2031	2032	2033	2034	2035
Program Inventory								
Mains								
Annual Productivity								
Bare Steel (Unprotected)	[redacted]							
Coated Steel (Unprotected)								
Cast Iron								
Coated Steel (Protected)								
Plastic								
Contingent Mains								
Totals								
Year Ending Balance								
Bare Steel (Unprotected)								
Coated Steel (Unprotected)								
Cast Iron								
Coated Steel (Protected)								
Plastic								
Contingent Mains								
Totals								
Services								
Annual Productivity								
Unprotected Steel (Bare Steel)								
Unprotected Steel (Coated Steel)								
Unprotected Steel (Cast Iron)								
Coated Steel (Protected)								
Copper								
Plastic								
Totals								
Year Ending Balance								
Unprotected Steel (Bare Steel)								
Unprotected Steel (Coated Steel)								
Unprotected Steel (Cast Iron)								
Coated Steel (Protected)								
Copper								
Plastic								
Totals								
Meters								
Meter Move outs								
Pressure Regulator Stations								
Less than 100 psig								
Net Program Impact								
Mains - PE								
Services - PE								
Meter Move outs								
Regulator Stations								

AVOIDED COST INPUTS	2036	2037	2038	2039	2040	2041	2042
Program Inventory							
Mains							
Annual Productivity							
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Contingent Mains							
Totals							
Year Ending Balance							
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Contingent Mains							
Totals							
Services							
Annual Productivity							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals							
Year Ending Balance							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals							
Meters							
Meter Move outs							
Pressure Regulator Stations							
Less than 100 psig							
Net Program Impact							
Mains - PE							
Services - PE							
Meter Move outs							
Regulator Stations							

AVOIDED COST INPUTS	2043	2044	2045	2046	2047	2048	2049
Program Inventory							
Mains							
Annual Productivity							
Bare Steel (Unprotected)	[redacted]						
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Contingent Mains							
Totals							
Year Ending Balance							
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Contingent Mains							
Totals							
Services							
Annual Productivity							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals							
Year Ending Balance							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals							
Meters							
Meter Move outs							
Pressure Regulator Stations							
Less than 100 psig							
Net Program Impact							
Mains - PE							
Services - PE							
Meter Move outs							
Regulator Stations							

AVOIDED COST INPUTS	2050	2051	2052	2053	2054
Program Inventory					
Mains					
Annual Productivity					
Bare Steel (Unprotected)	[redacted]				
Coated Steel (Unprotected)					
Cast Iron					
Coated Steel (Protected)					
Plastic					
Contingent Mains					
Totals					
Year Ending Balance					
Bare Steel (Unprotected)					
Coated Steel (Unprotected)					
Cast Iron					
Coated Steel (Protected)					
Plastic					
Contingent Mains					
Totals					
Services					
Annual Productivity					
Unprotected Steel (Bare Steel)					
Unprotected Steel (Coated Steel)					
Unprotected Steel (Cast Iron)					
Coated Steel (Protected)					
Copper					
Plastic					
Totals					
Year Ending Balance					
Unprotected Steel (Bare Steel)					
Unprotected Steel (Coated Steel)					
Unprotected Steel (Cast Iron)					
Coated Steel (Protected)					
Copper					
Plastic					
Totals					
Meters					
Meter Move outs					
Pressure Regulator Stations					
Less than 100 psig					
Net Program Impact					
Mains - PE					
Services - PE					
Meter Move outs					
Regulator Stations					

Avoided Leaks

Mains	LPM-Yr	Segment-Life	Total	
Bare Steel (Unprotected)				
Coated Steel (Unprotected)				
Cast Iron				
Coated Steel (Protected)				
Plastic				
Totals, All Leak Grades				
Bare Steel (Unprotected)				
Coated Steel (Unprotected)				
Cast Iron				
Coated Steel (Protected)				
Plastic				
Totals, Grade 1 Leaks				
Service				
Unprotected Steel (Bare Steel)				
Unprotected Steel (Coated Steel)				
Unprotected Steel (Cast Iron)				
Coated Steel (Protected)				
Copper				
Plastic				
Totals, All Leak Grades				
Unprotected Steel (Bare Steel)				
Unprotected Steel (Coated Steel)				
Unprotected Steel (Cast Iron)				
Coated Steel (Protected)				
Copper				
Plastic				
Totals, Grade 1 Leaks				

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Transfer Benefits

Excess Flow Valves	
Repaved Street (5 year life)	
Total Transfer Benefits	

GHG Emission Reduction	
CO2 Reduction (Metric Tons)	
Cumulative Reduction (Metric Tons)	

Avoided Leaks

Mains	2020	2021	2022	2023	2024	2025	2026	2027
Bare Steel (Unprotected)								
Coated Steel (Unprotected)								
Cast Iron								
Coated Steel (Protected)								
Plastic								
Totals, All Leak Grades								
Bare Steel (Unprotected)								
Coated Steel (Unprotected)								
Cast Iron								
Coated Steel (Protected)								
Plastic								
Totals, Grade 1 Leaks								
Service								
Unprotected Steel (Bare Steel)								
Unprotected Steel (Coated Steel)								
Unprotected Steel (Cast Iron)								
Coated Steel (Protected)								
Copper								
Plastic								
Totals, All Leak Grades								
Unprotected Steel (Bare Steel)								
Unprotected Steel (Coated Steel)								
Unprotected Steel (Cast Iron)								
Coated Steel (Protected)								
Copper								
Plastic								
Totals, Grade 1 Leaks								

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Transfer Benefits

Excess Flow Valves	
Repaved Street (5 year life)	
Total Transfer Benefits	

GHG Emission Reduction	
CO2 Reduction (Metric Tons)	
Cumulative Reduction (Metric Tons)	

Avoided Leaks

Mains	2028	2029	2030	2031	2032	2033	2034	2035
Bare Steel (Unprotected)								
Coated Steel (Unprotected)								
Cast Iron								
Coated Steel (Protected)								
Plastic								
Totals, All Leak Grades								
Bare Steel (Unprotected)								
Coated Steel (Unprotected)								
Cast Iron								
Coated Steel (Protected)								
Plastic								
Totals, Grade 1 Leaks								
Service								
Unprotected Steel (Bare Steel)								
Unprotected Steel (Coated Steel)								
Unprotected Steel (Cast Iron)								
Coated Steel (Protected)								
Copper								
Plastic								
Totals, All Leak Grades								
Unprotected Steel (Bare Steel)								
Unprotected Steel (Coated Steel)								
Unprotected Steel (Cast Iron)								
Coated Steel (Protected)								
Copper								
Plastic								
Totals, Grade 1 Leaks								

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Transfer Benefits

Excess Flow Valves	
Repaved Street (5 year life)	
Total Transfer Benefits	

GHG Emission Reduction	
CO2 Reduction (Metric Tons)	
Cumulative Reduction (Metric Tons)	

Avoided Leaks

Mains	2036	2037	2038	2039	2040	2041	2042
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Totals, All Leak Grades							
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Totals, Grade 1 Leaks							
Service							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals, All Leak Grades							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals, Grade 1 Leaks							

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Transfer Benefits

Excess Flow Valves	
Repaved Street (5 year life)	
Total Transfer Benefits	

GHG Emission Reduction	
CO2 Reduction (Metric Tons)	
Cumulative Reduction (Metric Tons)	

Avoided Leaks

Mains	2043	2044	2045	2046	2047	2048	2049
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Totals, All Leak Grades							
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Totals, Grade 1 Leaks							
Service							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals, All Leak Grades							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals, Grade 1 Leaks							

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Transfer Benefits

Excess Flow Valves	
Repaved Street (5 year life)	
Total Transfer Benefits	

GHG Emission Reduction	
CO2 Reduction (Metric Tons)	
Cumulative Reduction (Metric Tons)	

Avoided Leaks

Mains	2050	2051	2052	2053	2054
Bare Steel (Unprotected)					
Coated Steel (Unprotected)					
Cast Iron					
Coated Steel (Protected)					
Plastic					
Totals, All Leak Grades					
Bare Steel (Unprotected)					
Coated Steel (Unprotected)					
Cast Iron					
Coated Steel (Protected)					
Plastic					
Totals, Grade 1 Leaks					
Service					
Unprotected Steel (Bare Steel)					
Unprotected Steel (Coated Steel)					
Unprotected Steel (Cast Iron)					
Coated Steel (Protected)					
Copper					
Plastic					
Totals, All Leak Grades					
Unprotected Steel (Bare Steel)					
Unprotected Steel (Coated Steel)					
Unprotected Steel (Cast Iron)					
Coated Steel (Protected)					
Copper					
Plastic					
Totals, Grade 1 Leaks					

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Transfer Benefits

Excess Flow Valves	
Repaved Street (5 year life)	
Total Transfer Benefits	

GHG Emission Reduction	
CO2 Reduction (Metric Tons)	
Cumulative Reduction (Metric Tons)	

WGL PROJECTpipes CBA
Baseline Case - Mains Replacement
Project Risk Ranked

	Bare Steel		Unprotected Wrapped Steel		Cast Iron		Programs Total		Contingent Pipe	Total
Year	BoY	Replace	BoY	Replace	BoY	Replace	BoY	Replaced	Replaced	Installation
2,020	110,833	9,979	291,984	3,010	2,161,986	898	2,564,803	13,886	555	14,441
2,021	100,854	11,880	288,974	3,696	2,161,088	898	2,550,917	16,474	659	17,133
2,022	88,974	12,091	285,278	3,696	2,160,191	898	2,534,443	16,685	667	17,352
2,023	76,883	12,355	281,582	3,696	2,159,293	898	2,517,758	16,949	678	17,627
2,024	64,527	12,355	277,886	3,696	2,158,396	898	2,500,809	16,949	678	17,627
2,025	52,172	11,090	274,190	9,545	2,157,498	7,192	2,483,861	27,827	1,113	28,940
2,026	41,082	11,090	264,646	9,545	2,150,306	17,341	2,456,034	37,976	1,519	39,495
2,027	29,991	11,090	255,101	9,545	2,132,965	29,995	2,418,057	50,630	2,025	52,655
2,028	18,901	11,090	245,556	9,545	2,102,970	44,608	2,367,427	65,244	2,610	67,854
2,029	7,811	7,811	236,011	9,545	2,058,362	60,540	2,302,184	77,896	3,116	81,012
2,030	-		226,466	9,545	1,997,822	84,297	2,224,288	93,842	3,754	97,596
2,031	-		216,922	9,545	1,913,525	84,297	2,130,447	93,842	3,754	97,596
2,032	-		207,377	9,545	1,829,228	84,297	2,036,605	93,842	3,754	97,596
2,033	-		197,832	9,545	1,744,931	84,297	1,942,763	93,842	3,754	97,596
2,034	-		188,287	9,545	1,660,634	84,297	1,848,921	93,842	3,754	97,596
2,035	-		178,742	9,545	1,576,337	84,297	1,755,080	93,842	3,754	97,596
2,036	-		169,198	9,545	1,492,041	84,297	1,661,238	93,842	3,754	97,596
2,037	-		159,653	9,545	1,407,744	84,297	1,567,396	93,842	3,754	97,596
2,038	-		150,108	9,545	1,323,447	84,297	1,473,555	93,842	3,754	97,596
2,039	-		140,563	9,545	1,239,150	84,297	1,379,713	93,842	3,754	97,596
2,040	-		131,018	9,545	1,154,853	84,297	1,285,871	93,842	3,754	97,596
2,041	-		121,474	9,545	1,070,556	84,297	1,192,030	93,842	3,754	97,596
2,042	-		111,929	9,545	986,259	84,297	1,098,188	93,842	3,754	97,596
2,043	-		102,384	9,545	901,962	84,297	1,004,346	93,842	3,754	97,596
2,044	-		92,839	9,545	817,666	84,297	910,505	93,842	3,754	97,596
2,045	-		83,294	9,545	733,369	84,297	816,663	93,842	3,754	97,596
2,046	-		73,750	9,545	649,072	84,297	722,821	93,842	3,754	97,596
2,047	-		64,205	9,545	564,775	84,297	628,980	93,842	3,754	97,596
2,048	-		54,660	9,545	480,478	84,297	535,138	93,842	3,754	97,596
2,049	-		45,115	9,545	396,181	84,297	441,296	93,842	3,754	97,596
2,050	-		35,570	9,068	311,884	80,082	347,455	89,150	3,566	92,716
2,051	-		26,503	8,113	231,802	71,652	258,305	79,765	3,191	82,956
2,052	-		18,390	7,159	160,150	63,223	178,540	70,381	2,815	73,196
2,053	-		11,231	6,204	96,927	54,793	108,158	60,997	2,440	63,437
2,054	-		5,027	5,027	42,134	42,134	47,161	47,161	1,886	49,047

WGL PROJECTpipes CBA
Baseline Case - Services Replacement
Project Risk Ranked

	Bare Steel (Unprotected)			Coated Steel (Unprotected)				Cast Iron			Total Service Work		
Year	ScatteredBS	ReplacedBS	TransferedBS	ScatteredCSU	ReplaceCU	ReplacedCSU	TransferedCSU	ScatteredCI	ReplacedCI6	TransferedCI	Scattered8	Replaced9	Transfered10
2020	728	69	96	9	-	4	2	0	4	8	737	77	106
2021	860	82	114	32	-	37	22	0	7	15	892	126	151
2022	917	76	105	22	-	23	14	0	7	15	939	106	134
2023	875	123	171	24	-	6	3	0	-	-	899	129	174
2024	918	84	117	22	-	6	4	0	11	25	940	101	146
2025	823	78	108	58	-	40	24	0	44	102	881	162	234
2026	821	78	108	61	-	72	43	0	109	254	882	259	405
2027	835	64	89	59	-	109	65	0	186	433	894	359	587
2028	796	87	121	57	-	75	45	0	282	656	853	444	822
2029	607	60	83	61	-	101	61	0	377	879	668	538	1,023
2030				55	-	59	35	0	528	1,230	55	587	1,265
2031				61	-	78	47	0	528	1,228	61	606	1,275
2032				60	-	84	50	0	528	1,230	60	612	1,280
2033				58	-	42	25	0	526	1,224	58	568	1,249
2034				59	-	92	55	0	528	1,231	59	620	1,286
2035				59	-	104	62	0	528	1,230	59	632	1,292
2036				60	-	153	92	0	525	1,223	60	678	1,315
2037				59	-	144	87	0	528	1,231	59	672	1,318
2038				59	-	35	21	0	528	1,230	59	563	1,251
2039				57	-	102	61	0	528	1,229	57	630	1,290
2040				59	-	149	89	0	527	1,228	59	676	1,317
2041				58	-	93	56	0	525	1,221	58	618	1,277
2042				62	-	100	60	0	530	1,235	62	630	1,295
2043				57	-	94	56	0	528	1,229	57	622	1,285
2044				61	-	129	77	0	527	1,228	61	656	1,305
2045				55	-	68	41	0	524	1,221	55	592	1,262
2046				63	-	168	101	0	531	1,236	63	699	1,337
2047				58	-	128	77	0	524	1,221	58	652	1,298
2048				59	-	103	62	0	528	1,230	59	631	1,292
2049				59	-	44	26	0	530	1,233	59	574	1,259
2050				53	-	75	45	0	499	1,161	53	574	1,206
2051				53	-	109	65	0	450	1,048	53	559	1,113
2052				44	-	77	46	0	395	919	44	472	965
2053				37	-	50	30	0	343	799	37	393	829
2054				33	-	12	7	0	265	617	33	277	624

Description	PROGRAM TOTAL Units			Percent
Assets				
Mains	[redacted]			
Bare Steel				
Coated Unprotected				
Cast Iron				
Contingent Pipe				
Services				
Scattered				
Replaced				
Transferred				
		$/unit	PROJECTpipes	Percent
Construction (Direct Costs)				
Mains	[redacted]			
Materials				
Installation				
Paving				
Traffic Control				
Services				
Materials				
Installation				
Paving				
Traffic Control				
Contingent Pipe				
Materials				
Installation				
Paving				
Traffic Control				
Subtotal				
Program Support (Indirect Costs)				
Permitting				
Engineering				
Subtotal				
Other Costs				
Contingency				
Overhead				
Program Management				
Construction Management				
Subtotal				
Total (Real Cash Flow, 2020$)				
Escalation				
Labor				
All				
Materials				
Plastic				
Paving				
Total Escalation				
Total (Nominal Cash Flow)				

Description	2020	2021	2022	2023
Assets				
Mains	[redacted]			
Bare Steel				
Coated Unprotected				
Cast Iron				
Contingent Pipe				
Services				
Scattered				
Replaced				
Transferred				
Construction (Direct Costs)				
Mains				
Materials				
Installation				
Paving				
Traffic Control				
Services				
Materials				
Installation				
Paving				
Traffic Control				
Contingent Pipe				
Materials				
Installation				
Paving				
Traffic Control				
Subtotal				
Program Support (Indirect Costs)				
Permitting				
Engineering				
Subtotal				
Other Costs				
Contingency				
Overhead				
Program Management				
Construction Management				
Subtotal				
Total (Real Cash Flow, 2020$)				
Escalation				
Labor				
All				
Materials				
Plastic				
Paving				
Total Escalation				
Total (Nominal Cash Flow)				

Description	2024	2025	2026	2027
Assets				
Mains	[redacted]			
Bare Steel				
Coated Unprotected				
Cast Iron				
Contingent Pipe				
Services				
Scattered				
Replaced				
Transferred				
Construction (Direct Costs)				
Mains	[redacted]			
Materials				
Installation				
Paving				
Traffic Control				
Services				
Materials				
Installation				
Paving				
Traffic Control				
Contingent Pipe				
Materials				
Installation				
Paving				
Traffic Control				
Subtotal				
Program Support (Indirect Costs)				
Permitting				
Engineering				
Subtotal				
Other Costs				
Contingency				
Overhead				
Program Management				
Construction Management				
Subtotal				
Total (Real Cash Flow, 2020$)				
Escalation				
Labor				
All				
Materials				
Plastic				
Paving				
Total Escalation				
Total (Nominal Cash Flow)				

Description	2028	2029	2030	2031
Assets				
Mains	[redacted]			
Bare Steel				
Coated Unprotected				
Cast Iron				
Contingent Pipe				
Services				
Scattered				
Replaced				
Transferred				
Construction (Direct Costs)				
Mains	[redacted]			
Materials				
Installation				
Paving				
Traffic Control				
Services				
Materials				
Installation				
Paving				
Traffic Control				
Contingent Pipe				
Materials				
Installation				
Paving				
Traffic Control				
Subtotal				
Program Support (Indirect Costs)				
Permitting				
Engineering				
Subtotal				
Other Costs				
Contingency				
Overhead				
Program Management				
Construction Management				
Subtotal				
Total (Real Cash Flow, 2020$)				
Escalation				
Labor				
All				
Materials				
Plastic				
Paving				
Total Escalation				
Total (Nominal Cash Flow)				

Description	2032	2033	2034	2035
Assets				
Mains	[redacted]			
Bare Steel				
Coated Unprotected				
Cast Iron				
Contingent Pipe				
Services				
Scattered				
Replaced				
Transferred				
Construction (Direct Costs)				
Mains	[redacted]			
Materials				
Installation				
Paving				
Traffic Control				
Services				
Materials				
Installation				
Paving				
Traffic Control				
Contingent Pipe				
Materials				
Installation				
Paving				
Traffic Control				
Subtotal				
Program Support (Indirect Costs)				
Permitting				
Engineering				
Subtotal				
Other Costs				
Contingency				
Overhead				
Program Management				
Construction Management				
Subtotal				
Total (Real Cash Flow, 2020$)				
Escalation				
Labor				
All				
Materials				
Plastic				
Paving				
Total Escalation				
Total (Nominal Cash Flow)				

Description	2036	2037	2038	2039
Assets				
Mains	[redacted]			
Bare Steel				
Coated Unprotected				
Cast Iron				
Contingent Pipe				
Services				
Scattered				
Replaced				
Transferred				
Construction (Direct Costs)				
Mains	[redacted]			
Materials				
Installation				
Paving				
Traffic Control				
Services				
Materials				
Installation				
Paving				
Traffic Control				
Contingent Pipe				
Materials				
Installation				
Paving				
Traffic Control				
Subtotal				
Program Support (Indirect Costs)				
Permitting				
Engineering				
Subtotal				
Other Costs				
Contingency				
Overhead				
Program Management				
Construction Management				
Subtotal				
Total (Real Cash Flow, 2020$)				
Escalation				
Labor				
All				
Materials				
Plastic				
Paving				
Total Escalation				
Total (Nominal Cash Flow)				

Description	2040	2041	2042	2043
Assets				
Mains	[redacted]			
Bare Steel				
Coated Unprotected				
Cast Iron				
Contingent Pipe				
Services				
Scattered				
Replaced				
Transferred				
Construction (Direct Costs)				
Mains	[redacted]			
Materials				
Installation				
Paving				
Traffic Control				
Services				
Materials				
Installation				
Paving				
Traffic Control				
Contingent Pipe				
Materials				
Installation				
Paving				
Traffic Control				
Subtotal				
Program Support (Indirect Costs)				
Permitting				
Engineering				
Subtotal				
Other Costs				
Contingency				
Overhead				
Program Management				
Construction Management				
Subtotal				
Total (Real Cash Flow, 2020$)				
Escalation				
Labor				
All				
Materials				
Plastic				
Paving				
Total Escalation				
Total (Nominal Cash Flow)				

Description	2044	2045	2046	2047
Assets				
Mains	[redacted]			
Bare Steel				
Coated Unprotected				
Cast Iron				
Contingent Pipe				
Services				
Scattered				
Replaced				
Transferred				
Construction (Direct Costs)				
Mains				
Materials				
Installation				
Paving				
Traffic Control				
Services				
Materials				
Installation				
Paving				
Traffic Control				
Contingent Pipe				
Materials				
Installation				
Paving				
Traffic Control				
Subtotal				
Program Support (Indirect Costs)				
Permitting				
Engineering				
Subtotal				
Other Costs				
Contingency				
Overhead				
Program Management				
Construction Management				
Subtotal				
Total (Real Cash Flow, 2020$)				
Escalation				
Labor				
All				
Materials				
Plastic				
Paving				
Total Escalation				
Total (Nominal Cash Flow)				

Description	2048	2049	2050	2051
Assets				
Mains	[redacted]			
Bare Steel				
Coated Unprotected				
Cast Iron				
Contingent Pipe				
Services				
Scattered				
Replaced				
Transferred				
Construction (Direct Costs)				
Mains	[redacted]			
Materials				
Installation				
Paving				
Traffic Control				
Services				
Materials				
Installation				
Paving				
Traffic Control				
Contingent Pipe				
Materials				
Installation				
Paving				
Traffic Control				
Subtotal				
Program Support (Indirect Costs)				
Permitting				
Engineering				
Subtotal				
Other Costs				
Contingency				
Overhead				
Program Management				
Construction Management				
Subtotal				
Total (Real Cash Flow, 2020$)				
Escalation				
Labor				
All				
Materials				
Plastic				
Paving				
Total Escalation				
Total (Nominal Cash Flow)				

Description	2052	2053	2054
Assets			
Mains	[redacted]		
Bare Steel			
Coated Unprotected			
Cast Iron			
Contingent Pipe			
Services			
Scattered			
Replaced			
Transferred			
Construction (Direct Costs)			
Mains	[redacted]		
Materials			
Installation			
Paving			
Traffic Control			
Services			
Materials			
Installation			
Paving			
Traffic Control			
Contingent Pipe			
Materials			
Installation			
Paving			
Traffic Control			
Subtotal			
Program Support (Indirect Costs)			
Permitting			
Engineering			
Subtotal			
Other Costs			
Contingency			
Overhead			
Program Management			
Construction Management			
Subtotal			
Total (Real Cash Flow, 2020$)			
Escalation			
Labor			
All			
Materials			
Plastic			
Paving			
Total Escalation			
Total (Nominal Cash Flow)			

AVOIDED COST INPUTS				
Program Inventory			Feet of Pipe	
Mains				
Annual Productivity				
Bare Steel (Unprotected)	[redacted]			
Coated Steel (Unprotected)				
Cast Iron				
Coated Steel (Protected)				
Plastic				
Contingent Mains				
Totals				
Year Ending Balance				
Bare Steel (Unprotected)				
Coated Steel (Unprotected)				
Cast Iron				
Coated Steel (Protected)				
Plastic				
Contingent Mains				
Totals				
Services				
Annual Productivity				
Unprotected Steel (Bare Steel)				
Unprotected Steel (Coated Steel)				
Unprotected Steel (Cast Iron)				
Coated Steel (Protected)				
Copper				
Plastic				
Totals				
Year Ending Balance				
Unprotected Steel (Bare Steel)				
Unprotected Steel (Coated Steel)				
Unprotected Steel (Cast Iron)				
Coated Steel (Protected)				
Copper				
Plastic				
Totals				
Meters				
Meter Move outs				
Pressure Regulator Stations				
Less than 100 psig				
Net Program Impact				
Mains - PE				
Services - PE				
Meter Move outs				
Regulator Stations				

	2020	2021	2022	2023	2024	2025	2026	2027
Program Inventory								
Mains								
Annual Productivity								
Bare Steel (Unprotected)								
Coated Steel (Unprotected)								
Cast Iron								
Coated Steel (Protected)								
Plastic								
Contingent Mains								
Totals								
Year Ending Balance								
Bare Steel (Unprotected)								
Coated Steel (Unprotected)								
Cast Iron								
Coated Steel (Protected)								
Plastic								
Contingent Mains								
Totals								
Services								
Annual Productivity								
Unprotected Steel (Bare Steel)								
Unprotected Steel (Coated Steel)								
Unprotected Steel (Cast Iron)								
Coated Steel (Protected)								
Copper								
Plastic								
Totals								
Year Ending Balance								
Unprotected Steel (Bare Steel)								
Unprotected Steel (Coated Steel)								
Unprotected Steel (Cast Iron)								
Coated Steel (Protected)								
Copper								
Plastic								
Totals								
Meters								
Meter Move outs								
Pressure Regulator Stations								
Less than 100 psig								
Net Program Impact								
Mains - PE								
Services - PE								
Meter Move outs								
Regulator Stations								

	2028	2029	2030	2031	2032	2033	2034
Program Inventory							
Mains							
Annual Productivity							
Bare Steel (Unprotected)	[redacted]						
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Contingent Mains							
Totals							
Year Ending Balance							
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Contingent Mains							
Totals							
Services							
Annual Productivity							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals							
Year Ending Balance							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals							
Meters							
Meter Move outs							
Pressure Regulator Stations							
Less than 100 psig							
Net Program Impact							
Mains - PE							
Services - PE							
Meter Move outs							
Regulator Stations							

	2035	2036	2037	2038	2039	2040	2041
Program Inventory							
Mains							
Annual Productivity							
Bare Steel (Unprotected)	[redacted]						
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Contingent Mains							
Totals							
Year Ending Balance							
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Contingent Mains							
Totals							
Services							
Annual Productivity							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals							
Year Ending Balance							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals							
Meters							
Meter Move outs							
Pressure Regulator Stations							
Less than 100 psig							
Net Program Impact							
Mains - PE							
Services - PE							
Meter Move outs							
Regulator Stations							

	2042	2043	2044	2045	2046	2047	2048
Program Inventory							
Mains							
Annual Productivity							
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Contingent Mains							
Totals							
Year Ending Balance							
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Contingent Mains							
Totals							
Services							
Annual Productivity							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals							
Year Ending Balance							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals							
Meters							
Meter Move outs							
Pressure Regulator Stations							
Less than 100 psig							
Net Program Impact							
Mains - PE							
Services - PE							
Meter Move outs							
Regulator Stations							

	2049	2050	2051	2052	2053	2054
Program Inventory						
Mains						
Annual Productivity						
Bare Steel (Unprotected)	[redacted]					
Coated Steel (Unprotected)						
Cast Iron						
Coated Steel (Protected)						
Plastic						
Contingent Mains						
Totals						
Year Ending Balance						
Bare Steel (Unprotected)						
Coated Steel (Unprotected)						
Cast Iron						
Coated Steel (Protected)						
Plastic						
Contingent Mains						
Totals						
Services						
Annual Productivity						
Unprotected Steel (Bare Steel)						
Unprotected Steel (Coated Steel)						
Unprotected Steel (Cast Iron)						
Coated Steel (Protected)						
Copper						
Plastic						
Totals						
Year Ending Balance						
Unprotected Steel (Bare Steel)						
Unprotected Steel (Coated Steel)						
Unprotected Steel (Cast Iron)						
Coated Steel (Protected)						
Copper						
Plastic						
Totals						
Meters						
Meter Move outs						
Pressure Regulator Stations						
Less than 100 psig						
Net Program Impact						
Mains - PE						
Services - PE						
Meter Move outs						
Regulator Stations						

Avoided Leaks

Mains	LPM-Yr	Segment-Life	Total	
Bare Steel (Unprotected)				
Coated Steel (Unprotected)				
Cast Iron				
Coated Steel (Protected)				
Plastic				
Totals, All Leak Grades				
Bare Steel (Unprotected)				
Coated Steel (Unprotected)				
Cast Iron				
Coated Steel (Protected)				
Plastic				
Totals, Grade 1 Leaks				
Service				
Unprotected Steel (Bare Steel)				
Unprotected Steel (Coated Steel)				
Unprotected Steel (Cast Iron)				
Coated Steel (Protected)				
Copper				
Plastic				
Totals, All Leak Grades				
Unprotected Steel (Bare Steel)				
Unprotected Steel (Coated Steel)				
Unprotected Steel (Cast Iron)				
Coated Steel (Protected)				
Copper				
Plastic				
Totals, Grade 1 Leaks				

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Transfer Benefits

Excess Flow Valves	
Repaved Street (5 year life)	
Total Transfer Benefits	

GHG Emission Reduction	
CO2 Reduction (Metric Tons)	
Cumulative Reduction (Metric Tons)	

Avoided Leaks

Mains	2020	2021	2022	2023	2024	2025	2026	2027
Bare Steel (Unprotected)								
Coated Steel (Unprotected)								
Cast Iron								
Coated Steel (Protected)								
Plastic								
Totals, All Leak Grades								
Bare Steel (Unprotected)								
Coated Steel (Unprotected)								
Cast Iron								
Coated Steel (Protected)								
Plastic								
Totals, Grade 1 Leaks								
Service								
Unprotected Steel (Bare Steel)								
Unprotected Steel (Coated Steel)								
Unprotected Steel (Cast Iron)								
Coated Steel (Protected)								
Copper								
Plastic								
Totals, All Leak Grades								
Unprotected Steel (Bare Steel)								
Unprotected Steel (Coated Steel)								
Unprotected Steel (Cast Iron)								
Coated Steel (Protected)								
Copper								
Plastic								
Totals, Grade 1 Leaks								

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Transfer Benefits

Excess Flow Valves	
Repaved Street (5 year life)	
Total Transfer Benefits	

GHG Emission Reduction	
CO2 Reduction (Metric Tons)	
Cumulative Reduction (Metric Tons)	

Avoided Leaks

Mains	2028	2029	2030	2031	2032	2033	2034
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Totals, All Leak Grades							
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Totals, Grade 1 Leaks							
Service							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals, All Leak Grades							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals, Grade 1 Leaks							

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Transfer Benefits

Excess Flow Valves	
Repaved Street (5 year life)	
Total Transfer Benefits	

GHG Emission Reduction	
CO2 Reduction (Metric Tons)	
Cumulative Reduction (Metric Tons)	

Avoided Leaks

Mains	2035	2036	2037	2038	2039	2040	2041
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Totals, All Leak Grades							
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Totals, Grade 1 Leaks							
Service							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals, All Leak Grades							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals, Grade 1 Leaks							

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Transfer Benefits

Excess Flow Valves	
Repaved Street (5 year life)	
Total Transfer Benefits	

GHG Emission Reduction	
CO2 Reduction (Metric Tons)	
Cumulative Reduction (Metric Tons)	

Avoided Leaks

Mains	2042	2043	2044	2045	2046	2047	2048
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Totals, All Leak Grades							
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Totals, Grade 1 Leaks							
Service							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals, All Leak Grades							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals, Grade 1 Leaks							

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Transfer Benefits

Excess Flow Valves	
Repaved Street (5 year life)	
Total Transfer Benefits	

GHG Emission Reduction	
CO2 Reduction (Metric Tons)	
Cumulative Reduction (Metric Tons)	

Avoided Leaks

Mains	[redacted]
Bare Steel (Unprotected)	
Coated Steel (Unprotected)	
Cast Iron	
Coated Steel (Protected)	
Plastic	
Totals, All Leak Grades	
Bare Steel (Unprotected)	
Coated Steel (Unprotected)	
Cast Iron	
Coated Steel (Protected)	
Plastic	
Totals, Grade 1 Leaks	
Service	
Unprotected Steel (Bare Steel)	
Unprotected Steel (Coated Steel)	
Unprotected Steel (Cast Iron)	
Coated Steel (Protected)	
Copper	
Plastic	
Totals, All Leak Grades	
Unprotected Steel (Bare Steel)	
Unprotected Steel (Coated Steel)	
Unprotected Steel (Cast Iron)	
Coated Steel (Protected)	
Copper	
Plastic	
Totals, Grade 1 Leaks	

Avoided Costs Benefits

	[redacted]
Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Transfer Benefits

	[redacted]
Excess Flow Valves	
Repaved Street (5 year life)	
Total Transfer Benefits	

GHG Emission Reduction	[redacted]
CO2 Reduction (Metric Tons)	
Cumulative Reduction (Metric Tons)	

WGL PROJECTpipes CBA
Baseline Case - Mains Replacement
EV Mains Leaks Ranked

	Bare Steel		Unprotected Wrapped Steel		Cast Iron		Programs Total		Contingent Pipe	Total
Year	BoY	Replace	BoY	Replace	BoY	Replace	BoY	Replaced	Replaced	Installation
2020	110,833	9,979	291,984	3,010	2,161,986	898	2,564,803	13,886	555	14,441
2021	100,854	11,880	288,974	3,696	2,161,088	898	2,550,917	16,474	659	17,133
2022	88,974	12,091	285,278	3,696	2,160,191	898	2,534,443	16,685	667	17,352
2023	76,883	12,355	281,582	3,696	2,159,293	898	2,517,758	16,949	678	17,627
2024	64,527	12,355	277,886	3,696	2,158,396	898	2,500,809	16,949	678	17,627
2025	52,172	11,090	274,190	9,545	2,157,498	7,192	2,483,861	27,827	1,113	28,940
2026	41,082	11,090	264,646	9,545	2,150,306	17,341	2,456,034	37,976	1,519	39,495
2027	29,991	11,090	255,101	9,545	2,132,965	29,995	2,418,057	50,630	2,025	52,655
2028	18,901	11,090	245,556	9,545	2,102,970	44,608	2,367,427	65,244	2,610	67,854
2029	7,811	7,811	236,011	9,545	2,058,362	60,540	2,302,184	77,896	3,116	81,012
2030	-		226,466	9,545	1,997,822	84,297	2,224,288	93,842	3,754	97,596
2031	-		216,922	9,545	1,913,525	84,297	2,130,447	93,842	3,754	97,596
2032	-		207,377	9,545	1,829,228	84,297	2,036,605	93,842	3,754	97,596
2033	-		197,832	9,545	1,744,931	84,297	1,942,763	93,842	3,754	97,596
2034	-		188,287	9,545	1,660,634	84,297	1,848,921	93,842	3,754	97,596
2035	-		178,742	9,545	1,576,337	84,297	1,755,080	93,842	3,754	97,596
2036	-		169,198	9,545	1,492,041	84,297	1,661,238	93,842	3,754	97,596
2037	-		159,653	9,545	1,407,744	84,297	1,567,396	93,842	3,754	97,596
2038	-		150,108	9,545	1,323,447	84,297	1,473,555	93,842	3,754	97,596
2039	-		140,563	9,545	1,239,150	84,297	1,379,713	93,842	3,754	97,596
2040	-		131,018	9,545	1,154,853	84,297	1,285,871	93,842	3,754	97,596
2041	-		121,474	9,545	1,070,556	84,297	1,192,030	93,842	3,754	97,596
2042	-		111,929	9,545	986,259	84,297	1,098,188	93,842	3,754	97,596
2043	-		102,384	9,545	901,962	84,297	1,004,346	93,842	3,754	97,596
2044	-		92,839	9,545	817,666	84,297	910,505	93,842	3,754	97,596
2045	-		83,294	9,545	733,369	84,297	816,663	93,842	3,754	97,596
2046	-		73,750	9,545	649,072	84,297	722,821	93,842	3,754	97,596
2047	-		64,205	9,545	564,775	84,297	628,980	93,842	3,754	97,596
2048	-		54,660	9,545	480,478	84,297	535,138	93,842	3,754	97,596
2049	-		45,115	9,545	396,181	84,297	441,296	93,842	3,754	97,596
2050	-		35,570	9,068	311,884	80,082	347,455	89,150	3,566	92,716
2051	-		26,503	8,113	231,802	71,652	258,305	79,765	3,191	82,956
2052	-		18,390	7,159	160,150	63,223	178,540	70,381	2,815	73,196
2053	-		11,231	6,204	96,927	54,793	108,158	60,997	2,440	63,437
2054	-		5,027	5,027	42,134	42,134	47,161	47,161	1,886	49,047

WGL PROJECTpipes CBA
Baseline Case - Services Replacement
EV Mains Leaks Ranked

	Bare Steel (Unprotected)			Coated Steel (Unprotected)				Cast Iron			Total Services Work		
Year	ScatteredBS	ReplacedBS	TransferedBS	ScatteredCSU	ReplaceCU	ReplacedCSU	TransferedCSU	ScatteredCI	ReplacedCI6	TransferedCI	Scattered8	Replaced9	Transfered10
2020	728	69	96	9	0	4	2	0	4	8	737	77	106
2021	860	82	114	32	0	37	22	0	7	15	892	126	151
2022	917	76	105	22	0	23	14	0	7	15	939	106	134
2023	875	123	171	24	0	6	3	0	0	0	899	129	174
2024	918	84	117	22	0	6	4	0	11	25	940	101	146
2025	823	78	108	58	0	40	24	0	44	102	881	162	234
2026	821	78	108	61	0	72	43	0	109	254	882	259	405
2027	835	64	89	59	0	109	65	0	186	433	894	359	587
2028	796	87	121	57	0	75	45	0	282	656	853	444	822
2029	607	60	83	61	0	101	61	0	377	879	668	538	1023
2030				55	0	59	35	0	528	1230	55	587	1265
2031				61	0	78	47	0	528	1228	61	606	1275
2032				60	0	84	50	0	528	1230	60	612	1280
2033				58	0	42	25	0	526	1224	58	568	1249
2034				59	0	92	55	0	528	1231	59	620	1286
2035				59	0	104	62	0	528	1230	59	632	1292
2036				60	0	153	92	0	525	1223	60	678	1315
2037				59	0	144	87	0	528	1231	59	672	1318
2038				59	0	35	21	0	528	1230	59	563	1251
2039				57	0	102	61	0	528	1229	57	630	1290
2040				59	0	149	89	0	527	1228	59	676	1317
2041				58	0	93	56	0	525	1221	58	618	1277
2042				62	0	100	60	0	530	1235	62	630	1295
2043				57	0	94	56	0	528	1229	57	622	1285
2044				61	0	129	77	0	527	1228	61	656	1305
2045				55	0	68	41	0	524	1221	55	592	1262
2046				63	0	168	101	0	531	1236	63	699	1337
2047				58	0	128	77	0	524	1221	58	652	1298
2048				59	0	103	62	0	528	1230	59	631	1292
2049				59	0	44	26	0	530	1233	59	574	1259
2050				53	0	75	45	0	499	1161	53	574	1206
2051				53	0	109	65	0	450	1048	53	559	1113
2052				44	0	77	46	0	395	919	44	472	965
2053				37	0	50	30	0	343	799	37	393	829
2054				33	0	12	7	0	265	617	33	277	624

Description	PROGRAM TOTAL Units			Percent
Assets				
Mains	[redacted]			
Bare Steel				
Coated Unprotected				
Cast Iron				
Contingent Pipe				
Services				
Scattered				
Replaced				
Transferred				
		$/unit	PROJECTpipes	Percent
Construction (Direct Costs)				
Mains	[redacted]			
Materials				
Installation				
Paving				
Traffic Control				
Services				
Materials				
Installation				
Paving				
Traffic Control				
Contingent Pipe				
Materials				
Installation				
Paving				
Traffic Control				
Subtotal				
Program Support (Indirect Costs)				
Permitting				
Engineering				
Subtotal				
Other Costs				
Contingency				
Overhead				
Program Management				
Construction Management				
Subtotal				
Total (Real Cash Flow, 2020$)				
Escalation				
Labor				
All				
Materials				
Plastic				
Paving				
Total Escalation				
Total (Nominal Cash Flow)				

Description	2020	2021	2022	2023	2024
Assets					
Mains					
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains					
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

Description	2025	2026	2027	2028	2029
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains					
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

Description	2030	2031	2032	2033	2034
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains	[redacted]				
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

Description	2035	2036	2037	2038	2039
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains					
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

Description	2040	2041	2042	2043	2044
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains	[redacted]				
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

Description	2045	2046	2047	2048	2049
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains	[redacted]				
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

Description	2050	2051	2052	2053	2054
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains	[redacted]				
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

AVOIDED COST INPUTS				
Program Inventory			Feet of Pipe	
Mains				
Annual Productivity				
Bare Steel (Unprotected)	[redacted]			
Coated Steel (Unprotected)				
Cast Iron				
Coated Steel (Protected)				
Plastic				
Contingent Mains				
Totals				
Year Ending Balance				
Bare Steel (Unprotected)				
Coated Steel (Unprotected)				
Cast Iron				
Coated Steel (Protected)				
Plastic				
Contingent Mains				
Totals				
Services				
Annual Productivity				
Unprotected Steel (Bare Steel)				
Unprotected Steel (Coated Steel)				
Unprotected Steel (Cast Iron)				
Coated Steel (Protected)				
Copper				
Plastic				
Totals				
Year Ending Balance				
Unprotected Steel (Bare Steel)				
Unprotected Steel (Coated Steel)				
Unprotected Steel (Cast Iron)				
Coated Steel (Protected)				
Copper				
Plastic				
Totals				
Meters				
Meter Move outs				
Pressure Regulator Stations				
Less than 100 psig				
Net Program Impact				
Mains - PE				
Services - PE				
Meter Move outs				
Regulator Stations				

AV	2020	2021	2022	2023	2024	2025	2026	2027
Program Inventory								
Mains								
Annual Productivity								
Bare Steel (Unprotected)								
Coated Steel (Unprotected)								
Cast Iron								
Coated Steel (Protected)								
Plastic								
Contingent Mains								
Totals								
Year Ending Balance								
Bare Steel (Unprotected)								
Coated Steel (Unprotected)								
Cast Iron								
Coated Steel (Protected)								
Plastic								
Contingent Mains								
Totals								
Services								
Annual Productivity								
Unprotected Steel (Bare Steel)								
Unprotected Steel (Coated Steel)								
Unprotected Steel (Cast Iron)								
Coated Steel (Protected)								
Copper								
Plastic								
Totals								
Year Ending Balance								
Unprotected Steel (Bare Steel)								
Unprotected Steel (Coated Steel)								
Unprotected Steel (Cast Iron)								
Coated Steel (Protected)								
Copper								
Plastic								
Totals								
Meters								
Meter Move outs								
Pressure Regulator Stations								
Less than 100 psig								
Net Program Impact								
Mains - PE								
Services - PE								
Meter Move outs								
Regulator Stations								

AV	2028	2029	2030	2031	2032	2033	2034	2035
Program Inventory								
Mains								
Annual Productivity								
Bare Steel (Unprotected)								
Coated Steel (Unprotected)								
Cast Iron								
Coated Steel (Protected)								
Plastic								
Contingent Mains								
Totals								
Year Ending Balance								
Bare Steel (Unprotected)								
Coated Steel (Unprotected)								
Cast Iron								
Coated Steel (Protected)								
Plastic								
Contingent Mains								
Totals								
Services								
Annual Productivity								
Unprotected Steel (Bare Steel)								
Unprotected Steel (Coated Steel)								
Unprotected Steel (Cast Iron)								
Coated Steel (Protected)								
Copper								
Plastic								
Totals								
Year Ending Balance								
Unprotected Steel (Bare Steel)								
Unprotected Steel (Coated Steel)								
Unprotected Steel (Cast Iron)								
Coated Steel (Protected)								
Copper								
Plastic								
Totals								
Meters								
Meter Move outs								
Pressure Regulator Stations								
Less than 100 psig								
Net Program Impact								
Mains - PE								
Services - PE								
Meter Move outs								
Regulator Stations								

AV	2036	2037	2038	2039	2040	2041	2042
Program Inventory							
Mains							
Annual Productivity							
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Contingent Mains							
Totals							
Year Ending Balance							
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Contingent Mains							
Totals							
Services							
Annual Productivity							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals							
Year Ending Balance							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals							
Meters							
Meter Move outs							
Pressure Regulator Stations							
Less than 100 psig							
Net Program Impact							
Mains - PE							
Services - PE							
Meter Move outs							
Regulator Stations							

AV	2043	2044	2045	2046	2047	2048	2049
Program Inventory							
Mains							
Annual Productivity							
Bare Steel (Unprotected)	[redacted]						
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Contingent Mains							
Totals							
Year Ending Balance							
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Contingent Mains							
Totals							
Services							
Annual Productivity							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals							
Year Ending Balance							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals							
Meters							
Meter Move outs							
Pressure Regulator Stations							
Less than 100 psig							
Net Program Impact							
Mains - PE							
Services - PE							
Meter Move outs							
Regulator Stations							

AV	2050	2051	2052	2053	2054
Program Inventory					
Mains					
Annual Productivity					
Bare Steel (Unprotected)					
Coated Steel (Unprotected)					
Cast Iron					
Coated Steel (Protected)					
Plastic					
Contingent Mains					
Totals					
Year Ending Balance					
Bare Steel (Unprotected)					
Coated Steel (Unprotected)					
Cast Iron					
Coated Steel (Protected)					
Plastic					
Contingent Mains					
Totals					
Services					
Annual Productivity					
Unprotected Steel (Bare Steel)					
Unprotected Steel (Coated Steel)					
Unprotected Steel (Cast Iron)					
Coated Steel (Protected)					
Copper					
Plastic					
Totals					
Year Ending Balance					
Unprotected Steel (Bare Steel)					
Unprotected Steel (Coated Steel)					
Unprotected Steel (Cast Iron)					
Coated Steel (Protected)					
Copper					
Plastic					
Totals					
Meters					
Meter Move outs					
Pressure Regulator Stations					
Less than 100 psig					
Net Program Impact					
Mains - PE					
Services - PE					
Meter Move outs					
Regulator Stations					

Avoided Leaks

Mains	LPM-Yr	Segment-Life	Total	
Bare Steel (Unprotected)				
Coated Steel (Unprotected)				
Cast Iron				
Coated Steel (Protected)				
Plastic				
Totals, All Leak Grades				
Bare Steel (Unprotected)				
Coated Steel (Unprotected)				
Cast Iron				
Coated Steel (Protected)				
Plastic				
Totals, Grade 1 Leaks				
Service				
Unprotected Steel (Bare Steel)				
Unprotected Steel (Coated Steel)				
Unprotected Steel (Cast Iron)				
Coated Steel (Protected)				
Copper				
Plastic				
Totals, All Leak Grades				
Unprotected Steel (Bare Steel)				
Unprotected Steel (Coated Steel)				
Unprotected Steel (Cast Iron)				
Coated Steel (Protected)				
Copper				
Plastic				
Totals, Grade 1 Leaks				

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Transfer Benefits

Excess Flow Valves	
Repaved Street (5 year life)	
Total Transfer Benefits	

GHG Emission Reduction	
CO2 Reduction (Metric Tons)	
Cumulative Reduction (Metric Tons)	

Avoided Leaks

Mains	2020	2021	2022	2023	2024	2025	2026	2027
Bare Steel (Unprotected)								
Coated Steel (Unprotected)								
Cast Iron								
Coated Steel (Protected)								
Plastic								
Totals, All Leak Grades								
Bare Steel (Unprotected)								
Coated Steel (Unprotected)								
Cast Iron								
Coated Steel (Protected)								
Plastic								
Totals, Grade 1 Leaks								
Service								
Unprotected Steel (Bare Steel)								
Unprotected Steel (Coated Steel)								
Unprotected Steel (Cast Iron)								
Coated Steel (Protected)								
Copper								
Plastic								
Totals, All Leak Grades								
Unprotected Steel (Bare Steel)								
Unprotected Steel (Coated Steel)								
Unprotected Steel (Cast Iron)								
Coated Steel (Protected)								
Copper								
Plastic								
Totals, Grade 1 Leaks								

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Transfer Benefits

Excess Flow Valves	
Repaved Street (5 year life)	
Total Transfer Benefits	

GHG Emission Reduction	
CO2 Reduction (Metric Tons)	
Cumulative Reduction (Metric Tons)	

Avoided Leaks

Mains	2028	2029	2030	2031	2032	2033	2034	2035
Bare Steel (Unprotected)								
Coated Steel (Unprotected)								
Cast Iron								
Coated Steel (Protected)								
Plastic								
Totals, All Leak Grades								
Bare Steel (Unprotected)								
Coated Steel (Unprotected)								
Cast Iron								
Coated Steel (Protected)								
Plastic								
Totals, Grade 1 Leaks								
Service								
Unprotected Steel (Bare Steel)								
Unprotected Steel (Coated Steel)								
Unprotected Steel (Cast Iron)								
Coated Steel (Protected)								
Copper								
Plastic								
Totals, All Leak Grades								
Unprotected Steel (Bare Steel)								
Unprotected Steel (Coated Steel)								
Unprotected Steel (Cast Iron)								
Coated Steel (Protected)								
Copper								
Plastic								
Totals, Grade 1 Leaks								

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Transfer Benefits

Excess Flow Valves	
Repaved Street (5 year life)	
Total Transfer Benefits	

GHG Emission Reduction	
CO2 Reduction (Metric Tons)	
Cumulative Reduction (Metric Tons)	

Avoided Leaks

Mains	2036	2037	2038	2039	2040	2041	2042
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Totals, All Leak Grades							
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Totals, Grade 1 Leaks							
Service							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals, All Leak Grades							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals, Grade 1 Leaks							

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Transfer Benefits

Excess Flow Valves	
Repaved Street (5 year life)	
Total Transfer Benefits	

GHG Emission Reduction	
CO2 Reduction (Metric Tons)	
Cumulative Reduction (Metric Tons)	

Avoided Leaks

Mains	2043	2044	2045	2046	2047	2048	2049
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Totals, All Leak Grades							
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Totals, Grade 1 Leaks							
Service							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals, All Leak Grades							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals, Grade 1 Leaks							

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Transfer Benefits

Excess Flow Valves	
Repaved Street (5 year life)	
Total Transfer Benefits	

GHG Emission Reduction	
CO2 Reduction (Metric Tons)	
Cumulative Reduction (Metric Tons)	

Avoided Leaks

Mains	2050	2051	2052	2053	2054
Bare Steel (Unprotected)					
Coated Steel (Unprotected)					
Cast Iron					
Coated Steel (Protected)					
Plastic					
Totals, All Leak Grades					
Bare Steel (Unprotected)					
Coated Steel (Unprotected)					
Cast Iron					
Coated Steel (Protected)					
Plastic					
Totals, Grade 1 Leaks					
Service					
Unprotected Steel (Bare Steel)					
Unprotected Steel (Coated Steel)					
Unprotected Steel (Cast Iron)					
Coated Steel (Protected)					
Copper					
Plastic					
Totals, All Leak Grades					
Unprotected Steel (Bare Steel)					
Unprotected Steel (Coated Steel)					
Unprotected Steel (Cast Iron)					
Coated Steel (Protected)					
Copper					
Plastic					
Totals, Grade 1 Leaks					

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Transfer Benefits

Excess Flow Valves	
Repaved Street (5 year life)	
Total Transfer Benefits	

GHG Emission Reduction	
CO2 Reduction (Metric Tons)	
Cumulative Reduction (Metric Tons)	

WGL PROJECTpipes CBA
Baseline Case - Mains Replacement
EV Services Leaks Ranked

	Bare Steel		Unprotected Wrapped Steel		Cast Iron		Programs Total		Contingent Pipe	Total
Year	BoY	Replace	BoY	Replace	BoY	Replace	BoY	Replaced	Replaced	Installation
2,020	110,833	9,979	291,984	3,010	2,161,986	898	2,564,803	13,886	555	14,441
2,021	100,854	11,880	288,974	3,696	2,161,088	898	2,550,917	16,474	659	17,133
2,022	88,974	12,091	285,278	3,696	2,160,191	898	2,534,443	16,685	667	17,352
2,023	76,883	12,355	281,582	3,696	2,159,293	898	2,517,758	16,949	678	17,627
2,024	64,527	12,355	277,886	3,696	2,158,396	898	2,500,809	16,949	678	17,627
2,025	52,172	11,090	274,190	9,545	2,157,498	7,192	2,483,861	27,827	1,113	28,940
2,026	41,082	11,090	264,646	9,545	2,150,306	17,341	2,456,034	37,976	1,519	39,495
2,027	29,991	11,090	255,101	9,545	2,132,965	29,995	2,418,057	50,630	2,025	52,655
2,028	18,901	11,090	245,556	9,545	2,102,970	44,608	2,367,427	65,244	2,610	67,854
2,029	7,811	7,811	236,011	9,545	2,058,362	60,540	2,302,184	77,896	3,116	81,012
2,030	-		226,466	9,545	1,997,822	84,297	2,224,288	93,842	3,754	97,596
2,031	-		216,922	9,545	1,913,525	84,297	2,130,447	93,842	3,754	97,596
2,032	-		207,377	9,545	1,829,228	84,297	2,036,605	93,842	3,754	97,596
2,033	-		197,832	9,545	1,744,931	84,297	1,942,763	93,842	3,754	97,596
2,034	-		188,287	9,545	1,660,634	84,297	1,848,921	93,842	3,754	97,596
2,035	-		178,742	9,545	1,576,337	84,297	1,755,080	93,842	3,754	97,596
2,036	-		169,198	9,545	1,492,041	84,297	1,661,238	93,842	3,754	97,596
2,037	-		159,653	9,545	1,407,744	84,297	1,567,396	93,842	3,754	97,596
2,038	-		150,108	9,545	1,323,447	84,297	1,473,555	93,842	3,754	97,596
2,039	-		140,563	9,545	1,239,150	84,297	1,379,713	93,842	3,754	97,596
2,040	-		131,018	9,545	1,154,853	84,297	1,285,871	93,842	3,754	97,596
2,041	-		121,474	9,545	1,070,556	84,297	1,192,030	93,842	3,754	97,596
2,042	-		111,929	9,545	986,259	84,297	1,098,188	93,842	3,754	97,596
2,043	-		102,384	9,545	901,962	84,297	1,004,346	93,842	3,754	97,596
2,044	-		92,839	9,545	817,666	84,297	910,505	93,842	3,754	97,596
2,045	-		83,294	9,545	733,369	84,297	816,663	93,842	3,754	97,596
2,046	-		73,750	9,545	649,072	84,297	722,821	93,842	3,754	97,596
2,047	-		64,205	9,545	564,775	84,297	628,980	93,842	3,754	97,596
2,048	-		54,660	9,545	480,478	84,297	535,138	93,842	3,754	97,596
2,049	-		45,115	9,545	396,181	84,297	441,296	93,842	3,754	97,596
2,050	-		35,570	9,068	311,884	80,082	347,455	89,150	3,566	92,716
2,051	-		26,503	8,113	231,802	71,652	258,305	79,765	3,191	82,956
2,052	-		18,390	7,159	160,150	63,223	178,540	70,381	2,815	73,196
2,053	-		11,231	6,204	96,927	54,793	108,158	60,997	2,440	63,437
2,054	-		5,027	5,027	42,134	42,134	47,161	47,161	1,886	49,047

WGL PROJECTpipes CBA
Baseline Case - Services Replacement
EV Services Leaks Ranked

	Bare Steel (Unprotected)			Coated Steel (Unprotected)				Cast Iron			Total Services Work		
Year	ScatteredBS	ReplacedBS	TransferedBS	ScatteredCSU	ReplacedCU	ReplacedCSU	TransferedCSU	ScatteredCI	ReplacedCI6	TransferedCI	Scattered8	Replaced9	Transfered10
2020	728	69	96	9	0	4	2	0	4	8	737	77	106
2021	860	82	114	32	0	37	22	0	7	15	892	126	151
2022	917	76	105	22	0	23	14	0	7	15	939	106	134
2023	875	123	171	24	0	6	3	0	0	0	899	129	174
2024	918	84	117	22	0	6	4	0	11	25	940	101	146
2025	823	78	108	58	0	40	24	0	44	102	881	162	234
2026	821	78	108	61	0	72	43	0	109	254	882	259	405
2027	835	64	89	59	0	109	65	0	186	433	894	359	587
2028	796	87	121	57	0	75	45	0	282	656	853	444	822
2029	607	60	83	61	0	101	61	0	377	879	668	538	1023
2030				55	0	59	35	0	528	1230	55	587	1265
2031				61	0	78	47	0	528	1228	61	606	1275
2032				60	0	84	50	0	528	1230	60	612	1280
2033				58	0	42	25	0	526	1224	58	568	1249
2034				59	0	92	55	0	528	1231	59	620	1286
2035				59	0	104	62	0	528	1230	59	632	1292
2036				60	0	153	92	0	525	1223	60	678	1315
2037				59	0	144	87	0	528	1231	59	672	1318
2038				59	0	35	21	0	528	1230	59	563	1251
2039				57	0	102	61	0	528	1229	57	630	1290
2040				59	0	149	89	0	527	1228	59	676	1317
2041				58	0	93	56	0	525	1221	58	618	1277
2042				62	0	100	60	0	530	1235	62	630	1295
2043				57	0	94	56	0	528	1229	57	622	1285
2044				61	0	129	77	0	527	1228	61	656	1305
2045				55	0	68	41	0	524	1221	55	592	1262
2046				63	0	168	101	0	531	1236	63	699	1337
2047				58	0	128	77	0	524	1221	58	652	1298
2048				59	0	103	62	0	528	1230	59	631	1292
2049				59	0	44	26	0	530	1233	59	574	1259
2050				53	0	75	45	0	499	1161	53	574	1206
2051				53	0	109	65	0	450	1048	53	559	1113
2052				44	0	77	46	0	395	919	44	472	965
2053				37	0	50	30	0	343	799	37	393	829
2054				33	0	12	7	0	265	617	33	277	624

WGL PROJECTpipes CBA
Baseline Case - Avoided Costs
Grid Breaks Ranked

Description	PROGRAM TOTAL Units			Percent
Assets				
Mains	[redacted]			
Bare Steel				
Coated Unprotected				
Cast Iron				
Contingent Pipe				
Services				
Scattered				
Replaced				
Transferred				
		$/unit	PROJECTpipes	Percent
Construction (Direct Costs)				
Mains	[redacted]			
Materials				
Installation				
Paving				
Traffic Control				
Services				
Materials				
Installation				
Paving				
Traffic Control				
Contingent Pipe				
Materials				
Installation				
Paving				
Traffic Control				
Subtotal				
Program Support (Indirect Costs)				
Permitting				
Engineering				
Subtotal				
Other Costs				
Contingency				
Overhead				
Program Management				
Construction Management				
Subtotal				
Total (Real Cash Flow, 2020$)				
Escalation				
Labor				
All				
Materials				
Plastic				
Paving				
Total Escalation				
Total (Nominal Cash Flow)				

Description	2020	2021	2022	2023	2024
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains	[redacted]				
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

Description	2025	2026	2027	2028	2029
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains	[redacted]				
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

Description	2030	2031	2032	2033	2034
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains	[redacted]				
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

Description	2035	2036	2037	2038	2039
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains	[redacted]				
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

Description	2040	2041	2042	2043	2044
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains					
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

Description	2045	2046	2047	2048	2049
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains					
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

Description	2050	2051	2052	2053	2054
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains	[redacted]				
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

AVOIDED COST INPUTS				
Program Inventory			Feet of Pipe	
Mains				
Annual Productivity				
Bare Steel (Unprotected)				
Coated Steel (Unprotected)				
Cast Iron				
Coated Steel (Protected)				
Plastic				
Contingent Mains				
Totals				
Year Ending Balance				
Bare Steel (Unprotected)				
Coated Steel (Unprotected)				
Cast Iron				
Coated Steel (Protected)				
Plastic				
Contingent Mains				
Totals				
Services				
Annual Productivity				
Unprotected Steel (Bare Steel)				
Unprotected Steel (Coated Steel)				
Unprotected Steel (Cast Iron)				
Coated Steel (Protected)				
Copper				
Plastic				
Totals				
Year Ending Balance				
Unprotected Steel (Bare Steel)				
Unprotected Steel (Coated Steel)				
Unprotected Steel (Cast Iron)				
Coated Steel (Protected)				
Copper				
Plastic				
Totals				
Meters				
Meter Move outs				
Pressure Regulator Stations				
Less than 100 psig				
Net Program Impact				
Mains - PE				
Services - PE				
Meter Move outs				
Regulator Stations				

AV	2020	2021	2022	2023	2024	2025	2026	2027
Program Inventory								
Mains								
Annual Productivity								
Bare Steel (Unprotected)								
Coated Steel (Unprotected)								
Cast Iron								
Coated Steel (Protected)								
Plastic								
Contingent Mains								
Totals								
Year Ending Balance								
Bare Steel (Unprotected)								
Coated Steel (Unprotected)								
Cast Iron								
Coated Steel (Protected)								
Plastic								
Contingent Mains								
Totals								
Services								
Annual Productivity								
Unprotected Steel (Bare Steel)								
Unprotected Steel (Coated Steel)								
Unprotected Steel (Cast Iron)								
Coated Steel (Protected)								
Copper								
Plastic								
Totals								
Year Ending Balance								
Unprotected Steel (Bare Steel)								
Unprotected Steel (Coated Steel)								
Unprotected Steel (Cast Iron)								
Coated Steel (Protected)								
Copper								
Plastic								
Totals								
Meters								
Meter Move outs								
Pressure Regulator Stations								
Less than 100 psig								
Net Program Impact								
Mains - PE								
Services - PE								
Meter Move outs								
Regulator Stations								

A	2028	2029	2030	2031	2032	2033	2034
Program Inventory							
Mains							
Annual Productivity							
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Contingent Mains							
Totals							
Year Ending Balance							
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Contingent Mains							
Totals							
Services							
Annual Productivity							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals							
Year Ending Balance							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals							
Meters							
Meter Move outs							
Pressure Regulator Stations							
Less than 100 psig							
Net Program Impact							
Mains - PE							
Services - PE							
Meter Move outs							
Regulator Stations							

A	2035	2036	2037	2038	2039	2040	2041
Program Inventory							
Mains							
Annual Productivity							
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Contingent Mains							
Totals							
Year Ending Balance							
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Contingent Mains							
Totals							
Services							
Annual Productivity							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals							
Year Ending Balance							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals							
Meters							
Meter Move outs							
Pressure Regulator Stations							
Less than 100 psig							
Net Program Impact							
Mains - PE							
Services - PE							
Meter Move outs							
Regulator Stations							

A	2042	2043	2044	2045	2046	2047	2048
Program Inventory							
Mains							
Annual Productivity							
Bare Steel (Unprotected)	[redacted]						
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Contingent Mains							
Totals							
Year Ending Balance							
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Contingent Mains							
Totals							
Services							
Annual Productivity							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals							
Year Ending Balance							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals							
Meters							
Meter Move outs							
Pressure Regulator Stations							
Less than 100 psig							
Net Program Impact							
Mains - PE							
Services - PE							
Meter Move outs							
Regulator Stations							

A	2049	2050	2051	2052	2053	2054
Program Inventory						
Mains						
Annual Productivity						
Bare Steel (Unprotected)						
Coated Steel (Unprotected)						
Cast Iron						
Coated Steel (Protected)						
Plastic						
Contingent Mains						
Totals						
Year Ending Balance						
Bare Steel (Unprotected)						
Coated Steel (Unprotected)						
Cast Iron						
Coated Steel (Protected)						
Plastic						
Contingent Mains						
Totals						
Services						
Annual Productivity						
Unprotected Steel (Bare Steel)						
Unprotected Steel (Coated Steel)						
Unprotected Steel (Cast Iron)						
Coated Steel (Protected)						
Copper						
Plastic						
Totals						
Year Ending Balance						
Unprotected Steel (Bare Steel)						
Unprotected Steel (Coated Steel)						
Unprotected Steel (Cast Iron)						
Coated Steel (Protected)						
Copper						
Plastic						
Totals						
Meters						
Meter Move outs						
Pressure Regulator Stations						
Less than 100 psig						
Net Program Impact						
Mains - PE						
Services - PE						
Meter Move outs						
Regulator Stations						

Avoided Leaks

Mains	LPM-Yr	Segment-Life	Total	
Bare Steel (Unprotected)				
Coated Steel (Unprotected)				
Cast Iron				
Coated Steel (Protected)				
Plastic				
Totals, All Leak Grades				
Bare Steel (Unprotected)				
Coated Steel (Unprotected)				
Cast Iron				
Coated Steel (Protected)				
Plastic				
Totals, Grade 1 Leaks				
Service				
Unprotected Steel (Bare Steel)				
Unprotected Steel (Coated Steel)				
Unprotected Steel (Cast Iron)				
Coated Steel (Protected)				
Copper				
Plastic				
Totals, All Leak Grades				
Unprotected Steel (Bare Steel)				
Unprotected Steel (Coated Steel)				
Unprotected Steel (Cast Iron)				
Coated Steel (Protected)				
Copper				
Plastic				
Totals, Grade 1 Leaks				

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Avoided Leaks

Mains	2020	2021	2022	2023	2024	2025	2026	2027
Bare Steel (Unprotected)								
Coated Steel (Unprotected)								
Cast Iron								
Coated Steel (Protected)								
Plastic								
Totals, All Leak Grades								
Bare Steel (Unprotected)								
Coated Steel (Unprotected)								
Cast Iron								
Coated Steel (Protected)								
Plastic								
Totals, Grade 1 Leaks								
Service								
Unprotected Steel (Bare Steel)								
Unprotected Steel (Coated Steel)								
Unprotected Steel (Cast Iron)								
Coated Steel (Protected)								
Copper								
Plastic								
Totals, All Leak Grades								
Unprotected Steel (Bare Steel)								
Unprotected Steel (Coated Steel)								
Unprotected Steel (Cast Iron)								
Coated Steel (Protected)								
Copper								
Plastic								
Totals, Grade 1 Leaks								

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Avoided Leaks

Mains	2028	2029	2030	2031	2032	2033	2034
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Totals, All Leak Grades							
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Totals, Grade 1 Leaks							
Service							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals, All Leak Grades							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals, Grade 1 Leaks							

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Avoided Leaks

Mains	2035	2036	2037	2038	2039	2040	2041
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Totals, All Leak Grades							
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Totals, Grade 1 Leaks							
Service							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals, All Leak Grades							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals, Grade 1 Leaks							

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Avoided Leaks

Mains	2042	2043	2044	2045	2046	2047	2048
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Totals, All Leak Grades							
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Totals, Grade 1 Leaks							
Service							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals, All Leak Grades							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals, Grade 1 Leaks							

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Avoided Leaks

Mains	2049	2050	2051	2052	2053	2054
Bare Steel (Unprotected)	[redacted]					
Coated Steel (Unprotected)						
Cast Iron						
Coated Steel (Protected)						
Plastic						
Totals, All Leak Grades						
Bare Steel (Unprotected)						
Coated Steel (Unprotected)						
Cast Iron						
Coated Steel (Protected)						
Plastic						
Totals, Grade 1 Leaks						
Service						
Unprotected Steel (Bare Steel)						
Unprotected Steel (Coated Steel)						
Unprotected Steel (Cast Iron)						
Coated Steel (Protected)						
Copper						
Plastic						
Totals, All Leak Grades						
Unprotected Steel (Bare Steel)						
Unprotected Steel (Coated Steel)						
Unprotected Steel (Cast Iron)						
Coated Steel (Protected)						
Copper						
Plastic						
Totals, Grade 1 Leaks						

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

WGL PROJECTpipes CBA
Baseline Case - Avoided Costs
Grid Breaks Ranked

	Bare Steel		Unprotected Wrapped Steel		Cast Iron		Programs Total		Contingent Pipe	Total
Year	BoY	Replace	BoY	Replace	BoY	Replace	BoY	Replaced	Replaced	Installation
2020	110,833	9,979	291,984	3,010	2,161,986	898	2,564,803	13,886	555	14,441
2021	100,854	11,880	288,974	3,696	2,161,088	898	2,550,917	16,474	659	17,133
2022	88,974	12,091	285,278	3,696	2,160,191	898	2,534,443	16,685	667	17,352
2023	76,883	12,355	281,582	3,696	2,159,293	898	2,517,758	16,949	678	17,627
2024	64,527	12,355	277,886	3,696	2,158,396	898	2,500,809	16,949	678	17,627
2025	52,172	11,090	274,190	9,545	2,157,498	7,192	2,483,861	27,827	1,113	28,940
2026	41,082	11,090	264,646	9,545	2,150,306	17,341	2,456,034	37,976	1,519	39,495
2027	29,991	11,090	255,101	9,545	2,132,965	29,995	2,418,057	50,630	2,025	52,655
2028	18,901	11,090	245,556	9,545	2,102,970	44,608	2,367,427	65,244	2,610	67,854
2029	7,811	7,811	236,011	9,545	2,058,362	60,540	2,302,184	77,896	3,116	81,012
2030	-		226,466	9,545	1,997,822	84,297	2,224,288	93,842	3,754	97,596
2031	-		216,922	9,545	1,913,525	84,297	2,130,447	93,842	3,754	97,596
2032	-		207,377	9,545	1,829,228	84,297	2,036,605	93,842	3,754	97,596
2033	-		197,832	9,545	1,744,931	84,297	1,942,763	93,842	3,754	97,596
2034	-		188,287	9,545	1,660,634	84,297	1,848,921	93,842	3,754	97,596
2035	-		178,742	9,545	1,576,337	84,297	1,755,080	93,842	3,754	97,596
2036	-		169,198	9,545	1,492,041	84,297	1,661,238	93,842	3,754	97,596
2037	-		159,653	9,545	1,407,744	84,297	1,567,396	93,842	3,754	97,596
2038	-		150,108	9,545	1,323,447	84,297	1,473,555	93,842	3,754	97,596
2039	-		140,563	9,545	1,239,150	84,297	1,379,713	93,842	3,754	97,596
2040	-		131,018	9,545	1,154,853	84,297	1,285,871	93,842	3,754	97,596
2041	-		121,474	9,545	1,070,556	84,297	1,192,030	93,842	3,754	97,596
2042	-		111,929	9,545	986,259	84,297	1,098,188	93,842	3,754	97,596
2043	-		102,384	9,545	901,962	84,297	1,004,346	93,842	3,754	97,596
2044	-		92,839	9,545	817,666	84,297	910,505	93,842	3,754	97,596
2045	-		83,294	9,545	733,369	84,297	816,663	93,842	3,754	97,596
2046	-		73,750	9,545	649,072	84,297	722,821	93,842	3,754	97,596
2047	-		64,205	9,545	564,775	84,297	628,980	93,842	3,754	97,596
2048	-		54,660	9,545	480,478	84,297	535,138	93,842	3,754	97,596
2049	-		45,115	9,545	396,181	84,297	441,296	93,842	3,754	97,596
2050	-		35,570	9,068	311,884	80,082	347,455	89,150	3,566	92,716
2051	-		26,503	8,113	231,802	71,652	258,305	79,765	3,191	82,956
2052	-		18,390	7,159	160,150	63,223	178,540	70,381	2,815	73,196
2053	-		11,231	6,204	96,927	54,793	108,158	60,997	2,440	63,437
2054	-		5,027	5,027	42,134	42,134	47,161	47,161	1,886	49,047

WGL PROJECTpipes CBA
Baseline Case - Services Replacement
Grid Breaks Ranked

	Bare Steel (Unprotected)			Coated Steel (Unprotected)				Cast Iron			Total Services Worked		
Year	ScatteredBS	ReplacedBS	TransferedBS	ScatteredCSU	ReplacedCU	ReplacedCSU	TransferedCSU	ScatteredCI	ReplacedCI6	TransferedCI	Scattered8	Replaced9	Transfered10
2020	728	69	96	9	0	4	2	0	6	13	737	79	111
2021	860	82	114	32	0	37	22	0	4	10	892	123	146
2022	917	76	105	22	0	23	14	0	7	16	939	106	135
2023	875	123	171	24	0	6	3	0	3	8	899	132	182
2024	918	84	117	22	0	6	4	0	5	13	940	95	134
2025	823	78	108	58	0	40	24	0	46	108	881	164	240
2026	821	78	108	61	0	72	43	0	109	254	882	259	405
2027	835	64	89	59	0	109	65	0	185	430	894	358	584
2028	796	87	121	57	0	75	45	0	282	657	853	444	823
2029	607	60	83	61	0	101	61	0	378	881	668	539	1025
2030				55	0	59	35	0	528	1229	55	587	1264
2031				61	0	78	47	0	527	1228	61	605	1275
2032				60	0	84	50	0	527	1227	60	611	1277
2033				58	0	42	25	0	527	1228	58	569	1253
2034				59	0	92	55	0	528	1229	59	620	1284
2035				59	0	104	62	0	527	1227	59	631	1289
2036				60	0	153	92	0	528	1230	60	681	1322
2037				59	0	144	87	0	527	1227	59	671	1314
2038				59	0	35	21	0	528	1230	59	563	1251
2039				57	0	102	61	0	528	1230	57	630	1291
2040				59	0	149	89	0	527	1226	59	676	1315
2041				58	0	93	56	0	527	1227	58	620	1283
2042				62	0	100	60	0	528	1229	62	628	1289
2043				57	0	94	56	0	528	1229	57	622	1285
2044				61	0	129	77	0	528	1230	61	657	1307
2045				55	0	68	41	0	526	1225	55	594	1266
2046				63	0	168	101	0	527	1227	63	695	1328
2047				58	0	128	77	0	527	1227	58	655	1304
2048				59	0	103	62	0	529	1232	59	632	1294
2049				59	0	44	26	0	526	1224	59	570	1250
2050				53	0	75	45	0	503	1171	53	578	1216
2051				53	0	109	65	0	447	1041	53	556	1106
2052				44	0	77	46	0	398	926	44	475	972
2053				37	0	50	30	0	341	795	37	391	825
2054				33	0	12	7	0	265	617	33	277	624

Appendix B – Accelerated Asset Replacement

AAR 2054 Duration

- Program Costs, 123 [CONFIDENTIAL]
- Avoided Costs, 130 [CONFIDENTIAL]
- Mains Replacement, 138
- Services Replacement, 139

AAR 2052 Duration

- Program Costs, 140 [CONFIDENTIAL]
- Avoided Costs, 148 [CONFIDENTIAL]
- Mains Replacement, 156
- Services Replacement, 157

AAR 2048 Duration

- Program Costs, 158 [CONFIDENTIAL]
- Avoided Costs, 166 [CONFIDENTIAL]
- Mains Replacement, 174
- Services Replacement, 175

Description	PROGRAM TOTAL			
	Units			Percent
Assets				
Mains	[redacted]			
Bare Steel				
Coated Unprotected				
Cast Iron				
Contingent Pipe				
Services				
Scattered				
Replaced				
Transferred				
		$/unit	PROJECTpipes	Percent
Construction (Direct Costs)				
Mains	[redacted]			
Materials				
Installation				
Paving				
Traffic Control				
Services				
Materials				
Installation				
Paving				
Traffic Control				
Contingent Pipe				
Materials				
Installation				
Paving				
Traffic Control				
Subtotal				
Program Support (Indirect Costs)				
Permitting				
Engineering				
Subtotal				
Other Costs				
Contingency				
Overhead				
Program Management				
Construction Management				
Subtotal				
Total (Real Cash Flow, 2020$)				
Escalation				
Labor				
All				
Materials				
Plastic				
Paving				
Total Escalation				
Total (Nominal Cash Flow)				

Description	2020	2021	2022	2023	2024	2025
Assets						
Mains						
Bare Steel						
Coated Unprotected						
Cast Iron						
Contingent Pipe						
Services						
Scattered						
Replaced						
Transferred						
Construction (Direct Costs)						
Mains						
Materials						
Installation						
Paving						
Traffic Control						
Services						
Materials						
Installation						
Paving						
Traffic Control						
Contingent Pipe						
Materials						
Installation						
Paving						
Traffic Control						
Subtotal						
Program Support (Indirect Costs)						
Permitting						
Engineering						
Subtotal						
Other Costs						
Contingency						
Overhead						
Program Management						
Construction Management						
Subtotal						
Total (Real Cash Flow, 2020$)						
Escalation						
Labor						
All						
Materials						
Plastic						
Paving						
Total Escalation						
Total (Nominal Cash Flow)						

Description	2026	2027	2028	2029	2030	2031
Assets						
Mains	[redacted]					
Bare Steel						
Coated Unprotected						
Cast Iron						
Contingent Pipe						
Services						
Scattered						
Replaced						
Transferred						
Construction (Direct Costs)						
Mains	[redacted]					
Materials						
Installation						
Paving						
Traffic Control						
Services						
Materials						
Installation						
Paving						
Traffic Control						
Contingent Pipe						
Materials						
Installation						
Paving						
Traffic Control						
Subtotal						
Program Support (Indirect Costs)						
Permitting						
Engineering						
Subtotal						
Other Costs						
Contingency						
Overhead						
Program Management						
Construction Management						
Subtotal						
Total (Real Cash Flow, 2020$)						
Escalation						
Labor						
All						
Materials						
Plastic						
Paving						
Total Escalation						
Total (Nominal Cash Flow)						

Description	2032	2033	2034	2035	2036	2037
Assets						
Mains	[redacted]					
Bare Steel						
Coated Unprotected						
Cast Iron						
Contingent Pipe						
Services						
Scattered						
Replaced						
Transferred						
Construction (Direct Costs)						
Mains	[redacted]					
Materials						
Installation						
Paving						
Traffic Control						
Services						
Materials						
Installation						
Paving						
Traffic Control						
Contingent Pipe						
Materials						
Installation						
Paving						
Traffic Control						
Subtotal						
Program Support (Indirect Costs)						
Permitting						
Engineering						
Subtotal						
Other Costs						
Contingency						
Overhead						
Program Management						
Construction Management						
Subtotal						
Total (Real Cash Flow, 2020$)						
Escalation						
Labor						
All						
Materials						
Plastic						
Paving						
Total Escalation						
Total (Nominal Cash Flow)						

Description	2038	2039	2040	2041	2042	2043
Assets						
Mains	[redacted]					
Bare Steel						
Coated Unprotected						
Cast Iron						
Contingent Pipe						
Services						
Scattered						
Replaced						
Transferred						
Construction (Direct Costs)						
Mains	[redacted]					
Materials						
Installation						
Paving						
Traffic Control						
Services						
Materials						
Installation						
Paving						
Traffic Control						
Contingent Pipe						
Materials						
Installation						
Paving						
Traffic Control						
Subtotal						
Program Support (Indirect Costs)						
Permitting						
Engineering						
Subtotal						
Other Costs						
Contingency						
Overhead						
Program Management						
Construction Management						
Subtotal						
Total (Real Cash Flow, 2020$)						
Escalation						
Labor						
All						
Materials						
Plastic						
Paving						
Total Escalation						
Total (Nominal Cash Flow)						

Description	2044	2045	2046	2047	2048	2049
Assets						
Mains	[redacted]					
Bare Steel						
Coated Unprotected						
Cast Iron						
Contingent Pipe						
Services						
Scattered						
Replaced						
Transferred						
Construction (Direct Costs)						
Mains	[redacted]					
Materials						
Installation						
Paving						
Traffic Control						
Services						
Materials						
Installation						
Paving						
Traffic Control						
Contingent Pipe						
Materials						
Installation						
Paving						
Traffic Control						
Subtotal						
Program Support (Indirect Costs)						
Permitting						
Engineering						
Subtotal						
Other Costs						
Contingency						
Overhead						
Program Management						
Construction Management						
Subtotal						
Total (Real Cash Flow, 2020$)						
Escalation						
Labor						
All						
Materials						
Plastic						
Paving						
Total Escalation						
Total (Nominal Cash Flow)						

Description	2050	2051	2052	2053	2054
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains	[redacted]				
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

AVOIDED COST INPUTS				
Program Inventory			Feet of Pipe	
Mains				
Annual Productivity				
Bare Steel (Unprotected)	[redacted]			
Coated Steel (Unprotected)				
Cast Iron				
Coated Steel (Protected)				
Plastic				
Contingent Mains				
Totals				
Year Ending Balance				
Bare Steel (Unprotected)				
Coated Steel (Unprotected)				
Cast Iron				
Coated Steel (Protected)				
Plastic				
Contingent Mains				
Totals				
Services				
Annual Productivity				
Unprotected Steel (Bare Steel)				
Unprotected Steel (Coated Steel)				
Unprotected Steel (Cast Iron)				
Coated Steel (Protected)				
Copper				
Plastic				
Totals				
Year Ending Balance				
Unprotected Steel (Bare Steel)				
Unprotected Steel (Coated Steel)				
Unprotected Steel (Cast Iron)				
Coated Steel (Protected)				
Copper				
Plastic				
Totals				
Meters				
Meter Move outs				
Pressure Regulator Stations				
Less than 100 psig				
Net Program Impact				
Mains - PE				
Services - PE				
Meter Move outs				
Regulator Stations				

A	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Program Inventory														
Mains														
Annual Productivity														
Bare Steel (Unprotected)														
Coated Steel (Unprotected)														
Cast Iron														
Coated Steel (Protected)														
Plastic														
Contingent Mains														
Totals														
Year Ending Balance														
Bare Steel (Unprotected)														
Coated Steel (Unprotected)														
Cast Iron														
Coated Steel (Protected)														
Plastic														
Contingent Mains														
Totals														
Services														
Annual Productivity														
Unprotected Steel (Bare Steel)														
Unprotected Steel (Coated Steel)														
Unprotected Steel (Cast Iron)														
Coated Steel (Protected)														
Copper														
Plastic														
Totals														
Year Ending Balance														
Unprotected Steel (Bare Steel)														
Unprotected Steel (Coated Steel)														
Unprotected Steel (Cast Iron)														
Coated Steel (Protected)														
Copper														
Plastic														
Totals														
Meters														
Meter Move outs														
Pressure Regulator Stations														
Less than 100 psig														
Net Program Impact														
Mains - PE														
Services - PE														
Meter Move outs														
Regulator Stations														

A	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
Program Inventory													
Mains													
Annual Productivity													
Bare Steel (Unprotected)	[redacted]												
Coated Steel (Unprotected)													
Cast Iron													
Coated Steel (Protected)													
Plastic													
Contingent Mains													
Totals													
Year Ending Balance													
Bare Steel (Unprotected)													
Coated Steel (Unprotected)													
Cast Iron													
Coated Steel (Protected)													
Plastic													
Contingent Mains													
Totals													
Services													
Annual Productivity													
Unprotected Steel (Bare Steel)													
Unprotected Steel (Coated Steel)													
Unprotected Steel (Cast Iron)													
Coated Steel (Protected)													
Copper													
Plastic													
Totals													
Year Ending Balance													
Unprotected Steel (Bare Steel)													
Unprotected Steel (Coated Steel)													
Unprotected Steel (Cast Iron)													
Coated Steel (Protected)													
Copper													
Plastic													
Totals													
Meters													
Meter Move outs													
Pressure Regulator Stations													
Less than 100 psig													
Net Program Impact													
Mains - PE													
Services - PE													
Meter Move outs													
Regulator Stations													

A	2047	2048	2049	2050	2051	2052	2053	2054
Program Inventory								
Mains								
Annual Productivity								
Bare Steel (Unprotected)								
Coated Steel (Unprotected)								
Cast Iron								
Coated Steel (Protected)								
Plastic								
Contingent Mains								
Totals								
Year Ending Balance								
Bare Steel (Unprotected)								
Coated Steel (Unprotected)								
Cast Iron								
Coated Steel (Protected)								
Plastic								
Contingent Mains								
Totals								
Services								
Annual Productivity								
Unprotected Steel (Bare Steel)								
Unprotected Steel (Coated Steel)								
Unprotected Steel (Cast Iron)								
Coated Steel (Protected)								
Copper								
Plastic								
Totals								
Year Ending Balance								
Unprotected Steel (Bare Steel)								
Unprotected Steel (Coated Steel)								
Unprotected Steel (Cast Iron)								
Coated Steel (Protected)								
Copper								
Plastic								
Totals								
Meters								
Meter Move outs								
Pressure Regulator Stations								
Less than 100 psig								
Net Program Impact								
Mains - PE								
Services - PE								
Meter Move outs								
Regulator Stations								

Avoided Leaks

Mains	LPM-Yr	Segment-Life	Total	
Bare Steel (Unprotected)	[redacted]			
Coated Steel (Unprotected)				
Cast Iron				
Coated Steel (Protected)				
Plastic				
Totals, All Leak Grades				
Bare Steel (Unprotected)				
Coated Steel (Unprotected)				
Cast Iron				
Coated Steel (Protected)				
Plastic				
Totals, Grade 1 Leaks				
Service				
Unprotected Steel (Bare Steel)				
Unprotected Steel (Coated Steel)				
Unprotected Steel (Cast Iron)				
Coated Steel (Protected)				
Copper				
Plastic				
Totals, All Leak Grades				
Unprotected Steel (Bare Steel)				
Unprotected Steel (Coated Steel)				
Unprotected Steel (Cast Iron)				
Coated Steel (Protected)				
Copper				
Plastic				
Totals, Grade 1 Leaks				

Avoided Costs Benefits

Avoided Capital Spending	[redacted]
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Transfer Benefits

Excess Flow Valves	[redacted]
Repaved Street (5 year life)	
Total Transfer Benefits	

GHG Emission Reduction	[redacted]
CO2 Reduction (Metric Tons)	
Cumulative Reduction (Metric Tons)	

Avoided Leaks

Mains	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Bare Steel (Unprotected)														
Coated Steel (Unprotected)														
Cast Iron														
Coated Steel (Protected)														
Plastic														
Totals, All Leak Grades														
Bare Steel (Unprotected)														
Coated Steel (Unprotected)														
Cast Iron														
Coated Steel (Protected)														
Plastic														
Totals, Grade 1 Leaks														
Service														
Unprotected Steel (Bare Steel)														
Unprotected Steel (Coated Steel)														
Unprotected Steel (Cast Iron)														
Coated Steel (Protected)														
Copper														
Plastic														
Totals, All Leak Grades														
Unprotected Steel (Bare Steel)														
Unprotected Steel (Coated Steel)														
Unprotected Steel (Cast Iron)														
Coated Steel (Protected)														
Copper														
Plastic														
Totals, Grade 1 Leaks														

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Transfer Benefits

Excess Flow Valves	
Repaved Street (5 year life)	
Total Transfer Benefits	

GHG Emission Reduction	
CO2 Reduction (Metric Tons)	
Cumulative Reduction (Metric Tons)	

Avoided Leaks

Mains	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
Bare Steel (Unprotected)													
Coated Steel (Unprotected)													
Cast Iron													
Coated Steel (Protected)													
Plastic													
Totals, All Leak Grades													
Bare Steel (Unprotected)													
Coated Steel (Unprotected)													
Cast Iron													
Coated Steel (Protected)													
Plastic													
Totals, Grade 1 Leaks													
Service													
Unprotected Steel (Bare Steel)													
Unprotected Steel (Coated Steel)													
Unprotected Steel (Cast Iron)													
Coated Steel (Protected)													
Copper													
Plastic													
Totals, All Leak Grades													
Unprotected Steel (Bare Steel)													
Unprotected Steel (Coated Steel)													
Unprotected Steel (Cast Iron)													
Coated Steel (Protected)													
Copper													
Plastic													
Totals, Grade 1 Leaks													

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Transfer Benefits

Excess Flow Valves	
Repaved Street (5 year life)	
Total Transfer Benefits	

GHG Emission Reduction	
CO2 Reduction (Metric Tons)	
Cumulative Reduction (Metric Tons)	

Avoided Leaks

Mains	2047	2048	2049	2050	2051	2052	2053	2054
Bare Steel (Unprotected)								
Coated Steel (Unprotected)								
Cast Iron								
Coated Steel (Protected)								
Plastic								
Totals, All Leak Grades								
Bare Steel (Unprotected)								
Coated Steel (Unprotected)								
Cast Iron								
Coated Steel (Protected)								
Plastic								
Totals, Grade 1 Leaks								
Service								
Unprotected Steel (Bare Steel)								
Unprotected Steel (Coated Steel)								
Unprotected Steel (Cast Iron)								
Coated Steel (Protected)								
Copper								
Plastic								
Totals, All Leak Grades								
Unprotected Steel (Bare Steel)								
Unprotected Steel (Coated Steel)								
Unprotected Steel (Cast Iron)								
Coated Steel (Protected)								
Copper								
Plastic								
Totals, Grade 1 Leaks								

Avoided Costs Benefits

Avoided Capital Spending
Leak Repair ST & CU Services
Avoided O&M Spending
Leak Repairs-Unprotected ST Mains
Leak Repairs- Protected ST Mains
Leak Repairs-Plastic Mains
Leak Repairs-CI Mains
Leak Repairs-Plastic Services
Leak Rechecks
Inside Leak Survey
Emergency Response (Below Ground Leak)
Pressure Regulator Stations
Valve Inspection
Drips Drained
Subtotal Avoided Costs
Capital Spending
O&M Spending
Total Avoided Costs

Transfer Benefits

Excess Flow Valves
Repaved Street (5 year life)
Total Transfer Benefits

GHG Emission Reduction
CO2 Reduction (Metric Tons)
Cumulative Reduction (Metric Tons)

WGL PROJECTpipes CBA
Accelerated Asset Replacement - 2054
Mains Replacement

	Bare Steel		Unprotected Wrapped Steel		Cast Iron		Programs Total		Contingent Pipe	Total
Year	BoY	Replace	BoY	Replace	BoY	Replace	BoY	Replaced	Replaced	Installation
2020	110,833	9,979	350,064	3,010	2,161,986	898	2,622,883	13,886	555	14,441
2021	100,854	11,880	347,054	3,696	2,161,088	898	2,608,997	16,474	659	17,133
2022	88,974	12,091	343,358	3,696	2,160,191	898	2,592,523	16,685	667	17,352
2023	76,883	12,355	339,662	3,696	2,159,293	898	2,575,838	16,949	678	17,627
2024	64,527	12,355	335,966	3,696	2,158,396	898	2,558,889	16,949	678	17,627
2025	52,172	11,090	332,270	11,567	2,157,498	7,192	2,541,941	29,849	1,194	31,043
2026	41,082	11,090	320,704	11,567	2,150,306	17,341	2,512,092	39,998	1,600	41,598
2027	29,991	11,090	309,137	11,567	2,132,965	29,995	2,472,094	52,652	2,106	54,758
2028	18,901	11,090	297,571	11,567	2,102,970	44,608	2,419,442	67,265	2,691	69,956
2029	7,811	7,811	286,004	11,567	2,058,362	60,540	2,352,176	79,917	3,197	83,114
2030	-		274,437	11,567	1,997,822	84,297	2,272,259	95,863	3,835	99,698
2031	-		262,871	11,567	1,913,525	84,297	2,176,396	95,863	3,835	99,698
2032	-		251,304	11,567	1,829,228	84,297	2,080,532	95,863	3,835	99,698
2033	-		239,737	11,567	1,744,931	84,297	1,984,669	95,863	3,835	99,698
2034	-		228,171	11,567	1,660,634	84,297	1,888,805	95,863	3,835	99,698
2035	-		216,604	11,567	1,576,337	84,297	1,792,942	95,863	3,835	99,698
2036	-		205,038	11,567	1,492,041	84,297	1,697,078	95,863	3,835	99,698
2037	-		193,471	11,567	1,407,744	84,297	1,601,215	95,863	3,835	99,698
2038	-		181,904	11,567	1,323,447	84,297	1,505,351	95,863	3,835	99,698
2039	-		170,338	11,567	1,239,150	84,297	1,409,488	95,863	3,835	99,698
2040	-		158,771	11,567	1,154,853	84,297	1,313,624	95,863	3,835	99,698
2041	-		147,205	11,567	1,070,556	84,297	1,217,761	95,863	3,835	99,698
2042	-		135,638	11,567	986,259	84,297	1,121,897	95,863	3,835	99,698
2043	-		124,071	11,567	901,962	84,297	1,026,034	95,863	3,835	99,698
2044	-		112,505	11,567	817,666	84,297	930,170	95,863	3,835	99,698
2045	-		100,938	11,567	733,369	84,297	834,307	95,863	3,835	99,698
2046	-		89,371	11,567	649,072	84,297	738,443	95,863	3,835	99,698
2047	-		77,805	11,567	564,775	84,297	642,580	95,863	3,835	99,698
2048	-		66,238	11,567	480,478	84,297	546,716	95,863	3,835	99,698
2049	-		54,672	11,567	396,181	84,297	450,853	95,863	3,835	99,698
2050	-		43,105	10,988	311,884	80,082	354,989	91,070	3,643	94,713
2051	-		32,117	9,832	231,802	71,652	263,919	81,484	3,259	84,743
2052	-		22,285	8,675	160,150	63,223	182,435	71,898	2,876	74,774
2053	-		13,610	7,518	96,927	54,793	110,537	62,311	2,492	64,803
2054	-		6,092	6,092	42,134	42,134	48,226	48,226	1,929	50,155

WGL PROJECTpipes CBA
Accelerated Asset Replacement - 2054
Services Replacement

	Bare Steel (Unprotected)			Coated Steel (Unprotected)				Cast Iron			Total Services Work		
Year	ScatteredBS	ReplacedBS	TransferedBS	ScatteredCSU	ReplaceCU	ReplacedCSU	TransferedCSU	ScatteredCI	ReplacedCI6	TransferedCI	Scattered8	Replaced9	Transfered10
2020	728	69	96	14	32	5	3	-	4	8	774	78	107
2021	860	82	114	33	77	24	16	-	7	15	970	113	145
2022	917	76	105	25	57	23	15	-	7	15	999	106	135
2023	875	123	171	32	75	31	21	-	-	-	982	154	192
2024	918	84	117	28	65	5	3	-	11	25	1,011	100	145
2025	823	78	108	87	202	45	30	-	44	102	1,112	167	240
2026	821	78	108	76	176	57	38	-	109	254	1,073	244	400
2027	835	64	89	97	225	130	86	-	186	433	1,157	380	608
2028	796	87	121	84	195	101	67	-	282	656	1,075	470	844
2029	607	60	83	88	205	149	99	-	377	879	900	586	1,061
2030				87	201	87	58	-	528	1,230	288	615	1,288
2031				85	198	78	52	-	528	1,228	283	606	1,280
2032				79	183	95	63	-	528	1,230	262	623	1,293
2033				87	201	71	47	-	526	1,224	288	597	1,271
2034				95	220	120	80	-	528	1,231	315	648	1,311
2035				87	201	130	87	-	528	1,230	288	658	1,317
2036				83	192	197	131	-	525	1,223	275	722	1,354
2037				88	205	112	74	-	528	1,231	293	640	1,305
2038				87	203	115	76	-	528	1,230	290	643	1,306
2039				86	200	109	73	-	528	1,229	286	637	1,302
2040				79	184	178	118	-	527	1,228	263	705	1,346
2041				94	218	141	94	-	525	1,221	312	666	1,315
2042				78	182	108	72	-	530	1,235	260	638	1,307
2043				87	201	105	70	-	528	1,229	288	633	1,299
2044				91	211	175	116	-	527	1,228	302	702	1,344
2045				91	211	104	69	-	524	1,221	302	628	1,290
2046				86	200	208	138	-	531	1,236	286	739	1,374
2047				87	201	154	102	-	524	1,221	288	678	1,323
2048				86	201	133	89	-	528	1,230	287	661	1,319
2049				86	201	56	37	-	530	1,233	287	586	1,270
2050				80	187	96	64	-	499	1,161	267	595	1,225
2051				72	167	134	89	-	450	1,048	239	584	1,137
2052				67	155	98	65	-	395	919	222	493	984
2053				55	127	62	41	-	343	799	182	405	840
2054				48	111	14	10	-	265	617	159	279	627

Description	PROGRAM TOTAL			
	Units			Percent
Assets				
Mains	[redacted]			
Bare Steel				
Coated Unprotected				
Cast Iron				
Contingent Pipe				
Services				
Scattered				
Replaced				
Transferred				
		$/unit	PROJECTpipes	Percent
Construction (Direct Costs)				
Mains	[redacted]			
Materials				
Installation				
Paving				
Traffic Control				
Services				
Materials				
Installation				
Paving				
Traffic Control				
Contingent Pipe				
Materials				
Installation				
Paving				
Traffic Control				
Subtotal				
Program Support (Indirect Costs)				
Permitting				
Engineering				
Subtotal				
Other Costs				
Contingency				
Overhead				
Program Management				
Construction Management				
Subtotal				
Total (Real Cash Flow, 2020$)				
Escalation				
Labor				
All				
Materials				
Plastic				
Paving				
Total Escalation				
Total (Nominal Cash Flow)				

WGL PROJECTpipes CBA
Accelerated Asset Replacement - 2052
Project Costs

Description	2020	2021	2022	2023	2024
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains	[redacted]				
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

Description	2025	2026	2027	2028	2029
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains	[redacted]				
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

Description	2030	2031	2032	2033	2034
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains	[redacted]				
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

Description	2035	2036	2037	2038	2039
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains	[redacted]				
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

Description	2040	2041	2042	2043	2044
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains	[redacted]				
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

Description	2045	2046	2047	2048	2049
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains	[redacted]				
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

Description	2050	2051	2052	2053	2054
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains	[redacted]				
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

AVOIDED COST INPUTS				
Program Inventory			Feet of Pipe	
Mains				
Annual Productivity				
Bare Steel (Unprotected)	[redacted]			
Coated Steel (Unprotected)				
Cast Iron				
Coated Steel (Protected)				
Plastic				
Contingent Mains				
Totals				
Year Ending Balance				
Bare Steel (Unprotected)				
Coated Steel (Unprotected)				
Cast Iron				
Coated Steel (Protected)				
Plastic				
Contingent Mains				
Totals				
Services				
Annual Productivity				
Unprotected Steel (Bare Steel)				
Unprotected Steel (Coated Steel)				
Unprotected Steel (Cast Iron)				
Coated Steel (Protected)				
Copper				
Plastic				
Totals				
Year Ending Balance				
Unprotected Steel (Bare Steel)				
Unprotected Steel (Coated Steel)				
Unprotected Steel (Cast Iron)				
Coated Steel (Protected)				
Copper				
Plastic				
Totals				
Meters				
Meter Move outs				
Pressure Regulator Stations				
Less than 100 psig				
Net Program Impact				
Mains - PE				
Services - PE				
Meter Move outs				
Regulator Stations				

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Program Inventory															
Mains															
Annual Productivity															
Bare Steel (Unprotected)															
Coated Steel (Unprotected)															
Cast Iron															
Coated Steel (Protected)															
Plastic															
Contingent Mains															
Totals															
Year Ending Balance															
Bare Steel (Unprotected)															
Coated Steel (Unprotected)															
Cast Iron															
Coated Steel (Protected)															
Plastic															
Contingent Mains															
Totals															
Services															
Annual Productivity															
Unprotected Steel (Bare Steel)															
Unprotected Steel (Coated Steel)															
Unprotected Steel (Cast Iron)															
Coated Steel (Protected)															
Copper															
Plastic															
Totals															
Year Ending Balance															
Unprotected Steel (Bare Steel)															
Unprotected Steel (Coated Steel)															
Unprotected Steel (Cast Iron)															
Coated Steel (Protected)															
Copper															
Plastic															
Totals															
Meters															
Meter Move outs															
Pressure Regulator Stations															
Less than 100 psig															
Net Program Impact															
Mains - PE															
Services - PE															
Meter Move outs															
Regulator Stations															

	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
Program Inventory													
Mains													
Annual Productivity													
Bare Steel (Unprotected)	[redacted]												
Coated Steel (Unprotected)													
Cast Iron													
Coated Steel (Protected)													
Plastic													
Contingent Mains													
Totals													
Year Ending Balance													
Bare Steel (Unprotected)													
Coated Steel (Unprotected)													
Cast Iron													
Coated Steel (Protected)													
Plastic													
Contingent Mains													
Totals													
Services													
Annual Productivity													
Unprotected Steel (Bare Steel)													
Unprotected Steel (Coated Steel)													
Unprotected Steel (Cast Iron)													
Coated Steel (Protected)													
Copper													
Plastic													
Totals													
Year Ending Balance													
Unprotected Steel (Bare Steel)													
Unprotected Steel (Coated Steel)													
Unprotected Steel (Cast Iron)													
Coated Steel (Protected)													
Copper													
Plastic													
Totals													
Meters													
Meter Move outs													
Pressure Regulator Stations													
Less than 100 psig													
Net Program Impact													
Mains - PE													
Services - PE													
Meter Move outs													
Regulator Stations													

	2048	2049	2050	2051	2052	2053	2054
Program Inventory							
Mains							
Annual Productivity							
Bare Steel (Unprotected)	[redacted]						
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Contingent Mains							
Totals							
Year Ending Balance							
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Contingent Mains							
Totals							
Services							
Annual Productivity							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals							
Year Ending Balance							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals							
Meters							
Meter Move outs							
Pressure Regulator Stations							
Less than 100 psig							
Net Program Impact							
Mains - PE							
Services - PE							
Meter Move outs							
Regulator Stations							

Avoided Leaks

Mains	LPM-Yr	Segment-Life	Total	
Bare Steel (Unprotected)				
Coated Steel (Unprotected)				
Cast Iron				
Coated Steel (Protected)				
Plastic				
Totals, All Leak Grades				
Bare Steel (Unprotected)				
Coated Steel (Unprotected)				
Cast Iron				
Coated Steel (Protected)				
Plastic				
Totals, Grade 1 Leaks				
Service				
Unprotected Steel (Bare Steel)				
Unprotected Steel (Coated Steel)				
Unprotected Steel (Cast Iron)				
Coated Steel (Protected)				
Copper				
Plastic				
Totals, All Leak Grades				
Unprotected Steel (Bare Steel)				
Unprotected Steel (Coated Steel)				
Unprotected Steel (Cast Iron)				
Coated Steel (Protected)				
Copper				
Plastic				
Totals, Grade 1 Leaks				

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Transfer Benefits

Excess Flow Valves	
Repaved Street (5 year life)	
Total Transfer Benefits	

GHG Emission Reduction	
CO2 Reduction (Metric Tons)	
Cumulative Reduction (Metric Tons)	

Avoided Leaks

Mains	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Bare Steel (Unprotected)															
Coated Steel (Unprotected)															
Cast Iron															
Coated Steel (Protected)															
Plastic															
Totals, All Leak Grades															
Bare Steel (Unprotected)															
Coated Steel (Unprotected)															
Cast Iron															
Coated Steel (Protected)															
Plastic															
Totals, Grade 1 Leaks															
Service															
Unprotected Steel (Bare Steel)															
Unprotected Steel (Coated Steel)															
Unprotected Steel (Cast Iron)															
Coated Steel (Protected)															
Copper															
Plastic															
Totals, All Leak Grades															
Unprotected Steel (Bare Steel)															
Unprotected Steel (Coated Steel)															
Unprotected Steel (Cast Iron)															
Coated Steel (Protected)															
Copper															
Plastic															
Totals, Grade 1 Leaks															

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Transfer Benefits

Excess Flow Valves	
Repaved Street (5 year life)	
Total Transfer Benefits	

GHG Emission Reduction	
CO2 Reduction (Metric Tons)	
Cumulative Reduction (Metric Tons)	

Avoided Leaks

Mains	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
Bare Steel (Unprotected)													
Coated Steel (Unprotected)													
Cast Iron													
Coated Steel (Protected)													
Plastic													
Totals, All Leak Grades													
Bare Steel (Unprotected)													
Coated Steel (Unprotected)													
Cast Iron													
Coated Steel (Protected)													
Plastic													
Totals, Grade 1 Leaks													
Service													
Unprotected Steel (Bare Steel)													
Unprotected Steel (Coated Steel)													
Unprotected Steel (Cast Iron)													
Coated Steel (Protected)													
Copper													
Plastic													
Totals, All Leak Grades													
Unprotected Steel (Bare Steel)													
Unprotected Steel (Coated Steel)													
Unprotected Steel (Cast Iron)													
Coated Steel (Protected)													
Copper													
Plastic													
Totals, Grade 1 Leaks													

Avoided Costs Benefits

Avoided Capital Spending
Leak Repair ST & CU Services
Avoided O&M Spending
Leak Repairs-Unprotected ST Mains
Leak Repairs- Protected ST Mains
Leak Repairs-Plastic Mains
Leak Repairs-CI Mains
Leak Repairs-Plastic Services
Leak Rechecks
Inside Leak Survey
Emergency Response (Below Ground Leak)
Pressure Regulator Stations
Valve Inspection
Drips Drained
Subtotal Avoided Costs
Capital Spending
O&M Spending
Total Avoided Costs

Transfer Benefits

Excess Flow Valves
Repaved Street (5 year life)
Total Transfer Benefits

GHG Emission Reduction
CO2 Reduction (Metric Tons)
Cumulative Reduction (Metric Tons)

Avoided Leaks

Mains	2048	2049	2050	2051	2052	2053	2054
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Totals, All Leak Grades							
Bare Steel (Unprotected)							
Coated Steel (Unprotected)							
Cast Iron							
Coated Steel (Protected)							
Plastic							
Totals, Grade 1 Leaks							
Service							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals, All Leak Grades							
Unprotected Steel (Bare Steel)							
Unprotected Steel (Coated Steel)							
Unprotected Steel (Cast Iron)							
Coated Steel (Protected)							
Copper							
Plastic							
Totals, Grade 1 Leaks							

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Transfer Benefits

Excess Flow Valves	
Repaved Street (5 year life)	
Total Transfer Benefits	

GHG Emission Reduction	
CO2 Reduction (Metric Tons)	
Cumulative Reduction (Metric Tons)	

WGL PROJECTpipes CBA
Accelerated Asset Replacement - 2052
Mains Replacement

Mains

	Bare Steel		Unprotected Wrapped Steel		Cast Iron		Programs Total		Contingent Pipe	Total
Year	BoY	Replace	BoY	Replace	BoY	Replace	BoY	Replaced	Replaced	Installation
2020	110,833	9,979	350,064	3,010	2,161,986	898	2,622,883	13,886	555	14,441
2021	100,854	11,880	347,054	3,696	2,161,088	898	2,608,997	16,474	659	17,133
2022	88,974	12,091	343,358	3,696	2,160,191	898	2,592,523	16,685	667	17,352
2023	76,883	12,355	339,662	3,696	2,159,293	898	2,575,838	16,949	678	17,627
2024	64,527	12,355	335,966	3,696	2,158,396	898	2,558,889	16,949	678	17,627
2025	52,172	13,863	332,270	14,404	2,157,498	8,142	2,541,941	36,408	1,456	37,864
2026	38,309	13,863	317,867	14,404	2,149,356	19,540	2,505,532	47,806	1,912	49,718
2027	24,446	13,863	303,463	14,404	2,129,817	33,629	2,457,726	61,895	2,476	64,371
2028	10,583	10,583	289,059	14,404	2,096,188	49,740	2,395,831	74,727	2,989	77,716
2029	-	-	274,656	14,404	2,046,448	67,097	2,321,104	81,500	3,260	84,760
2030	-		260,252	14,404	1,979,351	94,255	2,239,603	108,659	4,346	113,005
2031	-		245,848	14,404	1,885,097	94,255	2,130,945	108,659	4,346	113,005
2032	-		231,444	14,404	1,790,842	94,255	2,022,286	108,659	4,346	113,005
2033	-		217,041	14,404	1,696,587	94,255	1,913,628	108,659	4,346	113,005
2034	-		202,637	14,404	1,602,332	94,255	1,804,969	108,659	4,346	113,005
2035	-		188,233	14,404	1,508,077	94,255	1,696,311	108,659	4,346	113,005
2036	-		173,830	14,404	1,413,822	94,255	1,587,652	108,659	4,346	113,005
2037	-		159,426	14,404	1,319,568	94,255	1,478,993	108,659	4,346	113,005
2038	-		145,022	14,404	1,225,313	94,255	1,370,335	108,659	4,346	113,005
2039	-		130,618	14,404	1,131,058	94,255	1,261,676	108,659	4,346	113,005
2040	-		116,215	14,404	1,036,803	94,255	1,153,018	108,659	4,346	113,005
2041	-		101,811	14,404	942,548	94,255	1,044,359	108,659	4,346	113,005
2042	-		87,407	14,404	848,293	94,255	935,701	108,659	4,346	113,005
2043	-		73,004	14,404	754,039	94,255	827,042	108,659	4,346	113,005
2044	-		58,600	14,404	659,784	94,255	718,384	108,659	4,346	113,005
2045	-		44,196	14,404	565,529	94,255	609,725	108,659	4,346	113,005
2046	-		29,792	12,243	471,274	94,255	501,066	106,498	4,260	110,758
2047	-		17,549	10,803	377,019	89,542	394,568	100,345	4,014	104,359
2048	-		6,746	6,746	287,477	80,117	294,223	86,863	3,475	90,338
2049	-				207,360	70,691	207,360	70,691	2,828	73,519
2050	-				136,669	61,266	136,669	61,266	2,451	63,717
2051	-				75,404	47,127	75,404	47,127	1,885	49,012
2052	-				28,276	28,276	28,276	28,276	1,131	29,407
2053	-						-	-	-	-
2054	-						-	-	-	-

WGL PROJECTpipes CBA
Accelerated Asset Replacement - 2052
Services Replacement

	Bare Steel (Unprotected)			Coated Steel (Unprotected)				Cast Iron			Total Services Work		
Year	ScatteredBS	ReplacedBS	TransferedBS	ScatteredCSU	ReplaceCU	ReplacedCSU	TransferedCSU	ScatteredCI	ReplacedCI6	TransferedCI	Scattered8	Replaced9	Transfered10
2020	728	69	96	14	32	5	3	0	4	8	774	78	107
2021	860	82	114	33	77	24	16	0	7	15	970	113	145
2022	917	76	105	25	57	23	15	0	7	15	999	106	135
2023	875	123	171	32	75	31	21	0	0	0	982	154	192
2024	918	84	117	28	65	5	3	0	11	25	1011	100	145
2025	1049	107	149	107	248	56	37	0	51	120	1404	214	306
2026	1017	72	100	109	253	109	73	0	121	282	1379	302	455
2027	1033	111	155	107	248	146	97	0	211	492	1388	468	744
2028	783	76	105	107	249	167	111	0	311	724	1139	554	940
2029	0	0	0	105	245	96	64	0	420	978	350	516	1042
2030				109	254	102	68	0	590	1375	363	692	1443
2031				109	253	127	84	0	589	1373	362	716	1457
2032				108	251	125	83	0	586	1365	359	711	1448
2033				106	247	143	95	0	593	1381	353	736	1476
2034				99	230	202	134	0	588	1369	329	790	1503
2035				115	267	193	128	0	592	1378	382	785	1506
2036				108	252	125	83	0	589	1371	360	714	1454
2037				108	252	236	156	0	590	1373	360	826	1529
2038				107	249	117	78	0	591	1375	356	708	1453
2039				105	245	146	97	0	590	1374	350	736	1471
2040				103	239	188	125	0	589	1373	342	777	1498
2041				113	262	153	102	0	589	1371	375	742	1473
2042				110	255	271	180	0	590	1375	365	861	1555
2043				103	239	171	114	0	590	1373	342	761	1487
2044				113	262	83	55	0	591	1376	375	674	1431
2045				106	248	126	84	0	589	1372	354	715	1456
2046				92	214	141	94	0	590	1375	306	731	1469
2047				81	188	120	79	0	559	1303	269	679	1382
2048				51	118	18	12	0	501	1166	169	519	1178
2049				0	0	0	0	0	444	1035	0	444	1035
2050				0	0	0	0	0	383	891	0	383	891
2051				0	0	0	0	0	295	688	0	295	688
2052				0	0	0	0	0	176	409	0	176	409
2053				0	0	0	0	0	0	0	0	0	0
2054				0	0	0	0	0	0	0	0	0	0

Description	PROGRAM TOTAL			
	Units			Percent
Assets				
Mains	[redacted]			
Bare Steel				
Coated Unprotected				
Cast Iron				
Contingent Pipe				
Services				
Scattered				
Replaced				
Transferred				
		$/unit	PROJECTpipes	Percent
Construction (Direct Costs)				
Mains	[redacted]			
Materials				
Installation				
Paving				
Traffic Control				
Services				
Materials				
Installation				
Paving				
Traffic Control				
Contingent Pipe				
Materials				
Installation				
Paving				
Traffic Control				
Subtotal				
Program Support (Indirect Costs)				
Permitting				
Engineering				
Subtotal				
Other Costs				
Contingency				
Overhead				
Program Management				
Construction Management				
Subtotal				
Total (Real Cash Flow, 2020$)				
Escalation				
Labor				
All				
Materials				
Plastic				
Paving				
Total Escalation				
Total (Nominal Cash Flow)				

Description	2020	2021	2022	2023	2024
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains	[redacted]				
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

Description	2025	2026	2027	2028	2029
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains	[redacted]				
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

Description	2030	2031	2032	2033	2034
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains	[redacted]				
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

Description	2035	2036	2037	2038	2039
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains	**$ 80,866,200**	**$ 80,503,663**	**$ 80,293,982**	**$ 81,027,627**	**$ 80,234,768**
Materials	2,405,540	2,371,358	2,373,280	2,415,169	2,372,277
Installation	60,138,506	59,283,960	59,331,998	60,379,226	59,306,922
Paving	6,410,725	6,958,926	6,700,772	6,410,224	6,651,687
Traffic Control	11,911,429	11,889,419	11,887,933	11,823,008	11,903,881
Services	**$ 13,166,154**	**$ 14,029,457**	**$ 13,622,793**	**$ 13,137,739**	**$ 13,550,169**
Materials	490,583	526,276	508,256	492,110	503,745
Installation	9,656,718	10,338,499	10,005,922	9,661,942	9,933,938
Paving	1,845,105	1,892,848	1,882,699	1,810,772	1,894,988
Traffic Control	1,173,747	1,271,834	1,225,917	1,172,914	1,217,498
Contingent Pipe	**$ 3,234,648**	**$ 3,220,147**	**$ 3,211,759**	**$ 3,241,105**	**$ 3,209,391**
Materials	96,222	94,854	94,931	96,607	94,891
Installation	2,405,540	2,371,358	2,373,280	2,415,169	2,372,277
Paving	256,429	278,357	268,031	256,409	266,067
Traffic Control	476,457	475,577	475,517	472,920	476,155
Subtotal	**$ 97,267,002**	**$ 97,753,267**	**$ 97,128,535**	**$ 97,406,471**	**$ 96,994,327**
Program Support (Indirect Costs)					
Permitting	972,670	977,533	971,285	974,065	969,943
Engineering	2,830,317	2,817,628	2,810,289	2,835,967	2,808,217
Subtotal	$ 3,802,987	$ 3,795,161	$ 3,781,575	$ 3,810,032	$ 3,778,160
Other Costs					
Contingency	25,267,497	25,387,107	25,227,527	25,304,126	25,193,122
Overhead	19,203,298	19,294,201	19,172,921	19,231,136	19,146,773
Program Management	2,021,400	2,030,969	2,018,202	2,024,330	2,015,450
Construction Management	1,702,173	1,710,682	1,699,749	1,704,613	1,697,401
Subtotal	**$ 48,194,367**	**$ 48,422,959**	**$ 48,118,400**	**$ 48,264,205**	**$ 48,052,745**
Total (Real Cash Flow, 2020$)	**149,264,356**	**149,971,387**	**149,028,509**	**149,480,707**	**148,825,232**
Escalation					
Labor					
All	65,854,229	71,594,972	76,857,460	83,031,524	88,594,783
Materials					
Plastic	1,191,721	1,286,342	1,375,639	1,487,575	1,571,639
Paving	403,315	463,430	479,439	488,299	538,148
Total Escalation	**67,449,265**	**73,344,744**	**78,712,538**	**85,007,399**	**90,704,570**
Total (Nominal Cash Flow)	**216,713,621**	**223,316,131**	**227,741,047**	**234,488,106**	**239,529,802**

Description	2040	2041	2042	2043	2044
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains	[redacted]				
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

Description	2045	2046	2047	2048	2049
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains	[redacted]				
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

Description	2050	2051	2052	2053	2054
Assets					
Mains	[redacted]				
Bare Steel					
Coated Unprotected					
Cast Iron					
Contingent Pipe					
Services					
Scattered					
Replaced					
Transferred					
Construction (Direct Costs)					
Mains	[redacted]				
Materials					
Installation					
Paving					
Traffic Control					
Services					
Materials					
Installation					
Paving					
Traffic Control					
Contingent Pipe					
Materials					
Installation					
Paving					
Traffic Control					
Subtotal					
Program Support (Indirect Costs)					
Permitting					
Engineering					
Subtotal					
Other Costs					
Contingency					
Overhead					
Program Management					
Construction Management					
Subtotal					
Total (Real Cash Flow, 2020$)					
Escalation					
Labor					
All					
Materials					
Plastic					
Paving					
Total Escalation					
Total (Nominal Cash Flow)					

AVOIDED COST INPUTS				
Program Inventory			Feet of Pipe	
Mains				
Annual Productivity				
Bare Steel (Unprotected)	[redacted]			
Coated Steel (Unprotected)				
Cast Iron				
Coated Steel (Protected)				
Plastic				
Contingent Mains				
Totals				
Year Ending Balance				
Bare Steel (Unprotected)				
Coated Steel (Unprotected)				
Cast Iron				
Coated Steel (Protected)				
Plastic				
Contingent Mains				
Totals				
Services				
Annual Productivity				
Unprotected Steel (Bare Steel)				
Unprotected Steel (Coated Steel)				
Unprotected Steel (Cast Iron)				
Coated Steel (Protected)				
Copper				
Plastic				
Totals				
Year Ending Balance				
Unprotected Steel (Bare Steel)				
Unprotected Steel (Coated Steel)				
Unprotected Steel (Cast Iron)				
Coated Steel (Protected)				
Copper				
Plastic				
Totals				
Meters				
Meter Move outs				
Pressure Regulator Stations				
Less than 100 psig				
Net Program Impact				
Mains - PE				
Services - PE				
Meter Move outs				
Regulator Stations				

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Program Inventory													
Mains													
Annual Productivity													
Bare Steel (Unprotected)													
Coated Steel (Unprotected)													
Cast Iron													
Coated Steel (Protected)													
Plastic													
Contingent Mains													
Totals													
Year Ending Balance													
Bare Steel (Unprotected)													
Coated Steel (Unprotected)													
Cast Iron													
Coated Steel (Protected)													
Plastic													
Contingent Mains													
Totals													
Services													
Annual Productivity													
Unprotected Steel (Bare Steel)													
Unprotected Steel (Coated Steel)													
Unprotected Steel (Cast Iron)													
Coated Steel (Protected)													
Copper													
Plastic													
Totals													
Year Ending Balance													
Unprotected Steel (Bare Steel)													
Unprotected Steel (Coated Steel)													
Unprotected Steel (Cast Iron)													
Coated Steel (Protected)													
Copper													
Plastic													
Totals													
Meters													
Meter Move outs													
Pressure Regulator Stations													
Less than 100 psig													
Net Program Impact													
Mains - PE													
Services - PE													
Meter Move outs													
Regulator Stations													

	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Program Inventory												
Mains												
Annual Productivity												
Bare Steel (Unprotected)												
Coated Steel (Unprotected)												
Cast Iron												
Coated Steel (Protected)												
Plastic												
Contingent Mains												
Totals												
Year Ending Balance												
Bare Steel (Unprotected)												
Coated Steel (Unprotected)												
Cast Iron												
Coated Steel (Protected)												
Plastic												
Contingent Mains												
Totals												
Services												
Annual Productivity												
Unprotected Steel (Bare Steel)												
Unprotected Steel (Coated Steel)												
Unprotected Steel (Cast Iron)												
Coated Steel (Protected)												
Copper												
Plastic												
Totals												
Year Ending Balance												
Unprotected Steel (Bare Steel)												
Unprotected Steel (Coated Steel)												
Unprotected Steel (Cast Iron)												
Coated Steel (Protected)												
Copper												
Plastic												
Totals												
Meters												
Meter Move outs												
Pressure Regulator Stations												
Less than 100 psig												
Net Program Impact												
Mains - PE												
Services - PE												
Meter Move outs												
Regulator Stations												

	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054
Program Inventory										
Mains										
Annual Productivity										
Bare Steel (Unprotected)	[redacted]									
Coated Steel (Unprotected)										
Cast Iron										
Coated Steel (Protected)										
Plastic										
Contingent Mains										
Totals										
Year Ending Balance										
Bare Steel (Unprotected)										
Coated Steel (Unprotected)										
Cast Iron										
Coated Steel (Protected)										
Plastic										
Contingent Mains										
Totals										
Services										
Annual Productivity										
Unprotected Steel (Bare Steel)										
Unprotected Steel (Coated Steel)										
Unprotected Steel (Cast Iron)										
Coated Steel (Protected)										
Copper										
Plastic										
Totals										
Year Ending Balance										
Unprotected Steel (Bare Steel)										
Unprotected Steel (Coated Steel)										
Unprotected Steel (Cast Iron)										
Coated Steel (Protected)										
Copper										
Plastic										
Totals										
Meters										
Meter Move outs										
Pressure Regulator Stations										
Less than 100 psig										
Net Program Impact										
Mains - PE										
Services - PE										
Meter Move outs										
Regulator Stations										

Avoided Leaks

Mains	LPM-Yr	Segment-Life	Total	
Bare Steel (Unprotected)				
Coated Steel (Unprotected)				
Cast Iron				
Coated Steel (Protected)				
Plastic				
Totals, All Leak Grades				
Bare Steel (Unprotected)				
Coated Steel (Unprotected)				
Cast Iron				
Coated Steel (Protected)				
Plastic				
Totals, Grade 1 Leaks				
Service				
Unprotected Steel (Bare Steel)				
Unprotected Steel (Coated Steel)				
Unprotected Steel (Cast Iron)				
Coated Steel (Protected)				
Copper				
Plastic				
Totals, All Leak Grades				
Unprotected Steel (Bare Steel)				
Unprotected Steel (Coated Steel)				
Unprotected Steel (Cast Iron)				
Coated Steel (Protected)				
Copper				
Plastic				
Totals, Grade 1 Leaks				

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Transfer Benefits

Excess Flow Valves	
Repaved Street (5 year life)	
Total Transfer Benefits	

GHG Emission Reduction	
CO2 Reduction (Metric Tons)	
Cumulative Reduction (Metric Tons)	

Avoided Leaks

Mains	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Bare Steel (Unprotected)													
Coated Steel (Unprotected)													
Cast Iron													
Coated Steel (Protected)													
Plastic													
Totals, All Leak Grades													
Bare Steel (Unprotected)													
Coated Steel (Unprotected)													
Cast Iron													
Coated Steel (Protected)													
Plastic													
Totals, Grade 1 Leaks													
Service													
Unprotected Steel (Bare Steel)													
Unprotected Steel (Coated Steel)													
Unprotected Steel (Cast Iron)													
Coated Steel (Protected)													
Copper													
Plastic													
Totals, All Leak Grades													
Unprotected Steel (Bare Steel)													
Unprotected Steel (Coated Steel)													
Unprotected Steel (Cast Iron)													
Coated Steel (Protected)													
Copper													
Plastic													
Totals, Grade 1 Leaks													

Avoided Costs Benefits

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Avoided Capital Spending													
Leak Repair ST & CU Services													
Avoided O&M Spending													
Leak Repairs-Unprotected ST Mains													
Leak Repairs- Protected ST Mains													
Leak Repairs-Plastic Mains													
Leak Repairs-CI Mains													
Leak Repairs-Plastic Services													
Leak Rechecks													
Inside Leak Survey													
Emergency Response (Below Ground Leak)													
Pressure Regulator Stations													
Valve Inspection													
Drips Drained													
Subtotal Avoided Costs													
Capital Spending													
O&M Spending													
Total Avoided Costs													

Transfer Benefits

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Excess Flow Valves													
Repaved Street (5 year life)													
Total Transfer Benefits													

GHG Emission Reduction	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
CO2 Reduction (Metric Tons)													
Cumulative Reduction (Metric Tons)													

Avoided Leaks

Mains	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Bare Steel (Unprotected)												
Coated Steel (Unprotected)												
Cast Iron												
Coated Steel (Protected)												
Plastic												
Totals, All Leak Grades												
Bare Steel (Unprotected)												
Coated Steel (Unprotected)												
Cast Iron												
Coated Steel (Protected)												
Plastic												
Totals, Grade 1 Leaks												
Service												
Unprotected Steel (Bare Steel)												
Unprotected Steel (Coated Steel)												
Unprotected Steel (Cast Iron)												
Coated Steel (Protected)												
Copper												
Plastic												
Totals, All Leak Grades												
Unprotected Steel (Bare Steel)												
Unprotected Steel (Coated Steel)												
Unprotected Steel (Cast Iron)												
Coated Steel (Protected)												
Copper												
Plastic												
Totals, Grade 1 Leaks												

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Transfer Benefits

Excess Flow Valves	
Repaved Street (5 year life)	
Total Transfer Benefits	

GHG Emission Reduction	
CO2 Reduction (Metric Tons)	
Cumulative Reduction (Metric Tons)	

Avoided Leaks

Mains	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054
Bare Steel (Unprotected)										
Coated Steel (Unprotected)										
Cast Iron										
Coated Steel (Protected)										
Plastic										
Totals, All Leak Grades										
Bare Steel (Unprotected)										
Coated Steel (Unprotected)										
Cast Iron										
Coated Steel (Protected)										
Plastic										
Totals, Grade 1 Leaks										
Service										
Unprotected Steel (Bare Steel)										
Unprotected Steel (Coated Steel)										
Unprotected Steel (Cast Iron)										
Coated Steel (Protected)										
Copper										
Plastic										
Totals, All Leak Grades										
Unprotected Steel (Bare Steel)										
Unprotected Steel (Coated Steel)										
Unprotected Steel (Cast Iron)										
Coated Steel (Protected)										
Copper										
Plastic										
Totals, Grade 1 Leaks										

Avoided Costs Benefits

Avoided Capital Spending	
Leak Repair ST & CU Services	
Avoided O&M Spending	
Leak Repairs-Unprotected ST Mains	
Leak Repairs- Protected ST Mains	
Leak Repairs-Plastic Mains	
Leak Repairs-CI Mains	
Leak Repairs-Plastic Services	
Leak Rechecks	
Inside Leak Survey	
Emergency Response (Below Ground Leak)	
Pressure Regulator Stations	
Valve Inspection	
Drips Drained	
Subtotal Avoided Costs	
Capital Spending	
O&M Spending	
Total Avoided Costs	

Transfer Benefits

Excess Flow Valves	
Repaved Street (5 year life)	
Total Transfer Benefits	

GHG Emission Reduction	
CO2 Reduction (Metric Tons)	
Cumulative Reduction (Metric Tons)	

WGL PROJECTpipes CBA
Accelerated Asset Replacement - 2048
Mains Replacement

	Bare Steel		Unprotected Wrapped Steel		Cast Iron		Programs Total		Contingent Pipe	Total
Year	BoY	Replace	BoY	Replace	BoY	Replace	BoY	Replaced	Replaced	Installation
2020	110,833	9,979	350,064	3,010	2,161,986	898	2,622,883	13,886	555	14,441
2021	100,854	11,880	347,054	3,696	2,161,088	898	2,608,997	16,474	659	17,133
2022	88,974	12,091	343,358	3,696	2,160,191	898	2,592,523	16,685	667	17,352
2023	76,883	12,355	339,662	3,696	2,159,293	898	2,575,838	16,949	678	17,627
2024	64,527	12,355	335,966	3,696	2,158,396	898	2,558,889	16,949	678	17,627
2025	52,172	18,484	332,270	15,087	2,157,498	9,380	2,541,941	42,951	1,718	44,669
2026	33,688	18,484	317,184	15,087	2,148,118	26,851	2,498,989	60,422	2,417	62,839
2027	15,204	15,204	302,097	15,087	2,121,266	42,425	2,438,567	72,716	2,909	75,625
2028	-	-	287,010	15,087	2,078,841	59,967	2,365,851	75,053	3,002	78,055
2029	-	-	271,923	15,087	2,018,874	82,250	2,290,797	97,337	3,893	101,230
2030	-		256,836	15,087	1,936,624	110,664	2,193,460	125,751	5,030	130,781
2031	-		241,749	15,087	1,825,960	110,664	2,067,709	125,751	5,030	130,781
2032	-		226,662	15,087	1,715,295	110,664	1,941,958	125,751	5,030	130,781
2033	-		211,575	15,087	1,604,631	110,664	1,816,206	125,751	5,030	130,781
2034	-		196,488	15,087	1,493,967	110,664	1,690,455	125,751	5,030	130,781
2035	-		181,401	15,087	1,383,303	110,664	1,564,704	125,751	5,030	130,781
2036	-		166,315	15,087	1,272,638	110,664	1,438,953	125,751	5,030	130,781
2037	-		151,228	15,087	1,161,974	110,664	1,313,202	125,751	5,030	130,781
2038	-		136,141	15,087	1,051,310	110,664	1,187,451	125,751	5,030	130,781
2039	-		121,054	15,087	940,646	110,664	1,061,700	125,751	5,030	130,781
2040	-		105,967	15,087	829,982	110,664	935,949	125,751	5,030	130,781
2041	-		90,880	15,087	719,317	110,664	810,197	125,751	5,030	130,781
2042	-		75,793	15,087	608,653	110,664	684,446	125,751	5,030	130,781
2043	-		60,706	15,087	497,989	110,664	558,695	125,751	5,030	130,781
2044	-		45,619	15,087	387,325	105,131	432,944	120,218	4,809	125,027
2045	-		30,533	15,087	282,194	94,065	312,726	109,151	4,366	113,517
2046	-		15,446	15,087	188,129	82,998	203,575	98,085	3,923	102,008
2047	-		359	359	105,131	71,932	105,490	72,291	2,892	75,183
2048	-		-	-	33,199	33,199	33,199	33,199	1,328	34,527
2049	-		-	-			-	-	-	-
2050	-		-	-			-	-	-	-
2051	-		-	-			-	-	-	-
2052	-		-	-			-	-	-	-
2053	-		-	-			-	-	-	-
2054	-		-	-			-	-	-	-

WGL PROJECTpipes CBA
Accelerated Asset Replacement - 2048
Services Replacement

	Bare Steel (Unprotected)			Coated Steel (Unprotected)				Cast Iron			Total Services Work		
Year	ScatteredBS	ReplacedBS	TransferedBS	ScatteredCSU	ReplaceCU	ReplacedCSU	TransferedCSU	ScatteredCI	ReplacedCI6	TransferedCI	Scattered8	Replaced9	Transfered10
2020	728	69	96	14	32	5	3	0	4	8	774	78	107
2021	860	82	114	33	77	24	16	0	7	15	970	113	145
2022	917	76	105	25	57	23	15	0	7	15	999	106	135
2023	875	123	171	32	75	31	21	0	0	0	982	154	192
2024	918	84	117	28	65	5	3	0	11	25	1011	100	145
2025	1387	136	189	114	264	58	39	0	56	131	1765	250	359
2026	1293	118	164	111	258	115	76	0	170	395	1662	403	635
2027	1202	112	156	114	264	160	106	0	267	621	1580	539	883
2028	0	0	0	109	252	163	108	0	375	873	361	538	981
2029	0	0	0	116	270	114	76	0	515	1199	386	629	1275
2030				113	262	131	87	0	692	1613	375	823	1700
2031				108	251	78	52	0	692	1612	359	770	1664
2032				117	272	151	100	0	692	1611	389	843	1711
2033				111	259	248	165	0	694	1615	370	942	1780
2034				113	262	155	103	0	690	1606	375	845	1709
2035				112	260	123	82	0	695	1619	372	818	1701
2036				113	264	238	158	0	692	1613	377	930	1771
2037				114	264	180	120	0	692	1612	378	872	1732
2038				109	254	140	93	0	692	1611	363	832	1704
2039				115	267	163	108	0	692	1612	382	855	1720
2040				113	263	165	110	0	693	1614	376	858	1724
2041				113	262	240	159	0	691	1609	375	931	1768
2042				111	258	240	159	0	693	1615	369	933	1774
2043				114	265	79	52	0	693	1614	379	772	1666
2044				109	254	124	82	0	656	1529	363	780	1611
2045				114	266	178	118	0	590	1374	380	768	1492
2046				115	266	118	78	0	519	1209	381	637	1287
2047				3	7	1	1	0	450	1048	10	451	1049
2048				0	0	0	0	0	207	482	0	207	482
2049				0	0	0	0	0	0	0	0	0	0
2050				0	0	0	0	0	0	0	0	0	0
2051				0	0	0	0	0	0	0	0	0	0
2052				0	0	0	0	0	0	0	0	0	0
2053				0	0	0	0	0	0	0	0	0	0
2054				0	0	0	0	0	0	0	0	0	0

CERTIFICATE OF SERVICE

I, the undersigned counsel, hereby certify that on this 13th day of September 2019, I caused copies of the foregoing to be hand-delivered, mailed, postage-prepaid, or electronically delivered to the following:

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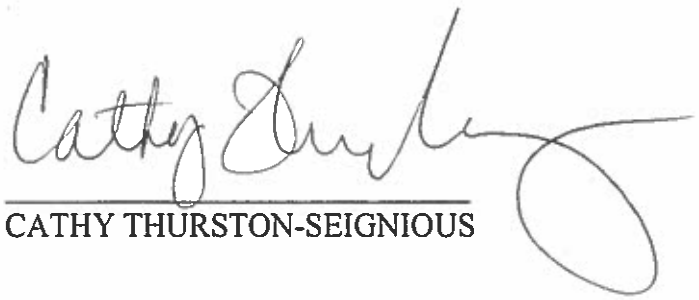

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