Sanitary Sewer Collection System Master Plan

An element of Arlington County's

Comprehensive Plan

August 2023

ARLINGTON
VIRGINIA

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List of Acronyms

Acronym	Meaning
BSF	Base sanitary flow
CCTV	Closed circuit television
CIP	Capital improvement plan
CIPP	Cured-in-place Pipe
CMOM	Capacity Management, Operations, and Maintenance
CPHD	Arlington County Department of Community Planning, Housing, and Development
DIP	Ductile Iron Pipe
FOG	Fats, oils, and grease
FTE	Full time equivalent
GIS	Geographic information system
GLUP	General Land Use Plan
gpd	gallons per day
GWI	Groundwater infiltration
HGL	Hydraulic grade line elevation
mgd	Million gallons per day
NASSCO	National Association of Sewer Service Companies
PACP	Pipeline Assessment Certification Program
PVC	Polyvinyl chloride
RDII	Rainfall derived inflow and infiltration
SWMM	Storm Water Management Model
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WPCP	Water Pollution Control Plant

Executive Summary

Introduction

Arlington County (the County) maintains a sanitary sewer collection and conveyance system that includes approximately 14,681 gravity sewer segments with a length of about 459 miles. The system currently serves approximately 237,300 residents in the County as of 2023 as well as portions in the City of Falls Church, Fairfax County, and the City of Alexandria. **Figure ES-1** presents the County sanitary sewer system and shows the areas that contribute flows to the County sewers.

The overall goal of the Arlington County Sanitary Sewer Collection System Master Plan is to guide future programs to maintain the gravity sewer system such that it continues to operate reliably and remains a valuable resource to the County residents. The Plan addresses the following objectives:

- Describes the County's sanitary sewer collection system.
- Documents ongoing programs and improvements undertaken by the County to maintain and upgrade the gravity sewer system to serve the needs of the residents and ensure continuous service.
- Identifies and addresses any portions of the gravity sanitary sewer system that do not have sufficient capacity for existing and projected future peak wastewater flow demands.
- Recommends potential programs to address current or future capacity issues, reduce backups and emergencies, optimize operation efficiency and improve service reliability.
- Recommends potential programs to maintain or reduce the rates of groundwater infiltration and stormwater inflow entering the public and private sewers to reduce treatment and pumping costs, conserve capacity, and improve overall system performance.
- Recommends an Action Plan to improve the condition of the system and ensure that it operates effectively, safely and efficiently.

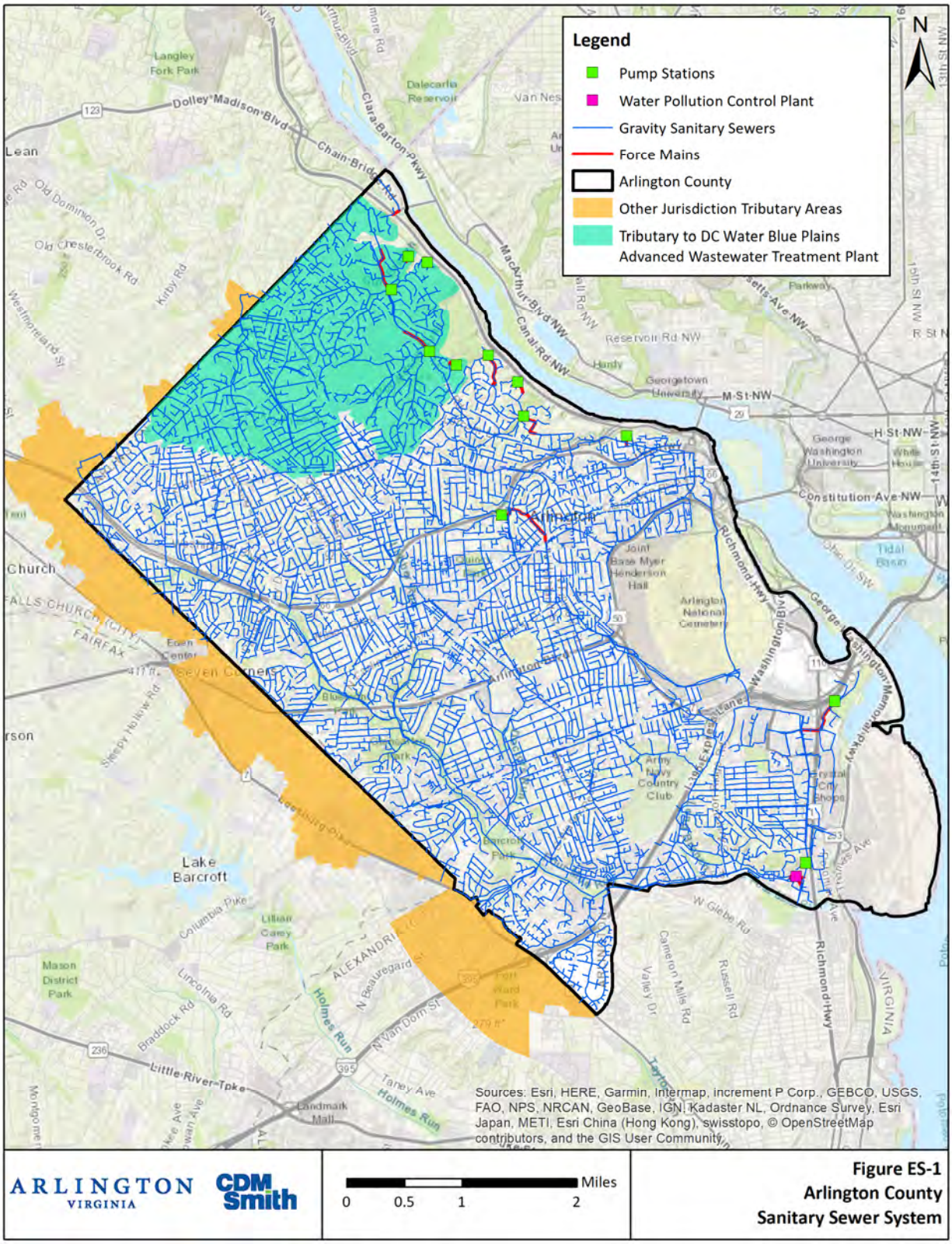

Figure ES-1
Arlington County
Sanitary Sewer System

Major System Improvements and Ongoing Programs

The County has implemented the following improvements to the major interceptor sewer system since the 2002 Sanitary Sewer Collection System Master Plan (the 2002 Master Plan) below:

- Arlington National Cemetery Potomac Interceptor sewer
- Four Mile Run relief sewer (I-395 to Glebe Road)
- Potomac Interceptor Sewer reinstatement on South Eads Street from Army Navy Drive to south of Fort Scott Drive
- Four Mile Run junction chamber improvements near Columbia Pike
- Fairlington relief sewer
- Four Mile Run large-diameter sewer lining
- Potomac Yard Lift Station and related sewers
- Lubber Run Sewer replacement

These improvements have eliminated capacity bottlenecks, improved operations, and improved reliability. The County has implemented various other sanitary sewer improvement projects to address localized capacity issues. Additional projects were implemented to realign sewers for highway construction projects and new development and redevelopment projects.

The major recommendation of the prior 2002 Master Plan was to shift to a proactive rehabilitation and renewal program wherein, initially, 1.5 percent of the sanitary sewers would be lined each year. By the year 2009, the sewer lining program was increased to include more than 2 percent of the County sewers each year and has increased to almost 4 percent or more each year in recent years. Lining involves inspecting and cleaning the sewer lines followed by liner installation to provide structural integrity and reduce groundwater infiltrating into the sanitary sewer. The program focuses on the older sewers and major interceptor sewers.

The County has ongoing programs to eliminate sewers without a manhole at the upstream terminus and to eliminate gravity sewers smaller than 8 inches in diameter. These programs make the system easier to maintain.

For further maintenance and capacity assurance of the gravity sewer collection system, the County implements a variety of other programs, including the following:

- Utilizes a Infrastructure Maintenance Management System, Cartegraph, to schedule and track maintenance activities.
- Maintaining and updating the GIS data of the existing gravity sewer system including new sewers that are added to the system.
- Conducting a gravity sewer main and manhole inspection program.
- Routine flushing of sewers with chronic issues related to grease and other debris on the requisite 1-month/3-month/6-month intervals.

- Apply root control foam treatments to the sewer segments in the root control programs once every five years.
- Inspect all 12-inch diameter and smaller sewers at least once every ten years.
- Grid program to comprehensively flush every 12-inch diameter and smaller sanitary sewer at least once over a five-year period.
- Repair, rehabilitate, or replace manhole structures and gravity sewer mains where deficiencies are identified.
- Identifying, inspecting, and rehabilitating gravity sewer segments that cross streams.

These programs have not made a significant reduction in the number of discharges from the sanitary sewer system. Any discharge is unacceptable and the County strives to further reduce their number.

Capacity Assessment

The County developed a state-of-the-art, dynamic sanitary sewer model that includes all sanitary sewers. This computer model allows for an accurate simulation of existing and future wastewater flows and the capacity evaluation of the existing sanitary sewer system to convey these flows. The model was calibrated based on observed flows from 42 temporary flowmeters and four rain gauges. Water billing data were used to identify the existing base sanitary flows. The model was calibrated to reproduce flows for both dry periods and for rainfall events. During rainfall events, some of the rainfall enters the sanitary sewer through defects in the sewer system. These additional flows from rainfall create peak flows much greater than during typical dry weather.

Future 2045 wastewater flows were estimated using Arlington County Department of Community Planning, Housing, and Development's (CPHD) estimates of the number of housing units and number of employees for 2020 through 2045. These demographic projections account for the buildout envisioned at National Landing. The average wastewater flow is projected to increase by 6.1 million gallons per day (mgd) or 27 percent.

Future adopted land use plans and policies may affect future population and density. In addition, changes in work habits after the COVID-19 pandemic may also affect future wastewater flows. The impact of these initiatives and their potential impact on the sanitary sewer system capacity should be evaluated in the future, but it is expected that the impacts will be small and isolated.

A design storm with a 10-year rainfall recurrence and a 24-hour duration was applied to the calibrated model for existing 2019 and future 2045 wastewater flows. Simulations for both scenarios produced one simulated overflow related to pump station capacity and three areas where the peak flows exceed the sewer capacity and cause the sewers to surcharge. All other sewer segments have sufficient capacity to convey the simulated peak flows. The simulated surcharging in the three surcharged sewer segments is small and likely does not produce backups into nearby houses.

The County is currently installing new 12-inch diameter sewers in Columbia Pike, which will address one of the current capacity concerns. A study is ongoing and is planned to be completed in 2023 to evaluate capacity concerns and needs at the Gulf Run wastewater pumping station. The

County is actively designing a project to upgrade the pump station force main and a portion of the downstream gravity sewers to increase capacity that is anticipated to be constructed in 2025. In the other two areas identified, the amount of surcharging is small and do not require a system improvement project.

System Improvement Plan

The Arlington County Sanitary Sewer Collection System Master Plan includes several programs to continue to improve and maintain the system as summarized below.

Large-Diameter Sewer Inspection and Rehabilitation

The County recognizes that large-diameter (15 inches and larger) major interceptor sewers are critical to the successful continued operation of the sanitary sewer collection system. Portions of the large-diameter Four Mile and Potomac Interceptor sewers recently have been inspected and lined. As outlined in Section 2.4, areas planned for future sewer lining projects in the near-term include the 0.64-mile Potomac Interceptor segment known as the Spout Run Deep Sewer from Spout Run stream to N. Nash Street; the 0.55-mile section of the Potomac Interceptor from N. Lynn Street to Arlington National Cemetery within Rossyln; and the 1.11-mile section of the Four Mile Run Relief sewer between Route 50 and Columbia Pike. Following these projects, the inspection program will transition to other 15-inch diameter and larger tributary, trunk, and interceptor sewers. The County typically targets one large-diameter sewer alignment for inspection and lining each year. The plan includes recommendations for inspecting at least 4.4 miles of large-diameter sewer each year to address critical interceptor sewers within a 10-year time frame.

Sewer Inspection and Rehabilitation Program

Since the adoption of the 2002 Master Plan, the County has implemented a comprehensive sewer lining program and has lined about 51 percent of its gravity sewer segments, which accounts for approximately 58 percent of the total system length. The program has focused on the older, smaller-diameter sewers.

In the near future, this lining program will reach a point of diminishing returns as the older sewers are all lined. At this point, there is no need to line more recently constructed sewers made of Polyvinyl Chloride (PVC) and Ductile Iron Pipe (DIP), and the rate of lining could potentially be reduced in the event that a portion of the funds programmed for the lining program need to be diverted to fund other sewer capital program needs. At the current lining rate of 15.72-miles per year executed over the past five years (2018 thru 2022), the entire small diameter system that is eligible to be lined would be lined by the year 2031.

The County should implement the following initiatives to improve the condition of its system:

- Continue to execute a comprehensive Closed Circuit Television (CCTV) inspection program of all currently unlined sewers using the National Association of Sewer Service Companies (NASSCO) Pipeline Assessment Certification Program (PACP) standards. County inspection crews are not currently consistently using the standardized NASSCO coding system to note defects in the pipes despite many of the staff possessing the NASSCO certification. Defect coding is needed to enable staff to more effectively prioritize future projects and repairs. There are approximately 120 miles of sewer that are smaller than 15 inches that have not

been lined and are not PVC or DIP pipes. Some of the current lining funding could also be used to increase the mileage of large-diameter pipe inspection from current levels to 4.4 miles per year as noted above.

- Continue to update the sanitary sewer system GIS data to have an accurate inventory of the sanitary sewer system including pipe material and construction year. Approximately 29.6% of the sewer main segments (over 4,900 segments) are missing an install date in GIS. Many of these missing install dates are readily available on the County's 50-scale sewer drawings but have not been entered due to staffing limitations. Staff is in the process of recruiting an engineer intern to research and enter the remaining install dates for which records exist.
- Pilot new technologies such as ASTM F2561-20 to trenchlessly rehabilitate and seal the connection of the privately owned sewer lateral connection to the public sewer in order to reduce the groundwater infiltration at this weak point location. Lateral seals can be made watertight via gaskets and resin materials. This is explained further in Section 4.5.2.
- Implement a more robust manhole inspection, condition assessment, and rehabilitation program as part of the existing Manhole Rehabilitation CIP program. Currently, this program is limited to County staff conducting visual manhole inspections as part of the flushing, lining, and SL-RAT/CCTV inspection activities, and when investigating reported backups. Any defects noted area assigned to County crews or contractors for repair. As the number of sewers eligible to be lined approaches zero, the most cost-effective way to reduce groundwater and rainwater from entering the system will be to rehabilitate leaky manhole structures and covers. A formal manhole visual inspection program should be implemented, following NASSCO Manhole Assessment Certification Program (MACP) protocols, with 20% of manholes inspected each year. Manhole prioritization for inspection can be based on the prioritization of the sewershed in which a manhole is located. A risk-based approach should be considered for prioritization of manholes for rehabilitation. Manholes identified through inspection and condition assessment to be in poor condition should be considered for open cut replacement or rehabilitation. It is understood that the County is planning to pilot the AquataFlex spray liner system for manhole rehabilitation.

Inflow and Infiltration Reduction

In addition to the sanitary flow entering the system from homes and businesses, the gravity sewer system must convey additional flows that result from groundwater and rainfall entering the system through defects in the sewers and other sources. These extraneous flows affect the sewer capacity and increase the cost to pump and treat the wastewater and reduce the effective capacity of the gravity sewer system. Reducing inflow and infiltration will free sewer capacity to handle additional wastewater flows from growth.

The County is responsible for maintaining the public gravity sewers from the private sewer lateral connections downstream to the treatment facilities (or to the downstream end of the County's system). Under current regulations and policies, the property owner is responsible for their private service lateral and its connection to the public sewer main.

Public Sewers

Based on review of the flow monitoring data, the County's current inflow and infiltration flows are not excessive, and capacity is not currently a major problem based on the current levels of inflow and infiltration. However, as the sanitary sewers age, these flows will likely increase. The County should continue to inspect and rehabilitate the public sewers to achieve the goal of maintaining or reducing inflow and infiltration.

Private Laterals and Sewer Systems

An estimated 30 percent or more of the inflow and infiltration enters through the privately owned sanitary sewer systems upstream from the connection to the County sewers. The proportion of inflow and infiltration from these private systems will become larger as the County continues to rehabilitate the public sewers. There will come a time when further reductions cannot be realized without addressing private system inflow and infiltration.

The County does not have any jurisdiction over the private laterals, and any improvements needed to address inflow and infiltration will need to be paid for by the property owners under current policy. The use of public funds to implement improvements on private property would involve complicated policy and legal issues. Innovative options exist for alternative funding sources potentially using public moneys or federal or state grant funding should the County decide to address the rehabilitation of private laterals and sewer systems.

There are additional measures that could potentially be undertaken by the County to reduce these sources in new construction or redevelopment. New home construction or redevelopment of residential properties frequently leave the portion of the service lateral in the street unrehabilitated as the portions of the lateral within the property limits are replaced if they are found to be in good condition. In some cases, the laterals within the property limits are not replaced. The County should evaluate a program to require redevelopment of residential properties to include a complete lateral replacement up to and including the rehabilitation of the connection to the County sewer mains.

The County should consider additional options to reduce inflow and infiltration originating from private sources to potentially include the following programs:

- Evaluate options to identify and disconnect existing basement sump pumps in older development from the sanitary sewer system and redirect the flows. A possible long-term solution would be to require that a licensed plumber inspect the homes to certify that sump pumps are disconnected from the sanitary sewer system at the time the property is sold.
- Evaluate options available under State Code to provide loans or financial incentives, such as a utility bill credit, for the inspection and rehabilitation or replacement of private service laterals.
- Expand existing public education programs (e.g. Stormwater outreach program) to include education on private inflow and infiltration sources, including sump pumps and downspout connections, and how they affect the capacity of the sewer system, affect cost of treatment, and contribute to sewer backups and discharges that may occur during major rainfall events.

Capacity, Operation, and Maintenance (CMOM) Program

The County is already implementing many of the elements of a CMOM program, which typically include the following activities:

- Implement sewer main and manhole inspection programs.
- Apply root control programs.
- Routine flushing of sewers with chronic issues related to grease and other debris.
- Periodic flushing and cleaning of sewers on a system wide basis once every five years.
- Implement a sewer system rehabilitation program.
- Identify, inspect, and rehabilitate sewer segments at stream crossings. This program should be repeated approximately every 10 years to identify and correct potential issues created by erosion or other factors.

Additionally, the County should continue programs to address fats, oils, and grease, collectively known as FOG, that can create blockages and cause overflows. This includes the ongoing public information program to instruct homeowners on how to properly dispose of FOG and keep it out of the sanitary sewer system. The County adopted Code Chapter 26.1 "Wastewater Pretreatment" January 22, 2022, which includes requirements for food services establishments to comply with the County's Fats, Oils, and Grease Discharge Policy. The County should establish a formal CMOM program and use it as a vehicle to track progress and document needs. It is typical for CMOM plans to be reviewed and updated on a regular basis (approximately every 10 years).

Periodic Flooding Events

The County has periodically been affected mostly by localized, high-intensity rainfall events that overwhelm the storm water conveyance systems. When basements and streets are flooded, water enters the sanitary sewer system and can produce downstream sanitary sewer backups and discharges. The County should continue to identify areas prone to this type of flooding, and in concert with the County's Stormwater Management program, implement programs and improvements to eliminate or minimize such periodic flooding events.

Future Flow Monitoring and Model Updates

The County should implement temporary flow monitoring programs at 10-year intervals to document and evaluate trends in wastewater flows over time and identify corrective actions that need to be taken to maintain or reduce wastewater flows. The County is building out a permanent flood monitoring network to monitor stormwater flow at key stormwater infrastructure locations and rainfall at those same points within the County. In conjunction with each 10-year future flow monitoring program, the dynamic hydraulic model should be updated to include recent facility improvements and the calibration checked against the recent flow and rainfall monitoring. Future flows should be updated using the then current projections, and the sanitary sewer capacity evaluation should be revisited.

Action Plan

Overall, results from the hydraulic modeling indicated that the County owned and maintained 459 miles sanitary system has adequate capacity to handle the future growth planned throughout

the County. While over 60% of the system was constructed prior to 1960, the effective age of the sewers has been significantly reduced as a result of the aggressive lining program started in the late 1990s. Below is a summary of the recommendations presented throughout this Master Plan Update that the County should implement to improve the condition of the system and ensure that it operates effectively, safely, and efficiently:

- Achieve the long-aspired objective of the Grid program to comprehensively flush every 12-inch diameter and smaller sanitary sewer at least once over a five-year period using contractor crews funded by increasing the future sewer maintenance operating budgets starting in FY 2025 by $330,000 adjusted annually for inflation. This would require the adjustment of the sewer charge rates to be increased by $0.0440 per thousand gallons (TG), which would increase the average household's annual bill by approximately $2.11 per year, representing a 0.46 percent increase. This will initially be implemented as a 5-year pilot program after which the benefits will be evaluated.
- Flush all 15-inch and 18-inch diameter trunk line sewer segments at least once every five years using contractor crews funded by increasing the future sewer maintenance operating budgets starting in FY 2025 by $33,000 adjusted annually for inflation. This would require the adjustment of the sewer charge rates to be increased by $0.0044 per thousand gallons (TG), which would increase the average household's annual bill by approximately $0.21 per year, representing a 0.05 percent increase.
- Accelerate the inspection of the large-diameter (15-inch and larger) sewers from the current pace of 2.1 miles per year to 4.4 miles per year so that all of the remaining unrehabilitated segments that are over 25 years old can be inspected over the next ten years to identify segments with maintenance and/or structural issues. Furthermore, when sewers larger than 18 inches in diameter are bypassed for the inspections, they should be cleaned as part of the inspection. The resources needed to execute this work should be programmed during the development of the FY 2025-2034 CIP starting in year FY 2025.
- Accelerate the rehabilitation of the large-diameter (15-inch and larger) sewers following the completion of the Spout Run Deep sewer, Potomac Interceptor, and Four Mile Run Relief sewer projects, which collectively total approximately 1.3 miles in length. Utilize federal funding opportunities when available as the rehabilitation of these types of interceptor sewers can typically be done trenchlessly with minimal disturbance. The rehabilitation rate is anticipated to be comparable to the aforementioned increased inspection rate. The resources needed to execute this work should be programmed during the development of the FY 2025-2034 CIP starting in year FY 2027.
- Implement a more robust manhole inspection, condition assessment, and rehabilitation program as part of the existing Manhole Rehabilitation CIP program. The increased resources needed to execute this work should be programed during the development of the FY 2025-2034 CIP starting in year FY 2027 as the number of small-diameter sewers eligible for lining nears zero.
- Identify, inspect, and rehabilitate sewer segments at stream crossings. The County is planning to repeat this inspection approximately every 10 years to identify and correct potential issues created by erosion or other factors.

- Utilize the standardized NASSCO defect coding whenever CCTV inspections are performed by either County crews or contractor crews to allow for better prioritization of rehabilitation projects and repairs. This will also enable a more accurate portrayal of remaining asset life in the County's asset management system, Cartegraph.
- Finish researching and updating the sanitary sewer system GIS data to populate the remaining missing pipe material and construction years where data is available.
- Update and refine sanitary sewer and gravity sewer related Construction Standard Details and Standards and Specifications to ensure easier and less frequent maintenance activities, as well as the proper sizing of newly constructed and modified sewer mains and manhole structures. Furthermore, staff should continue to monitor the system's performance during major storm events and if necessary, adjust sewer design peaking factors to be more conservative due to the impacts of climate change.
- Establish a formal written Capacity, Management, Operations, and Maintenance (CMOM) program under the Environmental Protection Agency's (EPA) framework and use it as a vehicle to track progress and document needs. One such element of this framework is the development of an Overflow Emergency Response Plan (OERP).
- Develop a more formal sanitary sewer overflow (SSO) tracking system for the consistent reporting of SSOs, discharges, and their cause. Retain this data electronically indefinitely.
- Continue and update, if necessary, programs to address fats, oils, and grease, collectively known as FOG, that can create blockages and cause overflows. This includes the ongoing public information program to instruct homeowners on how to properly dispose of FOG and keep it out of the sanitary sewer system. The County adopted Code Chapter 26.1 "Wastewater Pretreatment" January 22, 2022, which includes requirements for food services establishments to comply with the County's Fats, Oils, and Grease Discharge Policy.
- Update this Master Plan element ten years following adoption of the subject update.

Any increase in resources needs to be weighed against the impact to the rate payers. Cost benefit analysis should be performed to ensure resourcing is appropriately balanced.

Section 1
Background and Introduction

1.1 Introduction

Arlington County (the County) maintains the sanitary sewer collection and conveyance system that serves Arlington County. The system also receives flows from portions of Fairfax County, the city of Falls Church, and the city of Alexandria. Flows from the central and southern portions of the County are conveyed to the Arlington County Water Pollution Control Plant (WPCP). Areas in the northern portions of the County are conveyed to the DC Water Blue Plains Advanced Wastewater Treatment Plant.

Based on the County's geographic information system (GIS) data, the Arlington County owned and maintained collection system includes approximately 14,681 gravity sewer segments with a length of about 459 miles. The system serves approximately 237,300 persons in Arlington County and additional persons outside the county borders. **Figure 1-1** presents the Arlington County sanitary sewer system and shows the areas that contribute flows to the County sewers.

This report documents the Master Plan for the Arlington County Sanitary Sewer Collection System (the Plan) that will guide the near- and long-term operations, maintenance, and renewal of these facilities.

This Plan mainly addresses the gravity sanitary sewers within the sanitary sewer system. Wastewater pump stations, lift stations and the Water Pollution Control Plant are documented as features of the overall Sanitary Sewer Collection System. Operational plans of these features are prepared through a separate process and are not addressed here as part of this Master Plan effort.

The overall Sanitary Sewer Collection System Master Plan is one of 11 plans that make up the County's Comprehensive Plan. Established in 1960, the purpose of the Comprehensive Plan is to guide coordinated and harmonious development in the County by establishing high standards for public services and facilities. Required by the Commonwealth of Virginia, the Comprehensive Plan is an important decision-making and priority-setting tool used by the County Board, Planning Commission, County departments, and the community. The Comprehensive Plan comprises the following 11 plans:

- General Land Use Plan
- Master Transportation Plan
- Affordable Housing Master Plan
- Water Distribution System Master Plan
- Sanitary Sewer Collection System Master Plan
- Stormwater Master Plan
- Recycling Program Implementation Plan and Map
- Chesapeake Bay Preservation Ordinance and Plan
- Public Spaces Master Plan

- Historic Preservation Master Plan
- Community Energy Plan

The County's Master Plans vary from general policy guidance to more detailed technical assessment and implementation strategies. It is anticipated that changes in community goals, fiscal conditions, changing technology, government standards, and other conditions will require that the gravity sewer system be reevaluated and the plan updated in approximately 10 years.

1.2 Sanitary Sewer Collection System History and Description

At the time of Arlington's incorporation as a county in 1920, approximately 25 miles of trunk sewer mains and 75 miles of smaller sewers were in place. These were mostly private and small community systems sized to serve the existing low and medium population density areas developed at that time. In 1934, a sanitary sewer system master plan was produced and the planned system was constructed over a three-year period. During the 1940s and 1950s the County experienced rapid growth, and new trunk sewers were constructed to meet the expected growth. By 1962 high-density apartment and office construction began in earnest, and some of the trunk sewers were experiencing flows that exceeded their capacities. New sewer lines were constructed from 1962 through 1970 to provide the needed capacity to support this growth.

A 1970 study of the sanitary sewer system identified facility improvements needed to correct existing problems and provide capacity for expected growth. These facilities were constructed during the following decade. Subsequent facility improvements focused on correcting localized problems and capacity issues and included projects required for road construction and to serve development and redevelopment projects.

Sanitary sewer master plans were created periodically, with the last update prepared in 2002. Major recommendations were to increase the sewer replacement and rehabilitation program, fund system improvements, continue the ongoing operation programs, and implement a program to eliminate stubs. Stubs are sewer segments where the upstream terminal end does not have a manhole and therefore are difficult to maintain and service.

Table 1-1 summarizes the growth of the sanitary sewer collection systems since 1920 as indicated by the construction year of the gravity sewers based on the data contained in the sewer system GIS. The construction year is not available for 37 percent of the County gravity sewers. This table documents the total number of miles of gravity sewer per decade and the increase in each decade in miles and in percent of the gravity sewer system where data are available.

The County sanitary sewer system was expanded quite rapidly through 1950. As a result, about 65 percent of the system was constructed before 1950. A large percentage of the system was installed over 70 years ago and portions were installed 100 years ago. The age of the gravity sewers and the construction materials used at the time (short-length terracotta tile and unreinforced concrete) make maintaining the operation of the aging sewer system a major challenge. Starting in the late 1990s, the County has undertaken a sewer lining program that is effectively addressing the condition of the older sewers.

Table 1-1 Gravity Sewer System GIS Date of Construction*

Year	Approximate Total Length of Sewer (Miles)	Incremental Increase (Miles)	Incremental Increase (Percent)
1920	7.5		
1930	11.4	3.9	1.2%
1940	113.7	102.3	31.7%
1950	209.9	96.2	29.8%
1960	280.6	70.7	21.9%
1970	300.5	19.9	6.2%
1980	310.6	10.1	3.1%
1990	314.5	3.9	1.2%
2000	315.3	0.8	0.2%
2010	315.7	0.4	0.1%
2020	322.2	6.5	2.0%
2023	323.2	1.0	0.3%

* Includes only gravity sewers with date of construction data in GIS. 29.6 percent of the total gravity sewer length does not contain a construction install date in GIS at the time of this publication.

1.3 Plan Goals and Objectives

The overall goal of the Sanitary Sewer Collection System Master Plan is to guide future programs to maintain the gravity sewer system such that it continues to operate reliably and remains a valuable resource to the County residents. The Plan addresses the following objectives:

- Describes the County's sanitary sewer collection system.
- Documents ongoing programs and improvements undertaken by the County to maintain and upgrade the gravity sewer system to serve the needs of the residents and ensure continuous service.
- Identifies and addresses any portions of the gravity sanitary sewer system that do not have sufficient capacity for existing and projected future peak wastewater flow demands.
- Recommends potential programs to address current or future capacity issues, reduce backups and emergencies, optimize operation efficiency and improve service reliability.
- Recommends potential programs to maintain or reduce the rates of groundwater infiltration and stormwater inflow entering the public and private sewers to reduce treatment and pumping costs, conserve capacity, and improve overall system performance.
- Recommends an Action Plan to improve the condition of the system and ensure that it operates effectively, safely and efficiently.

Sewer system capacities are evaluated for existing and future wastewater flows. The future flows included in this evaluation are those that were available when the modeling study was performed in 2020. It includes consideration for changes in land use projected for National Landing as a result of the proposed Amazon HQ2 and associated development. Future adopted plans and policies may affect future population and density. In addition, changes in work habits after the COVID-19 pandemic may also affect future wastewater flows. These land use and planning initiatives and their potential impact on the sanitary sewer system capacity are discussed in greater detail in Section 3.4.

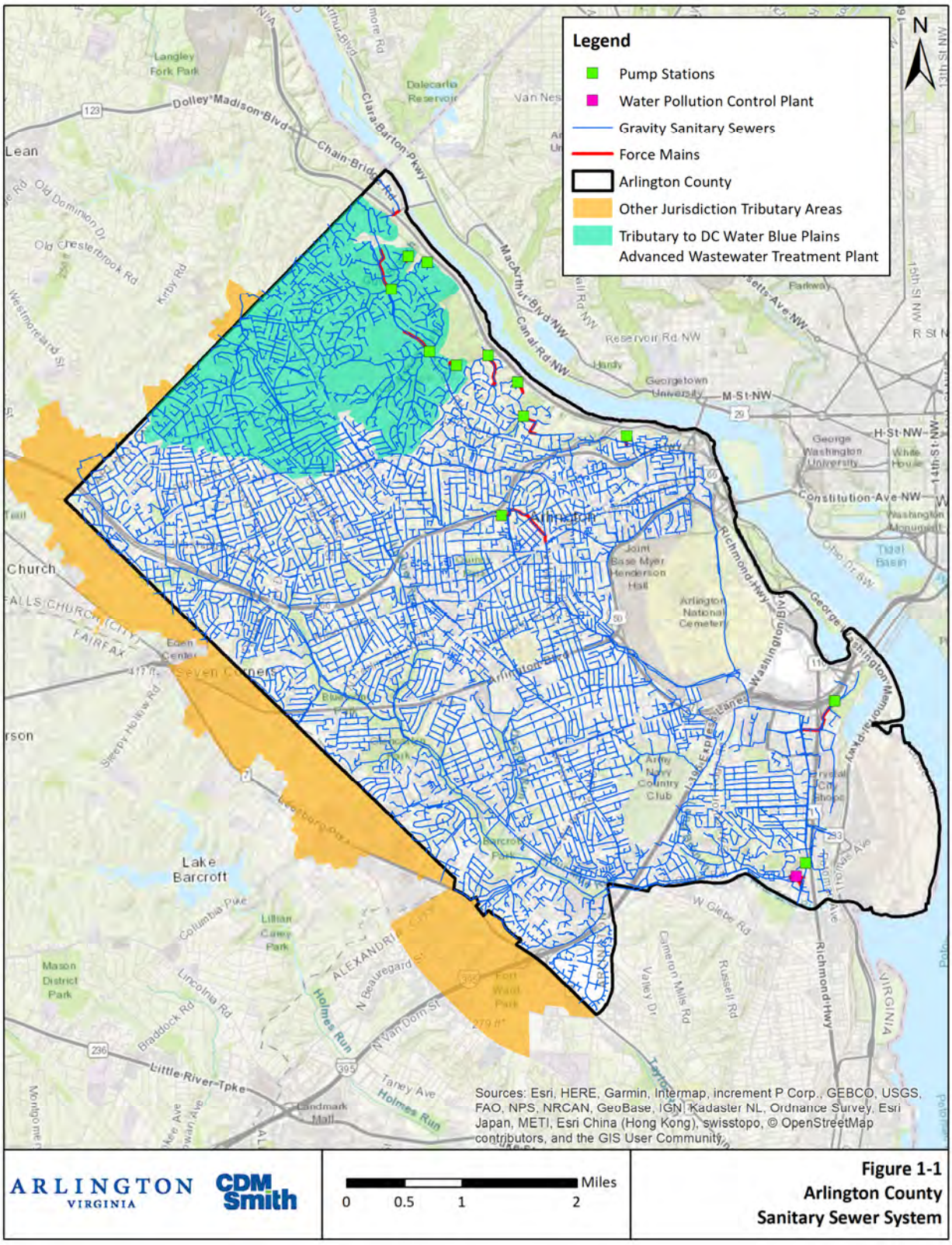

Figure 1-1
Arlington County
Sanitary Sewer System

1.4 Report Content

This Plan describes the existing gravity sewer system, ongoing programs, and evaluations of the capacity of the gravity sewer system. It also documents the County's overall system improvement program. In addition to this introductory section (Section 1), the report includes the following three sections:

- Section 2 documents ongoing programs and recent improvements to maintain the gravity sewer system and ensure continued service to the County and its residents.
- Section 3 documents dynamic sanitary sewer model creation, calibration, and capacity evaluations performed to identify locations where gravity sewer capacity improvements may be needed to convey wet-weather flows for existing and future conditions.
- Section 4 documents the recommended gravity sewer collection system improvements program that will guide future work and recommends an action plan to improve the operation and reliability of the system.

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Section 2
Ongoing Programs

2.1 Introduction

Historically, the County has performed various activities to evaluate and maintain its gravity sewer system, expand system capacity, and ensure that the system provides adequate service now and into the future. Recent major system improvements and ongoing maintenance programs are documented in the following sections.

2.2 Major System Improvements

The County has implemented the following improvements to the major interceptor sewer system since the 2002 Sanitary Sewer Collection System Master Plan (the 2002 Master Plan).

1. Arlington National Cemetery Potomac Interceptor sewer
2. Four Mile Run relief sewer (I-395 to Glebe Road)
3. Potomac Interceptor Sewer reinstatement on South Eads Street from Army Navy Drive to south of Fort Scott Drive
4. Four Mile Run junction chamber improvements near Columbia Pike
5. Fairlington relief sewer
6. Four Mile Run large-diameter sewer lining
7. Potomac Yard Lift Station and related sewers
8. Lubber Run Sewer replacement

These improvements have eliminated capacity bottlenecks, improved operations, and improved reliability. The County completed all the major projects included in the 2002 Master Plan, except for the planned relining of the South Eads Street large-diameter Potomac Interceptor sewer. The improvements are shown on **Figure 2-1** and briefly discussed in the following sections.

The County has implemented various other sanitary sewer improvement projects to address localized capacity issues. Additional projects were implemented to realign sewers for highway construction projects and new development and redevelopment projects.

2.2.1 Arlington National Cemetery Potomac Interceptor Sewer

The Arlington National Cemetery Potomac interceptor sewer relief and replacement project was completed in 2014 and provided 30-, 36-, and 48-inch parallel and replacement sewers through Arlington National Cemetery from River Place south to Columbia Pike. This sewer was constructed to meet several needs. The first and foremost objective was to eliminate a capacity bottleneck that caused infrequent but intermittent backups and overflows to ground floors of buildings in the River Place Apartments during major rainfall events. The County worked collaboratively with the cemetery to relocate the gravity sewer into designated utility corridors to

free space for additional interment sites. This construction took place during the night to avoid conflicts with cemetery operations and to reduce impacts on the U.S. Marine Corps War Memorial.

2.2.2 Four Mile Run Relief Sewer

The Four Mile Run Relief sewer project was constructed in 2010 to eliminate a bottleneck in this sanitary sewer system. This 1,600-foot-long, 48-inch-diameter gravity sewer begins downstream of I-395 and extends downstream of the West Glebe Road bridge. This project was coordinated with the Northern Virginia Regional Park Authority (Nova Parks) to include a multipurpose trail that provides a critical commuting and recreational link through this area.

2.2.3 Potomac Interceptor Sewer Reinstatement

The Potomac Interceptor sewer runs north to south, starting in Rosslyn and ending at the southern border of the County at the Arlington County WPCP. This critical asset to the County was constructed in the 1930s. A relief sewer was constructed in the 1970s within Crystal City along South Eads Street starting at Army Navy Drive and ending at the WPCP. Over the years, portions of the older parallel gravity sewer were removed from service primarily for development and roadway improvements. In a series of projects, portions of the parallel sewer have been reconstructed and rehabilitated to provide a continuous parallel sewer through this area. These projects were completed in 2014 and provide increased flow capacity and sewer system redundancy. The projects also allow one of the parallel sewers to be taken out of service for inspection and rehabilitation as needed.

2.2.4 Four Mile Run Junction Chamber Improvements

The Four Mile Run Junction Chamber south of Columbia Pike provides an important control on the amount of flow directed to the downstream interceptor and relief sewers. Through this project, the structure was rebuilt, which provided stem-operated control gates to replace the inoperable gates in the old structure. This project was completed in 2002 to provide a means to control the flow split between the two downstream major sewers and allow flows to be diverted from one sewer to the other for inspection and rehabilitation.

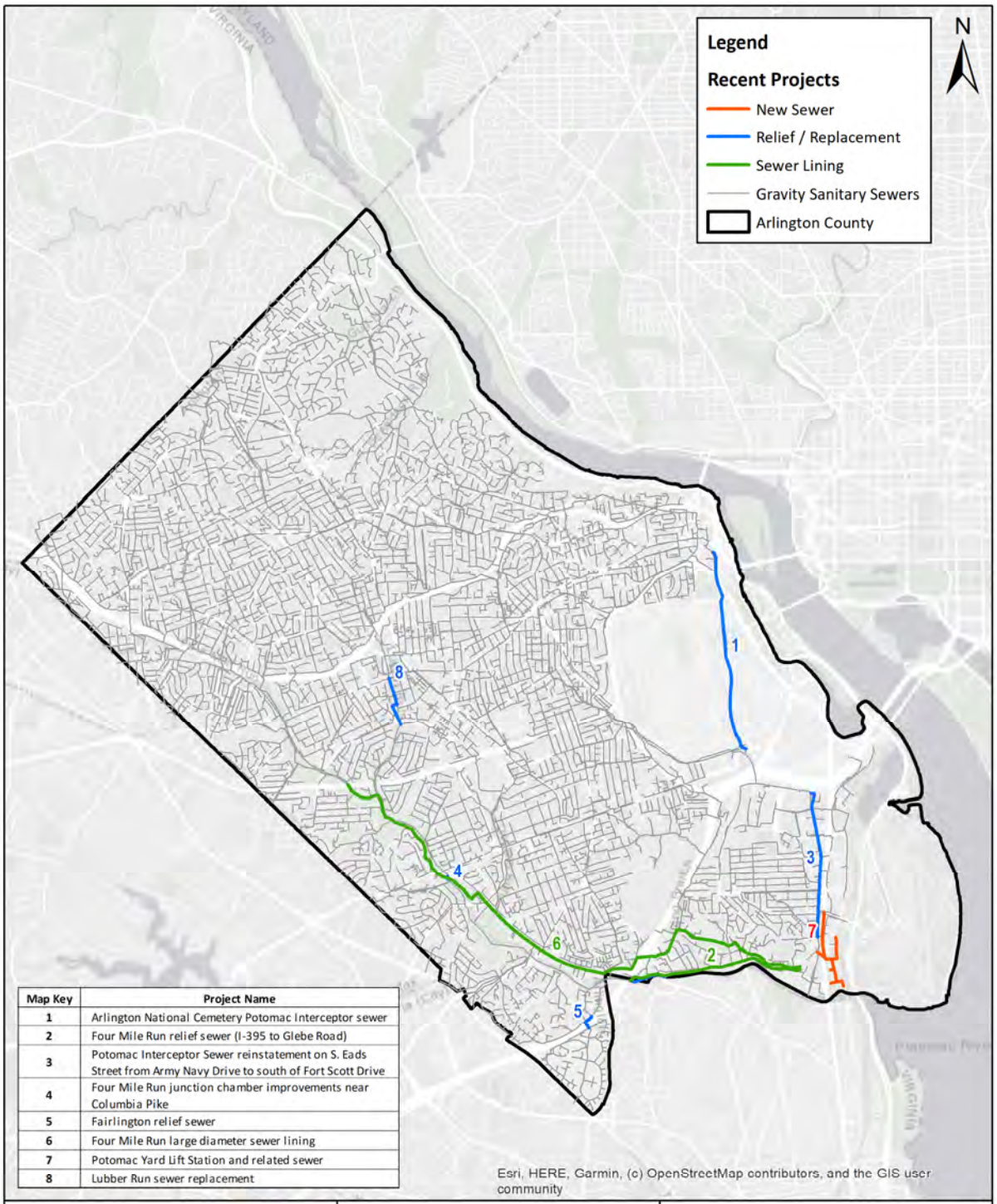
2.2.5 Fairlington Relief Sewer

A relief sewer was constructed in 2012 under I-395 and the adjacent neighborhood in Fairlington to provide additional capacity and eliminate persistent backups in several apartments. This project included installing a parallel 18-inch diameter sewer under I-395 using microtunneling starting near South Utah Street to divert flow away from the neighborhood and connecting to the collection system on the west side of I-395. A parallel 18-inch sewer was also constructed on the west side of I-395 along 31st Street South.

2.2.6 Four Mile Run Large-Diameter Sewer Lining

The County has undertaken several projects to line segments of the Four Mile Run Interceptor and Four Mile Relief sewers, including the following major segments:

- Four Mile Run Interceptor 36- through 42-inch-diameter sewer from I-395 to the Arlington County WPCP in 2012
- Four Mile Run Interceptor 30- through 42-inch-diameter sewer from Columbia Pike to I-395 in 2015



Map Key	Project Name
1	Arlington National Cemetery Potomac Interceptor sewer
2	Four Mile Run relief sewer (I-395 to Glebe Road)
3	Potomac Interceptor Sewer reinstatement on S. Eads Street from Army Navy Drive to south of Fort Scott Drive
4	Four Mile Run junction chamber improvements near Columbia Pike
5	Fairlington relief sewer
6	Four Mile Run large diameter sewer lining
7	Potomac Yard Lift Station and related sewer
8	Lubber Run sewer replacement

Figure 2-1
Major Sewer System Improvements Constructed Since 2002

- Four Mile Run Interceptor 27- through 30-inch-diameter sewer from near Route 50 to Columbia Pike in 2016
- Four Mile Run Relief 36- through 54-inch-diameter sewer from I-395 to the WPCP in 2018

2.2.7 Potomac Yard Lift Station and Related Sewers

The County constructed the Potomac Yard Lift Station on the grounds of the Arlington County WPCP and related sewers to serve the Potomac Yard development east of the WPCP and Route 1. A tunnel and sewer under Route 1 were constructed to divert flows from the southern part of Crystal City to the Potomac Yard Lift Station and allow the National Center Lift Station to be removed from service.

2.2.8 Lubber Run Sewer Replacement

The County undertook several sewer replacement projects for the Lubber Run interceptor sewer. This includes a bridge and sewer replacement project near the interchange for North Carlin Springs Road and North George Mason Drive in 2017. Also, a sewer replacement project was constructed on North Abingdon Street between Wilson Boulevard and North Carlin Springs Road.

2.3 Sewer System Lining Programs

Maintaining the structural integrity and functionality of the aging gravity sewer collection system is one of the major challenges for the County.

The major recommendation of the prior 2002 Master Plan was to shift to a proactive program wherein, initially, 1.5 percent of the sanitary sewers would be lined each year. By the year 2009, the sewer lining program was increased to include more than 2 percent of the County sewers each year. Lining involves inspecting and cleaning the sewers followed by liner installation to provide structural integrity and reduce groundwater infiltrating into the sanitary sewer. Most of the lining in the County was performed using a felt-like material that is impregnated with a resin, referred to as cured-in-place pipe (CIPP) lining. Heated steam or hot water is then applied to cure and harden the resin. A machine is used next to reopen existing laterals serving individual residences and commercial buildings, allowing flow to reenter the sewers. The program focuses mainly on the older, small-diameter (smaller than 15 inches) sewers. **Table 2-1** presents the number and length of sewer lined in five-year increments since 2000 and the last two years.

Currently, about 268 miles, or 58 percent, of the County's gravity sewer system has been lined, including most of the older sewers. **Figure 2-2** presents the percentage of the sewers lined each year since 1990 and the average pipe age in years. The lining program has reduced the effective age of the County sewers from the 74 years it would have been in 2020 without the lining program to 40 years. These age calculations assume that the sewers without a construction date have the same age distribution as those with construction dates and that lined sewers are considered to be new on the date they were lined.

Table 2-1 Overview of Gravity Sewer Lining Program

Fiscal Year	Approximate Number of Sewer Segments Lined in Previous 5 Years	Cumulative Number of Sewer Segments Lined at End of Fiscal Year	Cumulative Percent of Total Sewer Segments Lined at End of Fiscal Year	Approximate Length of Sewer Lined (Miles) in Previous 5 Years	Cumulative Length of Sewer Lined at End of Fiscal Year (Miles)	Cumulative Percent of Total Length of Sewer Lined at End of Fiscal Year
2000	655	655	4%	21.9	21.9	5%
2005	917	1,572	11%	34.4	56.3	12%
2010	1,253	2,825	19%	47.6	103.9	23%
2015	1,532	4,357	30%	52.0	155.9	34%
2020	1,959	6,316	43%	70.6	226.5	49%
2021-2023	1,237	7,553	51%	41.7	268.2	58%

Figure 2-3 presents the effective age of the gravity sewer segments assuming that the sewers are considered to be new at the time that they were lined. This figure shows how the lining program has greatly reduced the effective age of the sewers. The rate of lining has been more than 3.5 percent per year over the last five years. At the current rate, most of the small-diameter sewer system, not including the more modern polyvinyl chloride (PVC) and ductile iron (DIP) pipes, is anticipated to be lined by the year 2031.

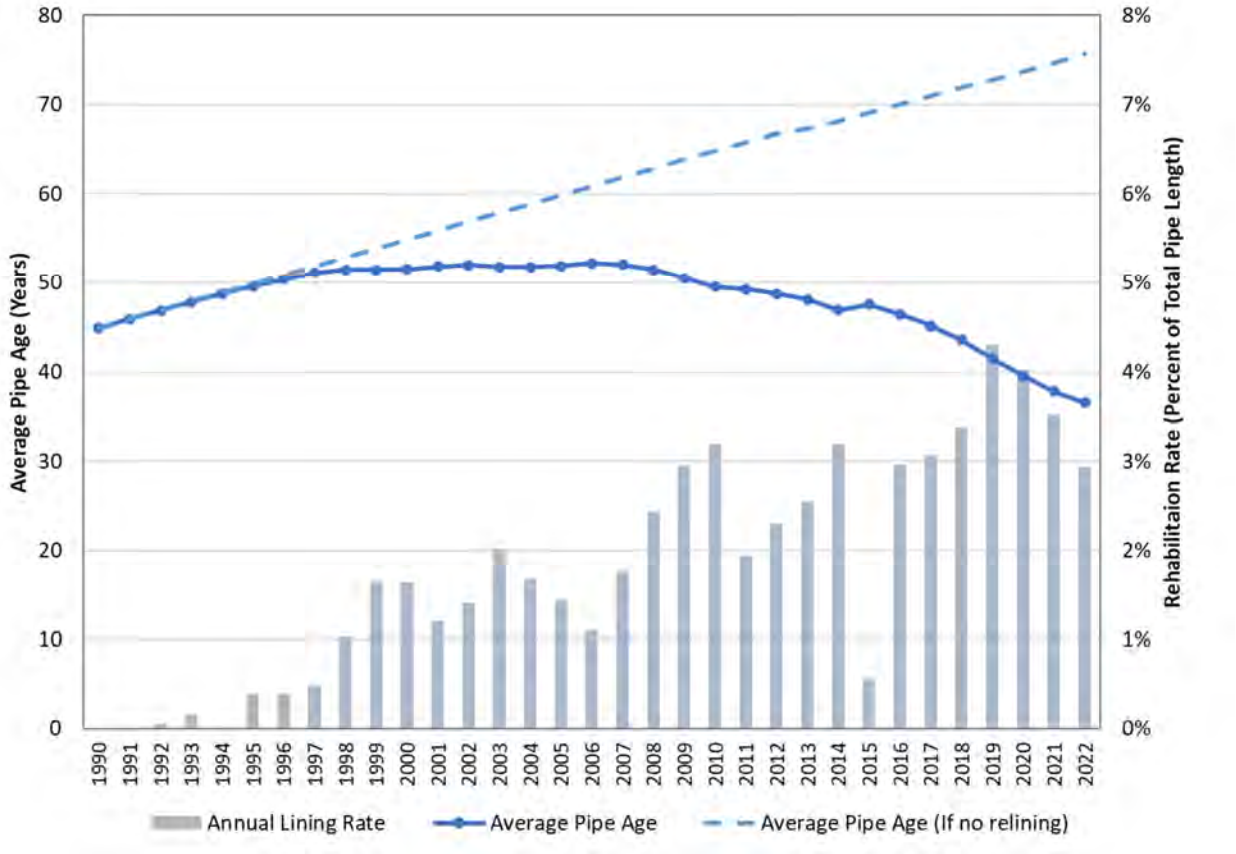


Figure 2-2 Lining Program Annual Lining Rate and Average Pipe Age

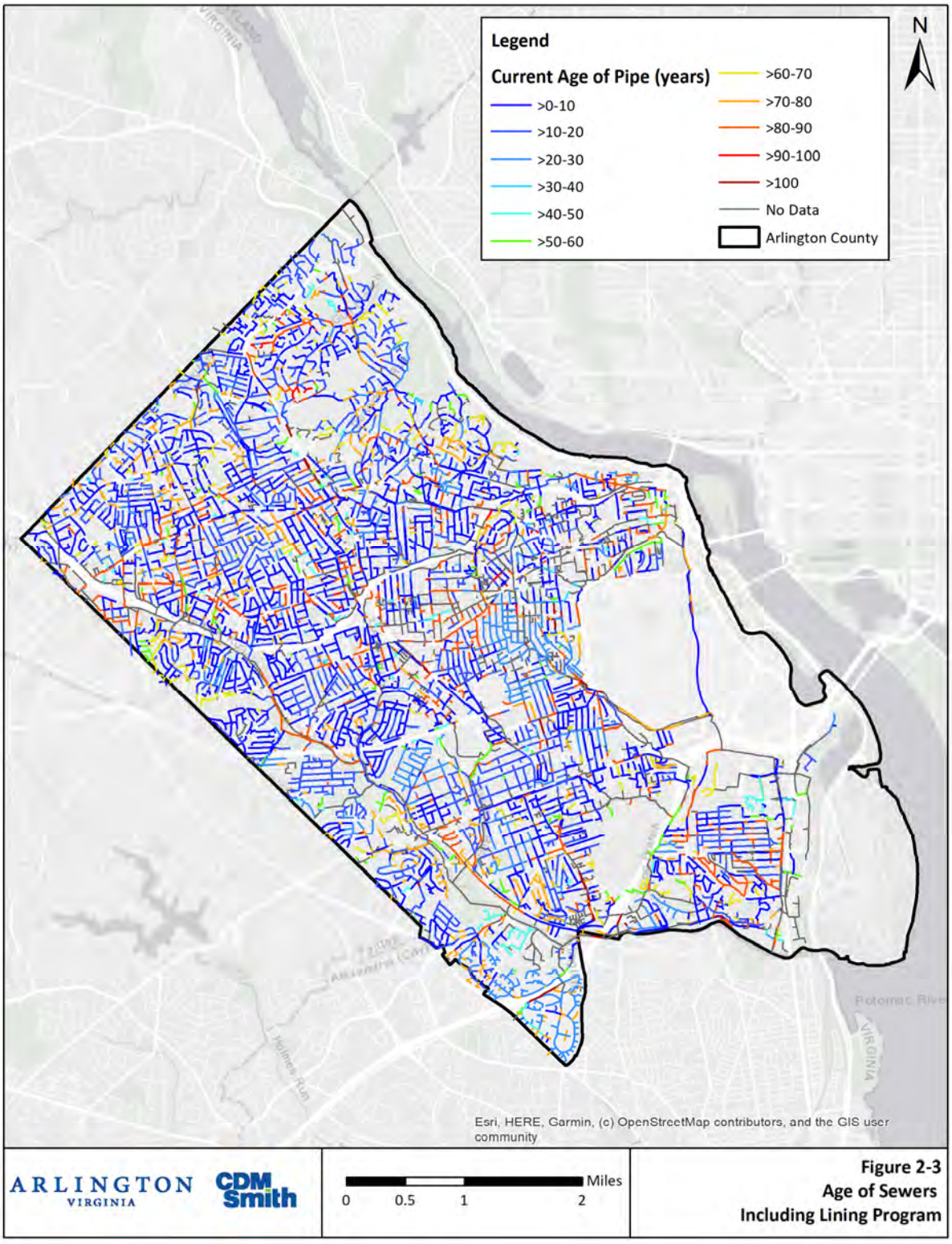


Figure 2-3
Age of Sewers
Including Lining Program

2.4 Large-Diameter Sewer Condition Assessment

The County gravity sewer system relies on the larger-diameter (15 inches and larger) sewers, also known as trunk and interceptor sewers, to convey flows to the Arlington County WPCP. Since some of these interceptor sewers are getting older, they may start to fail. The County has undertaken programs to identify, inspect, and rehabilitate these critical sewers, and provide a redundant sewer where possible. Where indicated by the inspection data, all or portions of these sewer segments are rehabilitated through lining or other means. Several of the replacement and lining projects described in Section 2.2 were established to address these concerns.

Periodic inspection and condition assessments are performed on the large-diameter sanitary sewer mains. Because of their diameter and the large flows involved, these inspections require advanced technology to inspect the complete circumference of the sewer for defects and leaks. Also, debris in the pipe such as rocks and other items needs to be removed before the sewers can be inspected. Therefore, the County relies on contractors to inspect these large-diameter lines. **Table 2-2** presents the historical inspection results for the 15-inch diameter and larger sewer mains Countywide over the past five-year period.

Table 2-2 Five-Year Sewer Inspection History for 15-inch and Larger Sewers

Calendar Year	Number of Sewer Segments Inspected	Sewer Segments Inspected (Miles)	Percent of Length of Sewer Segments 15-inch and Larger (57.68 miles)
2018-2022	328	11.16	19.3%

Expanding upon **Table 2-2** to include the segments that were flushed and lined over the past five years yields **Table 2-3**. It should be noted that prior to a sewer segment being lined, it is both flushed and CCTV inspected.

Table 2-3 Five-Year Sewer Maintenance and Inspection History for 15-inch and Larger Sewers

Calendar Year	Number of Sewer Segments Flushed	Sewer Segments Flushed (Miles)	Number of Sewer Segments CCTV	Sewer Segments CCTV (Miles)	Number of Sewer Segments Lined	Sewer Segments Lined (Miles)	Percent of Sewer Segments 15-Inches and Larger (57.68 miles) Inspected and or Maintained
2018-2022	148	5.38	328	11.16	78	3.15	34.1%

There is some double counting in **Table 2-3** given that a segment could have been flushed, CCTV inspected, and lined during the five-year analysis period, or experienced two of those activities. Therefore, **Table 2-4**, summarizes the portion of the 15-inch and larger sewer mains that were not seen or touched at all over the five-year period. This equates to approximately three-quarters of the large-diameter sewers.

Table 2-4 15-inch and Larger Sewers that were Untouched Over the Past Five Years

Calendar Year Period	Number of Sewer Segments Not Inspected	Sewer Segments Not Touched (Miles)	Percent of 15-Inch and Larger Sewers Not Touched (57.7 miles)
2018-2022	1,355	43.83	76.0%

Several recent major sewer inspection programs are discussed below.

Four Mile Run Relief Sewer Inspection

The Four Mile Run Relief sewer was constructed in two separate contracts, one in the 1950s and a later section in the 1970s. It is located largely within the banks of Four Mile Run. In 2015, the County implemented a program to internally inspect this sewer. These inspections found that the upper reaches installed in the 1970s were generally in good condition and did not require lining, while the lower reaches of the concrete sewer discharging to the Arlington County WPCP exhibited corroded rebar that warranted internal lining. These lower reaches were subsequently lined as discussed in Section 2.2.6. The County is receiving federal funds from the Transportation, Housing & Urban Development (HUD), and Related Agencies Appropriations Act, 2023 to rehabiliate the Four Mile Run Relief sewer segments located between Route 50 and Columbia Pike.

Potomac Interceptor Sewer Inspection

The Potomac Interceptor was constructed in the 1930s to direct flow from the northern portion of the County to the Arlington County WPCP. In 2016, the County performed an internal inspection of a 0.75-mile section of the interceptor from N. Nash Street to Arlington National Cemetery within Rossyln. Based on the inspection, the pipe is recommended to be lined. The County is receiving federal funds from the Transportation, Housing & Urban Development (HUD), and Related Agencies Appropriations Act, 2023 to rehabiliate the downstreammost 0.55-mile section of the aforementioned sewer segment as two adjoining development projects replaced the 0.20-mile upstream section.

Spout Run Deep Sewer Inspection

The Spout Run Deep Sewer was constructed as a tunnel that extends from Spout Run near the Spout Run Parkway to the vicinity of Rosslyn. This is a critical asset that would be a major concern if it were to fail. It has been inspected and cleaned twice since 2010 and the County is awarding a contract for the lining of the Spout Run Deep Sewer in Spring 2023.

2.5 Grid Program and Small-Diameter Condition Assessment

The goal of the County's Grid program is to comprehensively flush every sanitary sewer main up to and including 12 inches in diameter over a five-year period. The flushing program is organized based on the grid quadrants on the County sewer system maps. Historically, the County has fallen short of this goal because the County sanitary sewer maintenance crews spend approximately two-thirds of their time routinely flushing the sewer mains with a history of experiencing issues such as debris, clogging, and/or grease. Such sewers that receive a regularly scheduled flushing on a 1-month/3-month/6-month frequency make up what is known as the County's Preventive Maintenance (PM) program, which is outlined in Section 2.8.

Table 2-5 presents the historical flushing results for the 12-inch diameter and smaller sewer mains Countywide that are not part of the PM program – consisting of approximately 378.1 miles of sewer mains in total, 82 percent of the County's sewer system. It should be noted that prior to a sewer segment being lined, it is flushed; hence these segments are included in **Table 2-5**. The County uses a mix of internal crews and external contractors to flush these segments.

Table 2-5 Sewer Flushing History for 12-inch and Smaller Sewers Not in PM Program

Calendar Year	Number of Sewer Segments Flushed	Sewer Segments Flushed (Miles)	Number of Sewer Segments Lined	Sewer Segments Lined (Miles)	Percent of Sewers 12-Inch and Smaller Flushed (378.1 miles)
2018	736	27.13	388	13.94	10.9%
2019	373	13.70	488	17.80	8.3%
2020	497	18.39	458	15.66	9.0%
2021	445	16.25	456	15.84	8.5%
2022	469	17.64	409	13.00	8.1%
Annual Average	**504**	**18.62**	**440**	**15.25**	**9.0%**
Target Goal					20%

There is some double counting in **Table 2-5** given that some segments were flushed in multiple years over the five-year analysis period and some segments were both lined and flushed. **Table 2-6** summarizes the amount of 12-inch diameter and smaller sewer mains that were not flushed at all over the five-year period. This equates to approximately two-thirds of the small diameter system that is not part of the PM program.

Table 2-6 12-inch and Smaller Sewer Segments Not in PM Program that were Not Flushed in Past Five Years

Calendar Year Period	Number of Sewer Segments Not Flushed	Sewer Segments Not Flushed (Miles)	Percent of 12-inch and Smaller Not Flushed (378.1 miles)
2018-2022	8,491	249.61	66.0%

The County has historically evaluated sewer mains 12-inch diameter and smaller on an as-needed basis following overflows, backups reported by properties and plumbers, to verify unclear records, and in advance of lining. County crews use either traditional closed-circuit television (CCTV) methods or the rapid assessment sewer line inspection (SL-RAT) equipment. SL-RAT is a portable tool that requires a four (4) person crew and acoustically tests blockage conditions within a single segment of sanitary sewer main from the upstream manhole to the downstream manhole reporting a score from 1 (worst) to 10 (best) for the segment. A score of 7 or worse, indicates the need to flush the sewer main and re-perform the test using the SL-RAT until the blockage is clear and the score reported improves to 8 or better. For each sewer main segment, the test takes approximately one third of the time than inspecting the sewer with CCTV would; however, using the SL-RAT still requires traffic control and the end product is far less useful as it does not flag any defects in the pipe. SL-RAT can only be used on sewers 12-inch diameter and smaller.

The data that is collected during the CCTV inspections is uploaded and housed on a web-based platform called ITPipes where staff can access the video and inspection log, view it, and refer back to past inspections for any particular pipe segment. The crews operating the video equipment look for leaking and offset pipe joints, obstructions, and excessive deposits, as well as other pipe defects such as sags, cracks, and fractures. Additionally, when a defective service lateral connection or signs of a broken lateral are observed, the property address for that lateral is verified and the owner is notified to hire a contractor to inspect the lateral and make any

necessary repairs. The crews do not look for abandoned or unpermitted lateral connections (e.g., a roof drain connection) unless the CCTV inspection is being performed in advance of lining a sewer segment, in which case it will not re-establish those connections.

Table 2-7 presents the historical inspection results for the 12-inch diameter and smaller sewer mains Countywide that are not part of the PM program. As mentioned previously, prior to a sewer segment being lined, it is CCTV inspected; hence lined sewer segments are included in **Table 2-7**.

Table 2-7 Sewer Inspection History for 12-inch and Smaller Sewer Segments Not in PM Program

Calendar Year	Number of Sewer Segments SL-RAT	Sewer Segments SL-RAT (Miles)	Number of Sewer Segments CCTV	Sewer Segments CCTV (Miles)	Number of Sewer Segments Lined	Sewer Segments Lined (Miles)	Percent of Segments 12-inches and Smaller (378.1 miles)
2018	280	10.34	1,723	59.24	388	13.94	22.1%
2019	185	5.31	1,311	47.46	488	17.80	18.7%
2020	0	0.00	1,531	50.47	458	15.66	17.5%
2021	0	0.00	1,352	46.32	456	15.84	16.4%
2022	168	5.00	1,310	40.43	409	13.00	15.5%
Average	**127**	**4.13**	**1,445**	**48.79**	**440**	**15.25**	**18.0%**

There is some double counting in **Table 2-7** given that some segments were either CCTV inspected and/or SL-RAT inspected in multiple years over the five-year analysis period and some segments were both CCTV inspected and SL-RAT inspected during the same year. **Table 2-8** summarizes the amount of 12-inch diameter and smaller sewer mains that were not inspected at all over the five-year period. This equates to approximately one-third of the small diameter system that is not part of the PM program.

Table 2-8 12-inch and Smaller Sewer Segments Not in PM Program that were Not Inspected in Past Five Years

Calendar Year Period	Number of Sewer Segments Not Inspected	Sewer Segments Not Inspected (Miles)	Percent of 12-inch and Smaller Sewers Not Inspected (378.1 miles)
2018-2022	4,495	125.48	33.2%

2.6 Stub Elimination Program

Portions of the gravity sewer collection system were constructed where the most upstream segments did not have a manhole at the upstream end. The upstream ends of these segments are referred to as stubs. Stubs do not allow access to the gravity sewer pipe and make inspection and servicing of the downstream sewers difficult. To address these issues, the County created a program that either eliminated these segments where there were no building connections or constructed a manhole at the upstream end of the sewer segment. This program is ongoing and the available data show that there are 343 remaining stubs to be addressed under this program. The remaining stubs are shown on **Figure 2-4**.

2.7 Small-Diameter Pipe Elimination Program

The County has an ongoing program to eliminate the publicly owned gravity sewers smaller than 8 inches and replace them with 8-inch PVC pipe. The small-diameter sewers are difficult to maintain and can be prone to clogging from debris. They are unable to be lined due to the lack of available inner diameter inside the existing pipe. The available data indicate that there are 103 sewer segments with a total length of 14,761 feet remaining to be addressed under this program. Sewers less than 8 inches in diameter are shown on **Figure 2-4** based on the available GIS data. Some of these 6-inch diameter sewers are very challenging to replace with new 8-inch pipe as many are located along the rears of properties without easements and are built over by sheds, retaining walls, fences, trees, and detached garages.

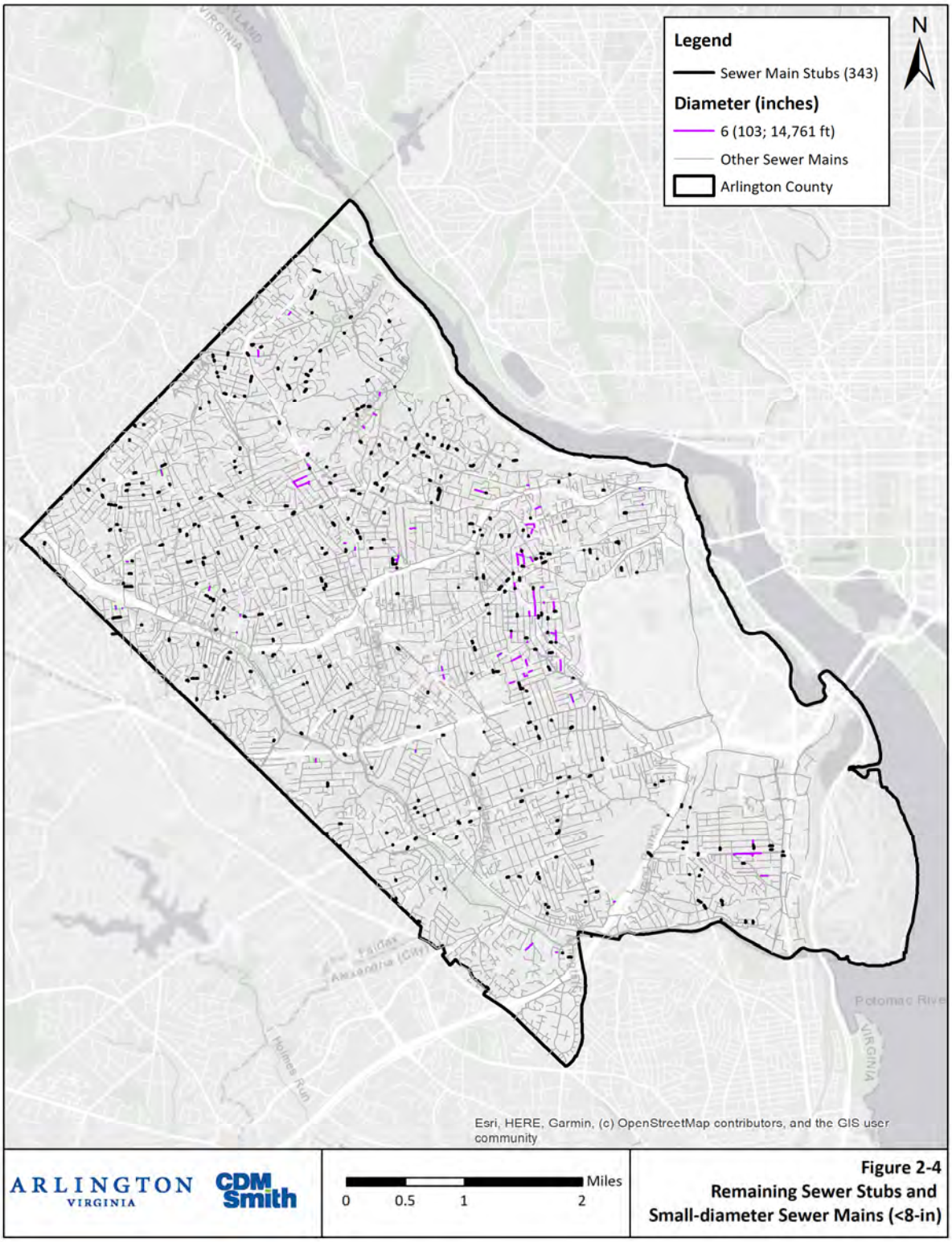


Figure 2-4
Remaining Sewer Stubs and Small-diameter Sewer Mains (<8-in)

2.8 Flushing of Sewers with Chronic Blockages (PM Program)

The County sewer maintenance crews complete regularly scheduled flushing of sewer segments on 1-month, 3-month, and 6-month cycles that have recurrent clogging issues mostly related to grease and debris buildup. This program requires significant staffing and equipment costs to ensure that these sewer segments continue to provide acceptable sanitary sewer service and as mentioned earlier in Section 2.5, this task accounts for approximately two-thirds of the workload for the sewer maintenance County crews despite only 5 percent of the County's sewer system being included in the 1/3/6-month PM Program.

Sewer segments that are regularly flushed to remove grease are shown on **Figure 2-5**. 554 sewer segments totaling approximately 15.4 miles in length are included in this grease flushing program.

Sewer segments that are regularly flushed for other reasons to avoid backups (e.g., segments with inadequate pipe velocities that fail to provide a self-cleansing velocity) are shown on **Figure 2-6**. 253 sewer segments totaling approximately 7.8 miles in length are included in this program.

Sewer segments that are treated with a root control foam to inhibit tree root intrusion are shown on **Figure 2-7**. 236 sewer segments totaling approximately 7.4 miles in length are included in this root treating program. This is the only element of the PM Program that is performed by an external contractor. Root control segments are not on a regular 1-month, 3-month, and 6-month cycle, but are done once every five years as the treatment is warrantied for five years. These segments are also considered part of the Grid program outlined in Section 2.5 because very minimal pressure is used during the jet cleaning performed as part of this task.

Tables 2-9 and 2-10 summarize the sewer mains in each respective PM program and their frequencies.

Table 2-9 PM Program by Type

PM Program	Number of Sewer Segments	Sewer Segments (Miles)
Grease	554	15.4
Trouble	253	7.8
Tree Root	236	7.4
Total	**1043**	**30.6**

Table 2-10 PM Program Flushing Frequencies

Flushing Frequency (Days)	Number of Sewer Segments	Sewer Segments (Miles)
30	161	3.9
90	438	12.7
180	208	6.6
Total	**807**	**23.2**

Figure 2-5 Sewer Segments Regularly Flushed to Remove Grease

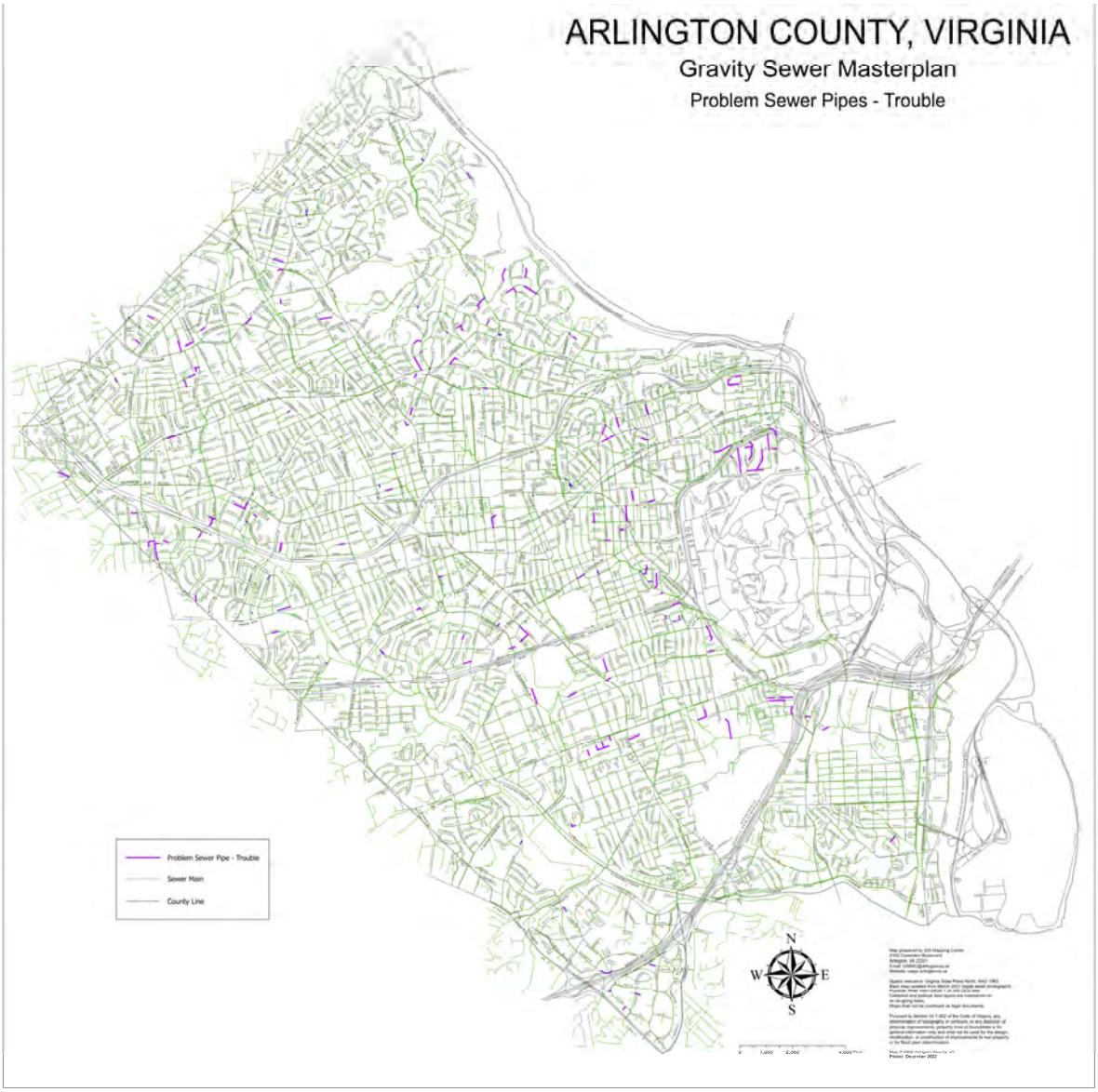


Figure 2-6 Sewer Segments Regularly Flushed Due to Other Issues

Figure 2-7 Sewer Segments Regularly Treated to Control Roots

2.9 Sewer Stream Crossing Inspection Program

The locations where gravity sanitary sewers cross streams are vulnerable to damage from flooding and stream erosion. These locations are tracked in the sewer system GIS. There are approximately 245 locations where sewers cross streams that the County inspects approximately every 10 years. Locations found to have potential issues are rehabilitated. The last inspection was completed in 2017.

2.10 Other Ongoing Programs

The County has implemented a variety of other programs for maintenance and capacity assurance of the gravity sewer collection system that perform the following duties:

- Utilize an Infrastructure Maintenance Management System, Cartegraph, to schedule and track maintenance activities
- Maintain and update the GIS data of the existing gravity sewer system including new sewers that are added to the system

The County plans to continue with these programs into the future as part of the ongoing sanitary sewer maintenance program.

2.11 Impact of Ongoing Programs on Reducing Sanitary Sewer Discharges

Figure 2-8 presents data on the annual number of sanitary sewer discharges from the public system since 1991. Discharges caused by failures or blockages of privately owned sewer laterals upstream of the public system are not included in this figure. The County system experienced between 10 and 70 discharges annually between 1991 and 2022, with an average of 42 discharges per year. For 459 miles of sewer in the County, this equates to an average of 92 backups per 1,000 miles per year. By comparison, WERF performed a study of sewer system performance (Effective Practices for Sanitary Sewer and Collection System Operations and Maintenance, 2003), which identified a benchmark of 193 backups per 1,000 miles per year, on average for the municipalities with reported data. Also, for reference, that study listed WSSC Water discharges as 118 per 1,000 miles per year. In general, the County has seen a slight downward trend in the overflow frequency over the years, however the change is small. Any discharge is unacceptable and the County strives to further reduce their number.

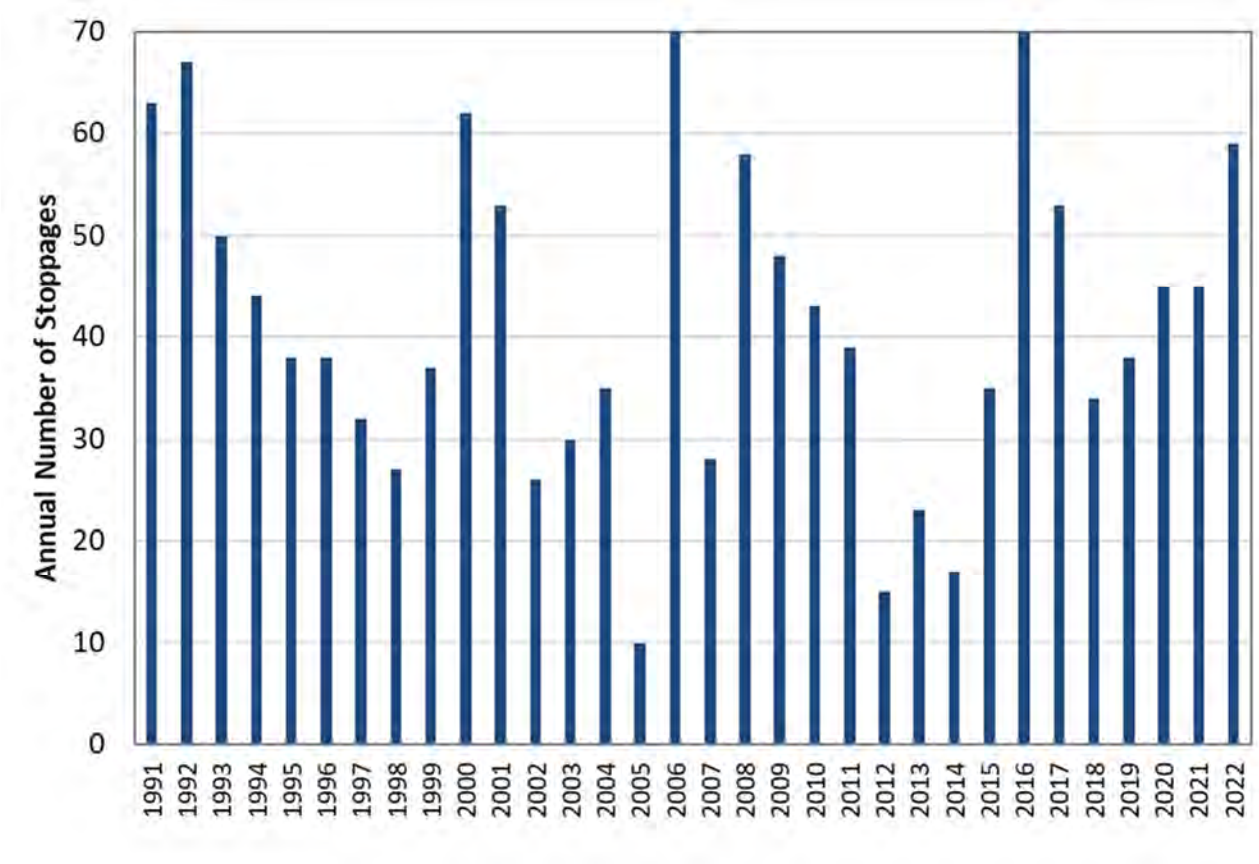


Figure 2-8 Reported Sanitary Sewer Dicharges from Public Sewers (1991–2022)

Section 3

Capacity Assessment

3.1 Introduction and Background

From 2018 through 2020, the County undertook an effort to develop a dynamic sanitary sewer system model to accurately represent the sanitary sewer system, which includes the following:

- Upgrade the current steady-state model to a dynamic model.
- Include all County sanitary sewers.
- Use current wastewater flows based on recent (2019) flow monitoring with a meter density appropriate for sewer model development and calibration.
- Use recent water billing information to distribute dry weather flows within the collection system.
- Calibrate to observed dry- and wet-weather flows at the temporary flow meters.
- Update future flows based on recent demographic projections that represent current (2020) estimates of growth projected to occur in the County.
- Use peak flows based on a design rainfall event with a uniform and known level of service for capacity planning and to identify future capacity needs.

This section provides an overview of the model development and calibration and documents the results of the capacity analysis. Details of the model development are documented in a separate Dynamic Sanitary Sewer Model Development Report (June 20, 2020).

Prior to 2020, the County maintained a planning-level peak flow routing model using the SewerCAD modeling software by Bentley Systems, which included 25 percent of the major gravity sewer network that focused on sewers 10 inches and larger. This model was originally developed in the early 1990s and was updated periodically through 2014. The planning-level peak flow routing model used peak flows from historical events that produced large peak flows based on monitoring data from 1990. The updated model is a considerable improvement over the previous model.

3.2 Flow and Rainfall Monitoring Program

3.2.1 Flow Meters and Rainfall Gauges

Overall, 42 temporary flow meters and four rainfall gauges were installed from June through November 2019 to characterize dry- and wet-weather flows in the system. Data from the U.S. Geological Survey (USGS) rainfall gauge associated with the Four Mile Run stream gauge at Shirlington Road (USGS Gauge Number 01652500) was also used.

Temporary flow meters were located to evaluate the flows and flow depths in the major interceptor sewers. Approximately 81 percent of the County's total pipe length was directly

tributary to one or more of the temporary flow meters. Of the remaining total pipe length, approximately 12 percent was directly upstream of the Arlington County WPCP, 5 percent was upstream of County lift stations, and 2 percent was unmetered and flowed to other jurisdictions. Additional meters were installed at 10 connections from the city of Falls Church and one connection from the city of Alexandria to monitor the flows entering the County's sanitary sewer system. **Figure 3-1** shows the location of the temporary flow meters and rainfall gauges.

The modeling also used flow data available at permanent flow meters installed in the major wastewater pumping stations and the three influent sewers to the Arlington County WPCP for the same 2019 monitoring period as the temporary meters.

3.2.2 Flow Meter Data Analysis

The flow meter and rainfall data were analyzed to determine the components of dry-weather and wet-weather flow at each flow meter for input to the dynamic sanitary sewer system model. The following sections provide definitions and descriptions of these flows.

Base Sanitary Flow

Base sanitary flow (BSF) is the wastewater flow discharged to the sewers from residential , commercial, institutional, and industrial uses for treatment. These flows have daily variation, with a typical peak in the late morning hours and in the evening. Typical weekday and weekend variations were determined from the flow meter data. The assignment of the BSF distribution in the model was based on the billed wintertime water use.

Groundwater Infiltration

Groundwater infiltration (GWI) is the inflow of groundwater into the sanitary sewer system and a function of groundwater table depth. Depending on the condition of the sewers and the time of year, up to 50 percent of the flow in the sanitary sewer can be groundwater infiltration. These flows increase the energy costs needed to pump and treat these flows. Since the flows can affect pumping and treatment costs, they should be eliminated where possible.

GWI flow rates vary gradually as groundwater levels rise and fall seasonally in response to long-term rainfall and evapotranspiration. GWI is largely unavoidable where the sanitary sewers are below the groundwater table because groundwater enters the sewers through defects, including cracks and joints in the sewer pipes and manholes. Sewers near perennial streams are typically below the groundwater table year-round. Smaller-diameter sewers located in upland areas away from perennial streams may be below the groundwater table only during wet-weather periods (e.g., late winter and spring).

GWI can enter the sanitary sewer system from privately owned laterals that are leaking. Building footing drains and sump pumps that connect to the sanitary sewer system also contribute to GWI. While these stormwater drain connections are illegal for new construction, some older homes may still have these connections.

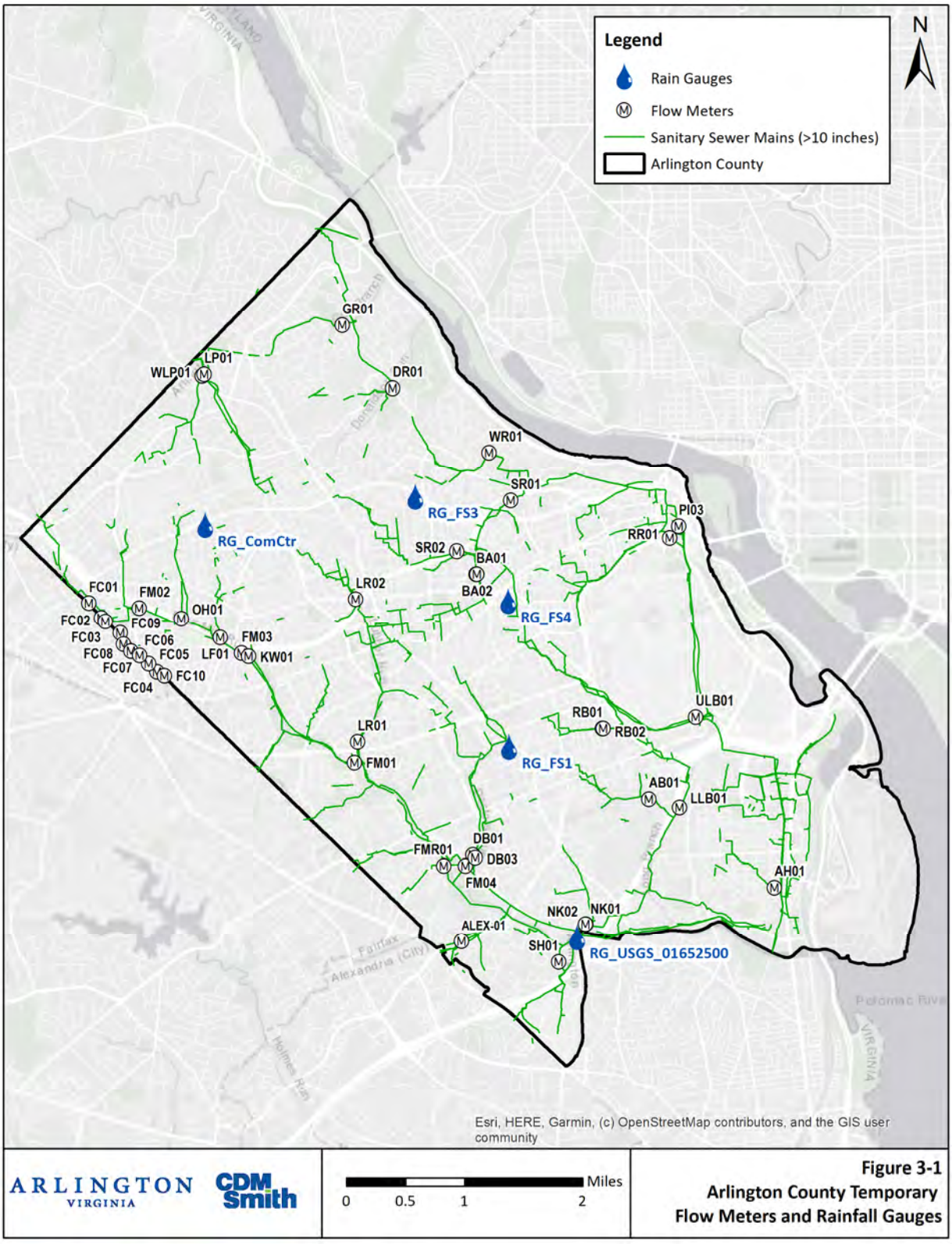


Figure 3-1
Arlington County Temporary Flow Meters and Rainfall Gauges

Table 3-1 documents the dry weather flow characteristics determined at each of the flow meters with flows in million gallons per day (mgd). The model was developed and calibrated to reproduce these observed existing dry weather wastewater flows. The average groundwater infiltration flows in the Arlington County system are not considered to be excessive.

Rainfall-Derived Inflow and Infiltration (I&I)

Rainfall-derived inflow and infiltration (RDII) represents the wet-weather flows that enter the sewer as a direct result of a rainfall or snowmelt event. RDII is zero before the rainfall event and returns to zero after the rainfall stops. These flows can be quite large and can consume a large portion of the sanitary sewer capacity. Reducing these flows can eliminate the need to construct new facilities that may be needed to convey these flows.

RDII can have many sources, including manhole lids and rims, direct or indirect connections with the storm sewer system, or other defects in the public sewers. Private RDII sources include missing or broken lateral cleanout caps or other defects in the laterals. Downspouts and areaway drains connected to the sanitary sewer system can also contribute to RDII.

Table 3-2 documents the wet weather flow total R value for the flow meters. The total R value represents the average fraction of the rainfall that enters the sanitary sewer system as RDII for the observed rainfall events. In other words, a value of 0.02 means that, on the average, 2 percent of the rainfall that falls on the area upstream from the meter shows up as inflow and infiltration for the meter flows. A sewer system with a small value indicates that the sewers generally have smaller sources of inflow and infiltration and a larger value suggests that the sewers have more or larger sources of these flows.

Typical sewer systems of the age and construction material as those used in Arlington County will have a value around 0.02. Values 0.01 or smaller indicate that the sewers have small sources of inflow and infiltration. Eleven of the 37 meters have values of 0.01 or less. Values of 0.04 or greater suggest that the sewers are in poorer condition with additional or larger sources of inflow and infiltration. The value at meter AB01 is 0.044. The weighted average for the county equals 0.016. These data indicate that the Arlington County sanitary sewers are in general good condition and there are no areas with extremely high values that would require immediate attention.

Table 3-1 Dry Weather Flow Components at Flow Meters

Flow Meter	Average Dry Weather Flow (mgd)	Average Groundwater Infiltration (mgd)	Average Base Sanitary Flow (mgd)
AB01	0.90	0.34	0.56
AH01	0.16	0.074	0.084
BA01_BA02	1.13	0.38	0.75
DB01_DB03	1.78	0.82	0.96
DR01	0.33	0.16	0.17
FC01	0.20	0.082	0.121
FC02	0.043	0.018	0.025
FC03	0.046	0.021	0.026
FC04	0.030	0.011	0.019
FC05	0.021	0.009	0.012
FC06	0.044	0.016	0.028
FC07	0.014	0.002	0.012
FC08	0.014	0.002	0.011
FC09	0.012	0.005	0.006
FC10	0.003	0.001	0.002
FM01	3.24	1.28	1.95
FM02	0.96	0.43	0.53
FM03	1.94	0.83	1.11
FM04_FMR01	8.08	3.50	4.58
GR01	0.32	0.17	0.15
KW01	0.14	0.054	0.082
LF01	0.48	0.17	0.31
LLB01	0.93	0.45	0.48
LP01	0.47	0.24	0.23
LR01	2.17	0.88	1.29
LR02	0.65	0.33	0.32
NK01_NK02	0.37	0.15	0.22
OH01	0.27	0.13	0.14
PI03	2.64	1.02	1.62
RB01_RB02	0.32	0.15	0.16
RR01	2.06	0.69	1.37
SH01	0.63	0.23	0.40
SR01	0.45	0.21	0.24
SR02	0.53	0.25	0.28
ULB01	2.42	0.95	1.48
WLP01	0.48	0.27	0.22
WR01	0.42	0.20	0.23

Table 3-2 Total R Value Wet Weather Flow Parameters at Flow Meters

Meter	Sewered Area (Acres)	Total R Value
AB01	174.0	0.0443
AH01	142.2	0.0366
BA01_BA02	181.3	0.0205
DB01_DB03	503.4	0.0349
DR01	219.2	0.0200
FC01	279.3	0.0084
FC02	78.3	0.0083
FC03	60.0	0.0078
FC04	8.8	0.0107
FC05	2.2	0.0376
FC06	25.5	0.0099
FC07	6.2	0.0242
FC08	3.6	0.0204
FC09	10.3	0.0067
FC10	6.3	0.0163
FM01	2,333.9	0.0146
FM02	1,073.5	0.0081
FM03	1,798.4	0.0068
FM04_FMR01	4,902.4	0.0151
GR01	246.0	0.0067
KW01	91.1	0.0060
LF01	237.0	0.0089
LLB01	270.1	0.0320
LP01	343.1	0.0106
LR01	654.6	0.0210
LR02	235.1	0.0228
NK01_NK02	195.0	0.0192
OH01	252.6	0.0107
PI03	864.0	0.0148
RB01_RB02	153.1	0.0231
RR01	251.5	0.0258
SH01	321.0	0.0194
SR01	203.9	0.0264
SR02	258.8	0.0287
ULB01	718.4	0.0275
WLP01	423.9	0.0031
WR01	288.8	0.0108

3.3 Sewer System Model Development and Calibration

The dynamic sanitary sewer system model includes all County sanitary sewer manholes, sewer segments, pump stations, and force mains. The modeled network includes 14,723 manholes (junctions) and 15,097 sewer segments (conduits), which range from 4 to 72 inches in diameter and have a total length of 470 miles, some of which is owned and maintained by other utility providers (e.g., City of Alexandria and Fairfax County) or by private property owners. The sewer system model uses the United States Environmental Protection Agency (EPA) Storm Water Management Model (SWMM5) modeling software and the PCSWMM model interface by Computational Hydraulic International (CHI).

Since the dynamic model was developed primarily to evaluate the capacity and operation of the gravity sewer system, the 12 wastewater pump stations were simulated using an idealized pump station where all inflows to the wet well are conveyed to the downstream sewers. In addition, the inflows to the Arlington County WPCP were conveyed using idealized pumps.

BSF determined at the flowmeters were distributed to the modeled manholes based on billed water use data. GWI and RDII were distributed based on the estimated sewered area and parcel data.

The County sewers receive flows from portions of Fairfax County (18 connections), the city of Falls Church (10 connections), and the city of Alexandria (seven connections). Flows from all Falls Church connections and the city of Alexandria Lucky Run connection were metered in 2019, and the flow monitoring data were used to define the average daily flow, GWI, and BSF for these connections. The BSF and GWI for areas not monitored were approximated as a flow per unit area based on unit flow rates per acre for areas of similar development in the County, and these were adjusted to provide a dry-weather flow mass balance at the downstream flowmeters.

The dynamic model was calibrated to simulate dry-weather flows. Simulated dry-weather peak flows, maximum depths, and flow volumes match those observed at all flowmeters within acceptable calibration standards.

The model then was calibrated to simulate wet-weather flow for the eight rainfall events that produced the largest peak flows within the monitoring period. Simulated peak flows, peak depth of flow, and flow volumes match those observed at all flowmeters within acceptable calibration standards.

3.4 Future Wastewater Flows

Future 2045 BSF was estimated using the number of housing units and number of employees for 2020 through 2045 provided by the Arlington County Department of Community Planning, Housing and Development (CPHD). These data were applied to estimate the BSF increase for the year 2045 from existing conditions based on the increase in population and employment and flow factors of 130 gallons per day (gpd) per housing unit and 35 gpd per employee.

The net BSF increase between 2020 and 2045 was projected to equal 6.1 million gallons per day (mgd), which is largely directed to the WPCP. North Arlington had a very small projected BSF increase (27,000 gpd) to the DC Water Blue Plains Advanced Wastewater Treatment Plant. The

average effluent flow from the WPCP during the period from June 1 through November 30, 2019, equaled 22.3 mgd. The average flows for other periods may be different. From the average flows observed during the 2019 flow monitoring period, the average flows are projected to increase 27 percent through 2045.

This capacity evaluation included planned development at the time this study was performed, in the spring of 2020, and considered the expected employment changes envisioned for National Landing.

Recently approved land use policies such as accessory dwelling unit regulations and expanded by-right options for missing middle housing in areas that currently permit only single-household homes, as well as potential new future policies, such as adoption of a new vision for Plan Langston Boulevard, may affect future population and density. Changes in work habits after the COVID-19 pandemic may also affect future wastewater flows.

Changes in Work Habits after COVID-19

The COVID-19 pandemic caused the closure of workplaces and schools in March 2020. The results of working and schooling from home affected the wastewater flow patterns in the County. As the public health emergency declaration ends, it is expected that future wastewater flows will correlate closer to the pre-pandemic conditions. However, it is anticipated that working from home and teleworking at least part of the time will be more prevalent moving forward than it was in the pre-pandemic conditions. This will result in more wastewater flow from residential areas and reduced flows from commercial and office land uses. The diurnal curve for residential sewer flow has larger peaks in the morning and evening hours than commercial and office uses, but reduced flows through the day and virtually none overnight.

Based on flow patterns and analyses, the impact of the pandemic did shift BSF distribution. These changes will become smaller in the future. As discussed in the next section, small changes in BSF have a relatively small effect on the peak wastewater flows that primarily control the sewer system capacity.

Impact of Land Use Changes and COVID-19 on Sanitary Sewer System Capacity

During most of the year, the sanitary sewer system conveys only BSF and GWI during dry weather. During the daily dry-weather flow, these two combined take up less than 20 percent of the total sanitary sewer capacity in 95 percent of the gravity sewers. The gravity sewers, wastewater pump stations, and water pollution control plant have more than sufficient capacity for typical flows under dry-weather conditions.

Issues potentially arise during storms when rainfall enters the sanitary sewer system through existing and largely unavoidable defects. As described in Section 2, the County has implemented sewer lining and repair programs to reduce these flows. Depending on the rainfall distribution and volume, additional flows may tax the collection system.

As documented in Section 3.5, the sewer system capacity was evaluated for a 10-year design storm rainfall event. BSF comprises, on average, about 15 percent (with a range of 5 to 65 percent) of the simulated total peak flow for the 10-year design storm event. Thus, the projected 27-percent BSF increase produces, on average, a 4-percent increase in the total peak flow. As a

result, the sewer system capacity is not very sensitive to changes in BSF due to growth, especially since most of the system has more than sufficient capacity for peak wastewater flows. BSF changes resulting from the new construction of accessory dwelling units and Missing Middle Housing, as well as potential density increases driven by Plan Langston Boulevard, generally have small impacts on the County's sewer capacity.

Large-scale local redevelopment projects may impact the small-diameter sewers that currently serve these areas. These impacts are typically addressed during the development review process.

The planned sewer lining programs in the publicly and privately owned sewers and connections discussed in Section 4.5 will reduce peak flows; therefore, freeing additional capacity for BSF increases.

3.5 Capacity Evaluation

The dynamic sanitary sewer model calibrated to dry- and wet-weather flows was applied to check if portions of the County sanitary sewer system have insufficient capacity to convey simulated peak flows for existing and future (2045) dry-weather and wet-weather design storm conditions.

The existing and future condition dry-weather-capacity evaluation results indicate that the system has sufficient capacity to convey the dry-weather flows for existing and future conditions.

A design storm with a 10-year rainfall recurrence and a 24-hour duration was applied to the calibrated model for existing 2019 and future 2045 wastewater flows. Simulations for both scenarios produced one simulated overflow and only three areas where the sewers surcharge, as described in the following sections. All other sewer segments had sufficient capacity to convey the simulated peak flows without surcharging. As discussed in the following sections, the simulated surcharging in the three surcharged sewer segments is small and likely does not produce backups into nearby houses.

The number of sewer segments with capacity concerns is greatly reduced from those identified in the 2002 Master Plan. The prior modeling used inflow and infiltration rates that were based on a few meters installed in the early 1990s. This current evaluation is based on recent flow monitoring and therefore is more representative of existing conditions. The following sections discuss four areas identified as having potential capacity concerns from the updated modeling.

Gulf Run Wastewater Pump Station

A simulated overflow occurred for existing (2019) and future (2045) scenarios where the Gulf Run pump station force main discharges to the gravity sewer, as shown on **Figure 3-2.** The pump station is simulated with idealized pumps where the pumped flow equals the wet well inflow. For the Gulf Run pump station, the simulated pump flow exceeded the capacity of the receiving downstream gravity sewer, resulting in the simulated overflow. It is likely that the simulated peak flows exceed the pump station capacity. The County is undertaking studies to evaluate the need for capacity increases at the force main, pump station, and downstream gravity sewers targeted to be completed in 2023. Also, there is an active project at the 30 percent design stage to upgrade the force main and install a larger diameter gravity sewer downstream from the force main

discharge. This project is anticipated to be constructed in Spring 2025. Therefore, a project to address this concern is not explicitly included in this Master Plan.

Columbia Pike Between South Quincy Street and South Oakland Street

Figure 3-3 shows the extent of the simulated surcharged sewers in Columbia Pike between South Quincy Street and South Oakland Street. Profiles of the sewers and the maximum hydraulic grade line elevation (HGL) for existing 2019 and future 2045 flows are shown in **Figures 3-4 and 3-5**. The extent of the surcharged sewers is the same for these two conditions, but future flows reach a higher elevation. The profiles present the manhole rim elevation, crown and invert of the sewers, and the simulated maximum HGL for existing (2019) and future (2045) flows.

The simulated HGL was 7 and 5.5 feet below the manhole rim elevations for existing and future conditions, respectively.

The Columbia Pike Multimodal Segment F Project, which began construction in Fall 2022, is replacing the subject 8-inch diameter sewer with a properly sized new 12-inch diameter sewer. Therefore, this Master Plan does not include a project to address this capacity concern.

Four Mile Run Interceptor Between 28th Street South and South Lang Street

Figure 3-6 shows the extent of the simulated surcharged sewers for the Four Mile Run Interceptor between 28th Street South and South Lang Street. Short segments surcharged for existing simulated flows and the extent of surcharging increased for future simulated flows. The profile of this sewer is shown in **Figure 3-7**.

The amount of simulated surcharging above the sewer crown for future conditions was about 0.5 feet. Planned efforts to address inflow and infiltration within the upstream sewershed area are anticipated to reduce the future surcharging and eliminate the need for a future project. Therefore, no project is proposed to address this simulated surcharging as it does not produce an overflow or user backup.

Sewer Between 28th Street South and South Glebe Road

This sewer segment is between South Meade Street and South Lang Street. **Figure 3-8** shows the 8-inch sewer segment between 28th Street South and South Glebe Road and **Figure 3-9** shows the profile of this sewer. The simulated flows were nearly equal for existing and future conditions. Therefore, the existing 2019 and future 2045 HGL overlay each other in this figure. The maximum surcharge elevation was 1.5 feet above the sewer crown. The minimum distance between the manhole rim and the HGL was 7 feet. No project is needed to address this surcharging as it does not produce an overflow or user backup. This sewer should be upsized if the two adjacent parcels, which contain a strip center style retail shopping center, are redeveloped.

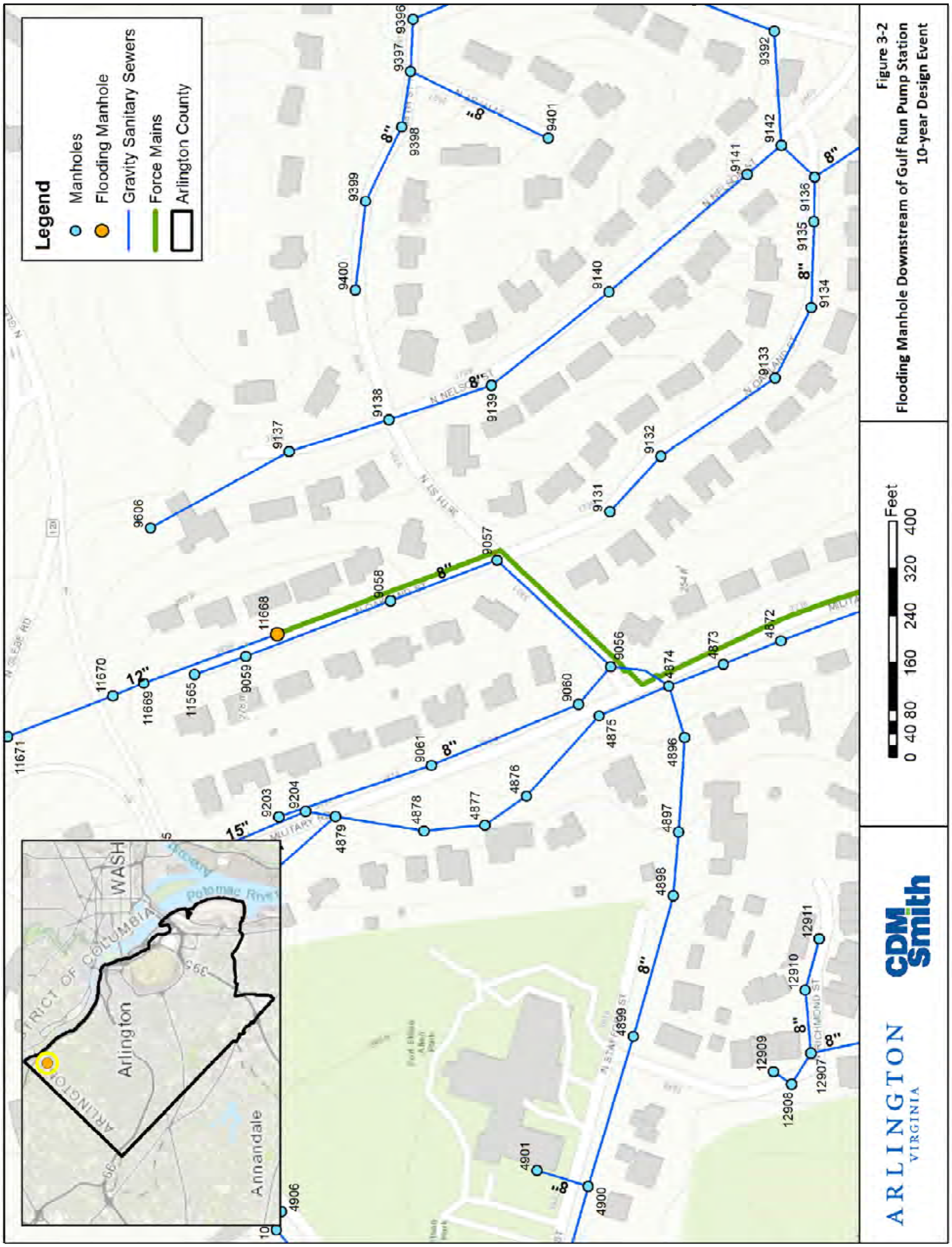


Figure 3-2
Flooding Manhole Downstream of Gulf Run Pump Station
10-year Design Event

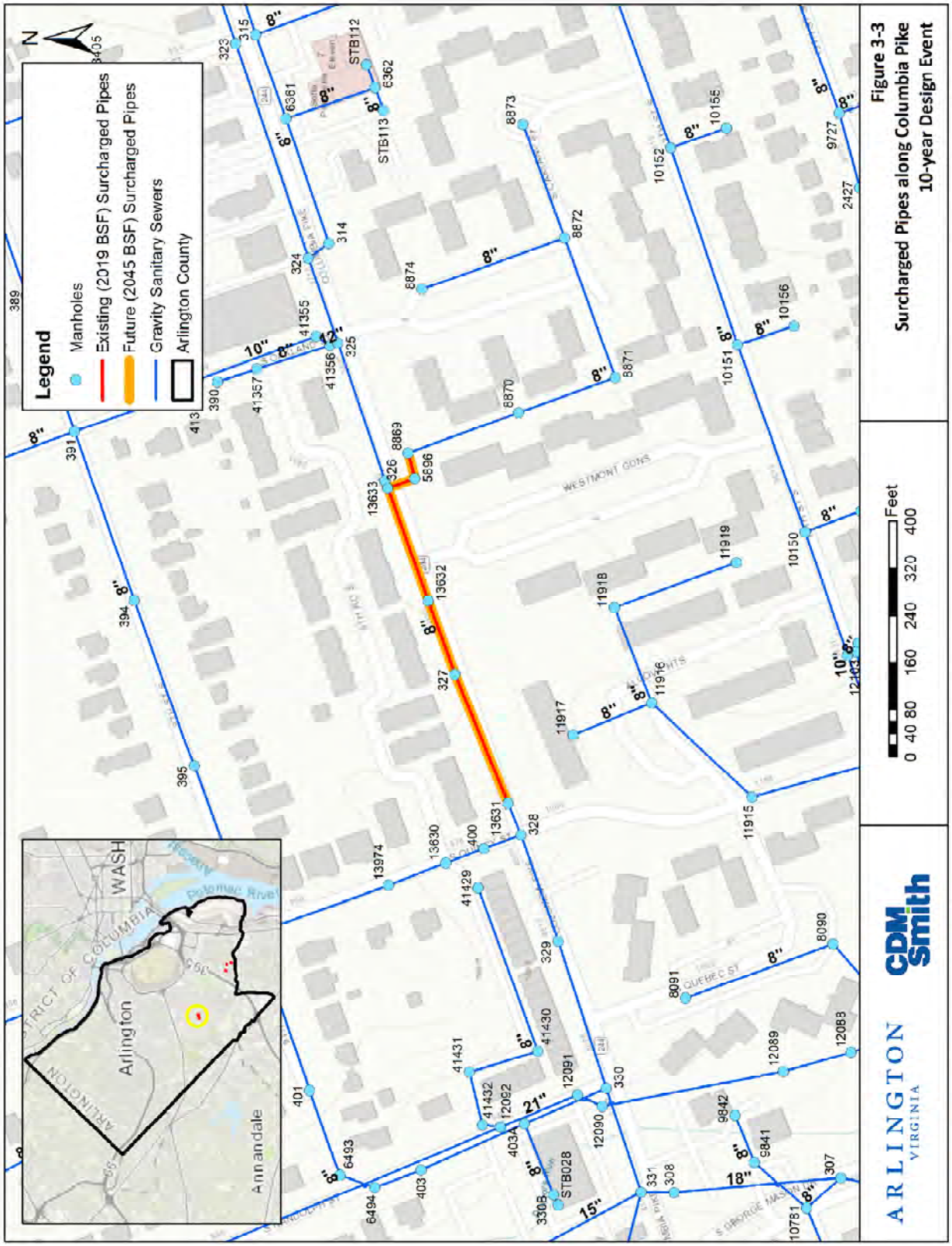


Figure 3-3
Surcharged Pipes along Columbia Pike
10-year Design Event

Figure 3-4. Profile of Surcharged Pipes Along Columbia Pike, 10-Year Design Event

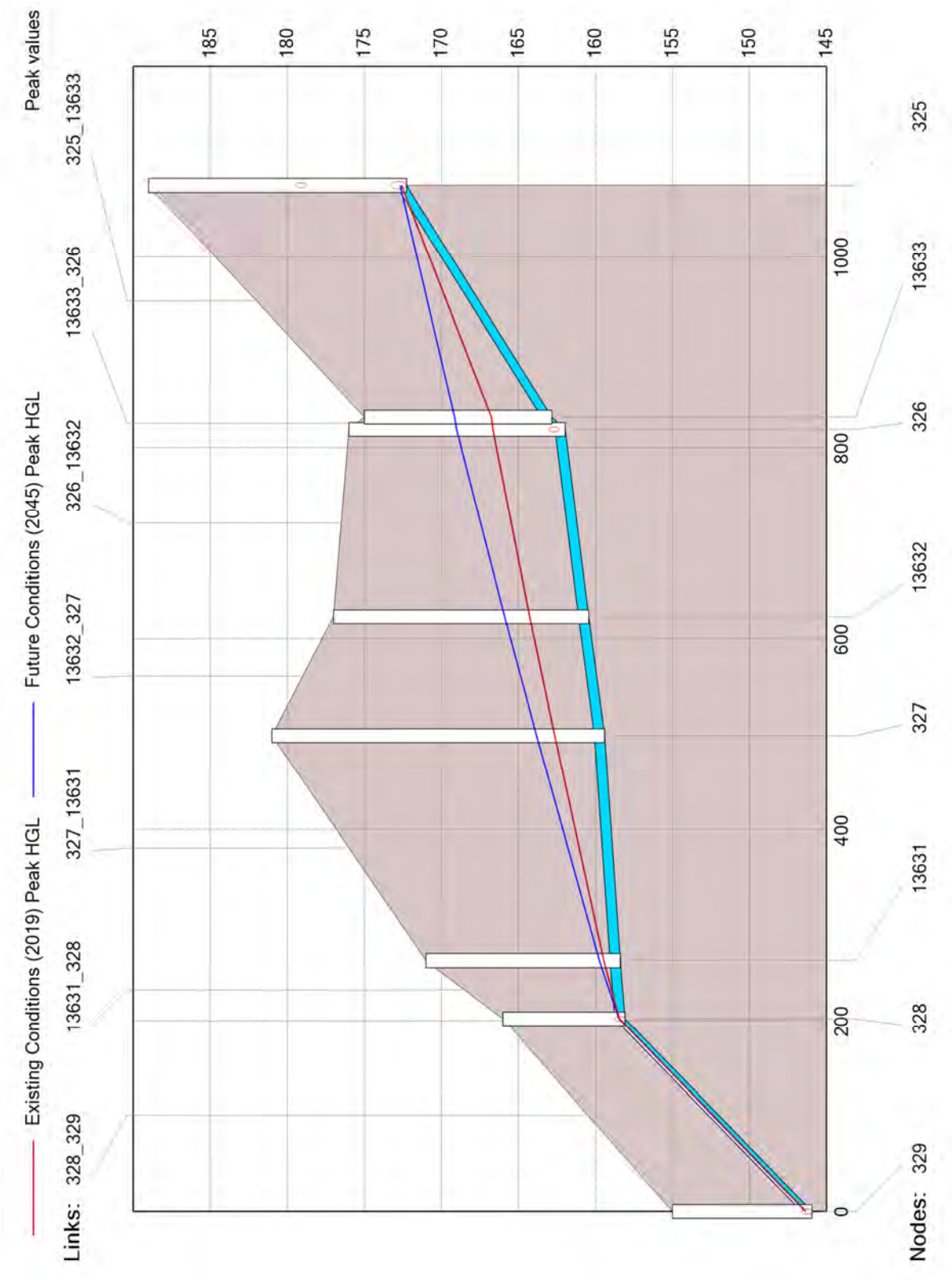
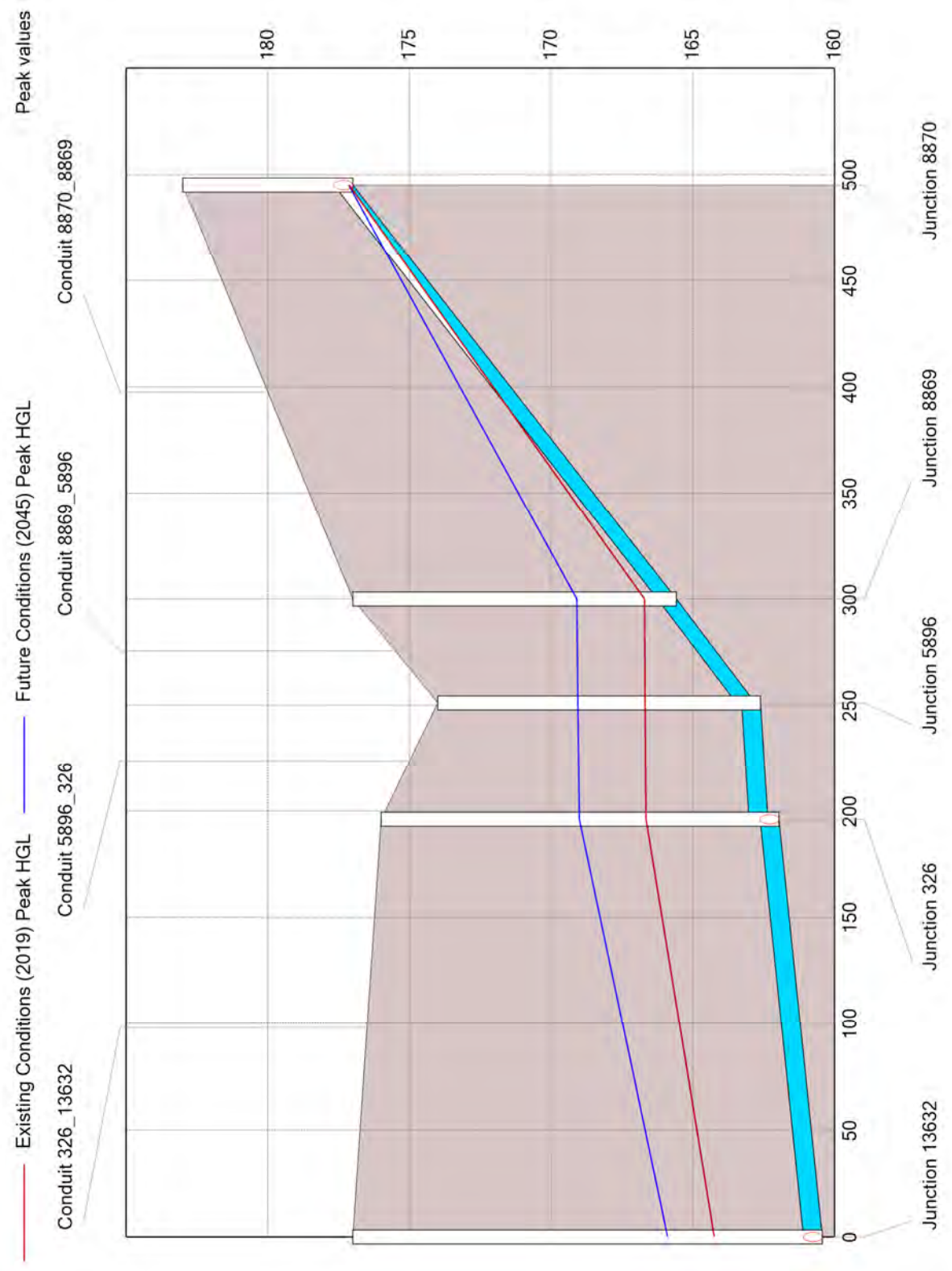


Figure 3-5. Profile of Surcharged Pipes Tributary to Columbia Pike, 10-Year Design Event



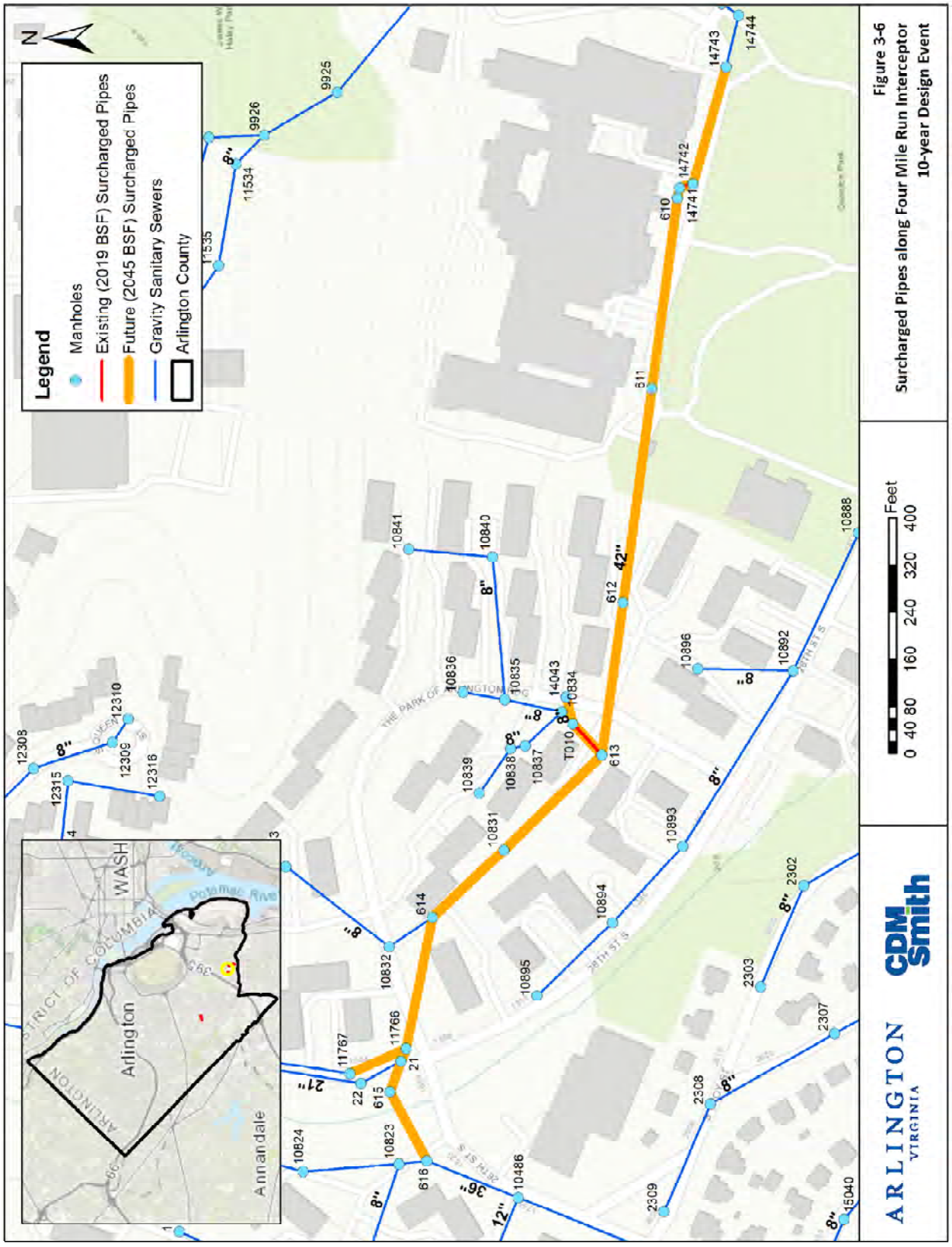
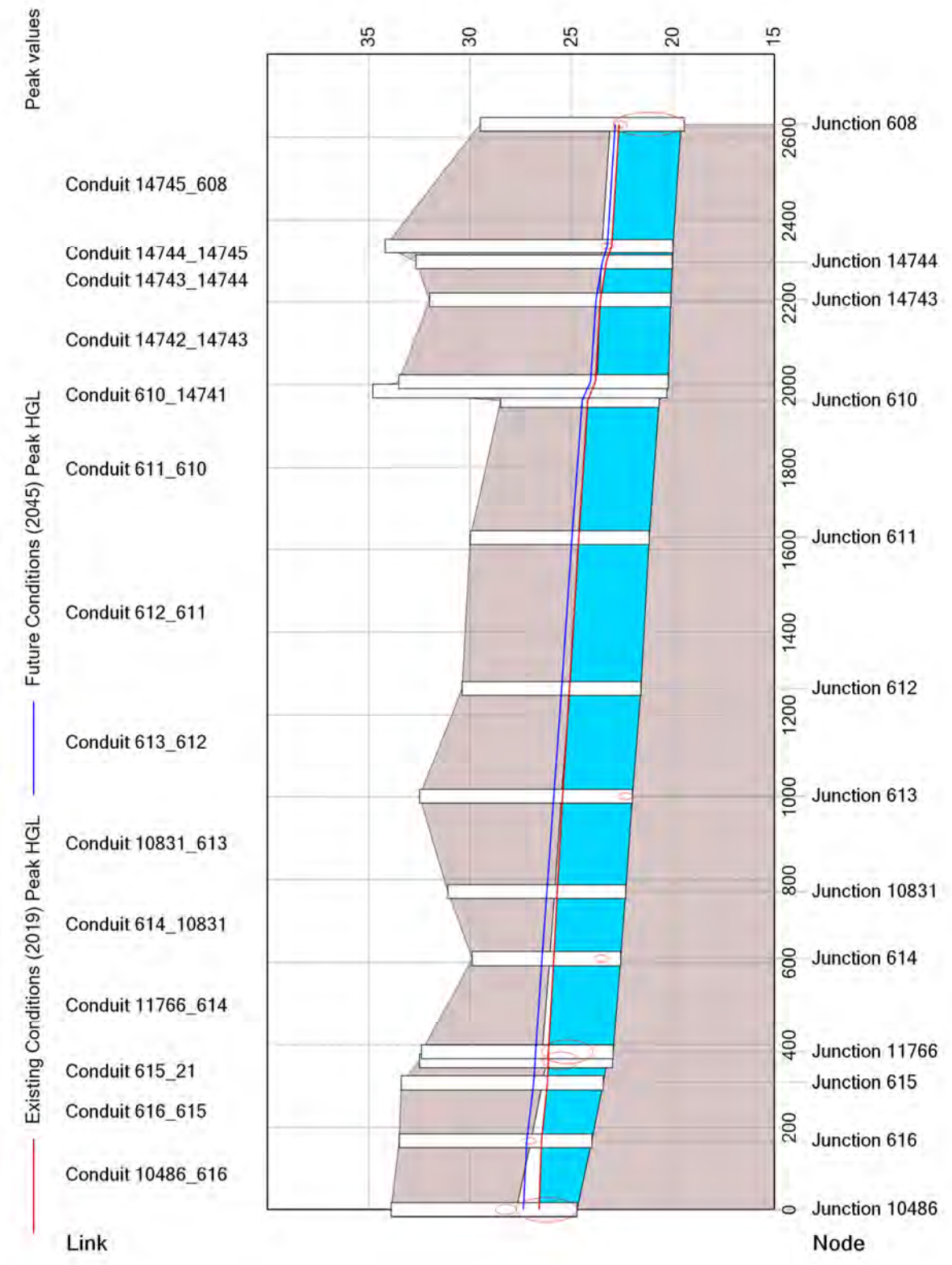


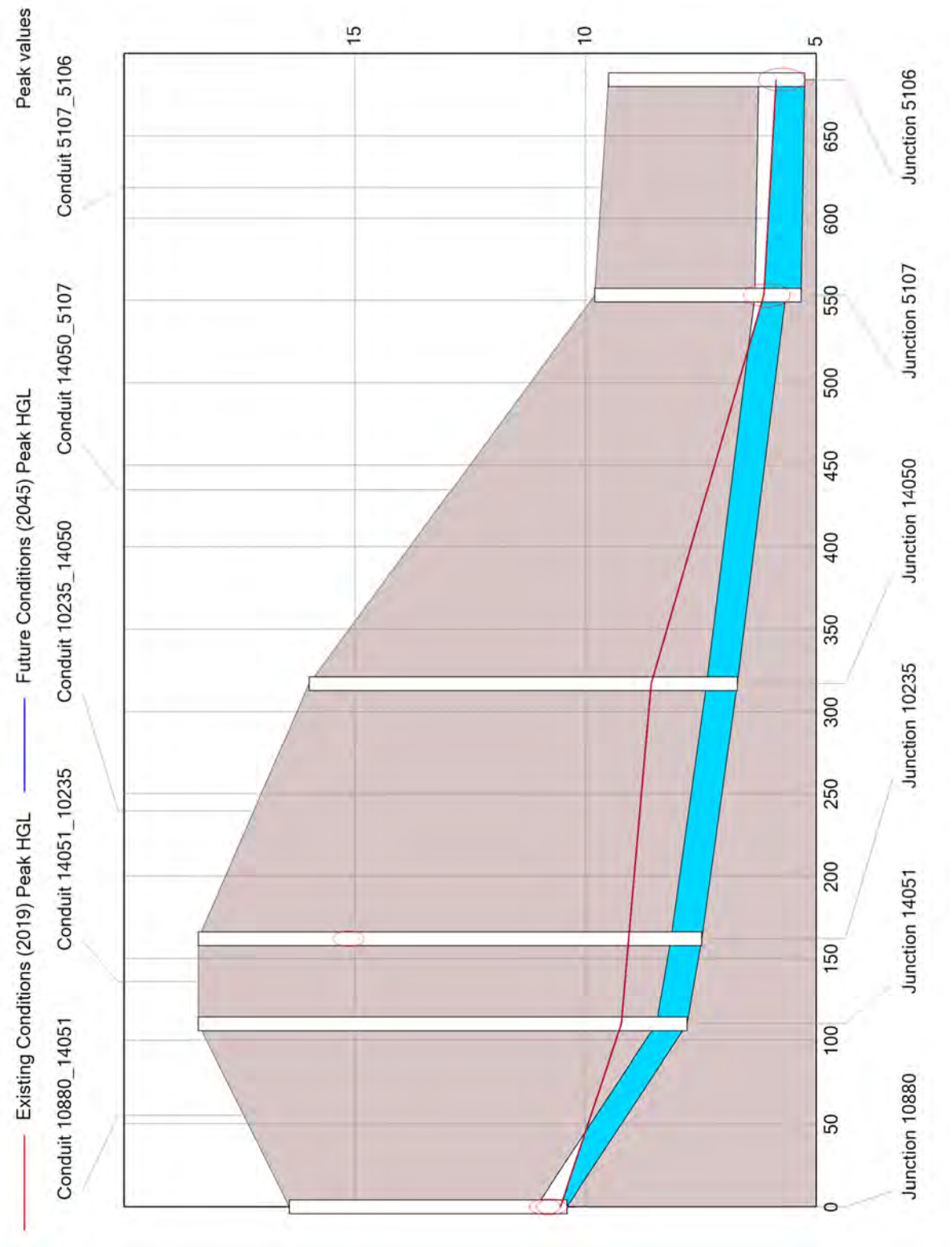
Figure 3-6
Surcharged Pipes along Four Mile Run Interceptor
10-year Design Event

Figure 3-7. Profile of Surcharged Pipes Along Four Mile Run Interceptor, 10-Year Design Event




Legend
Manholes
Existing (2019 BSF) Surcharged Pipes
Future (2045 BSF) Surcharged Pipes
Gravity Sanitary Sewers
Arlington County
N
Feet
0 20 40 80 120 160 200
ARLINGTON
VIRGINIA
CDM Smith
Figure 3-8
Surcharged Sewers Between 28th Street South and South Glebe Road - 10-year Design Event

Figure 3-9. Profile of Surcharged Pipes for Sewer Between 28th Street South and South Glebe Road, 10-year Design Event



3.6 Future 4X Planning Scenario Capacity Assessment Results

To identify any capacity concerns within the development corridors, where wet weather conditions do not necessarily represent the peak flow conditions, flows were analyzed using a peak flow factor of 4.0 and applying that to the average daily flows in the existing (2020) dry conditions model. The 2045 future conditions 4X planning model was created by adding the future flows generated by the additional housing and jobs forecasted based on Metropolitan Washington Council of Governments (COG) Round 9.1 to the dry conditions (2020) 4X model.

The results of this model confirm that the County's sewer system has adequate capacity in its development corridors to support the long-term future planned growth and land uses and no near-term improvements are needed. The model shows that there is one flooding manhole (MH-5896) on Columbia Pike between S. Quincy Street and S. Oakland Street that is projected to overflow. This is the same sewer that has capacity issues, though no flooding, for the 10-year, 24-hour rainfall event as previously described in Section 3.5 and **Figure 3-5**. However, this capacity issue will be resolved in Spring 2023 with the completion of the new 12-inch diameter sewer main along Columbia Pike between S. Oakland St and S. Quincy St during an early underground utility construction phase of the Columbia Pike Multimodal Segment F project.

Figures 3-10 thru 3-16 illustrate seven areas that the model results flagged to monitor closely in the future where the peak flow in the sewer segments illustrated in red are over 90 percent of the full-flow capacity (q/Q) under the 2045 buildout conditions. In these segments, a significant increase in density beyond what is forecasted in Round 9.1 and/or a change in a sewer outfall of an existing high-rise development that is not currently connected to these sewer segments redevelops and re-routes their lateral to connect to these segments, could cause capacity issues and result in surcharging pipes. Staff will review development applications closely that contribute directly to these sewer segments. Applicants will be expected to submit detailed sewer capacity computations using the average daily flows and Peak Flow Factors found in the latest version of the *Arlington County Construction Standards and Specifications – Section 02510, Sanitary Sewers and Appurtenances*, as well as take into account future planned growth in these areas based on the land uses and densities found in the latest *Arlington County Comprehensive Plan General Land Use Plan (GLUP)* Element, to identify sewer capacity improvement needs and ensure their application doesn't preclude future planned growth already assumed in these areas.

Figure 3-10. >90% Full-Flow Sewer Segments Along Crystal Drive in National Landing, Future 4X Planning Scenario

Figure 3-11. >90% Full-Flow Sewer Segments Along S. Joyce St in Pentagon City, Future 4X Planning Scenario

Figure 3-12. >90% Full-Flow Sewer Segments on N. Quincy St and Fairfax Dr in Ballston, Future 4X Planning Scenario

Figure 3-13. >90% Full-Flow Sewer Segments Along Fairfax Dr in Clarendon West, Future 4X Planning Scenario

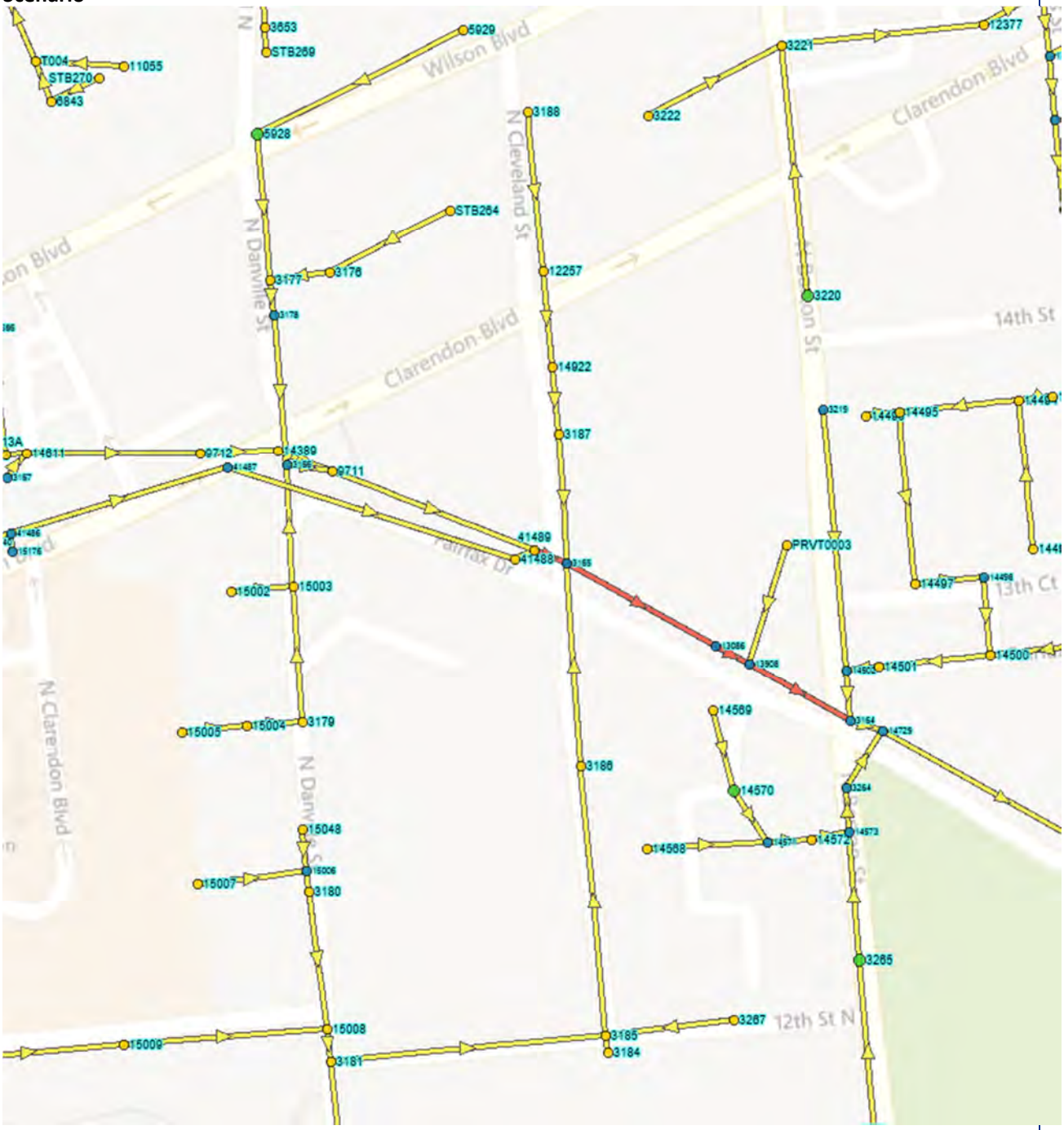
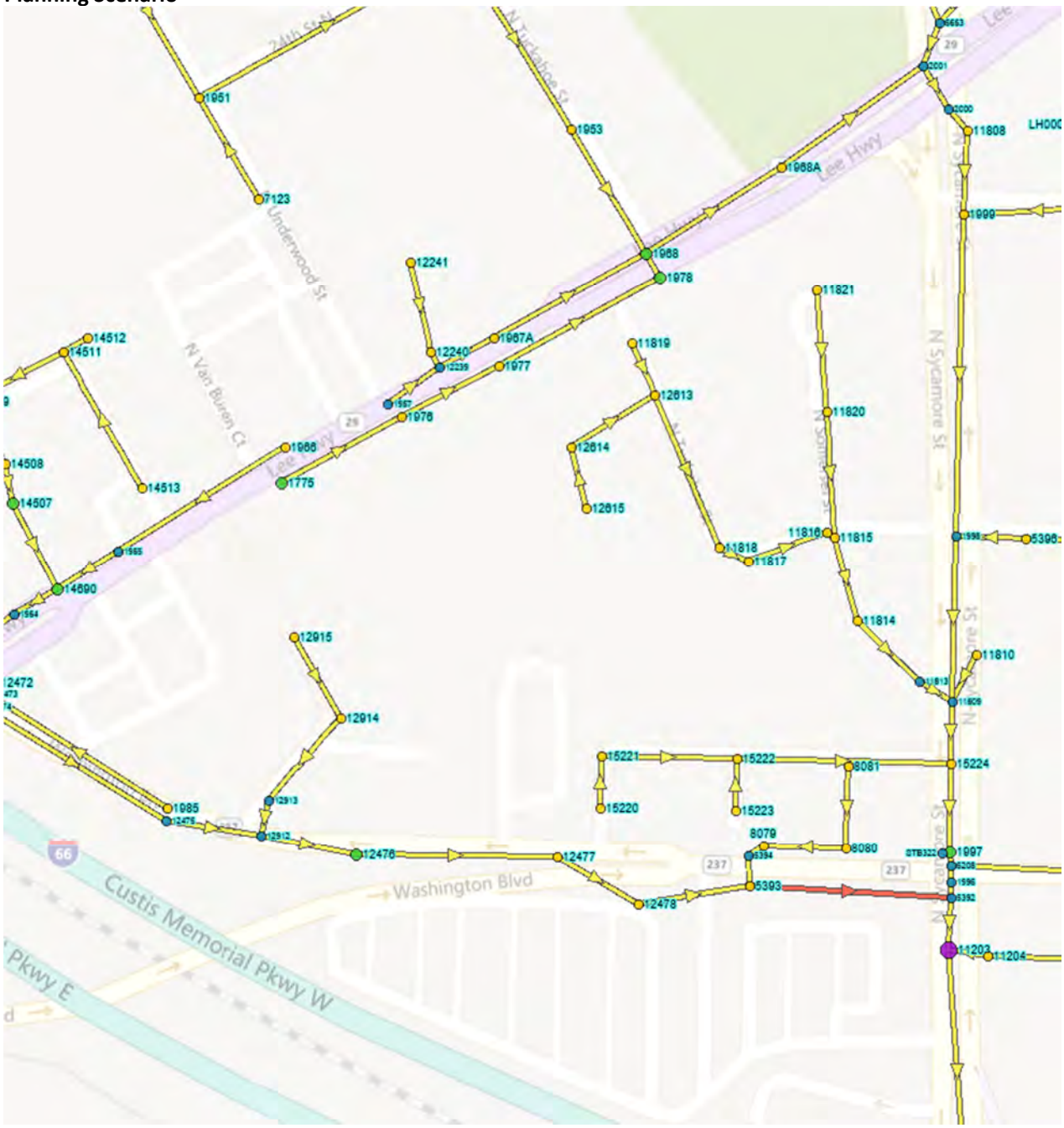


Figure 3-14. >90% Full-Flow Sewer Segments Along Meade St and Fairfax Dr in Rosslyn and Ft Myer Heights, Future 4X Planning Scenario

Figure 3-15. >90% Full-Flow Sewer Segment Along S. Scott St in Columbia Heights, Future 4X Planning Scenario

Figure 3-16. >90% Full-Flow Sewer Segment Along Washington Blvd in East Falls Church, Future 4X Planning Scenario



3.7 Discussion of Capacity Assessment Results

Overall, the results from the capacity analysis indicated that most of the County sanitary sewer system has sufficient capacity for the peak flows produced by the existing and future conditions, both in dry conditions and under a 10-year storm event. No capacity concerns were identified for dry-weather conditions, and only four locations had wet-weather capacity concerns, as discussed in Section 3.4. At two of the locations, the amount of surcharging is small and there is no immediate need to implement projects to address these concerns. The County has plans for sewer improvements that address the capacity concerns identified along Columbia Pike.

A simulated overflow occurs at the force main discharge from the Gulf Run wastewater pump station. The modeling assumes that the pump stations can pump the simulated peak flows. It is possible that surcharging, basement backups, and simulated overflows may occur in the upstream gravity sewers if the pumped flows are limited to the maximum pumping capacity of a downstream pump station or the Arlington County WPCP influent pumping facilities. The County is undertaking a separate study to evaluate the pump station capacity and impact of pump station capacity and operations on the gravity sewer system that is anticipated to be completed in 2023. Work has started on designing a project to replace the force main and upsize the uppermost portions of the downstream gravity sewer. Therefore, this gravity sewer system Master Plan does not include a project to address this capacity concern.

The Future 4X Planning scenario (2045) model results described in Section 3.6 show adequate capacity throughout the County's major development corridors to accommodate the future growth forecasted in COG's Round 9.1. There were only a handful of sewer segments flagged with capacity concerns that staff will monitor closely when reviewing development applications that contribute to these segments, thus reducing the likelihood of surcharging and overflow conditions.

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Section 4

System Improvement Plan

4.1 Introduction and Purpose

This section presents facility improvements and other programs that will allow the gravity sewer collection system to continue to provide reliable service to the residents and businesses of the County. The various improvements and programs described in the following sections include:

- **Major Infrastructure Improvements:** The County is currently working on multiple major infrastructure improvements of large size and high cost. These projects include the upgrade of Gulf Run Pump Station force main and downstream gravity sewer to address capacity concerns, Columbia Pike Multimodal project to resolve predicted surcharging issues and the Spout Run Deep sewer lining project to extend its useful life. The documented capacity evaluation shows that no other major infrastructure improvements are needed due to future demand.

- **Large-Diameter Sewer Inspection and Rehabilitation:** Large diameter sewer inspections and rehabilitations are crucial to continuing the sewer system's reliable operation. Currently, 44 miles of sewer larger than 15 inches and older than 25 years have not been lined. The County plans to increase the large diameter sewer inspection rate to ensure that all remaining sewers can be inspected in a 10-year time frame.

- **Sewer Inspection and Rehabilitation Program:** The sewer inspection and rehabilitation program has successfully lined 51% of the smaller diameter gravity sewers by increasing rehabilitation percentage from 1.5% to 4% per year. The County plans to continue inspecting smaller diameter sanitary sewers via Closed Circuit Television (CCTV), as well as update the current Geographic Information System (GIS) and test new technologies. Additionally, the County plans to implement a more rigorous manhole visual inspection program, including institution of risk-based prioritization measures followed by rehabilitation or replacement.

- **Inflow and Infiltration Reduction:** The County has an overall goal to reduce rainfall inflow and groundwater infiltration entering the sanitary sewer system, though recent flow monitoring indicates that these extraneous flows are not excessive. The County plans to continue inspecting and rehabilitating the public sewers through ongoing sewer lining programs. Privately operated gravity sewers pose a challenge for capacity as they contribute a large proportion of the infiltration and inflow to the County gravity sewer system. The County plans to evaluate options to mitigate private infiltration and inflow that include redirecting flows from basement sump pumps, using public funds to inspect private laterals, and growing current educational programs to include issues surrounding inflow and infiltration.

- **Operation and Maintenance Programs:** The County's Grid program has a goal to comprehensively flush each 12-inch diameter and smaller sewer main at least once every

five years. In order to meet this goal, the County plans to expand this program and devote additional funds and staff. Also, the County is planning to contract out flushing of 15-inch and 18-inch lines. Additionally, the County is planning to update and refine its sanitary sewer related Construction Standard Details and Standard Specifications based on past experience, continue implementing the current maintenance programs and establish a formal Capacity, Management, Operations, and Maintenance (CMOM) program.

- **Periodic Flooding Events:** During high intensity storms, flooding can cause sanitary sewer backups. The County plans to monitor areas of high-risk flooding and make adjustments to manholes located in the floodplain.
- **Future Flow Monitoring and Model Updates:** Wastewater flow monitoring is important to identify trends that will help the County maintain or reduce wastewater flows. The County plans to implement a 10-year future flow monitoring program and update the dynamic hydraulic model as needed to update and track future flow trends.
- **Action Plan:** The County has identified an Action Plan to improve the condition of the sanitary sewer system and ensure that it operates effectively, safely, and efficiently.

Major infrastructure improvements are planned and tracked through the CIP. These improvements and other sanitary sewer improvements, maintenance, and operation programs are funded through user fees included in wastewater rate. Additional funds are provided by the availability fees paid by new development and redevelopment projects to fund continuing maintenance capital and capital upgrades to the system to meet capacity needs and perform rehabilitation. None of these operating maintenance, capital maintenance, or capital improvements and programs receive funding from the County's general fund. Additionally, some funding is received from the County's inter-jurisdictional partners for rehabilitation of the Four Mile Run Interceptor, which conveys their wastewater within the County limits to the WPCP. The County's wastewater system also serves portions of Alexandria Sanitation Authority; the City of Alexandria, Virginia; the City of Falls Church, Virginia; and Fairfax County, Virginia. The funding is based on allocated capacity as laid out in each partner's agreement.

4.2 Major Infrastructure Improvements

Sanitary sewer capacity evaluations for the 10-year recurrence design storm show a capacity concern downstream of the Gulf Run wastewater pump station for both existing and future conditions, though there is little growth projected that outfall to this sewer area of north Arlington. The pump station capacity itself will be further evaluated by the County to determine the need for potential improvements in a study targeted to be completed in 2023. The County is actively designing a project to upgrade the pump station force main and a portion of the downstream gravity sewers to increase capacity that is anticipated to be constructed in 2025.

Construction of the sewer capacity improvements are underway as part of the Columbia Pike Multimodal Segment F project that will resolve the forecasted surcharging and future 4X planning condition simulated overflow between S. Quincy St and S. Oakland St. Furthermore, the three remaining Columbia Pike Multimodal project segments (Segments A, C, and D) include replacing and upsizing all of the existing sewer segments located within the Columbia Pike right-of-way,

approximately 1.8 miles of new sewer mains (including Segment F), to facilitate future growth and development along this corridor.

The capacity evaluation documented in Section 3 shows that no additional major improvements are needed at this time to provide capacity through the year 2045 for the 10-year design storm peak flows.

The Spout Run Deep Sewer lining project discussed in the next section is considered a major infrastructure improvement due to its high cost, approximately $8 million.

Major sanitary sewer system improvements may be required in the future due to major unanticipated redevelopment and to accommodate utility relocations that may be needed for complete streets or other transportation projects. In such cases, the project or application triggering the need for the system improvement should bear the cost of the improvement and/or relocation.

4.3 Large-Diameter Sewer Inspection and Rehabilitation

The County recognizes that large-diameter (15 inches and larger) major interceptor sewers are critical to the successful continued operation of the sanitary sewer collection system. Portions of the large-diameter Four Mile and Potomac Interceptor sewers recently have been inspected and lined. As outlined in Section 2.4, areas planned for future sewer lining projects in the near-term include the 0.64-mile Potomac Interceptor segment known as the Spout Run Deep Sewer from Spout Run stream to N. Nash Street; the 0.55-mile section of the Potomac Interceptor from N. Lynn Street to Arlington National Cemetery within Rossyln; and the 1.11-mile section of the Four Mile Run Relief sewer between Route 50 and Columbia Pike. Following these projects, the inspection program should transition to 15-inch diameter and larger tributary and trunk sewers identified as approaching their expected life span and potentially being susceptible to deterioration. Approximately 44 miles of 15-inch diameter and larger gravity sewers have not been lined and are more than 25 years old. The timeframe of 25 years was used as an analysis metric because this subsample of pipes was all constructed following the start of the County's lining program and the pipe material is either PVC, DIP, or fiberglass reinforced pipe and should not need to be lined in the future. Furthermore, there are no sewers 15-inch diameter and larger with install dates between 1986 thru 2002 in the County's asset management database. The County has historically targeted one large-diameter sewer segment for inspection and lining each year. **Table 4-1** presents the portion of the County's large diameter sewers, approximately one-quarter, that do not require rehabilitation because they have either already been lined, or they are less than 25 years old.

Table 4-1 Summary of 15-inch & Larger Sewers that Do Not Require Rehabilitation

Number of Sewer Segments Lined to Date	Sewer Segments Lined (Miles)	Number of Sewer Segments Less Than 25 Years Old	Sewer Segments Less Than 25 Years Old (Miles)	Percent of Sewer Segments 15-inch and Larger Lined or Less Than 25 Years Old (57.68 miles)
320	11.21	77	2.56	23.9%

The cost to rehabilitate the remaining three-quarters of large diameter sewers is forecasted in **Table 4-2** and is estimated to be $112,604,367 in 2023 dollars under the current on-call contract rates. The County's adopted FY 2023-2032 CIP allocates $22,745,000 in funding toward large-diameter sewer rehabilitation over the next ten years. At the current funding levels, it will take approximately 50 years to rehabilitate the large-diameter sewer system.

Table 4-2 Cost Estimate to Line Remaining 15-inch & Larger Sewers

Pipe Diameter	Sewer Segment Length (LF)	Cost per LF of Pipe (2023 $)	Total Cost (2023 $)
15"	47,532	$65	$3,089,580
18"	37,045	$83	$3,074,735
20"	2,032	$105	$213,360
21"	21,988	$108	$2,374,704
24"	21,415	$109	$2,334,235
27"	20,192	$131	$2,645,152
30"	29,448	$153	$4,505,544
33"	10,007	$176	$1,761,232
36"	13,456	$196	$2,637,356
42"	8,671	$265	$2,297,815
48"	8,332	$300	$2,499,600
54"	6,960	$339	$2,359,440
58"	397	$493	$195,721
72"	4,351	$502	$2,184,202
Subtotal	**231,826**		**$32,172,676**
Bypass + MOT + Other Costs		2.5 x lining cost	$80,431,691
Overall Total			**$112,604,367**

As per **Table 2-2**, the County is averaging approximately 2.2 miles per year in large-diameter sewer inspections. At this rate, it would take 20 years to inspect all remaining unlined large-diameter sewers. Since large-diameter sewers typically have a high consequence of failure, inspecting at least 4.4 miles of large-diameter sewer each year would allow for inspection of the remaining 44 miles of critical interceptor sewers within a 10-year time frame. **Table 4-3** estimates the cost to inspect the remaining three-quarters of large-diameter sewers that are eligible to be lined. Assuming a 10-year time frame to complete all these inspections, this comes out to $232,669 per year in 2023 dollars using the current on-call contract rates. The additional resources needed to accelerate the inspection of the large-diameter sewers within this 10-year time frame will be requested as part of the development of the FY 2025-2034 CIP. It should be noted that the funds for large-diameter sewer inspections come out of the $22,745,000 allocated in funding for large-diameter sewer rehabilitation in the County's adopted FY 2023-2032 CIP mentioned previously.

Table 4-3 Cost Estimate to Inspect Remaining 15-inch & Larger Sewers

Pipe Diameter	Sewer Segment Length (LF)	Cost per LF of Pipe (2023 $)	Total Cost (2023 $)
15"	47,532	$5.95	$282,815
18"	37,045	$6.95	$257,462
20"	2,032	$7.95	$16,154
21"	21,988	$8.95	$196,792
24"	21,415	$9.95	$213,079
27"	20,192	$10.95	$221,102
30"	29,448	$11.95	$351,903
33"	10,007	$12.95	$129,590
36"	13,456	$13.95	$187,709
42"	8,671	$14.95	$129,631
48"	8,332	$15.95	$132,895
54"	6,960	$16.95	$117,972
58"	397	$17.95	$7,126
72"	4,351	$18.95	$82,451
Total	**231,826**		**$2,326,687**

4.4 Sewer Inspection and Rehabilitation Program

Since the adoption of the 2002 Master Plan, the County has implemented a comprehensive sewer lining program and has lined about 51 percent of its gravity sewer segments, which accounts for approximately 58 percent of the total system length. The program has focused on the older, smaller-diameter sewers. This program initially started with the goal of lining 1.5 percent of the system each year, has increased to almost 4 percent or more each year in recent years. This program is referred to as the Infiltration and Inflow Program in the County CIP.

The lining program has generally progressed by selecting an area to investigate, such as a given neighborhood or commercial area. CCTV inspections then are completed for all sewers within the identified area. As outlined in Section 2.5, the County currently uses CCTV to inspect approximately 49 miles of sewer each year. Based on these condition assessments, the County decides which sewers to line. If a large percentage of the sewers are found to be in poor condition, all sewers in that area are lined. All clay pipes are lined where identified, regardless of condition. The County's Cartegraph asset management system is used to plan and track the CCTV inspection and lining program.

The current sewer lining program does not address the lining of laterals and rehabilitation of the connection of the lateral to the County sewer because these are the responsibility of the property owner, nor include comprehensive manhole rehabilitation as this is a separate program in the CIP.

In the near future, this lining program will reach a point of diminishing returns as the older sewers are all lined. At this point, there is no need to line more recently constructed sewers made

of PVC and ductile iron pipe, and the rate of lining could potentially be reduced in the event that a portion of the funds programmed for the lining program need to be diverted to fund other sewer capital program needs. At the current lining rate of 15.72 miles per year executed over the past five years (2018 thru 2022), the entire small diameter system that is eligible to be lined would be lined by the year 2031.

By the year 2050, the sewers lined in 2000 will be 50 years old and may need further rehabilitation. 50 years is the design life for CIPP liner, a trenchless structural sewer rehab technology dating back to the early 1970s. Given that the technology is just a little over 50 years old, the limited available data show that lined sewers continue to function up to an age of 50 years and may continue to function properly over longer periods. It is expected that by the year 2050, technologies will be available to rehabilitate previously lined sewers where evaluations find that it is necessary to do so.

The County should implement the following initiatives to improve the condition of its system:

- Continue to execute a comprehensive CCTV inspection program of all currently unlined sewers using the National Association of Sewer Service Companies (NASSCO) Pipeline Assessment Certification Program (PACP) standards. County inspection crews are not currently consistently using the standardized NASSCO coding system to note defects in the pipes despite many of the staff possessing the NASSCO certification. Defect coding is needed to enable staff to more effectively prioritize future projects and repairs. As shown in **Table 4-4**, there are approximately 120 miles of sewer that are smaller than 15 inches that have not been lined and are not PVC or DIP pipes. Some of the current lining funding could also be used to increase the mileage of large-diameter pipe inspection from current levels to 4.4 miles per year as noted above.
- Continue to update the sanitary sewer system GIS data to have an accurate inventory of the sanitary sewer system including pipe material and construction year. Approximately 29.6 percent of the sewer main segments (over 4,900 segments) are missing an install date in GIS. Many of these missing install dates are readily available on the County's 50-scale sewer drawings but have not been entered due to staffing limitations. Staff is in the process of recruiting an engineer intern to research and enter the remaining install dates for which records exist.
- Pilot new technologies such as ASTM F2561-20 to trenchlessly rehabilitate and seal the connection of the privately owned sewer lateral connection to the public sewer in order to reduce the groundwater infiltration at this weak point location. Lateral seals can be made watertight via gaskets and resin materials. This is explained further in Section 4.5.2.
- Implement a more robust manhole inspection, condition assessment, and rehabilitation program as part of the existing Manhole Rehabilitation CIP program. Currently, this program is limited to County staff conducting manhole inspections as part of the flushing, lining, and SL-RAT/CCTV inspection activities, and when investigating reported backups. Any defects noted are assigned to County crews or contractors for repair. As the number of sewers eligible to be lined approaches zero, the most cost-effective way to reduce groundwater and rainwater from entering the system will be to rehabilitate leaky manhole structures and covers.

The manhole inspection, condition assessment and rehabilitation program should include:

- A formal manhole visual inspection program, following NASSCO Manhole Assessment Certification Program (MACP) protocols to document and assess conditions, with 20% of the manholes inspected each year, such that all manholes are inspected every 5 years. Manhole prioritization for inspection can be based on the prioritization of the sewershed in which a manhole is located. The same approach used in the past for prioritization of sewersheds during the I&I reduction and sewer line rehabilitation program can be utilized for sewershed prioritization to be used for manhole inspection prioritization. The premise for this approach is based on the expectation that manholes and sewer pipes are expected to be of similar condition and age by general location.
- A risk-based approach should be considered for prioritization of manholes for rehabilitation. The risk is defined as the product of the likelihood of failure (LOF) and consequence of failure (COF). The LOF determination will be based on inspection results, while COF determination will be based on factors such as asset location, criticality, and environmental and customer impact.
- Manholes identified through inspection and condition assessment to be in poor condition should be considered for open cut replacement or rehabilitation.
- The following rehabilitation methods should be considered: chemical grouting, coating systems, structural lines, and frame/cover/chimney rehabilitation. Pilot studies are best suited to evaluate the efficacy and applicability of these methods for the rehabilitation of manholes in the County's sewer system. It is understood that the County is planning to pilot the AquataFlex spray liner system for manhole rehabilitation.

Table 4-4 Sewer Lining and Pipe Material History for 12-inch and Smaller Sewers

Number of Sewer Segments Lined	Sewer Segments Lined (Miles)	Number of PVC or DIP Sewer Segments	PVC or DIP Segments (Miles)	Percent of Sewer Segments 12-inch and Smaller Lined or are PVC or DIP (401.03 miles)
7,229	256.91	1,067	24.32	70.1%

4.5 Inflow and Infiltration Reduction

4.5.1 Introduction and Background

In addition to the BSF entering the system from homes and businesses, the gravity sewer system must convey additional flows that result from groundwater and rainfall entering the system through defects in the sewers and other sources, as discussed in Section 3.2. These extraneous flows affect the sewer capacity and increase the cost to pump and treat the wastewater and reduce the effective capacity of the gravity sewer system for BSF. Flow monitoring data evaluations discussed in Section 3.2 indicates that these extraneous flows are not excessive. The County has an overall goal to reduce the amount of inflow and infiltration that enters the sanitary

sewer system. Reducing inflow and infiltration will free sewer capacity to handle additional BSF from growth and will reduce the cost of treatment and pumping.

The County is responsible for maintaining the public gravity sewers from the private sewer lateral connections downstream to the treatment facilities (or to the downstream end of the County's system). Under current regulations and policies, the property owner is responsible for their private service lateral and its connection to the public sewer main. Some larger developments also have on-site, privately owned sewer mains and manhole structures upstream from the public sewers.

The following sections discuss ongoing and potential future programs that the County may consider implementing to achieve the overall goal of reducing the rates of inflow and infiltration into the County's sanitary sewer system.

4.5.2 Inflow and Infiltration Reduction Program

The County's current inflow and infiltration flows are not excessive, and capacity, as discussed in Section 3, is not an immediate challenge based on the current levels of inflow and infiltration. One measure of the amount of inflow and infiltration entering the sanitary sewer system is the total R value. As discussed in Section 3.2.2. this parameter represents the fraction of the rainfall that enters the sanitary sewer system as inflow and infiltration. A sewer system with a small value indicates that the sewers generally have smaller sources of inflow and infiltration and a larger value suggests that the sewers have more or larger sources of these flows.

Sewer systems of the age and construction material as those in Arlington County will have a total R value around 0.02 meaning that 2 percent of the rainfall enters the sanitary sewer through inflow and infiltration. Values 0.01 or less indicate that the sewers are in good condition. Eleven of the 37 meters have values of 0.01 or less. Values of 0.04 or greater suggest that the sewers are in poorer condition with additional or larger sources of inflow and infiltration. The value at meter AB01 is 0.044. These data indicate that the Arlington County sanitary sewers are in general good condition and there are no areas with extremely high values that would require immediate attention to address excessive inflow and infiltration flows.

Arlington County has an overall goal to reduce inflow and infiltration through various programs to address these flows in the public and private sewers as discussed in the following sections.

Public Sewers

The County should continue to inspect and rehabilitate the public sewers through the ongoing sewer lining programs to maintain or reduce inflow and infiltration. Flow monitoring data suggests that these efforts have been successful in that the flows remain within acceptable limits even as the sewers continue to age.

Studies have shown significant amounts of inflow and infiltration can enter the sewer at the private lateral connection to the public sewer system. There are measures that can be taken at the time of the public sewer rehabilitation to prevent water from entering the sewer at this connection and therefore increase the inflow and infiltration reduction attained through the ongoing lining program. Proprietary systems are available and are used by many utilities to rehabilitate the lateral/sewer line junctions without requiring excavation. The mainline pipe

should be lined first followed by the rehabilitation of the lateral connection. This will minimize any damage to the liner.

Service lateral connection liners are cured–in-place liners used to seal the service connection between the sewer main and lateral as well as some portion of the lateral. The liner, installed by remote device, typically consists of felt fabric and polyester resin. A short portion of the liner is placed in the sewer main around the full diameter, and a second portion is located a defined distance up the lateral. The two pieces are attached during the hardening process to form a complete sleeve that encompasses both the lateral and the mainline sewer pipe.

Private Laterals and Sewer Systems

A significant amount of inflow and infiltration enter the sanitary sewer system through the privately owned sanitary sewer systems upstream from the connection to the County sewers. There are approximately 459 miles of public sewer and 230 miles of laterals according to the County sewer system GIS. If these sewers had equal defects, this would suggest that as much as 33 percent of the total inflow and infiltration may originate in the private sewers. The proportion of inflow and infiltration from these private systems will become larger as the County continues to rehabilitate the public sewers. There will come a time when further significant inflow and inflow reductions cannot be realized without addressing private system inflow and infiltration.

Under current regulations and policy, the County does not have jurisdiction over the private systems, and any repairs needed to a service lateral are performed by licensed plumbing contractors hired by the property owner. However, innovative options exist for alternative funding sources, potentially using public moneys or federal or state grant funding, should the County decide to address the rehabilitation of private laterals and sewer systems.

There are additional measures that could potentially be undertaken by the County to reduce these sources of inflow and infiltration in new construction or redevelopment. The County has changed the building code to not allow sump pumps, areaway drains, building foundation drains, and roof downspouts to connect to the sanitary sewers. New home construction or redevelopment of residential properties frequently leave the portion of the service lateral in the street unrehabilitated as the portions of the lateral within the property limits are replaced if they are found to be in poor condition. In some cases, the laterals within the property limits are not replaced. The County should evaluate and implement regulations and guidelines that require that redevelopment of residential properties to include a complete lateral replacement up to and including the rehabilitation of the connection to the County sewer mains.

The County should consider additional options to reduce inflow and infiltration originating from private sources to potentially include the following programs:

- Evaluate options to identify and disconnect existing basement sump pumps in older development from the sanitary sewer system and redirect the flows. A possible long-term solution would be to require that a licensed plumber inspect the homes to certify that sump pumps are disconnected from the sanitary sewer system at the time the property is sold.
- Evaluate options available under State Code to provide loans or financial incentives, such as a utility bill credit, for the inspection and rehabilitation or replacement of private service laterals.

- Expand existing public education programs (e.g. Stormwater outreach program) to include education on private inflow and infiltration sources, including sump pumps and downspout connections, and how they affect the capacity of the sewer system, affect cost of treatment, and contribute to sewer backups and discharges that may occur during major rainfall events.

4.6 Operation and Maintenance Programs

The County should continue the ongoing maintenance programs presented in Sections 2.5 and 2.8 to assure effective and reliable operation of the system. As mentioned in Section 2.5, the County is falling well short of accomplishing the Grid program, which consists of the comprehensive flushing of every 12-inch diameter and smaller sewer main in the system at least once every five years. 66 percent of this system that is not part of the 1-month/3-month/6-month PM Program was not flushed between 2018 and 2022. **Table 4-5** forecasts the cost of flushing these unflushed segments using the current sewer cleaning on-call contractor.

Table 4-5 Contractor Cost Projection to Flush All 12-inch Diameter and Smaller Segments that were Not Flushed in the Past Five Years

Diameter (Inches)	Sewer Length (Linear Feet)	Estimated Cost Per Linear Foot	Total Cost
6	11,594	$1.25	$14,493
8	1,158,322	$1.25	$1,447,903
10	55,252	$1.25	$69,065
12	92,758	$1.25	$115,948
Total	**1,317,926**		**$1,647,408**
Cost per Year	**263,585 LF**		**$329,481/year**

Based on the work history performed over the past five years and current contract rates, it would cost approximately $330,000 additional per year to accomplish the Grid program by assigning all of the unflushed segments to the on-call contractor. Alternatively, in lieu of increasing the amount of contract work, the County could hire an additional three-person crew consisting of one Equipment Operator FTE and two Service Technician FTEs, as well as acquire one additional flusher truck to flush the remaining segments that haven't been flushed at all in the past five years. This is projected to cost approximately $291,000 per year based on FY 2024 budget values for personnel and equipment maintenance as summarized in **Table 4-6**.

Table 4-6 Annual Additional Cost Projection to Achieve Grid Program Using County Forces

FTE Position Title / Equipment	Annual Cost
Equipment Operator	$95,007
Service Technician	$82,587
Service Technician	$72,706
Flusher Truck (HV607 SBA 4x2) Annual Maintenance & Replacement expense	$40,764
Total	**$291,064**
Crew Flushing Capacity (based on 2022 data)	279,414 LF/year
Cost per LF	$1.04/LF

While the ongoing annual cost is projected to be 13 percent more to achieve the Grid program goals using in-house staff in the near-term, this method is preferred over increasing permanent FTE staff due primarily to the one-time cost of purchasing one new flusher truck – estimated to be $293,000 in 2023. Using contract staff also allows an evaluation of outcomes from achieving Grid program goals, without committing the County to long term staffing obligations. After several years of flushing at least 20 percent of the small-diameter sewers per year, the County should re-evaluate crew performance history, system performance measures, and personnel/equipment /contractor costs to determine whether it would be more beneficial in the long-term to add the additional three-person crew and flusher truck. Therefore, consideration should be given to increasing future sewer maintenance operating budgets starting in FY 2025 by $330,000 per year and adjusted annually with inflation to expand the flushing work performed by the on-call contractor to ensure that the Grid program is being completed. This would require the adjustment of the sewer charge rates to be increased by approximately $0.0440 per thousand gallons (TG), which would increase the median household's annual impact (48 TG) by approximately $2.11 per year.

Furthermore, the County should contract out flushing all 15-inch and 18-inch diameter trunk line sewers at least once every five years. The on-call contractor has specialized equipment and nozzle attachments that can flush and clean the entire limits of an up to 18-inch diameter pipe under flow without using a bypass. **Table 4-7** forecasts the cost of flushing these unflushed segments using the current sewer cleaning on-call contractor.

Table 4-7 Cost Projection to Flush All 15-inch and 18-inch Segments that were Not Flushed in Past Five Years

Diameter (Inches)	Sewer Length (Linear Feet)	Estimated Cost Per Linear Foot	Total Cost
15	35,614	$2.25	$80,131
18	36,981	$2.25	$83,206
Total	**72,594**		**$163,337**
Cost per Year			**$32,667/year**

Based on the work history performed over the past five years and current contract rates, it would cost approximately $33,000 additional per year to clean all the 15-inch and 18-inch diameter trunk sewers once every five years. Consideration should be given to increasing future sewer

maintenance operating budgets by this amount accordingly, which would require the adjustment of the sewer charge rates to be increased by $0.0044 per thousand gallons (TG), thus increasing the median household's annual impact (48 TG) by approximately $0.21 per year. This is a cost-effective strategy to ensure proper functioning of these sewers as they don't necessarily have enough scouring velocity to keep debris from accumulating. Flushing sewers larger than 18-inch in diameter is not effective without bypassing the existing flow in the pipe, which is costly and requires significant planning in advance of the work.

In addition to implementing the proposed additional flushing activities needed to achieve the Grid program, the County should continue the following ongoing maintenance programs and activities:

- Routine flushing of sewers with chronic issues related to grease and other debris on the requisite 1-month/3-month/6-month intervals.
- Apply root control foam treatments to the sewer segments in the root control programs once every five years.
- Inspect all 12-inch diameter and smaller sewers at least once every ten years, which the County is on track to accomplish (see **Table 2-8**).
- Identify, inspect, and rehabilitate sewer segments at stream crossings. The County is planning to repeat this inspection approximately every 10 years to identify and correct potential issues created by erosion or other factors.
- Continue programs to address fats, oils, and grease, collectively known as FOG, that can create blockages and cause overflows. This includes the ongoing public information program to instruct homeowners on how to properly dispose of FOG and keep it out of the sanitary sewer system. The County adopted Code Chapter 26.1 "Wastewater Pretreatment" January 22, 2022, which includes requirements for food services establishments to comply with the County's Fats, Oils, and Grease Discharge Policy. County sewers collection engineering and operations staff meet quarterly with the Pretreatment Program Coordinator leading the FOG program to review the grease maintenance and inspection activities that occurred during the past quarter and select several grease segments to CCTV prior to the next scheduled flushing to determine the source(s) of the grease and whether that segment can be placed on a less frequent preventative maintenance flushing cycle.
- Update and refine its sanitary sewer related Construction Standard Details and Standards and Specifications based on past maintenance challenges and issues. The County released an update to the Construction Standard Details and Standards and Specifications in February 2023 to add a requirement for tracer wire to be placed around non-metallic pipe that is not node to node (e.g., private sanitary sewer house laterals), as well as to require detectable utility warning/marking tape above all newly placed underground utilities in the street right-of-way. These updates will reduce the likelihood of construction breaking sanitary sewer laterals and other critical buried utilities. The next round of standard updates will focus on updating the manhole details to better clarify how drop connections should be aligned so that they can always be seen when flushing from the manhole, provide a cleanout at the property line, and update the CCTV specification to require the necessary

data and video coding formats to upload the footage into ITPipes, the data management program used to store the results of CCTV inspections.

Finally, the County should establish a formal Capacity, Management, Operations, and Maintenance (CMOM) program under the Environmental Protection Agency's (EPA) framework and use it as a vehicle to track progress and document needs. One such element of this framework is the development of an Overflow Emergency Response Plan (OERP) that the County currently lacks. In addition, the County should develop a more formal sanitary sewer overflow (SSO) tracking system for the consistent reporting of SSOs, discharges, and their cause. The reporting of SSOs changes as staffing turns over and the result has been inconsistent reporting of these events and inadequate data retained for past events that preclude going back more than 5 years and standardizing how many SSOs and discharges there have historically been that were caused by a maintenance or capacity failure in the public sewer. Standardized, consistent tracking of these events is crucial in accurately assessing the impact of implementing the proposed flushing enhancements.

4.7 Periodic Flooding Events

The County has periodically been affected by mostly localized, high-intensity rainfall events that overwhelm the storm water conveyance systems. When basements and streets are flooded, water enters the sanitary sewer system, and that flood water can produce downstream sanitary sewer backups and discharges. The County should continue to identify areas prone to this type of flooding, and in concert with the County's Stormwater Management program, implement programs and improvements to eliminate or minimize such periodic flooding.

As is the case in much of the Arlington sewer system, manholes located within the floodplain of streams will have the manhole lids raised above the flood level and/or have bolted-down manhole covers to prevent floodwaters from entering the sanitary sewer system.

4.8 Future Flow Monitoring and Model Updates

The County should implement temporary flow monitoring programs at 10-year intervals to document and evaluate trends in wastewater flows over time and identify corrective actions that need to be taken to maintain or reduce wastewater flows. The County is building out a permanent flood monitoring network to monitor stormwater flow at key stormwater infrastructure locations and rainfall at those same points within the County. The first location will be at Cardinal Elementary School with a second location to follow at Columbia Pike and South Greenbrier Street. Other future stormwater flow monitoring locations will be installed at Kirkwood Road and Langston Boulevard (Route 29), Military Road and Gulf Branch, and North Dumbarton Street and Little Pimmit Run.

In conjunction with each 10-year future flow monitoring program, the dynamic hydraulic model should be updated to include recent facility improvements. The model should be applied to verify the model calibration using the collected flow and rainfall data, and adjustments will be made where necessary, so the model accurately represents the then current system conditions. Future flows should be updated using the then current projections, and the sanitary sewer capacity evaluation should be revisited.

Lastly, the County should continue to update and review its sanitary sewer and gravity sewer related Construction Standards and Specifications. This includes updating the design criteria, peak flow factors, average daily usage rates, pipe slope, and velocity requirements to ensure newly constructed sewers by development are adequately sized to accommodate future growth.

4.9 Action Plan

Overall, results from the hydraulic modeling indicated that the County owned and maintained 459 miles sanitary system has adequate capacity to handle the future growth planned throughout the County. While over 60 percent of the system was constructed prior to 1960, the effective age of the sewers has been significantly reduced as a result of the aggressive lining program started in the late 1990s. Below is a summary of the recommendations presented throughout this Master Plan Update that the County should implement to improve the condition of the system and ensure that it operates effectively, safely, and efficiently:

- Achieve the long-aspired objective of the Grid program to comprehensively flush every 12-inch diameter and smaller sanitary sewer at least once over a five-year period via using contractor crews funded by increasing the future sewer maintenance operating budgets starting in FY 2025 by $330,000 adjusted annually for inflation. This would require the adjustment of the sewer charge rates to be increased by $0.0440 per thousand gallons (TG), which would increase the average household's annual bill by approximately $2.11 per year, representing a 0.46 percent increase.
- Flush all 15-inch and 18-inch diameter trunk line sewer segments at least once every five years via contractor crews funded by increasing the future sewer maintenance operating budgets starting in FY 2025 by $33,000 adjusted annually for inflation. This would require the adjustment of the sewer charge rates to be increased by $0.0044 per thousand gallons (TG), which would increase the average household's annual bill by approximately $0.21 per year, representing a 0.05 percent increase.
- Accelerate the inspection of the large-diameter (15-inch and larger) sewers from the current pace of 2.1 miles per year to 4.4 miles per year so that all of the remaining unrehabilitated segments that are over 25 years old can be inspected over the next ten years to identify segments with maintenance and/or structural issues. Furthermore, when sewers larger than 18 inches in diameter are bypassed for the inspections, they should be cleaned as part of the inspection. The resources needed to execute this work should be programmed during the development of the FY 2025-2034 CIP starting in year FY 2025.
- Accelerate the rehabilitation of the large-diameter (15-inch and larger) sewers following the completion of the Spout Run Deep sewer, Potomac Interceptor, and Four Mile Run Relief sewer lining projects, which collectively total approximately 1.3 miles in length. Utilize federal funding opportunities when available as the rehabilitation of these types of interceptor sewers can typically be done trenchlessly with minimal disturbance. The rehabilitation rate is anticipated to be comparable to the aforementioned increased inspection rate. The resources needed to execute this work should be programmed during the development of the FY 2025-2034 CIP starting in year FY 2027.
- Implement a more robust manhole inspection, condition assessment, and rehabilitation program as part of the existing Manhole Rehabilitation CIP program. The manhole

condition assessment and rehabilitation program should include a formal manhole visual inspection program following NASSCO MACP protocols, with 20% of manholes inspected each year. Manholes identified through inspection and condition assessment to be in poor condition should be considered for open cut replacement or rehabilitation. The increased resources needed to execute this work should be programed during the development of the FY 2025-2034 CIP starting in year FY 2027 as the number of small-diameter sewers eligible for lining nears zero.

- Identify, inspect, and rehabilitate sewer segments at stream crossings. The County is planning to repeat this inspection approximately every 10 years to identify and correct potential issues created by erosion or other factors.
- Utilize the standardized NASSCO defect coding whenever CCTV inspections are performed by either County crews or contractor crews to allow for better prioritization of rehabilitation projects and repairs. This will also enable a more accurate portrayal of remaining asset life in the County's asset management system, Cartegraph.
- Finish researching and updating the sanitary sewer system GIS data to populate the remaining missing pipe material and construction years where data is available.
- Update and refine sanitary sewer and gravity sewer related Construction Standard Details and Standards and Specifications to ensure easier and less frequent maintenance activities, as well as the proper sizing of newly constructed and modified sewer mains and manhole structures. Furthermore, staff should continue to monitor the system's performance during major storm events and if necessary, adjust sewer design peaking factors to be more conservative due to the impacts of climate change.
- Establish a formal written Capacity, Management, Operations, and Maintenance (CMOM) program under the Environmental Protection Agency's (EPA) framework and use it as a vehicle to track progress and document needs. One such element of this framework is the development of an Overflow Emergency Response Plan (OERP).
- Develop a more formal sanitary sewer overflow (SSO) tracking system for the consistent reporting of SSOs, discharges, and their cause. Retain this data electronically indefinitely.
- Continue and update, if necessary, programs to address fats, oils, and grease, collectively known as FOG, that can create blockages and cause overflows. This includes the ongoing public information program to instruct homeowners on how to properly dispose of FOG and keep it out of the sanitary sewer system. The County adopted Code Chapter 26.1 "Wastewater Pretreatment" January 22, 2022, which includes requirements for food services establishments to comply with the County's Fats, Oils, and Grease Discharge Policy.
- Update this Master Plan element ten years following adoption of the subject update.

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Department of Environmental Services
Water, Sewer and Streets Bureau
4200 28th St. South
Arlington, VA 22206