City of Baltimore

Department of Public Works (DPW)

BUREAU OF WATER AND WASTEWATER

United States, et al v. Mayor and City Council of Baltimore

Civil Action No. JFM-02-1524

Modified Consent Decree (MCD)

Phase II Plan

January 18, 2023

Mayor
BRANDON M. SCOTT

BALTIMORE CITY
DEPARTMENT OF
PUBLIC WORKS

Jason W. Mitchell
Director

Table of Contents

1 Executive Summary

ES-1 Background

On September 30, 2002, the City of Baltimore ("the City" or "Baltimore City") entered into a Consent Decree (CD) in the matter captioned *United States, et al v. Mayor and City Council of Baltimore,* Maryland, JFM02-CV154 (D. Maryland) with the United States (U.S.) Environmental Protection Agency (EPA), the Maryland Department of the Environment (MDE) and the U.S. Department of Justice (DOJ), to address Sanitary Sewer Overflows (SSOs) from the City's sanitary sewer collection system. Thereafter, a Modified Consent Decree (MCD) was agreed by the parties, which was entered by the Court on October 6, 2017 (Civil Action No. JFM-02-1524, Docket Number JMF-02-1524). Paragraph 9(b) of the MCD requires the City to submit a Phase II Plan by December 31, 2022.

ES-2 Overview

The City has substantially reduced the frequency and volume of SSOs since beginning its work in 2002 with the original CD. Overall, the City has spent over $1.6 Billion(B) on various projects needed to accomplish goals set by the CD and MCD, respectively. Notable accomplishments include eliminating 60 out of 62 originally identified SSO structures; completing the MCD Appendix B.1 Headworks Project; completing 34 out of 36 MCD Appendix B (Phase I) projects; and improving the hydraulic capacity at the Back River Wastewater Treatment Plant (WWTP), enabling better peak flow attenuation, which improves treatment performance to better manage compliance with permit limits. Receiving water quality monitoring conducted by the City as well as that conducted by Blue Water Baltimore in City receiving streams and the Inner Harbor have shown a trend of decreasing bacteria counts in samples taken from 2010 to present. Furthermore, the City has implemented an industry standard asset management process that prioritizes operation and maintenance activities such as targeted sewer cleaning, root control, and Fats, Oils, and Grease (FOG) management, among others.

Prior to construction of any Phase I projects, the City estimated that the MCD 20-year typical rain period yielded 2.4 Billion Gallons (BG) of SSOs. In 2022, the MCD 20-year typical rain period yielded only 235 Million Gallons (MG), or a 90% reduction. Even more, the completion of the major Headworks Project and many MCD Phase I projects has shown (and will continue to show) a more pronounced reduction of SSOs. In Calendar Year (CY) 2020, prior to the Headworks Project coming on-line, the City recorded 335 wet-weather designated SSO activations that discharged 84 MG. In CY 2021, the City recorded 223 SSO activations for a total discharge of 26 MG. Finally, in CY 2022, the City has recorded only 155 SSO activations for a total of 5.7 MG. Over a period of three years, this represents an approximate 93% reduction in recorded wet-weather SSO volume. This great volume reduction has contributed to the improved water quality in the receiving waters mentioned above. These reduction trends will continue as the City progresses with ongoing projects and initiates additional initiatives as part of the Phase II Plan described in this report.

The Phase II Plan presented in this report identifies a forward thinking and advanced maintenance-related program as well as possible capital projects in achieving MCD Level of Protection (LOP) that will begin immediately. Strategically and cost-effectively, performing rehabilitation and replacement is the most optimal solution for reducing separate sanitary sewer wastewater collection system SSOs given the 90% reductions in SSOs the City has achieved. An intensive analysis of observed SSO events recorded between 2003 and 2022, categorized as wet weather derived, found that 81% of them were in fact related to blockage issues. Also, 97% of the blockage related SSOs were on pipes 20" and less. A focused push on Operation and Maintenance (O&M), especially on smaller pipes, will lead to tremendous reductions in SSOs, will inform further enhancements to the City's asset management risk-based improvement prioritization program, and will identify instances of needed repair or rehabilitation that will be incorporated into capital projects.

In parallel with the advanced maintenance-related program, the City is planning other capital projects to rehabilitate and replace sewer assets in basins that are most prone to extraneous Infiltration and Inflow (I/I) that contributes the greatest to SSOs. These projects will specifically target high I/I areas and only fix assets which have defects. Nevertheless, strategically and cost-effectively, performing advanced maintenance is the most optimal solution for reducing separate sanitary sewer wastewater collection system SSOs (given the 90% reductions in SSOs the City has achieved) because this focused activity will remove the cause of the problem rather than store and/or directly convey the problem downstream to contribute to additional challenges and incur additional energy and treatment costs.

In conjunction with the above, and in line with the adaptive management approach to the MCD program implementation, the City plans to evaluate and potentially apply an optimized wet weather control strategy for its existing collection system and treatment facilities. More specifically, the control strategy involves implementation of Real-Time Decision Support System (RT-DSS) to provide control and optimization strategies for the City's sanitary sewer system in two phases. In the first phase that is expected to last a few months, the City will identify opportunities, determine feasibility, and evaluate an implementation plan for RT-DSS through the application of hydraulic modeling, use of Artificial Intelligence (AI) and Machine Learning (ML) to develop digital twins, field data acquisition, and hydro informatics engineering. In the second and implementation phase, the City will run ML output through the hydraulic model, test ML recommendations to assess performance of proposed modifications to the sewer system to further reduce wet-weather SSOs, and contribute to attaining LOP. Phase II projects will then be optimized using the ML-based model to leverage return on investment and prioritize MCD Phase 2 projects and delivery methods, as well as develop tactical operation plans for system operators. The City believes that the wet-weather SSO optimization as described here will rebalance and optimize the performance of existing sewer systems to avoid flooding, reduce wet SSO volumes, and balance flows into the treatment plants during wet and dry weather conditions. In addition, this approach will enable the City to predict real-time flows into treatment facilities for wet weather operations and enhance operational decision-making across the enterprise.

ES-3 Specific Phase II Plan Activity

The City has identified a suite of potential I/I reduction, rehabilitation, and replacement capital projects in certain areas of the City that will be needed to contribute to achieving MCD LOP. The City will embark

assessing the collection system via our enhanced O&M program and create recommendations for design and implementation of these projects. Table ES-1 provides details for potential projects within each City sewershed. The linear footages presented below represent the worst case scenario. The City's targeted I/I reduction approach means only assets with defects will be rehabbed or replaced. There are no projects currently identified in the Patapsco and Dundalk sewersheds since they are either low in the overall basin ranking or the issues have been addressed by Phase I projects.

Table ES-1. Initial Phase II Plan Capital Projects

Sewershed	Rehab Length (Linear Feet [LF])	Implementation Cost
Gwynns Falls	36,596	$6,474,000
Herring Run	474,109	$87,644,000
High Level	140,921	$27,539,000
Jones Falls	391,131	$85,443,000
Low Level	162,053	$32,553,000
Outfall	8,633	$1,614,000
Grand Total	1,213,442	$241,265,000

Figure ES-1 identifies the Phase II I/I rehabilitation basins by sewershed. As presented above, the estimated cost of this suite of projects is approximately $241M. This cost assumes all assets within each sewershed will require rehabilitation. With further assessments in the near future, the City anticipates the actual rehabilitation cost will be less, but no more, than that. The City estimates that only approximately 80% of the assets will require rehabilitation at a total cost of $200M. The City will determine the actual need through sewerage asset inspection via the advanced maintenance program, condition assessment, and design.

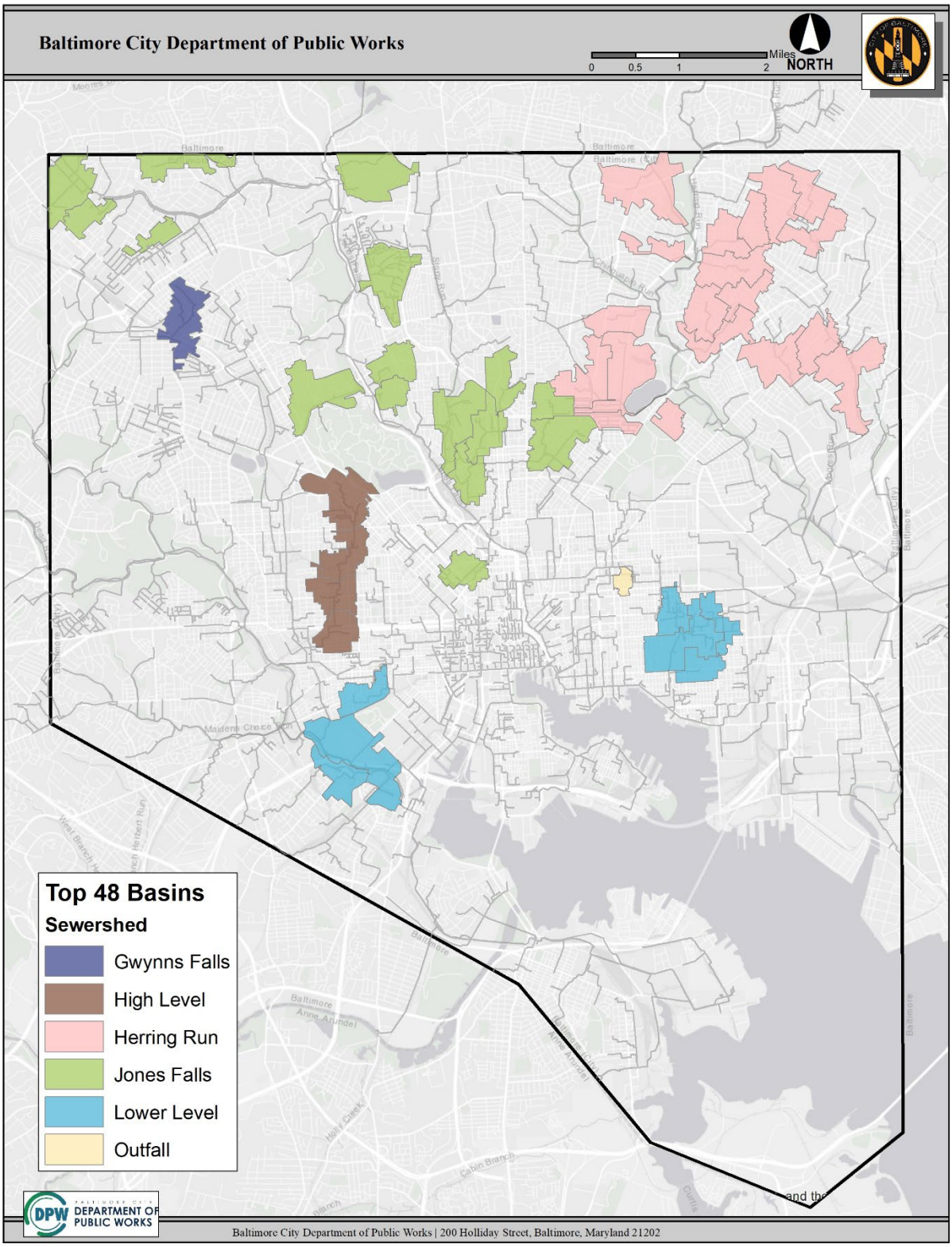


Figure ES-1. Location of Proposed Phase II Plan I/I Reduction Projects

ES-4 Phase II Plan Challenges

There are several issues that challenge the City's ability to determine the actual need for the potential rehabilitation and replacement capital projects.

ES-4.1 Baltimore County Flow Uncertainty

The most prominent challenge for the City is the uncertainty of flow contribution estimates from Baltimore County ("the County"). At the time of this report, their planning efforts are incomplete and the nature and magnitude (timing, peak, volume, and duration) of the flows the City will need to accommodate is uncertain. In a letter dated October 26, 2022, the County responded to an official inquiry by the City and stated they are in the process of hydraulic modeling the rehabilitation and relief sewers and working on a new Long Term Capacity/Peak Flow Management Plan (LTC/PFMP). The amount of rehabilitation or capacity relief needed for the City to comply with MCD requirements greatly depends on flows originating in the County and flowing into the City. The County has not provided definitive information on expected future flows that will flow into the City as they are still progressing with their Baltimore County Consent Decree (BCCD)-required LTC/PFMP.

The BCCD compliance requirements are different than those of the City's MCD. The BCCD requires the County to *ensure adequate long-term transmission capacity in the Collection System*. While the County must determine predicted peak flows for each of its sewersheds under baseline and future (2025) flow conditions for, at a minimum, two-, 10-, and 20-year/24-hour, it is not clear the design storm flow event that will be selected for capital projects and what flows (peak and volume) will arrive at the City for transmission through the City and on to WWTPs. Furthermore, the City will need to reconcile and reach agreement on the County's 2025 projections extrapolated to 2030, which is the City's MCD Baseline condition.

Without flow assumption certainty, the City is unable to perform alternative analysis that may recommend various improvements that are most cost-effective and appropriate to safely manage the County's flows, including individual or combinations of technologies such as storage upstream of the City's boundaries (and the County), further I/I reduction in County sewersheds, and/or additional conveyance capacity from the County line through the City to WWTPs. This information is critical to ensure the City meets its LOP mandates under the MCD.

ES-4.2 Contractor and Procurement Capacity

Water and wastewater infrastructure construction is in high demand at the time of this report. There has been a strong infusion of State and Federal stimulus funding as the nation comes out of the COVID-19 pandemic. As a result, many of the contractor firms that can deliver the type of work required for the MCD are at their capacity limits. This can result in the City receiving unfavorable bids for work and/or not receiving enough bids for the competitive process. Furthermore, the City's internal resources for managing procurement, design, and construction are limited due to staff turnover and retirements, which is a national issue in this industry. While the City is addressing both issues through hiring, incentives, and training, there will be delays in advancing the proposed capital projects.

The City believes that the magnitude of project work described in Section 1.2 is at the bounds of what can reasonably be implemented in the near term. However, the City's proposed advanced and forward-thinking maintenance-related program will produce great results in further reducing SSOs over the City's current 90% success in volume reduction, as well as 96% reduction within the last three years.[1] This model has been proven by other consent decrees nationally.

ES-4.3 City Funding Responsibilities

The Department of Public Works (DPW) Water and Wastewater Enterprise must shoulder several financial burdens in addition to the MCD-related wastewater collection and facility projects. Projects span across water and wastewater infrastructure, water and wastewater treatment, and stormwater infrastructure improvement, other consent decrees/orders, and permit compliance. The entirety of the DPW's capital and operational expenditures must be covered through enterprise customer rates. The DPW must closely manage its financial obligations to minimize future rate increases for customers and maintain its borrowing/bonding capacity to preserve financial flexibility and to retain capacity for unanticipated capital needs. City rate payers have already endured significant rate increases, 9.9% annually over the past 20+ years, to fund the MCD Phase I improvements and other regulatory and facility upgrades and needed improvements. In addition to customer utiltity rate increases, the nation is facing increased federal fund rates, which is increasing interest rates on future debt service, which further erodes purchasing power and the cost to keep up with said capital program will prove to be unsustainable without additional support from State and Federal sources.

ES-5 EPA's Financial Capability Assessment Guidance

The City has invested in developing a support tool to evaluate the equity aspects of capital project planning. This *Quadruple Bottom Line Project Evaluation Framework* tool enables a comprehensive and thorough estimate of equity considerations across the City and the impacts that capital projects may have. The City intends to continue using this tool to further evaluate the equity, economic, social, environmental, and operational aspects of the MCD Phase II Plan, especially in the context of the United States (U.S.) Environmental Protection Agency's (EPA) evolving efforts to update and refine their Financial Capability Assessment Guidance. This tool will support the City's intensive focus on continual improvement, especially in the context of adaptively adjusting specific MCD projects not only to get the greatest return on investment for SSO reduction, but also to assure the City is doing everything it can to advance the City's Equity goals.

ES-6 Phase II Plan Progress Observation and Adaptive Management

In several locations, the MCD pays tribute to the concept of adaptive management in relation to the overall long-term process of achieving the goal of reducing and eliminating SSOs, and moreover, improving receiving water quality in local Baltimore area streams and the Inner Harbor. The intent of the

[1] An intensive analysis of observed SSO events recorded between 2003 and 2022, categorized as wet-weather derived, found that 81% of them were in fact related to blockage issues. Also, 97% of the blockage-related SSOs were on pipes 20" and less.

adaptive management process is the two-step sequence of accomplishing the suite of projects identified in Paragraph 8 / Appendix A (plus newly discovered SSO structures), along with the Phase I projects identified in Paragraph 9 / Appendix B, followed by a performance evaluation period, then a definition and implementation of Phase II projects to accomplish what remains to achieve MCD LOP. The City seeks to achieve performance goals while continually gaining as much knowledge as possible and, where new information or analysis contributes to ways to improve (process, technology, or sequence), adaptively implement.

The City will actively and rigorously monitor progress and observe the beneficial SSO reduction results and other value of the efforts described in Section 1.2 through continuous system monitoring, modeling, and performance evaluation. In approximately two to three years post-initiation, the City will review the remaining efforts needed to achieve MCD's LOP. Thereafter, the City will then engage comprehensively with EPA, Maryland Department of the Environment (MDE), and stakeholders, to discuss and agree on the remaining activities needed in closing out this MCD.

2 Regulatory Context

On September 30, 2002, Baltimore City entered into a CD with EPA, the U.S. Department of Justice (DOJ), and MDE to address SSOs from the City's sanitary sewer collection system, which violate the Clean Water Act (CWA) and Maryland Law. To resolve these issues, the Baltimore City, DPW performed a sanitary sewer evaluation survey (SSES) comprised of a comprehensive study of the collection system including, but not limited to, smoke testing, dye testing, closed circuit television (CCTV) analyses, and a complete risk-consequence assessment of all the basins within the eight (8) sewersheds in the system. The outcome was a sewershed plan to remediate issues identified during the study. In addition, DPW designed or completed 23 major capital projects, closed 60 of 62 identified structured overflows, and separated the combined sewer system. Finally, the DPW discovered a hydraulic restriction in the collection system and designed the Headworks Project to upgrade the City's Back River WWTP to address the restriction. Recognizing that additional time and resources were required to complete this work and comply with the CD, the United States, State of Maryland, and the City negotiated a modification to extend the CD beyond its January 1, 2016, deadline. On October 10, 2017, the U.S. District Court filed an MCD, with all projects scheduled for completion by December 31, 2030.

Paragraph 9(b)i of the MCD requires the City to submit a Phase II Sewershed Plan (Phase II Plan) for approval by EPA and MDE by December 31, 2022. The specific language of the requirement is excerpted below:

By December 31, 2022, Baltimore shall submit a Phase II Plan for approval by EPA and MDE in accordance with Paragraph 20. Baltimore shall propose a Phase II schedule to complete rehabilitation projects and/or corrective actions as expeditiously as possible, but at a maximum the schedule for the Phase II Plan shall not extend beyond December 31, 2030. The Phase II Plan shall include specific rehabilitation projects and/or corrective actions to address the deficiencies identified by Baltimore during its evaluation of its sewersheds conducted pursuant to Paragraph 9 of the 2002 CD and confirmed or revised following the Phase I PCFM which have not yet been addressed. In addition, the Phase II Plan shall identify any rehabilitation projects and corrective actions necessary to achieve, at a minimum, a five-year LOP with additional measures necessary to achieve, at a minimum, a 10-year LOP for overflows located in sensitive areas. The LOP shall be based on continuous simulation hydraulic modeling, based on historical precipitation data from a 20-year period at a minimum, to determine peak flow recurrence. The MCD requires that the "baseline" condition shall be the future conditions based on reasonable population and sewer condition deterioration projects for the year 2030.

Paragraph 7(p) of the MCD, excerpted below, defines the LOP:

"Level of Protection" or "LOP" shall mean all the rehabilitation projects and corrective actions necessary to limit the occurrence of sanitary sewer overflows to one event for each of the specified return periods of time (e.g., one overflow event in five years). LOP shall be based on peak flow recurrence.

The City interprets the literal statement *one overflow event in five years* to mean *on average, one overflow event in five years*. This is in line with the well-established hydrologic frequency definition that an X-year event is an event that will occur on average, over a period much longer than X years, one time every X years, or the superior definition that an X-year event is an event that has a probability of

occurring 1/X in any given year (e.g., a five-year event occurs with a probability of 20% in any given year).

The City appropriately and thoroughly described the importance of considering peak flow recurrence in sanitary sewer systems rather than storm event recurrence. Peak flows in sewer systems are related to the myriad ways in which rainfall and groundwater can ingress into a sewer system and not directly based on the characteristics of the rainfall, as is the case for stormwater and combined sewer systems. Peak flow recurrence is determined through continuous simulation of a well-calibrated hydraulic model for a period long enough to be statistically valid, then calculating an annual or partial series frequency analysis. The City's peak flow determination process was summarized in the June 30, 2011 report, entitled "Continuous Simulation Methodology." The City used the 63-year (at the time) long-term precipitation record from Baltimore/Washington International (BWI) Airport Weather Service Office (WSO) station rainfall gauge. The result enabled the City to determine the peak flow recurrence interval at modeled network locations and what peak flows were most cost-effective to target for SSO mitigation. The effort concluded that a five-year peak flow recurrence for non-sensitive areas and a 10-year peak flow recurrence for sensitive areas were most cost-effective and appropriate for SSO control. In other words, the City proposes to implement projects designed to eliminate SSOs associated with those peak flows.

The City then determined the rainfall data from 1999-2010 was a "typical" rainfall period long-enough to represent the five- and 10-year peak flow recurrence values in that a five-year peak flow could occur four times in response to the 20-year period, and the 10-year peak flow could occur twice, hence the derivation of the "five- and 10-year LOP."

The criteria to achieve LOP is no more than two SSO occurrences at any distinct location in response to the continuous simulation 20-year rainfall period previously approved by EPA and MDE (period 1991-2010) for sensitive areas, and no more than four SSO occurrences at any distinct location elsewhere within City limits. The basis of the terminology is the simple correlation of the 20-year period divided by two, and four, respectively to arrive at the "ten-year" and "five-year" terminology (20 years divided by 10, and five years, respectively). The terminology should not be conflated with the colloquial terms used in statistical hydrologic frequency analysis. For example, the term "10-year" storm is one that would occur *on average* once every ten years over a statistically valid long duration, e.g., 100 years. However, that same storm is more accurately and precisely defined as a storm with a *10% probability of occurring in any given year*, and likely will occur (much) more or less than once during any particular 10-year period.

3 Background and Purpose

Since lodging the MCD, the City has been actively engaged in complying with the terms of the MCD, including implementing projects and corrective actions to eliminate SSO structures listed in Appendix A of the MCD as well as those discovered after the lodging of the MCD, and accomplishing Phase I projects listed in Appendix B of the MCD. Based on a comparison analysis of pre- and Post-Construction Flow Monitoring (PCFM), trends of SSO and building backup frequency and volume, and comprehensive Hydrologic and Hydraulic (H&H) modeling, the City has determined the suite of activities that are the most appropriate to initiate and implement. The City's implementation of the forward-thinking and advanced maintenance-related program as well as the potential Phase II rehabilitation projects will further reduce I/I and SSOs in the most optimal way.

4 Expected Effectiveness of Proposed Projects to Eliminate SSO Structures [9.c.(i)]

4.1 Background and History of Baltimore City SSO Structures

Historically, many utilities, including the City, managed high sewage flows by constructing overflow structures that provided relief to interceptor sewers by discharging excessive flows to adjacent receiving waters through overflow pipes. Prior to the Clean Water Act of 1972, the approach for designing sewer systems was to place these overflow structures at various locations within the system for these relief discharges to occur. In many places in the late 1800s and early 1900s, sewers were designed and constructed as combined sewers to carry both stormwater and residential, commercial, and industrial wastewater. Combined sewer relief through structures, known as Combined Sewer Overflows (CSOs), discharged frequently at high volumes during wet weather/snowmelt events.

The City, with foresight, recognized that a separate sewerage system for both sanitary wastes and stormwater was ideal and more environmentally appropriate. However, in deference to the engineering standards of the time, the City decided to build in relief structures to their separate sanitary system as a "fail-safe" mechanism should their wastewater collection system become overwhelmed for any reason. Overflow activations at these strategic locations would be preferable to the consequence of sewage backing up into buildings and City streets. To this day, certain City SSO structures still activate on occasion, usually during wet weather (rainfall or snowmelt). The excess water from these wet-weather events may enter the collection system from public or private assets and cause overflows into rivers and streams before reaching the City's wastewater treatment plants.

4.2 Regulatory Basis for Baltimore City SSO Structures

The CWA designates any unauthorized spill, release, or discharge of wastewater from any portion of the collection system as an SSO, unless discharged from an approved outfall in accordance with a National Pollutant Discharge Elimination System (NPDES) permit.

The 2002 CD identified SSO structures and required that they be eliminated. All but two of the original lists of SSO structures in the 2002 CD were eliminated at the time of lodging of the 2017 MCD. The timeline for eliminating the remaining two (SSO Structures #67 & #72) was extended because several construction projects necessary to address SSO activation root causes were pending completion. In addition to SSO Structures #67 & #72, several SSO structures had been newly discovered since 2002 and were incorporated into the MCD to be eliminated through a plan and schedule according to sub-paragraph 8.b. Furthermore, four SSO structures have been identified since the lodging of the MCD. All newly discovered SSO structures must be reported to EPA and MDE with a plan and schedule for elimination.

4.3 Expected Effectiveness

As of December 1, 2022, 10 SSO structures remain. They are listed in Table 1 along with compliance dates and completion estimates.

Table 1. SSO Structure Status as of December 1, 2022

Appendix A

Other/Additional per Paragraph 8.b.(iii)

Eliminated

Active #	SSO Structure #	Manhole ID	Location	Sewershed	MCD Date of Substantial Completion of Construction	MCD Date of Elimination (after PCFM)	Latest Estimate for Date of Substantial Completion of Construction	Latest Estimate for Date of Elimination (after PCFM)	Potential Issues Or Notes
1	**67**	S31MM_013MH	1911 Falls Road, approx.1,100' northwest of US 1 bridge intersection	Jones Falls	Jan 1, 2021	Jul 1, 2022	Headworks substantially complete Jan 1, 2021. PCFM and auxiliary work ongoing.	Jul 1, 2023	Dependent on SC918 Back River Headworks Project (Complete). Projects that also may contribute to elimination include SC941 (Active, Delayed), SC934 (Complete) and SC894 (Complete). Downstream Interceptor Sediment cleaning that is needed to eliminate the structure is ongoing through Project SC 966.
2	**72**	S37GG_007MH	Rear of 428 East Preston St.	Jones Falls	Jan 1, 2021	Jul 1, 2022	Headworks substantially complete Jan 1, 2021. PCFM and auxiliary work ongoing.	Jul 1, 2023	Dependent on SC918 Back River (Complete). Projects that also may contribute to elimination include SC941 (Active, Delayed), SC934 (Complete) and SC894 (Complete). Downstream Interceptor

Active #	SSO Structure #	Manhole ID	Location	Sewershed	MCD Date of Substantial Completion of Construction	MCD Date of Elimination (after PCFM)	Latest Estimate for Date of Substantial Completion of Construction	Latest Estimate for Date of Elimination (after PCFM)	Potential Issues Or Notes
									Sediment cleaning that is needed to eliminate the structure is ongoing through Project SC 966.
No	**132**	S09UU_010MH	North Hilton & Springdale Avenue	High Level	Jan 1, 2016	Jul 1, 2017	N/A	N/A	Eliminated June 27, 2016, under SC879. Documented in CD QR #60.
No	**134**	S11UU_016MH	3200 Liberty Heights Avenue	High Level	Jan 1, 2016	Jul 1, 2017	N/A	N/A	Eliminated June 27, 2016, under SC879. Documented in CD QR #60.
3	**135**	S11UU_008MH	3104 Liberty Heights Ave.	High Level	Jan 1, 2021	Jul 1, 2022	Jul 26, 2022	Jan 26, 2024	PCFM ongoing
No	**137**	S57UU_007MH	Shannon Drive & Brehms Lane	Herring Run	Jan 1, 2019	Jul 1, 2020	N/A	N/A	Eliminated August 13, 2019, per SC 911 Completion of Construction. Documented in MCD QR #8
4	**138**	S07EE 1023MH	W. Cold Spring La. & Ayrdale Ave.	High Level	Jan 1, 2021	Jul 1, 2022	Jul 26, 2022	Jan 26, 2024	PCFM ongoing
5	**139**	S11QQ 1002MH	W. Garrison Ave. & Queensberry Ave.	High Level	Jan 1, 2021	Jul 1, 2022	Jul 26, 2022	Jan 26, 2024	PCFM ongoing
No	**150**	S35CC1008MH	N. Calvert Street & Chancery Road	Jones Falls	Jan 1, 2017	Jul 1, 2018	N/A	N/A	Eliminated on November 30,

Active #	SSO Structure #	Manhole ID	Location	Sewershed	MCD Date of Substantial Completion of Construction	MCD Date of Elimination (after PCFM)	Latest Estimate for Date of Substantial Completion of Construction	Latest Estimate for Date of Elimination (after PCFM)	Potential Issues Or Notes
									2017. Documented in MCD QR #1
No	151	S47G2_016MH	4210 Curtis Avenue	Patapsco	Jan 1, 2017	Jul 1, 2018	N/A	N/A	Eliminated on December 04, 2017. Documented in MCD QR #1
6	152	S33II_004MH	N. Charles St. & W. Lanvale St.	Jones Falls	Jan 1, 2021[1]	Jul 1, 2022[1]	Jan 1, 2021	July 1, 2023	Notes above for SSO Structures 67 & 72 apply
No	153	S01GG1011MH	Fernhill Avenue & Hillsdale Road	Gwynns Falls	Jan 1, 2018	Jul 1, 2019	N/A	N/A	Eliminated on March 16, 2018. Documented in MCD QR #2
7	154	S33KK_033MH	N. Charles St. & W. Lafayette Ave.	Jones Falls	Jan 1, 2021[1]	Jul 1, 2022[1]	Jan 1, 2021	July 1, 2023	Notes above for SSO Structures 67 & 72 apply
8	155[2]	S03WW1008MH	3404 Glen Avenue	Jones Falls	Jan 1, 2023	Jul 1, 2024	Oct 13, 2022	Apr 13, 2024	Dependent on SC946R. Design of SC946 is in progress. ROEs are outstanding. Advertisement estimate is unknown. Letter transmitted to Regulators requesting extension. Update letter to request extension will be sent as soon as timeline is updated.

Active #	SSO Structure #	Manhole ID	Location	Sewershed	MCD Date of Substantial Completion of Construction	MCD Date of Elimination (after PCFM)	Latest Estimate for Date of Substantial Completion of Construction	Latest Estimate for Date of Elimination (after PCFM)	Potential Issues Or Notes
9	156[2]	S08G__001MH	Charing Cross Road & Greenwich Avenue	Gwynns Falls	Jan 1, 2024	Jul 1, 2025	Jan 1, 2024	Jul 1, 2025	Alternate plan developed to further reduce I/I in Baltimore County drainage area rather than implement downstream upsizing. Regulators approved alternate plan and 1-year extension in letter of 5/5/2022.
10	157[2]	S35YY_036MH	East 32nd Street & St. Paul/Hargrove Alley	Jones Falls	Jan 1, 2023	Jul 1, 2024	Jan 1, 2023	Jul 1, 2024	Rehabilitation of selected assets in Basins JF18 & JF20 to enable closure of the SSO Structure is complete. PCFM is ongoing.
No	158[2]	S37GG_040MH	428 E. Preston St.	Jones Falls	Jan 1, 2024	Jan 1, 2024[3]	Jul 5, 2022	Jul 5, 2022[3]	Construction project to reroute flow and eliminate this structure is complete.

Notes

[1] *Revised per MDE Letter sent by Electronic Mail on Aug 24, 2020*

[2] *Four SSO structures (#155, #156, #157, and #158, identified on Sep 13, 2016, Jun 6, 2017, Sep 19, 2017, and Nov 9, 2017, respectively) were not included in Appendix A of the MCD. Flow meters are installed at SSO Structures #155, #156, and #157, and these locations are monitored for overflow activity. The City's proposed corrective plans for SSO Structures #155, #156, and #157 were approved by EPA and MDE on Jul 25, 2018. The City's submitted corrective plans for SSO Structure #158 was approved by MDE on Nov 15, 2018.*

[3] *The City has eliminated SSO Structure #158. The tributary area previously draining to SSO 158 was re-routed from Manhole S37GG_024 to the Lower Jones Falls Interceptor downstream of SSO72 at Manhole S37GG_041. Therefore, there is no reason to perform post-construction flow monitoring since SSO Structure #158 has been eliminated, sealed, and abandoned. Date of elimination is accordingly the same as date of substantial completion.*

5 Rationale for Advanced Maintenance Program Due to Effectiveness of Phase I Projects [9.c.(ii)]

5.1 Post-Construction Flow Monitoring (PCFM)

The MCD requires the City to conduct PCFM at SSO structures listed in Appendix A, upon completion of projects required for their elimination, and later added SSO structures upon the substantial completion of projects required for their elimination, as well as upon substantial completion of Appendix B Phase I projects. Appendix B Phase I projects included those targeting high I/I as well as those with assets needing structural rehabilitation. The language describing these requirements is excerpted below:

5.1.1 Paragraph 8 Requirements

[8.c.(i)] Immediately following completion of any SSO structure elimination project, Baltimore shall monitor flow and rainfall for a period of 18 months to determine the effectiveness of the project. Such flow monitoring shall be performed in accordance with the requirements of sub-paragraph 9.d of this CD.

[8.c.(iii)] The results of any flow and rainfall monitoring conducted by Baltimore pursuant to this Paragraph prior to July 1, 2022, shall be submitted to EPA and MDE as part of the Phase II Plan required by sub-paragraph 9.b.

5.1.2 Paragraph 9 Requirements

[9.a] Upon completion of the Phase I Plan projects and prior to submittal of a Phase II Plan, Baltimore shall conduct PCFM to determine the effectiveness of the Phase I Plan projects.

[9.d] Baltimore shall conduct rainfall and flow monitoring to analyze the effectiveness of the projects required by Paragraph 9 of this CD and identify any additional rehabilitation, or other corrective action proposed by Baltimore in the Phase II Plan to reduce peak wet weather flows and/or increase capacity such that SSOs do not occur.

[9.d.(ii).(a)] Baltimore shall use flow data collected from its system of permanent and temporary flow monitors placed throughout the collection system to address the deficiencies identified by Baltimore during its evaluation of its sewersheds conducted pursuant to Paragraph 9 of the 2002 CD and to confirm the effectiveness of Phase I projects following the Phase I PCFM. Phase I PCFM shall start following the completion of Phase I projects and shall be completed no later than December 31, 2022.

5.1.3 PCFM Analysis

Throughout 2021, the City performed analyses of the data obtained at from each PCFM high I/I and structural meter within the Dundalk (DU), Gwynns Falls (GF), High Level (HL), Herring Run (HR), Jones Falls (JF), Low Level (LL), Outfall (OUT), and Patapsco (PA) sewersheds. In August 2021, the City prepared a final PCFM Analysis Memo summarizing the results of the analyses performed. The memo included information for rehabilitation basin performance, structural basin performance, dry weather flow results, and Rainfall-Derived Infiltration and Inflow (RDII) results. The memo also described the Quality Assurance/Quality

Control (QA/QC) that was performed prior to the data being analyzed; the regression analysis methods performed to determine Capture Coefficients for each meter, along with a performance summary; conclusions; and next steps. The following section is a summary of the PCFM Analysis Memo.

The analyses performed made use of a tool named SLiiCER, developed and maintained by third-party vendor Advanced Drainage Systems (ADS), Inc. to quantify the I/I in the sanitary sewer collection system based on rainfall and flow data. SLiiCER is designed to help find the locations with I/I concerns in a sanitary sewer collection system using rainfall and flow data. By itself in its raw form, flow data can be difficult to interpret. The purpose of SLiiCER is to make interpreting flow data easier, so that conclusions about how to enhance the performance of the collection system can be developed. SLiiCER also supports generating the flow components necessary to calibrate the hydraulic model.

For the PCFM meters, the City used two distinct data sets – one for a pre-construction period and the other for a post-construction period. Meter locations in all but a few cases were the same for the pre- and post-construction periods. Exceptions were because the original location no longer existed or was no longer appropriate, so a suitable alternate location was used. The periods for the pre- and post-construction monitoring were:

- Pre-construction period: May 2006 – April 2007
- Post-construction period: December 2020 – November 2021

Gauge Adjusted Radar Rainfall (GARR) and 20 rain gauges (nine from the City and 11 from the County) were used for the SLiiCER analysis. The rainfall data was provided in five-minute increments.

For this analysis, data from the following flow meters was analyzed:

- 10 high I/I meters that represent areas where rehabilitation construction was conducted: HL02, HR07A, LL17, LL18, LL30, LL34, OUT01, PA05, PA05A, and PA11
- 24 structural meters that represent areas where structural rehabilitation was conducted: DU01, DU05, HL02B, HL12, HL15, HR06, HR09A, HR09B, HR42, HR45, JF03, JF06, JF11, JF13, JF17, JF22-1, JF32, JFWR12, JFWR17, JFWR22, OUT05, PA01, PA03-A, and TSPA03
- Eight control meters that represent areas where no construction activity occurred: HL04, HR19, HR07B, LL21, LL35, LL36, DU04, and PA04

Prior to conducting the SLiiCER flow analyses, the City performed a QA/QC of the 2020 – 2021 monthly data (flow, velocity, depth, and rainfall). The goal of the PCFM meter monthly data check was to identify suitable data for the pre- and post-construction comparison of I/I and for model calibration.

Flow was analyzed in two groupings – dry weather and wet weather – so that rainfall effects could be separated from dry weather flows. Weekday and weekend flows were further broken out for analysis. Additionally, summer and winter flows were further considered during the analysis.

A total of 29 pre-rehabilitation and 41 post-rehabilitation storms during the metering periods met the criteria for a storm event as defined by the SLiiCER global settings. Each storm was analyzed for each flow meter using the SLiiCER software. The dry weather flow components (sanitary and base infiltration) and percent capture (the percentage of rainfall coming into the wastewater collection system) was

calculated for each storm event. Regression equations were used to calculate an overall percent capture for both pre- and post-conditions at each meter.

The change in percent capture from pre- to post-conditions was evaluated in two ways. First, a method referred to as the Control Basin Method was used. A control basin is a basin near a basin that underwent rehabilitation and has similar characteristics. No rehabilitation was performed in control basins. The Control Basin Method reviewed percent capture for a rehabilitated basin on one axis of a graph and the percent capture for the control basin for the same period on the other axis. The change in the slope of this line from pre- vs. post-conditions should reflect the impact rehabilitation had on percent capture. This method, however, produced results that were inconsistent or difficult to interpret in some cases and was therefore not used. For this reason, the change in the percent capture of the control basins and rehabilitated basins were evaluated separately. Using an area weighted average from pre- to post-conditions, there was a 51% reduction in the high I/I rehabilitation basins, a 9% increase in the control basins, and a 33% decrease in percent capture for basins that had structural rehabilitation performed.

5.1.4 PCFM Conclusions

In summary, the City used SLiiCER to perform Dry Weather Flow (DWF) and RDII analyses, and to determine capture coefficients using rainfall and flow data. Analyses were performed based on pre- and post-condition periods (2006/2007 and 2020/2021) using rain gauge and GARR data. Analyses included adjustments on dry day traces for dry day analysis and storm periods/pre-compensation for RDII analysis. Wet weather analysis excluded storms with no data/unreliable data/no matching storms between pre- vs. post-condition periods. Wet Weather Flow (WWF) results were evaluated on the I/I volumes against total rainfall to calculate percent capture. As stated above, rehabilitation performance weighted averages were as follows:

- 51% reduction in the high I/I rehabilitation basins
- 9% increase in the control basins
- 33% decrease in the structurally rehabilitated basins

The I/I reduction results achieved by the City exceeded initial expectations. The City originally assumed that a 40% reduction in I/I would be achieved and 0% reduction in I/I in structural basins. Exceeding these expectations shows the efficacy of the City's Phase I projects in reducing I/I and corresponding reductions in SSO frequency and volume.

5.2 SSO Frequency and Volume

5.2.1 Blockage-Related SSOs

There is no industry standard definition of a "wet weather" SSO. The primary reason is because rainfall patterns vary greatly in different parts of the country. They can also vary more gradually across locales within a similar climactic region. Furthermore, a separate sanitary sewer system, and SSOs that occur within it, are not always directly linked to rainfall. Every sanitary sewer system is unique relative to its exhibited response to rainfall, depending on how much comes from direct inflow (e.g., roof leaders, yard drains, sump pumps, etc.) versus how much comes from indirect sources (e.g., slight offesets in pipe joints, cracks and leaks in pipes and manholes, etc.). Traditionally, the City has very conservatively

designated an SSO as "wet" if the sum of rainfall in the prior 72 hours at the closest rain gauge is equal to or greater than 0.1 inches. All SSOs not meeting this criterion were designated as "dry." The City recently analyzed the field notes of all recorded SSOs from 2003 to 2022 and found that, regardless of whether they were recorded as "wet" or "dry", they were most likely caused by a blockage. The City now defines blockage related SSOs as SSOs that occur either during dry or wet weather conditions but are demonstrably due to pipe blockages or pipe/mechanical failures and are not related to wet weather surcharging. Figure 1 presents, for the years 2018 through 2022, the number of SSOs that were originally designated as "dry", as well as the number that were found to be blockage-related, irrespective of how they were classified. For example, for 2018, 199 SSOs were designated as "dry" based on rainfall and 384 were found to be blockage-induced, regardless of "dry" or "wet" designation. There is a downward trend in the blockage-related SSOs from 2018 that is interrupted in 2020 and 2021, likely due to City maintenance staff work slowdowns related to the Coronavirus Disease of 2019 (COVID-19) pandemic.

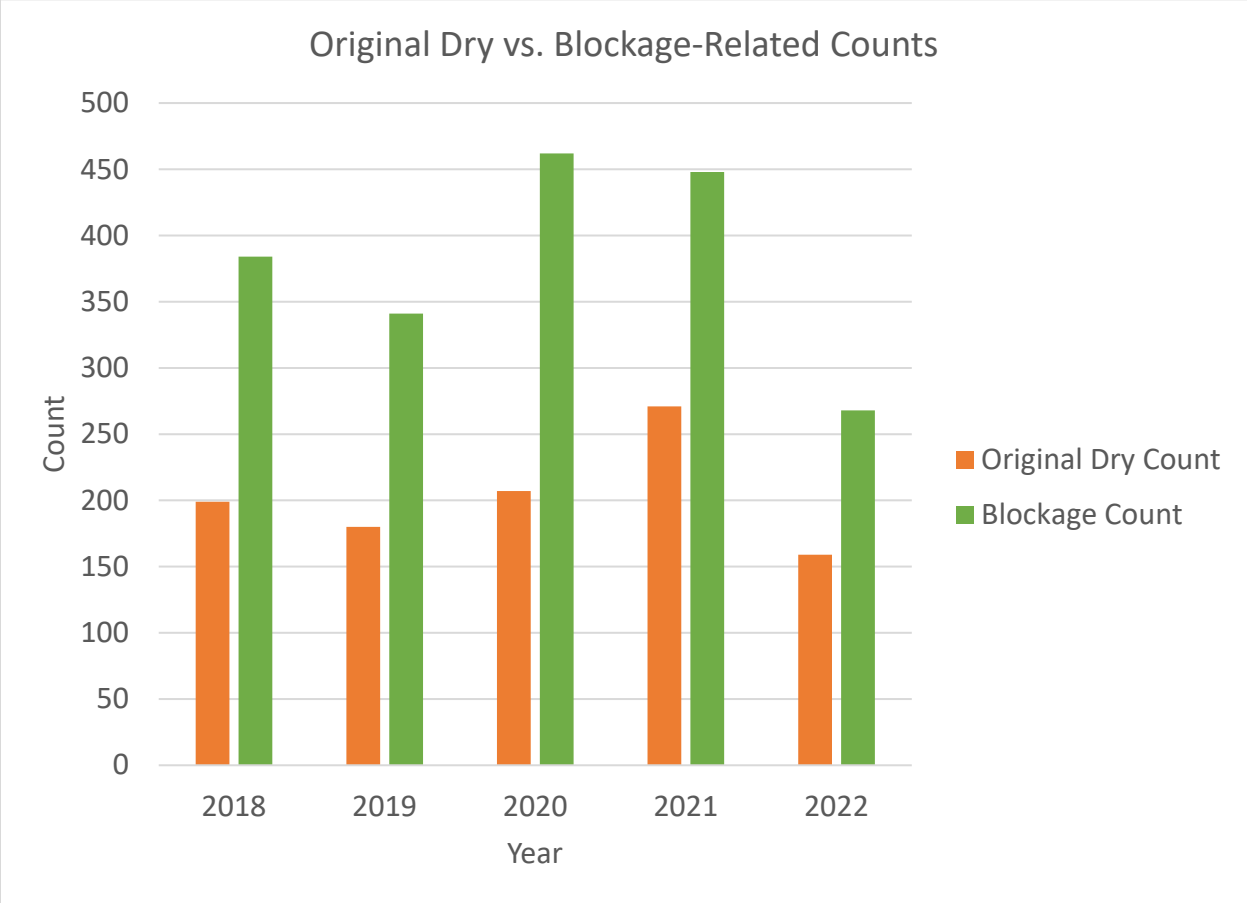


Figure 1. Blockage-Related and Original Dry SSOs by Count

The sum of the volume of the overflows by year are shown for blockage related SSOs and the original dry weather SSOs in Figure 2. An individual overflow in 2018 appeared to be anomalous and should be excluded as it is not related to wet or blockage-related issues because it was described in field notes as "occurring because of a failure of a contractor to control their work resulting in two lengths of pipe

coming loose and causing a discharge." This data point was removed in Figure 3, which is labeled "Amended."

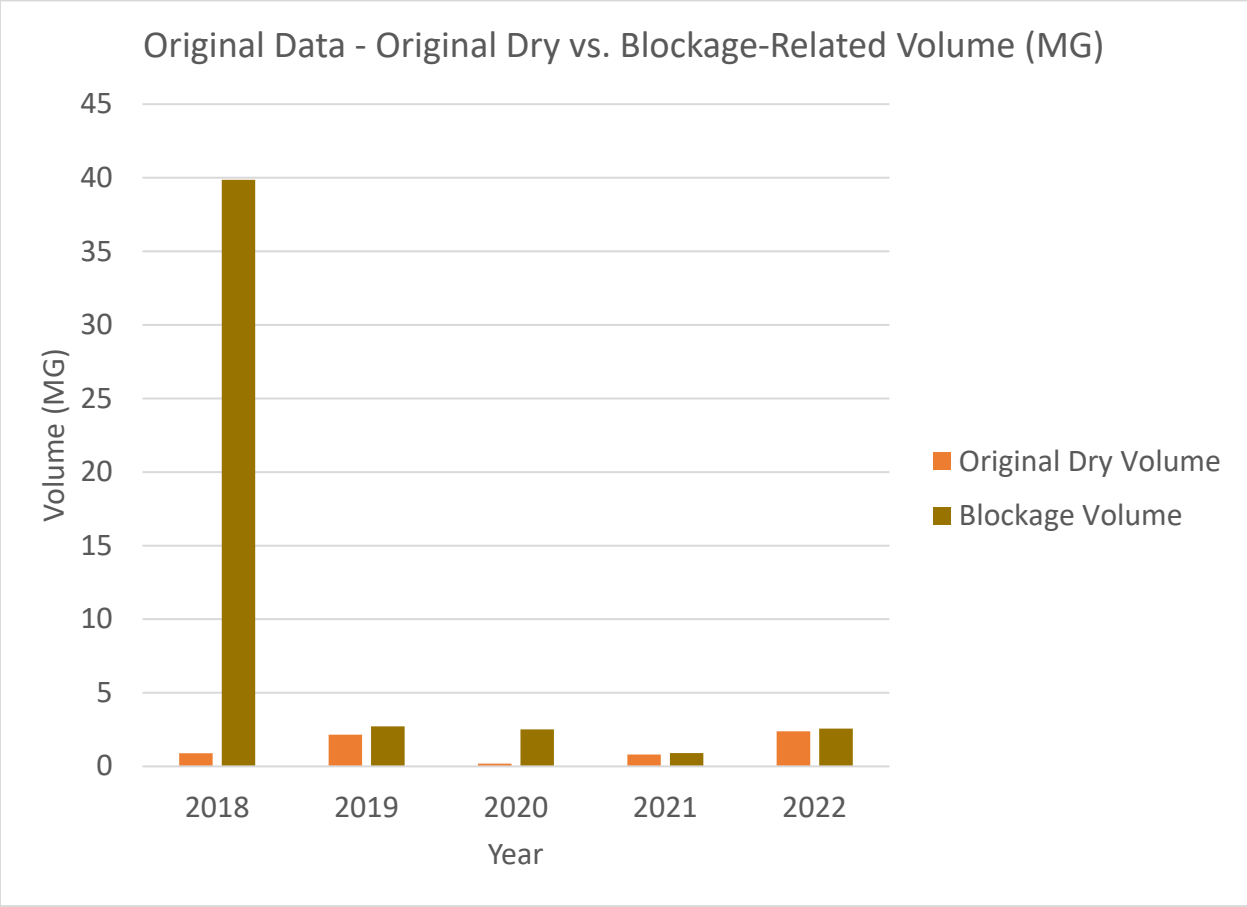


Figure 2. Blockage-Related and Original Dry SSOs by Volume – Original Data

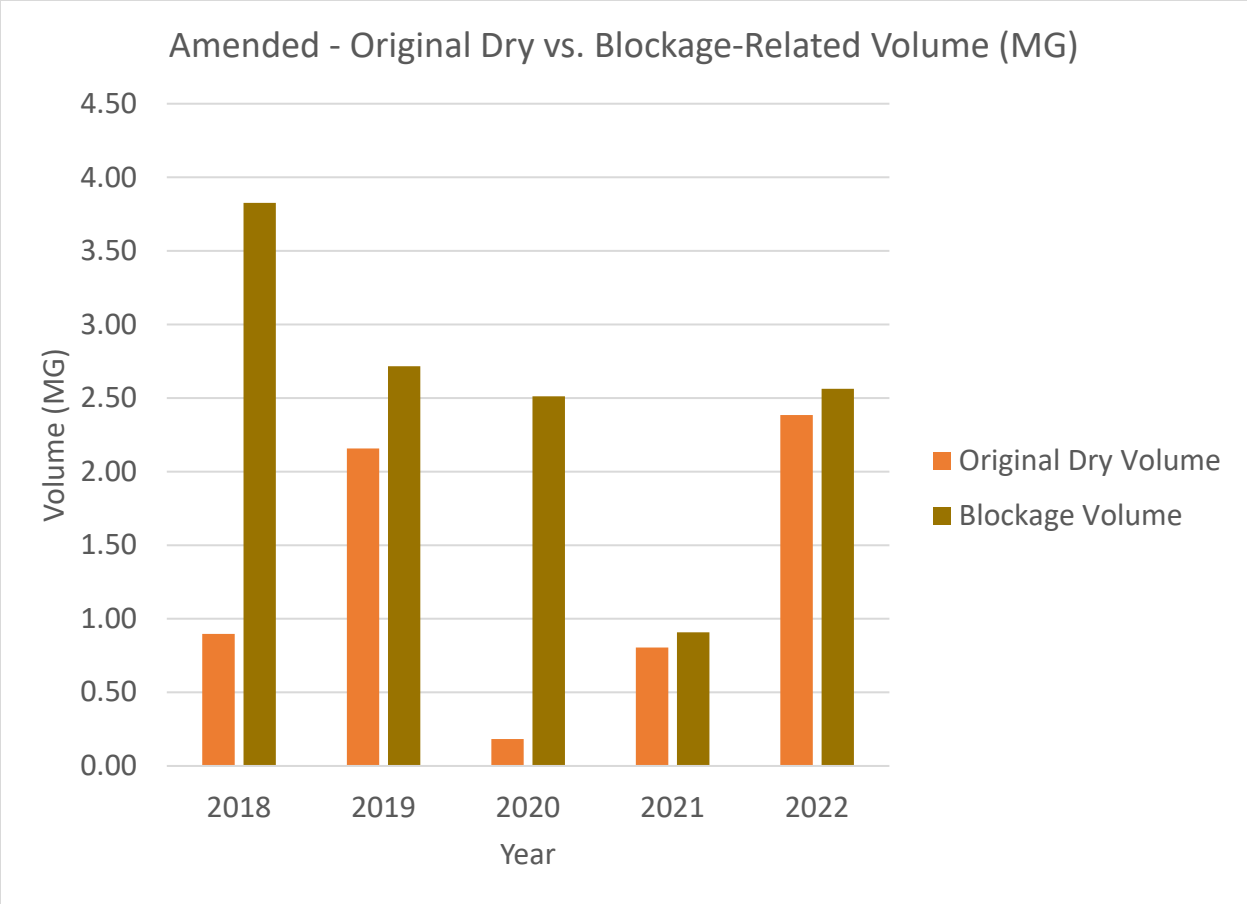


Figure 3. Blockage-Related and Original Dry SSOs by Volume – Amended

5.2.2 Wet Weather SSOs

The City designates SSOs as "wet" within their Computerized Maintenance Management System (CMMS) if the sum of rainfall in the prior 72 hours at the closest rain gauge is equal to or greater than 0.1 inches. Records support that rainfall of this magnitude does not correlate with surcharge-inducing wet weather response in the sanitary sewer system. This is a very conservative classification and likely records many SSOs as "wet", when in fact the root cause is more related to symptoms of blockage related SSOs. In a large wet weather event where pipes are surcharged and manholes are overflowing, pipe-cleaning equipment typically used to relieve blockages will have no effect on relieving the overflow. In summary, many wet weather SSOs are more accurately classified as blockage related. An intensive analysis of observed SSO events, categorized as wet weather, found that 81% of them were in fact related to blockage.

There are multiple examples in the SSO database where SSOs are designated "wet" when one or more of the following criteria apply:

- A mainline or lateral choke or blockage that was relieved using pipe cleaning equipment was indicated
- A mainline or lateral failure requiring repair was indicated

- A mechanical or operator issue was indicated
- The weather was recorded as “clear”
- Only one or two gallons of overflow volume were recorded
- The SSO was recorded against a lateral
- A “consumer issue” was indicated

Both classifications of wet weather SSO counts, original and true (without the blockage related SSOs), are shown in Figure 4 from 2018 to October 2022.

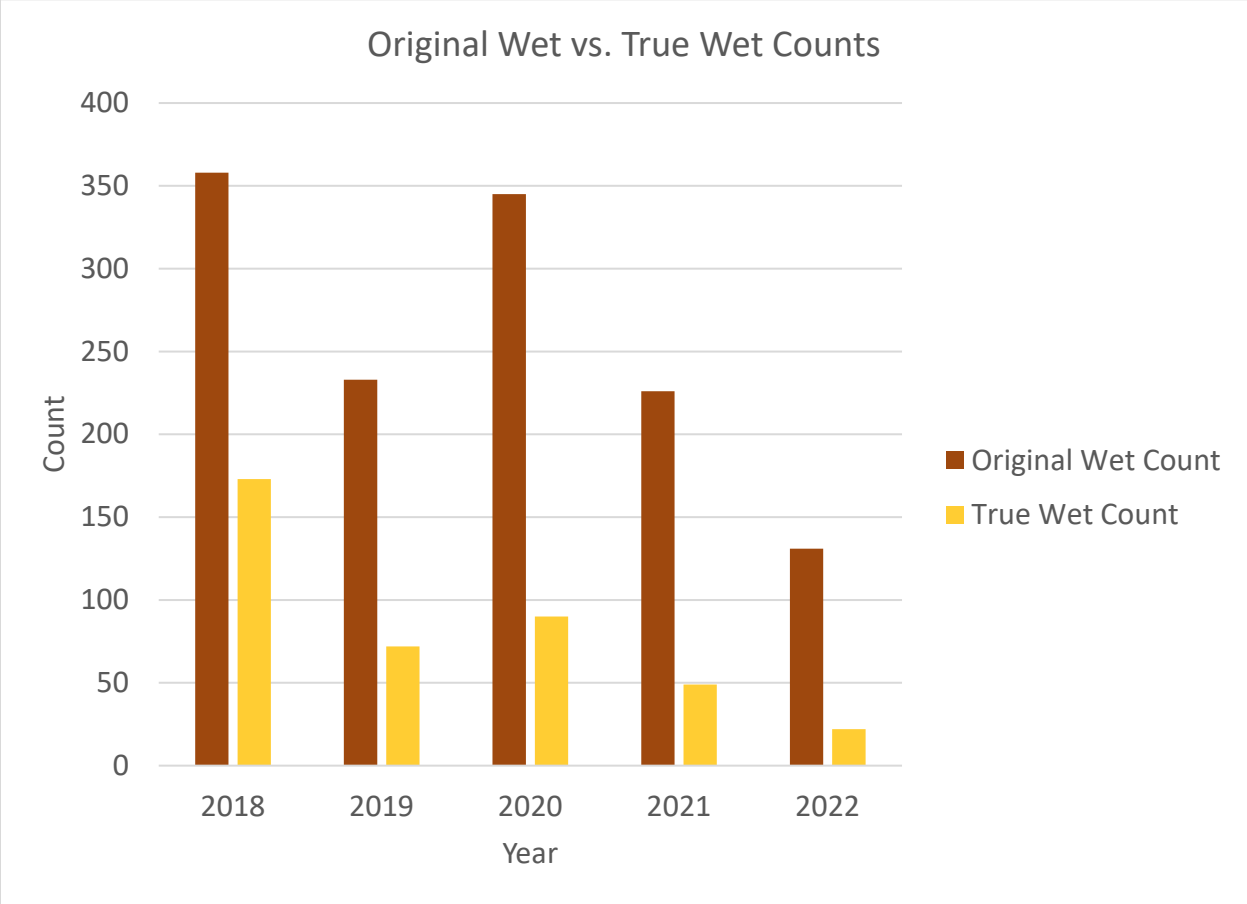


Figure 4. True Wet SSOs and Original Wet SSOs by Count

The sum of the volume of the overflows by year are shown for true wet SSOs and the original wet-weather SSOs in Figure 5. As mentioned above, an individual overflow in 2018 appeared to be anomalous and should be excluded as it is not related to wet or blockage-related issues. As a result, this data point was removed in Figure 6, which is labeled “Amended.” The fact that there is little difference in total volume in Figure 5 between original and true wet weather SSOs indicates that most of the volume comes from relatively few SSOs.

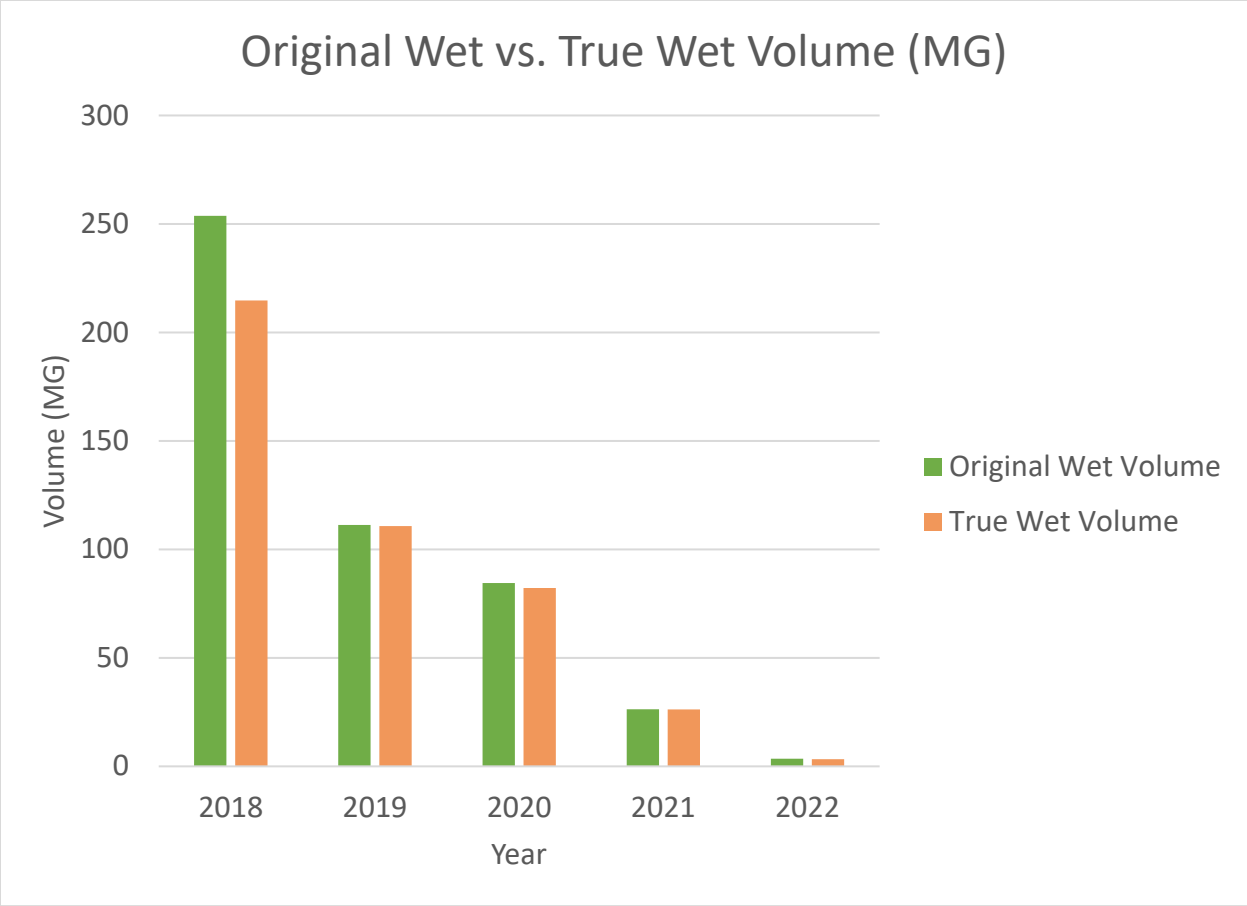


Figure 5. True Wet SSOs and Original Wet SSOs by Volume – Original Data

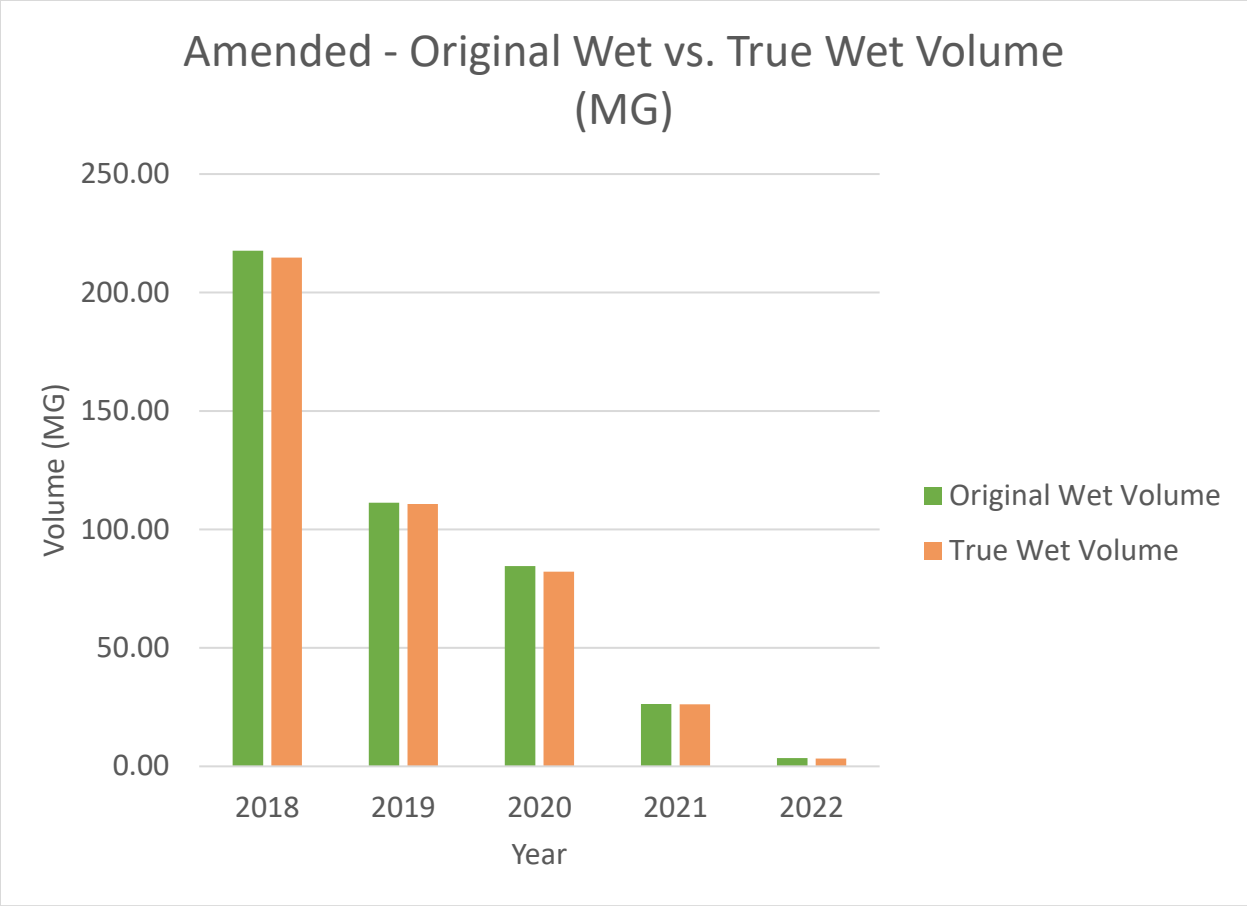


Figure 6. True Wet SSOs and Original Wet SSOs by Volume – Amended

5.2.3 Wet Weather SSOs – Recent Trends

Despite the City's very conservative criteria that designates wet weather SSOs, there is a clear trend that SSOs have reduced dramatically in the last several years. A suitable distinction to evaluate trends is December 30, 2020, the date the Back River WWTP Headworks pumping facility became operational. The functioning Headworks pumping facility removed the hydraulic restriction described in the MCD (MCD at p. 3, WHEREAS) as *a significant hydraulic restriction that impacts flow to the Back River Wastewater Treatment Plant, extending six miles upstream and contributing to recurring manhole overflows, and which should be addressed before implementation of certain other rehabilitation projects required by the 2002 Consent Decree*. The completed project enabled "free-flow", i.e., flow that is not capacity constrained, into the plant.

The Headworks pumping facility enables all arriving flow to be safely and effectively managed. If flows are below the plant's output treatment capacity, the flow proceeds through the treatment process. If flows exceed that capacity, it is stored in one or two 18 MG-volume storage tanks, then to be drained into the treatment process once the plant treatment capacity is deemed adequate, usually within no more than two days after the wet-weather event that caused the elevated flows. The storage tanks became fully operational in June 2021 and since that time, up through November 2022, they have

activated and stored volume 30 times for a total storage volume of 245 MG. The maximum storage volume of the 30 events was 23.9 MG, well below the storage tank maximum capacity of 36 MG.

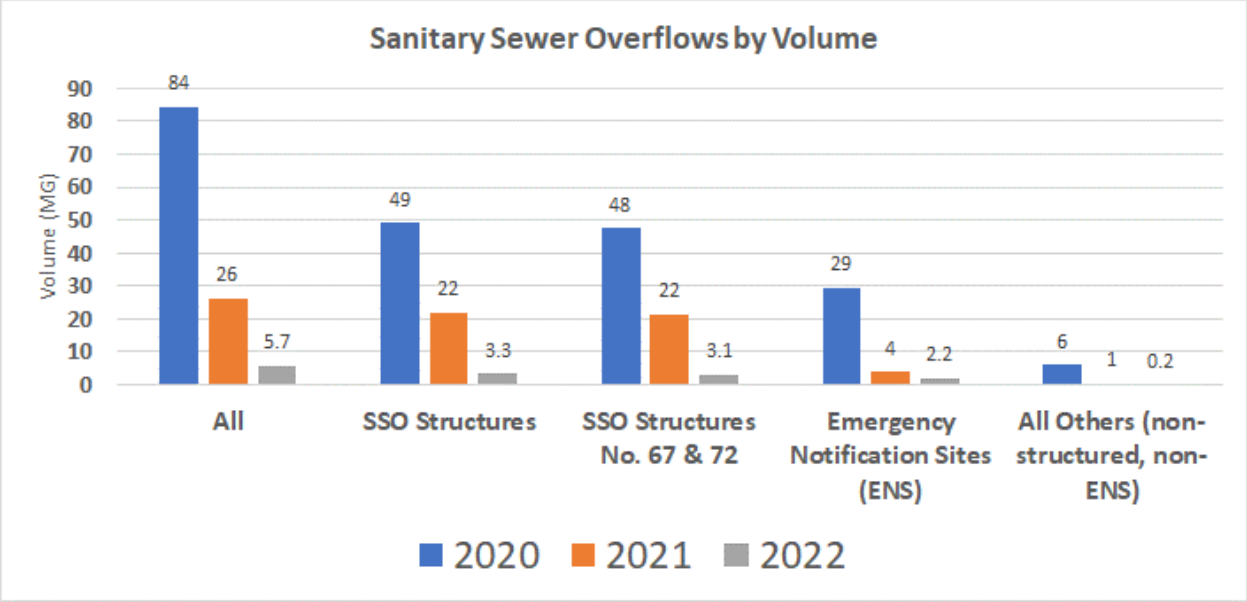
Prior to the Headworks project, this volume would have been discharged into area rivers, streams, and the Inner Harbor and would have impeded the treatment performance of the WWTP. It now is routed safely and efficiently through the treatment process and discharged in compliance with all receiving water quality requirements. Notably, the designed storage volume has proven to be adequate.

In addition to the tremendous benefit of the Headworks project in reducing wet-weather SSOs, there are several other factors contributing to a reduction in the frequency and volume of SSOs. First, the ongoing completion of Phase I MCD projects has steadily reduced extraneous I/I flows, which lessens the capacity needed by the wastewater collection system to convey flows.

Second, the City's Office of Asset Management (OAM) has implemented a robust targeted cleaning program that implements asset management tools to target maintenance and cleaning to achieve the highest return on investment.

Finally, in early 2022, the City began to clean out the major, large diameter interceptor sewers that transport sewage the last several miles to the Back River WWTP Headworks facility. This cleaning was necessary because prior to hydraulic restriction relief, these interceptors were highly prone to sedimentation. Sediments had built up over the many years of the hydraulic restriction and the compromised interceptor capacity contributed to upstream SSOs even after Headworks came online.

All the above together is rapidly paying dividends. Comparing the annual calendar years of 2021 and 2022 to 2020 shows substantial decreases in all SSOs as well as within the three categories of SSO structures, Emergency Notification Sites (ENS), and all other locations, as shown in Figure 7. ENSs are those manholes where SSOs occur frequently, and the City has installed flow metering equipment to determine frequency and volume more precisely. The City acknowledges that differences in rainfall contribute to reported wet weather SSOs and therefore influence any observed trend. However, the trends presented are significant and likely transcend any differences in rainfall among the three calendar years.



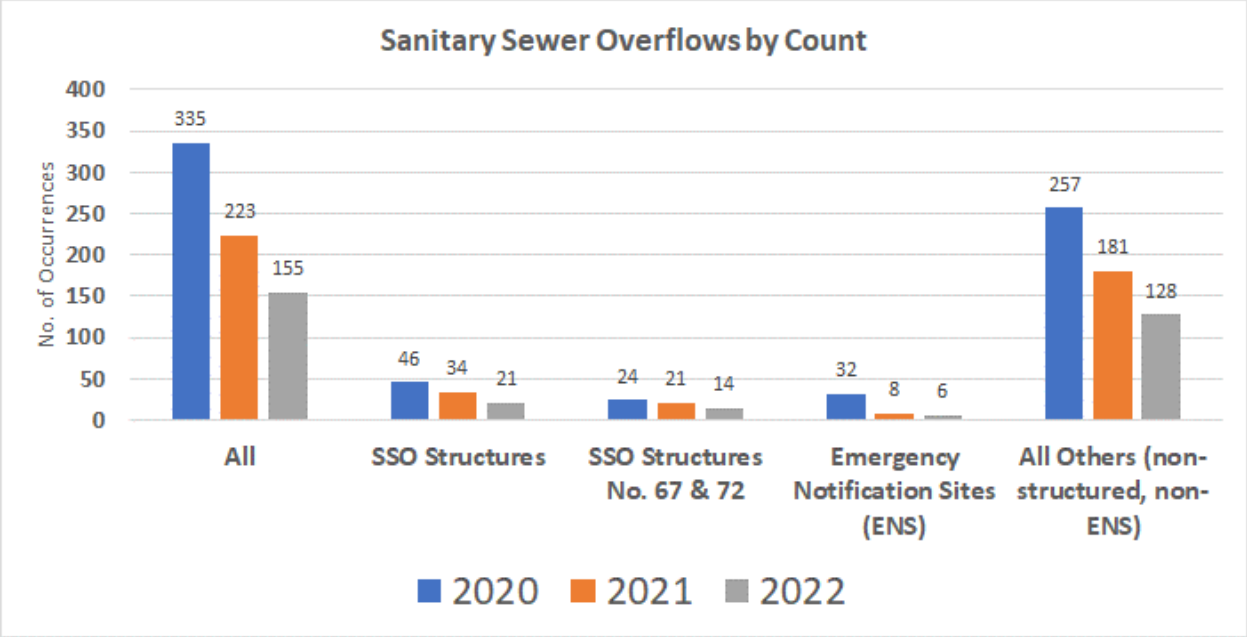


Figure 7. Wet Weather SSO Reduction Trends

5.2.4 Plan for Wet Weather Categorization and Reporting

In Section 5.2.1, the City emphasized that criteria for designating a "wet" SSO is exceedingly conservative, resulting in many SSOs that are blockage related being designated as "wet" SSOs. The consequence of the erroneous designation is that the appropriate remediation tactics for reducing any SSOs may be compromised. For example, the City will use different means and technologies to address true wet SSOs and blockage related SSOs. Based on the conclusions derived from analyzing the true

cause of recorded SSOs and the recognition that many previously recorded as wet are blockage-related, the City proposes to revise its process for categorizing SSOs. The City proposes the following:

Future SSOs will be designated as "wet" if the maintenance field staff who responded to and mitigated the SSO indicate:

1. The SSO is not attributed to a blockage, pipe failure, or pump failure
2. Wet weather is causing surcharging in the system

Following the field report, office staff will perform a check to evaluate if available rainfall data from neighboring rain gauges supports the indication of rain by the maintenance staff in the previous 72 hours. If rainfall is identified, it will be designated as "confirmed" wet weather. If no rainfall is identified, further investigation will be undertaken with maintenance staff and the supervisor will make a final designation.

SSOs previously designated as "wet" shall be re-designated using the same criteria. These updated records will be factored into all trend analyses and reporting going forward.

The City also intends to modify its very conservative criteria for which SSOs must be reported to MDE to be aligned with the Code of Maryland Regulations (COMAR), Section 26.08.10.01, which states:

> *(3) "Overflow" does not include:*
>
> > *(a) An overflow or discharge of 50 gallons or less to the ground that are cleaned up within 1 hour of its occurrence; and*
> >
> > *(b) An overflow or discharge to impervious surfaces that are effectively contained and cleaned up so that there is no direct or potential pollution of waters of the State as a result of the overflow or discharge.*

5.2.5 Effect of Tidal/Nuisance/Riverine Flooding on SSOs, Infiltration and Inflow (I/I), and Model Representation

Environmental conditions such as higher tides, the presence of riverine flooding, and antecedent rainfall (how much rainfall has occurred in the days leading up to a storm event) can all impact the amount of I/I entering the system. When soils are saturated due to such factors, there can be more infiltration in the system. This effect also can also be seen seasonally; since evapotranspiration is lower in the winter and early spring, systems may see more inflow during storm events.

To account for this phenomenon, the model was recalibrated to the multiple meters throughout the system. Part of the recalibration involved using the software's groundwater infiltration model where meter analysis showed evidence of environmental conditions varying the inflow response. The model recalibration is discussed more in Section 8.

5.3 Water Quality Monitoring

5.3.1 City of Baltimore

Baltimore City is implementing two stream water quality monitoring programs – the Ammonia Screening (AS) Program (which includes monitoring for nitrogen-ammonia) and the Stream Impact Sampling (SIS) Program, which includes monitoring for Escherichia coli (E. coli) bacteria in non-tidal freshwaters and Enterococcus bacteria in tidal or brackish waters. This information is detailed in Table 2. The City follows the Code of Maryland for Water Quality Criteria Specific to Designated Uses (Sec. 26.08.02.03-3) (http://mdrules.elaws.us/comar/26.08.02.03-3).

Table 2. Types of Bacteria Being Monitored and Threshold Values

	Bacteria	Geometric Mean	Statistical Threshold Value
Indicator	Enterococci (fresh or marine) - culturable	35	130
	E. coli (fresh) - culturable	126	410

The City is observing decreased bacteria in most of the samples (see links below); however, none of the locations meet criteria for recreation. The City is also maintaining several websites for reporting and information purposes:

- https://publicworks.baltimorecity.gov/watching-waters
- https://publicworks.baltimorecity.gov/regulatory-mandates-plans-and-reports
- https://publicworks.baltimorecity.gov/sites/default/files/MS4%20Annual%20Report%202021%20Final.pdf
- https://cityservices.baltimorecity.gov/resources/BaltimoreHarborWAFINAL11_10_2021,pdf
- https://publicworks.baltimorecity.gov/pw-bureaus/water-wastewater/surface/restoration
- https://publicworks.baltimorecity.gov/sites/default/files/Water-Quality-Monitoring-and-IDDE-Brochure_121416%20%282%29.pdf
- https://publicworks.baltimorecity.gov/pw-bureaus/water-wastewater/surface/operations

5.3.2 Blue Water Baltimore

Blue Water Baltimore has 49 monitoring sites and began collecting bacteria data in 2009. They reported the following in their 2020 Water Quality Report Card:

"There are significantly improving trends in bacteria at 34 of our 49 monitoring stations.

- *While we do not know exactly WHY bacteria is improving, these trends indicate that sewer replacement and relining projects are working to reduce the amount of sewage flowing into our waterways.*
- *Most of the bacteria improvements were seen in our streams during dry weather. This could indicate that illegal sewer connections and leaky pipes have been discovered and fixed by both Baltimore City DPW and Baltimore County DEPS/DPW.*
- *Three stations showed significantly improving bacteria trends during wet weather. While we are only seeing this trend at 3 stations, they are 3 of our most degraded stations: Gwynns Run,*

the Inner Harbor at the Jones Falls Outlet, and the Inner Harbor near the Downtown Sailing Center.

- *This is extremely encouraging news because it appears the locations most affected by sewage overflows are showing signs of improvement.*
- *We do not know if these data are linked with specific projects in the ground, but we believe the message here is clear: We must prioritize sewer rehabilitation project investments because they are working to measurably improve water quality.*

Blue Water Baltimore is also maintaining several websites for informational purposes:

- https://baltimorewaterwatch.org/
- https://baltimorewaterwatch.org/current-conditions
- https://baltimorewaterwatch.org/parameters
- https://bluewaterbaltimore.org/blog/2020-water-quality-report-card-is-here/

5.4 Decision

Based on the foregoing, a forward-thinking and advanced maintenance-related is critical in addressing the reamining 10% of SSOs (in volume) to ensure compliance of the MCD. Over a period of three years, this represents an approximate 93% reduction in recorded wet-weather SSO volume. Strategically and cost-effectively, performing this approach is the most optimal solution for reducing separate sanitary sewer wastewater collection system SSOs given the City's currenct success. An intensive analysis of observed SSO events recorded between 2003 and 2022, categorized as wet-weather derived, found that 81% of them were in fact related to blockage issues. Also, 97% of the blockage-related SSOs were on pipes 20" and less. A focused push on O&M, especially on smaller pipes, will lead to tremendous reductions in SSOs, will inform further enhancements to the City's asset management risk-based improvement prioritization program, and will identify instances of needed repair or rehabilitation projects that will be incorporated into the City's capital program, therefore meeting the requirements of the MCD.

6 Remaining Deficiencies Not Addressed by Phase I Projects [9.c.(iii)]

6.1 SSO Frequency and Volume

The MCD requires that the City meets a specific LOP described in Section 2.0. The City has developed a baseline condition H&H model, described in Section 8.2, that is used to identify remaining SSOs that do not meet the MCD LOP criteria. This model is then used iteratively to conduct alternative analyses of various combinations of technologies and measures considered for Phase II actions (See Section 7.0). In its 2012 Sewershed Plan, the City estimated that Phase I projects would achieve a reduction in cumulative SSOs over the 20-year typical rainfall from a 2.4 BG baseline in 2002 to less than 400 MG at the conclusion of Phase I. Current modeling confirms that this objective was achieved with the total 2030 baseline volume estimated at 235 million gallons. There were 397 storms in the 20-year period that caused SSOs in the Baseline 2002 simulation versus 100 storms in the Baseline 2030 simulation that caused SSOs. Baseline 2030 estimated wet weather SSO frequency is presented in Figure 8.

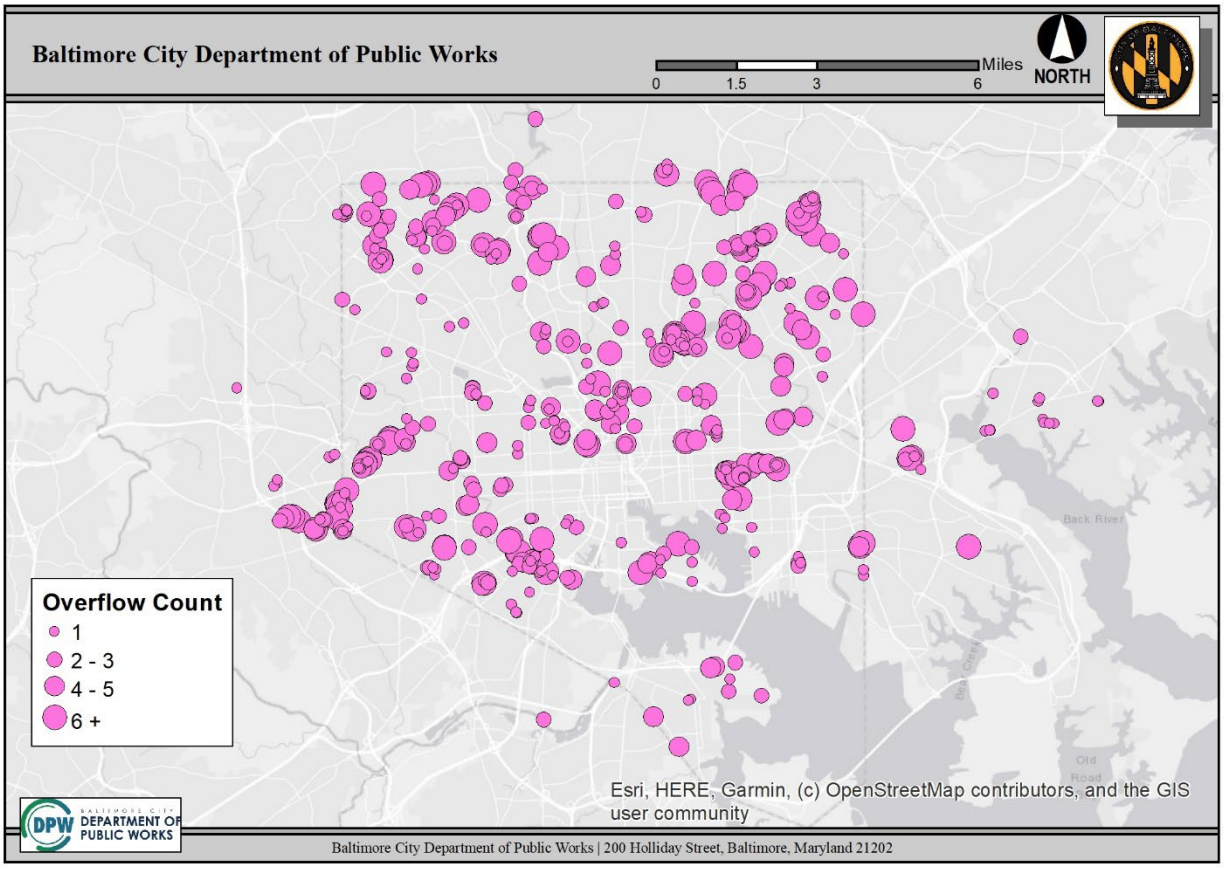


Figure 8. Baseline 2030 Condition SSO Frequency

6.2 Building Backup Extent and Frequency

Appendix E of the MCD requires an Expedited Reimbursement Program to reimburse City residents for verified cleanup/disinfection costs arising from building backups caused by wet weather surcharging in the collection system. The City has proposed a long-term plan to replace the Expedited Reimbursement Program that EPA and MDE are now considering. Data from the program is reported on an annual basis.

The extent and frequency of building backups are documented in the publicly available MCD Quarterly Reports and provided here. The MCD requires reporting of building backups that occur during each calendar quarter. Quarterly Report Attachments (attachments to the Quarterly Report, not this document) specific to building backups include:

- Attachment 3. Reported Building Backups during the Calendar Quarter, pursuant to sub paragraph 21.i.
- Attachment 4. Map of Reported Building Backups during the Calendar Quarter, pursuant to sub paragraph 21.i.

To distinguish between building backups recorded in previous Quarterly Reports and those recorded in the current calendar quarter, Attachment 3 is formatted so that previously reported building backups are formatted in grey italicized text and current calendar quarter building backups are formatted in plain black font. The events listed in Attachments 3 and 4 and Tables 2 through 9 may have a variety of causes, including:

- Roots
- Improper disposal of wipes, FOG, or other inappropriate items
- Infiltration and/or inflow
- Issues in public or private infrastructure

Building backups are addressed once they are reported to the City. The DPW has several proactive programs to address building backups including targeted cleaning, FOG abatement, root control, and SSO root cause analysis.

7 Technologies and Measures Considered for Phase II Actions [9.f.(ii)]

7.1 Human Behavioral Improvements

A key to ensuring the greatest success with technical improvements and efforts being made to prevent SSOs is to educate Baltimore City residents on the proper disposal of non-flushable items, as well as FOG. The City, through the efforts of DPW's communications and outreach teams, has worked to adopt a specific communications approach that not only educates the public but encourages mindfulness of their current behavior.

7.1.1 Promoting Positive Behavior Change

Behavior change communication is a communication strategy which encourages residents to change their conduct or behavior. This type of strategy triggers communities to adopt healthy, beneficial, and positive behavioral practices. It is an interactive process with communities to create customized messages and methodologies utilizing various channels to create positive practices; advance and support individual, network, and cultural conduct change; and maintain best practices.

At the Individual-Level – Behavior change helps in learning, mindfulness, convictions, and sentiments about day-to-day best practices.

At the Community-Level – Behavior change approach stimulates the community to take ownership towards the approach. Additionally, it will also help the community to replicate the positive practices on a larger scale.

All City Clean Drain Campaign materials have been designed to be accessible so that **all** residents can readily understand the information being shared. Refer to the link below.

- https://publicworks.baltimorecity.gov/sewer-consent-decree/clean-drain-campaign

7.1.2 Non-flushables

Using basic tenets of behavior change communication, the City has developed several collateral campaigns to address non-flushable items including:

Trash the Wipes – Provided as a downloadable/printable collateral material and for use on social media, this campaign encourages community members to think before they flush. It details specific items that should NOT be flushed.

BCDPW Sewer Heroes – Soon to be released coloring book to help educate Baltimore City youth and their families about the dangers of unflushable items and to promote positive behavior change. This book features the adventures of Piper the Pipe Protector and Dwayne the Drain Defender and their efforts to protect Baltimore City's sewer system by stopping the improper disposal of unflushable items.

Basement Backups – Provided as three downloadable/printable brochures, this material features detailed information on:

- How to prevent backups
- What to do if you have a backup
- BCDPW Expedited Reimbursement Program

Sewage Onsite Support (SOS) Program – Provided as a brochure for both print and website use and additional handout material for BCDPW SOS Program. This program provides cleaning, disinfection, and disposal services free of charge to Baltimore City residential customers impacted by sewage damage caused by a capacity-related wet-weather event resulting from heavy or sustained rain.

7.1.3 Fats, Oils, and Grease (FOG)

As part of efforts to promote behavior change, the City has developed the following collateral campaigns to address FOG:

Clear the FOG – Featuring a series of proper disposal Do's and Don'ts, this campaign (designed for print, web, and social media use) raises awareness about proper disposal practices for cooking fats, oils, and grease.

Cost of FOG – Don't let FOG clog your pipes; it will cost you TIME, MONEY, and HEALTH! This campaign, also designed for print, web and social media use, features a few lesser-considered facts about how FOG in the pipes can cost individuals.

Clear the FOG/Commercial Restaurants – A Frequently Asked Question (FAQ) poster and flyer have been created for distribution to commercial businesses featuring the recognizable Clear the FOG campaign branding. A commercial establishments FOG manual has also been rebranded with Clear the FOG.

7.2 Sediment and Debris Cleaning

There are many sources of sediment in the collection system, including pipe failures, wastewater, construction sites, winter salting, and flooding, among others. Once sediment enters the collection system, it is deposited over time during dry weather flow. Wet weather flows tend to resuspend the lighter sediment and push it downstream while the heavier sediment continues to settle and decrease the pipe capacity. The collection system was originally designed to achieve self-cleansing velocity even during dry weather; however, it has been commonly found that even the best designed systems still experience sediment deposition. There are many causes which include exceedingly high design dry weather flows and introduction of large sedimentation.

Regular flushing and cleaning of the sewer system is essential to prevent surcharging, backups, and overflows. Every inch of debris in a pipe occupies vital capacity within the collection system. The sewer system can be cleaned in several different ways depending on the size, location, and debris type within the system. The larger interceptors require pre-planning, staging of equipment, and potential access issues while the smaller pipes tend to be more efficient and easier to access. There are also other types of debris cleaning such as root cutting, grease removal, and trimming back lateral pipes that protrude into the mainline sewer.

7.3 Public Asset I/I Rehabilitation, Repair, and Replacement

This methodology includes rehabilitating the sewer system utilizing Cured-in-Place Pipe (CIPP), point repairs, public side lateral repairs, and manhole rehabilitation. The approach is to select basins that have not been rehabilitated in Phase I of the MCD and inspect every sewer main and manhole. From there, sewer mains which have been identified to have defects will be scheduled for CIPP including the public side laterals, for up to four feet from the lateral connection with the main. Some mains will require point repairs before CIPP can be installed. If there are multiple point repairs needed, the pipe will typically be replaced completely rather than rehabilitated. Concurrently, the manholes with defects will be rehabilitated to meet current standards. This plan will renew the public side sewer system efficiently and cost effectively.

As part of our adaptive management approach we will continue to look at other technologies such as conveyance upgrades, wet weather storage, and pump station upgrades to meet MCD requirements.

7.4 Private Lateral Rehabilitation, Repair, and Replacement

Privately owned laterals are not planned to be rehabilitated or replaced as part of projects associated with the MCD. However, if there are cases where high I/I levels are discovered within certain private laterals, the City could look at options of coordinating with the property owner to potentially fix the defects, or initiate enforcement proceedings in partnership with MDE.

8 Analysis Methodologies for Phase II Action Evaluation

The City's InfoWorks ICM H&H model is the software tool applied to analyze the hydraulic impact of proposed alternatives on SSO frequency and volume. The City developed the model to analyze their system in support of both the Phase I and II plans associated with the original CD. The model has been maintained since its development, undergoing annual updates as required by the terms of the MCD. The model is currently represented in InfoWorks ICM Version 2023. This section outlines the status of the hydraulic model, its limitations, and the assumptions made to develop baseline conditions.

8.1 Comprehensive Collection System Hydrologic and Hydraulic Model [9.b.(i)]

The current extent of the City's collection system model is shown in Figure 9. The horizontal datum is based on the Maryland State Plane Coordinate System (NAD83) and the vertical datum is based on NAVD88**.** The model was originally developed to include major gravity sewer pipes as defined by the original CD. In the CD, the definition of major gravity pipe was defined as any of the following:

- All gravity sewer pipes that are ten inches in diameter or larger
- All eight-inch pipes that convey or are necessary to accurately represent flow attributable to a service area in each of the wastewater collection system's sewershed service areas
- All gravity sewer pipes that convey wastewater from one pumping station service area to another pumping station service area
- All gravity sewer pipes that have caused or contributed, or that Baltimore City knows are likely to cause or contribute, to capacity-related overflows

The model developed as per the CD has been updated annually to reflect changes in the system over time. The City's annually updated Back River (BR) and PA major sewershed model networks were considered the starting configuration. The most recent update involved a model recalibration effort conducted in early 2022 and is documented in the draft MCD Model Calibration Report. Calibration updates to the model include:

- The City's sewer record drawings, along with the Geographic Information System (GIS), were utilized to make numerous editing changes. Information was sometimes inferred in places where it was not available
- During recalibration, diurnal curves were developed where needed for daily wastewater generation and annual profiles developed for base infiltration. Hydrology was modified to make the sewersheds consistent with each other in terms of hydrologic setup
- The model was extended to include additional eight-inch pipes for several portions of the collection system at the City's request, including extension of the pipe network and hydrology updates

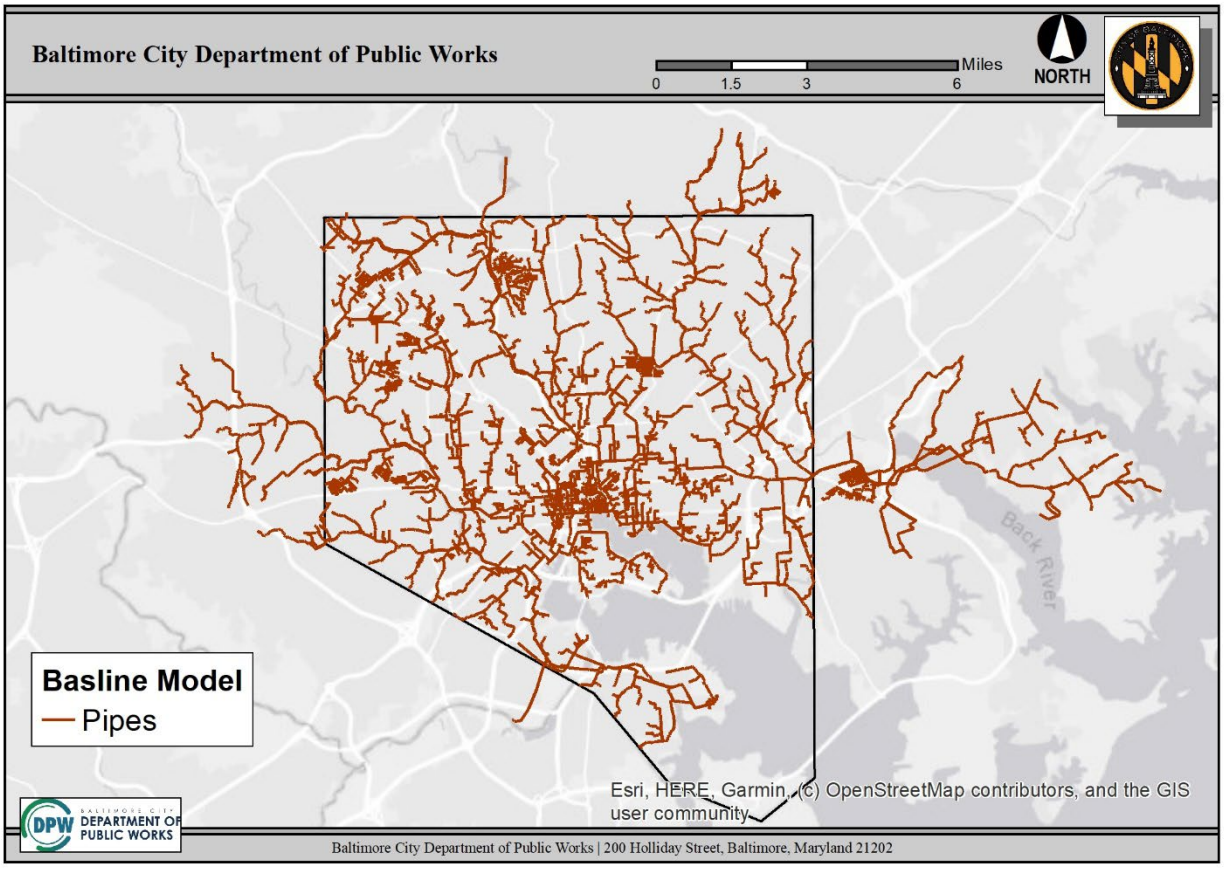


Figure 9. Baseline Model Network

- The model was recalibrated using approximately 22 meters at the County and City borders, as well as 130 meters installed throughout the City

For a more detailed list of the updates made for the recalibration, please refer to the 2022 MCD Model Calibration Report.

8.2 Hydrologic and Hydraulic (H&H) Model Limitations

The H&H model is a representation of a vast network of wastewater collection and transmission sewerage assets (pipes, manholes, pumps, etc.) and the flow within, both normal or dry weather flows and elevated flows that occur in response to wet weather. The City has calibrated the model to a minimum of industry standards by adjusting parameters such that model simulation results reasonably replicate observed data. However, as with any model, there are inherent uncertainties that must be acknowledged and factored into all model uses, and in particular, flows not ascertainable or controllable by the City (from the County), and its use to evaluate alternatives and develop the MCD Phase II Plan.

The 2021 collection system H&H model was recalibrated using available information. This included flow metering, sediment measurements in select locations, and comparison to reported SSOs throughout the system. Although the model has been calibrated to this information, there will still be uncertainty in the

predicted SSOs. There are several sources of uncertainty to be considered in developing the Phase II Plan.

8.2.1 Flow Meter Resolution

The H&H model was re-calibrated with 114 meters. In stormwater and combined sewer systems, it is possible to estimate inflow using physical basin characteristics such as total impervious area and ground slope. However, in a separated sewer system such as in Baltimore City, the flow generation simulated by the parameters in the model rely mostly on flow measurements. Therefore, the more flow meters, the better the resolution and accuracy of the predicted flow. The process used for the 2021 model re-calibration, to the fullest extent practical, preserved the intelligence from the previous 2006-2007 calibration effort that utilized more than 350 flow meters. The meter resolution of the latest monitoring period was not as dense but does assist in represent changing conditions over time. However, uncertainty still exists and may lead to uncertainty in inflow predictions as well as predicted SSOs.

8.2.2 Sediment

Sediment measurements were made at select locations throughout the City. Sediment depths were also inferred based on flow metering data where possible. However, sediment measurements were not available for the entire H&H model and in most cases, the City assumed modeled pipes are clean. Where sediment exists but the pipes were assumed clean, other factors in the model may have been adjusted as part of the calibration to compensate for the incomplete sediment information. For example, to calibrate the model in a section where pipes are assumed clean to replicate a high water levels in response to a calibration rainfall event, a modeler might increase the pipe roughness coefficient. If the high-water level was caused by sediment buildup (unknown to the modeler) then the model would be calibrated erroneously with greater pipe roughness. The higher roughness coefficient pipes might then overpredict SSOs at these locations in the baseline model; thus, the City will need to implement a more rebust forward-thinking and advanced maintenance (i.e., O&M) program, which also is cost effective.

8.2.3 SSOs in Unmodeled Pipes

The H&H model mostly includes pipes 10 inches or larger in diameter as specified in the CD and MCD. In some cases, the model was extended to known upstream wet weather-related SSOs. As noted in Section 5.2, there are multiple blockage related SSOs during wet weather. However, RDII flow generation is based on flow metering. Flow from blockage related SSOs that occur in the upstream system of smaller than 10-inch pipes generally exits the sewer system and does not re-enter the sewer system because it runs overland to the nearest inlet point of the separate stormwater system. As a result, downstream sewer flow meters do not record this flow. During model calibration, parameters may have been adjusted to lower inflow during storm events accordingly. When these maintenance concerns are fixed, however, the flow that used to exit during wet weather events will now enter the system, increasing the flow coming into the system. It is possible that maintenance will increase flows to the interceptor, and this impact will not be reflected in the model. Phase II improvements in these areas may be impacted by this increase in flow; thus, a more accurate determination of necessary projects can be determined. However, unknown County flows will still be an issue.

Continuing model refinement using additional measurement of sediment, flow data, and reported SSOs as part of an Adaptive Management approach is very important.

8.3 Baseline 2030 Condition H&H Model Representation

The recalibrated H&H model was considered to represent 2021 existing conditions. Because the MCD requires the Phase II Plan to be based on 2030 conditions, the City adjusted the model to reflect 2030 conditions as follows:

- Sediment was removed in the model to reflect interceptor cleaning
- SSO outfall structures in the existing conditions model were closed (per MCD requirements). This included the following 10 SSOs: 67, 72, 135, 138, 139, 152, 154, 155, 156, and 157
- For Phase I projects recently completed but without PCFM data available during calibration, the City assumed a 0% reduction in I/I to ensure Phase II performance exceeds our assumptions. Hydraulic improvements from these projects were coded into the baseline model during the 2021 Annual Model Update based on available design drawings (75% or 100%)
- Incorporated best available information and estimates from County future condition models. According to the County, these models, and planning exercises that will use the models, are not complete. Figure 10 shows the areas and extent of the County models in relation to the City H&H model.

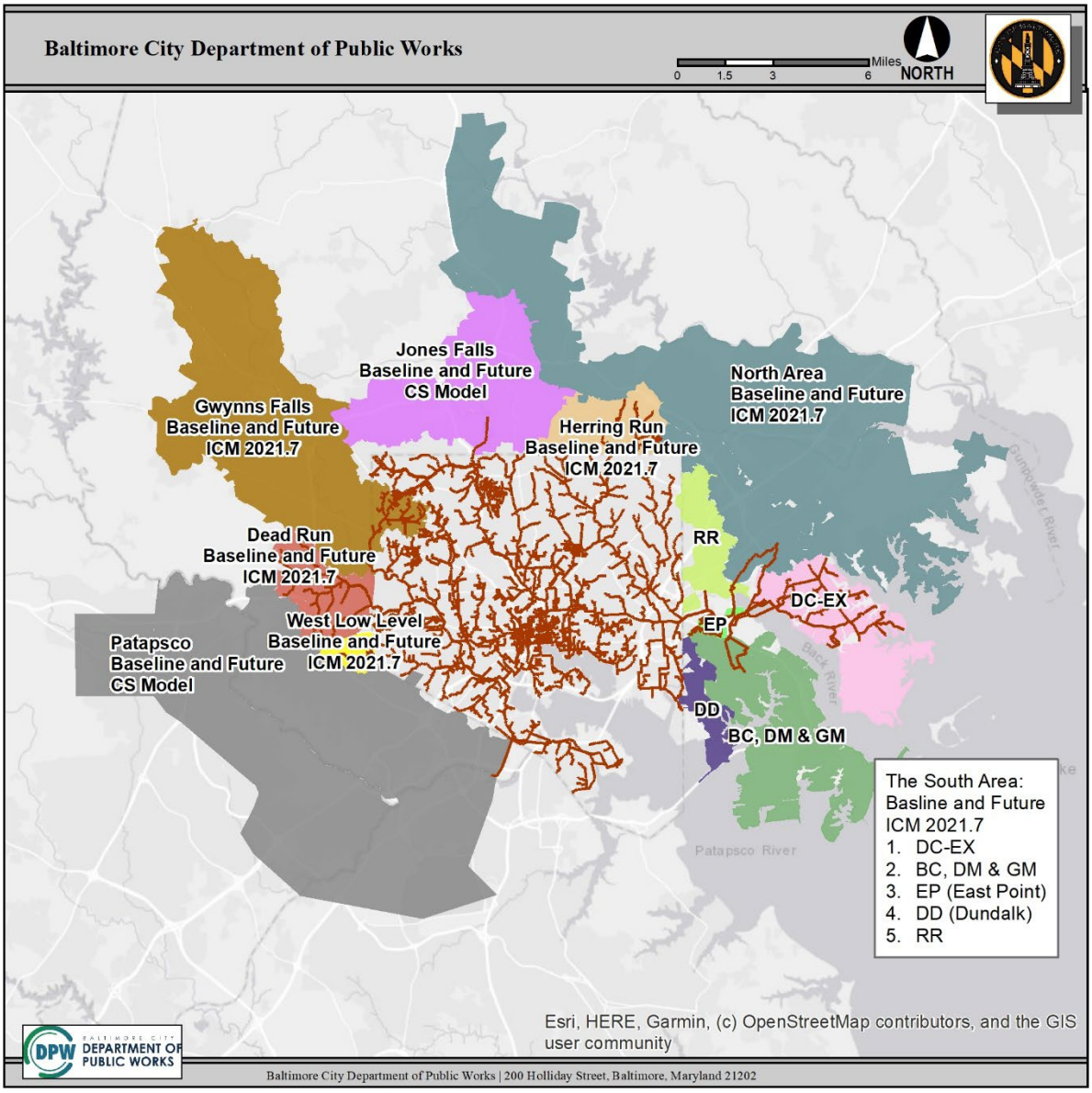


Figure 10. Baseline and Future Model Representation

8.4 20-Year Historical Precipitation Simulation [9.b.(i)]

The MCD requires the system meet a “five-year” LOP and “10-year” LOP in sensitive areas. To evaluate if SSO frequency is meeting that goal, the model is simulated using the agreed upon 20-year period from 1991-2010. This period was selected in association with the original CD and is being used for Phase II Plan analysis.

8.5 Year 2030 Reasonable Population Projection [9.f(ii)]

The City increased dry weather flow to reflect changes in City and County population between existing conditions and 2030. For population increase, population adjustments were made in a manner consistent with the 2008 Baltimore Sewer Evaluation Standards (BaSES) manual [2]used for development of the original CD Phase I model. This procedure used City and County Transportation Analysis Zone (TAZ) Employee and House Projections Round 9A to estimate wastewater flows. That analysis assumed 150 gallons per day per household, plus 20 gallons per day per employee. The analysis was updated to use the latest TAZ available at the time of the baseline model development, TAZ 9a, which was endorsed by the Baltimore Regional Transportation Board (BRTB) in July 2020.

As described in Table 3, the flows in 2021 were interpolated from 2020 and 2025 and will be used to estimate the flow increase from 2021 to 2030 for the City areas. For the County areas, the flow increase from 2025 to 2030 will be used because the flows of County models were in 2025.

The changes in estimated flows were turned into percent increases to apply to the City as well as portions of the County that were imported from the County's 2025 future conditions models. At the time of this report, County planning efforts are incomplete and the nature and magnitude (timing, peak, volume, and duration) of the flows the City will need to accommodate is uncertain. In a letter dated October 26, 2022, the County responded to an official inquiry by the City and stated they are in the process of hydraulic modeling the rehabilitation and relief sewers and working on a new LTC/PFMP. The amount of rehabilitation or capacity relief needed for the City to comply with MCD requirements greatly depends on flows originating in the County and flowing into the City. The County has not provided definitive information on expected future flows that will flow into the City as they are still progressing with their Baltimore County Consent Decree (BCCD)-required LTC/PFMPLong Term Capacity/Peak Flow Management Plan. The City used best available interim information from the County to estimate the flows projected by sewershed and by City and County for each sewershed. A summary of these changes is described in Table 3.

[2] Baltimore Sewer Evaluation Standards (BaSES) Manual. Section Seven Hydraulic Modeling – V09.01. January 2008.

Table 3. Wastewater Flow Projections

SEWERSHED WASTEWATER FLOWS (MGD)	2015	2020	2025	2030	2035	2040	2045	2021 – Interpolated from 2020 and 2025	Flows Increase from 2021 to 2030	Flows increase from 2025 to 2030
Dundalk_CITY	0.788	0.826	0.851	0.874	0.895	0.915	0.938	0.827	5.6%	2.6%
Dundalk_COUNTY	1.298	1.299	1.304	1.308	1.311	1.316	1.320	1.301	0.6%	0.3%
Gwynns Falls_CITY	3.976	4.020	4.060	4.095	4.128	4.148	4.179	4.028	1.7%	0.9%
Gwynns Falls_COUNTY	12.197	12.359	12.550	12.692	12.888	13.049	13.185	12.403	2.3%	1.1%
Herring Run_CITY	9.081	9.217	9.287	9.355	9.422	9.466	9.534	9.214	1.5%	0.7%
Herring Run_COUNTY	3.014	3.022	3.034	3.045	3.061	3.084	3.103	3.024	0.7%	0.4%
High Level_CITY	5.363	5.240	5.333	5.410	5.446	5.458	5.502	5.328	1.5%	1.4%
Jones Falls_CITY	10.356	10.594	10.810	11.001	11.161	11.258	11.396	10.641	3.4%	1.8%
Jones Falls_COUNTY	4.766	4.792	4.869	4.935	4.998	5.074	5.141	4.821	2.4%	1.4%
Lower Level_CITY	11.217	11.833	12.376	12.733	13.475	13.922	14.221	11.918	6.8%	2.9%
Outfall_CITY	2.309	2.325	2.428	2.513	2.567	2.601	2.654	2.376	5.8%	3.5%
Outfalls_COUNTY	22.354	23.092	23.748	24.184	24.721	25.359	25.807	23.173	4.4%	1.8%
Patapsco_CITY	1.448	1.459	1.480	1.501	1.521	1.540	1.564	1.466	2.4%	1.4%
Patapsco_COUNTY	28.015	29.470	31.255	32.650	33.807	34.495	34.951	30.043	8.7%	4.5%
Total City Flow	**44.54**	**45.51**	**46.62**	**47.48**	**48.61**	**49.31**	**49.99**	**46.08**	**3.0%**	
To Back River Plant	39.11	40.03	41.08	41.89	42.97	43.62	44.24	40.30	3.9%	
To Patapsco Plant	5.42	5.48	5.54	5.60	5.65	5.69	5.74	5.49	1.8%	
Total County Flows to City	**71.64**	**74.03**	**76.76**	**78.81**	**80.79**	**82.38**	**83.51**	**74.76**	**5.4%**	
To Back River Plant	31.43	32.21	32.95	33.47	34.09	34.83	35.37	32.32	3.6%	
To Patapsco Plant	40.21	41.83	43.80	45.34	46.69	47.54	48.14	42.45	6.8%	

SEWERSHED WASTEWATER FLOWS (MGD)	2015	2020	2025	2030	2035	2040	2045	2021 – Interpolated from 2020 and 2025	Flows Increase from 2021 to 2030	Flows increase from 2025 to 2030
% County Flow	62%	62%	62%	62%	62%	63%	63%	62%		
Grand Total	**116.18**	**119.55**	**123.38**	**126.30**	**129.40**	**131.69**	**133.50**	**120.84**	**4.5%**	
To Back River Plant	70.55	72.24	74.04	75.36	77.06	78.45	79.62	72.62	3.8%	
To Patapsco Plant	45.64	47.31	49.34	50.94	52.34	53.23	53.88	47.94	6.3%	

8.6 Sewer Condition Deterioration Assumptions [9.f.(ii)]

For wastewater collection system degradation, wet weather flows generated in the model were increased by increasing the tributary area and basin width model parameters. This represents the increased flow in future conditions due to deteriorating pipes.

For the City, a 6% degradation, or increase in wet weather inflow, was assumed between 2021 and 2030. This is based on the analysis results of the control meters from the City's PCFM program as described in Section 5.1. There was an average of 9% degradation over a 14-year period from 2007 to 2021. This would translate to 5.8% degradation over a nine-year period from 2021 to 2030. This value was rounded to 6%.

For County models that were imported into the City's model, a 3.5% degradation was assumed as the future condition County models are assumed to represent 2025 conditions.

8.7 Phase II Plan I/I Reduction Estimates

Based on PCFM analysis results, the City is assuming it will achieve a 50% reduction in wet weather (I/I) flows in response to basin wide I/I rehabilitation projects. This is based on the evaluation of meters installed downstream of completed Phase I rehabilitation projects as described in Section 5.1.

8.8 Coordination with City Capital Improvement Project Planning

The City incorporates proposed and built construction on a regular basis. This work is summarized in an annual report. Analysis of new alternatives considers other City capital projects that may need to be synchronized from a proximity consideration as well as synergy and financial perspective.

8.9 Flow Basin Prioritization for I/I Rehabilitation Projects

The City has evaluated all City sewershed flow basins to determine their ranking relative to their overall contribution to I/I and consequent SSOs. The ranking considers several factors. The process is described in this section.

The weighted ranking of flow basins considers various basin characteristics or factors. Each basin is ranked relative to the other basins on each factor and the weighted sum computed for each basin. The basins are then ranked based on this weighted sum.

A similar effort was undertaken and reported on in the City's 2012 Sewershed Study and Plan Amendment. The approach taken in 2012 was used to guide the current initial weighted ranking of basin factors. In 2012, the City considered the factors shown in Table 4.

Table 4. 2012 Study Flow Basin Prioritization Factors

Factor	Threshold Rule	Factor	Threshold Rule
I/I (% capture)	> 5%	RDII volume (gal/lf-in)	> 10
Water In Cellar occurrences	> 0	I/I flow (gpd/IDM)	> 5,000
Reported SSO occurrences	> 0	Number of times downstream pump stations were activated	None: Simple Count
Predicted SSO occurrences	> 0		

In 2012, threshold rules for all these factors were established except in the case of the number of times a downstream pump station was activated, as shown above. If the threshold for a factor was exceeded, a value of "1" was assigned as a score for that factor. In the case of the pump station factor, the number of incidents was noted as the score. The sum of all seven scored factors was then computed. Generally, if the total exceeded 3, the basin was assigned for rehabilitation. There were exceptions to this rule, i.e., basins with a score > 3 that were not assigned to rehabilitation and those with a score < 3 assigned to rehabilitation. Further, only 179 of the 319 basins met the threshold rules shown in Table 4 and therefore were considered as part of the 2012 study.

In the revised, current methodology, the City considered all basins and identified seven alternate factors to use in the weighted ranking, listed in Table 5. Some of these were included in the 2012 methodology.

Table 5. Current Flow Basin Prioritization Factors

I/I (% capture)	**Modeled SSOs (# per acre)**
Reported Wet SSOs (#/mile)	**Modeled SSO Volume (gal/acre)**
Reported Wet SSO Volume (gal/IDM)	**Modeled DS SSOs (#)**
Reported DS Wet SSOs (#)	

The seven factors in Table 5 were assigned importance weights using the Analytical Hierarchy Process (AHP). The AHP develops factor weights through pairwise comparison. Individual City staff were asked to perform a pairwise comparison of factors using a scale of importance as shown in Table 6.

Table 6. Pairwise Comparison of Flow Basin Prioritization Factors

Very Strongly Less Important	**1/7**
	1/6
Strongly Less Important	**1/5**
	1/4
Moderately Less Important	**1/3**
	1/2
Equal Importance	**1**
	2
Moderately More Important	**3**
	4

Strongly More Important	**5**
	6
Very Strongly More Important	**7**

To affect the comparison, the factors are arranged in a matrix format, an example of which is shown in Table 7.

Table 7. Pairwise Comparison of Flow Basin Prioritization Factors - Matrix Format

Factor#	1. I/I % Capture	2. Reported Wet SSO #	3. Reported Wet SSO volume	4. Reported DS Wet SSO #	5. Modeled SSO (#)	6. Modeled SSO volume	7. Modeled DS SSO #
1. I/I % Capture	1	1	1	3	4	5	5
2. Reported Wet SSO #	1	1	1	3	4	5	5
3. Reported Wet SSO volume	1	1	1	3	4	3	3
4. Reported DS Wet SSO #	1/3	1/3	1/3	1	1	4	4
5. Modeled SSO #	1/4	1/4	1/4	1	1	2	2
6. Modeled SSO volume	1/5	1/5	1/3	1/4	1/2	1	1
7. Modeled DS SSO #	1/5	1/5	1/3	1/4	1/2	1	1

The green cells in Table 7 are filled in by the engineer, and the gray are filled in automatically via formula. Every factor is equally important relative to itself, so diagonal elements are “1”. In contrast, in the above example, Factor #1 (I/I % capture) is deemed moderately more important than Factor #4 (reported downstream Wet SSO #) and assigned a value of “3” in the cell in the first row and third column. Note that the importance of factors in gray below the diagonal are reciprocals of those above the diagonal and are automatically computed (in the above example Factor #4 is 1/3 as important compared to Factor #1, as shown in the cell in the third row and first column).

The mathematics behind the AHP permits translating these pairwise comparisons to relative weights and allows for the detection of inconsistences in the pairwise comparisons. For example, an inconsistency occurs when Factor #1 is deemed more important than Factor #2 and less important than Factor #3, but Factor #2 is deemed more important than Factor #3. With more factors, such inconsistencies are more easily encountered and the AHP allows one to correct these.

The result of four engineers performing these pairwise comparisons is multiple candidate factor weightings. Each individual’s evaluation is accompanied by two measures of inconsistency, and these are used to combine the individual weights into a final set of weights. The more inconsistent an individual’s rankings, the less their resultant weights contribute to the final weightings.

The final weightings developed from the individual weights through pairwise comparison are shown in Table 8.

Table 8. Flow Basin Prioritization Final Weightings

Risk Factor	Weight
I/I, % Capture	19%
Reported Wet SSO, # per mile	21%
Reported Wet SSO, volume/inch-diameter-mile	19%
Reported Wet SSO Downstream, #	7%
Modeled SSO, #/AC	21%
Modeled SSO, Volume/AC	7%
Modeled SSO Downstream, #	6%

Each basin is ranked relative to the others for each factor, with ties assigned the average value of all rank positions involved. Thus, if two basins are tied for what would be positions 11 and 12, they are assigned the average 11.5. Ranks are weighted then summed. The results of the weighted ranking are shown in Figure 11. Gray basins are excluded due to existing Phase I plans that are beyond 70% design or engineering review.

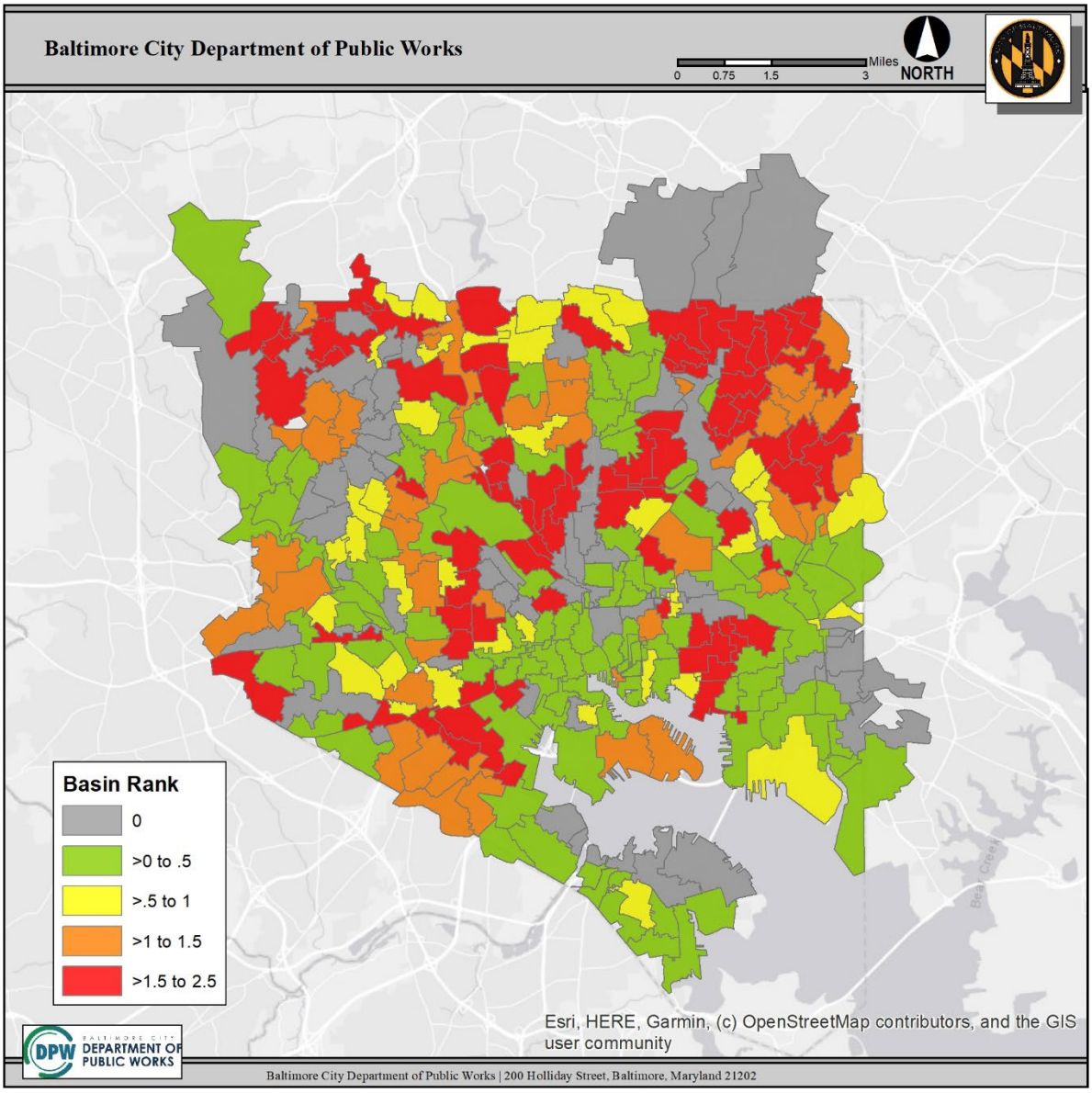


Figure 11. Flow Basin Prioritization Weighted Rankings

To determine the degree to which changes in weights impact ranking, the City performed a sensitivity analysis. All weights determined by the AHP method were varied randomly, first between ±10% then between ±20%, and the corresponding change in rank was recorded. This process was repeated multiple times and the median change in rank noted. Results are shown in Table 9.

Table 9. Weighting Sensitivity Analysis

Median % Variation in Random Weights	Median % top 100 within 10 places of original rank	Median % top 50 within 10 places of original rank	Median # out of top 100	Median MAX rank change of top 100	Median MIN rank change of top 100
±10%	96	98	2.5	10.5	11
±20%	84	91	5	21	26

For a median variation in weight of ±10%, some 96% of the top ranked 100 basins did not change rank by more than 10 places, while 98% of the top ranked 50 basins did not change rank by more than 10 places. Furthermore, the median number of top 100 ranked basins that dropped out of the top 100 was 2.5. The median largest increase in rank was a jump of 10.5 places, and the median largest drop in rank was 11 places. For a median variation in weight of ±20%, the change in rank observed is greater, but still quite reasonable. Some 84% of the top ranked 100 basins did not change rank by more than 10 places, while 91% of the top ranked 50 basins did not change rank by more than 10 places. Furthermore, the median number of top 100 ranked basins that dropped out of the top 100 was 5. The median largest increase in rank was a jump of 21 places, and the median largest drop in rank was 26 places.

The weighted ranking approach has limitations in that it does not capture all the subtleties of the basins' hydrology, hydraulics, connectivity, up-to-date county flows, and overall network configuration. Therefore, to finalize the prioritization, the City conducted an additional ranking process based on engineering review as described below.

8.9.1 Engineering Review #1

Under this review the following two factors were considered for basin ranking:

- Wet SSO Impact Factor from actual reported wet SSOs since 06/30/2015 to 10/07/2022
- Flow Peaking Factor from actual flow meter data from 12/01/2020 to 11/30/2021

The Wet SSO Impact Factor was a measure of the presence of SSOs in the basin or the likelihood that the basin contributes to major overflows downstream. The factor was set to a number between 0 and 5. Basins that experienced wet SSOs received a 5. Basins that were upstream of wet SSOs received scores of 4 or less with the score decreasing the further away the basin was from the SSO or cluster of SSOs. If there were no SSOs downstream of the SSOs, the basin received a score of zero.

The Flow Peaking Factor was also set to a number between 1 and 5. For basins with actual flow data, a nominal average peaking factor was calculated as the peak flow divided by the average daily flow. These were then grouped so that any nominal peaking factor of ten or greater was allocated a score of 5, five to ten was allocated a 4, four to five a 3, three to four a 2 and zero to three a 1. If there were basins

upstream of a meter that did not have meters of their own, their scores were assigned by subtracting 0.5 from the score of the downstream meter. Basins that were not monitored that were not upstream of a meter were assigned an assumed score of 2.2.

The Wet SSO Impact Factor was added to the Flow Peaking Factor to yield a final overall score and the basins were ranked with the highest score being the worst. It should be noted that for basins where there were clusters of large SSOs on interceptors, these basins were ranked lower as the source of I/I is most likely from upstream basins.

Basins that themselves did not show high percent capture or peaking factor, and/or whose downstream basins did not have reported wet weather SSOs were ranked lower. Basins with high peaking factor and/or high I/I that contributes to actual wet in-basin or downstream basin SSOs were ranked higher.

8.9.2 Engineering Review #2

Under this review, the following factors were considered for basin ranking:

- Status of rehabilitation (% sewer design/as-built)
- Boundary basins
- Basin I/I
- Reported wet SSOs
- Qualitative assessment of Flow meter data and model calibration
- SSOs caused by conveyance as predicted by model

All basins above 70% design or as-built, as well as the County basins, were excluded under this review. The basins with low I/I but high reported SSO volume or reported SSO count were assigned a non-I/I designation (e.g., caused by blockage or conveyance restrictions) and not considered for I/I reduction. The quality of flow meter data was assessed in conjunction with the basin I/I and the calibration of the basins. This assessment and the weighted ranking presented above were used to refine the basin ranking.

8.9.3 Final Combined Basin Ranking

The basin rankings described in the above three subsections were then combined to form a final ranked list as follows:

- All basins above 70% design or as built were excluded in the final ranking
- Basin ranks under each of the three ranking systems (weighted ranking, engineering review #1, and engineering review #2) were grouped into six categories numbered 0-5, with 5 assigned to the top 50 basins under each ranking, 4 assigned to the next 50, etc. A score of 1 was assigned to basins ranking lower than 200 (out of 319 basins). A score of 0 was assigned to basins under all rankings that are to be excluded due to ongoing capital work (> 70% design) or engineering judgement. Basins assigned to conveyance solutions under engineering review #2 were assigned a score of 3. The result is that each basin has a score of 0-5 for each ranking system.

- For each basin, the score based on the weighted ranking system is multiplied by ½ and added to the scores derived from engineering review. Thus, the weighted ranking is assigned a lower

weight relative to the rankings derived from engineering review as these latter build on the former by considering more detailed model results as well as basin and network characteristics.

Figure 12 shows the three basin rankings despite uncertain information, with red representing the highest ranking and green representing the lowest. Gray basins represent those that have been excluded. The basins symbolized in red and orange are the top two tiers in the final combined ranking, totaling 107 basins. The engineering rankings (rankings 2 and 3) can be seen to be very similar, and the top tiers of the final ranking is representative of all three ranking approaches.

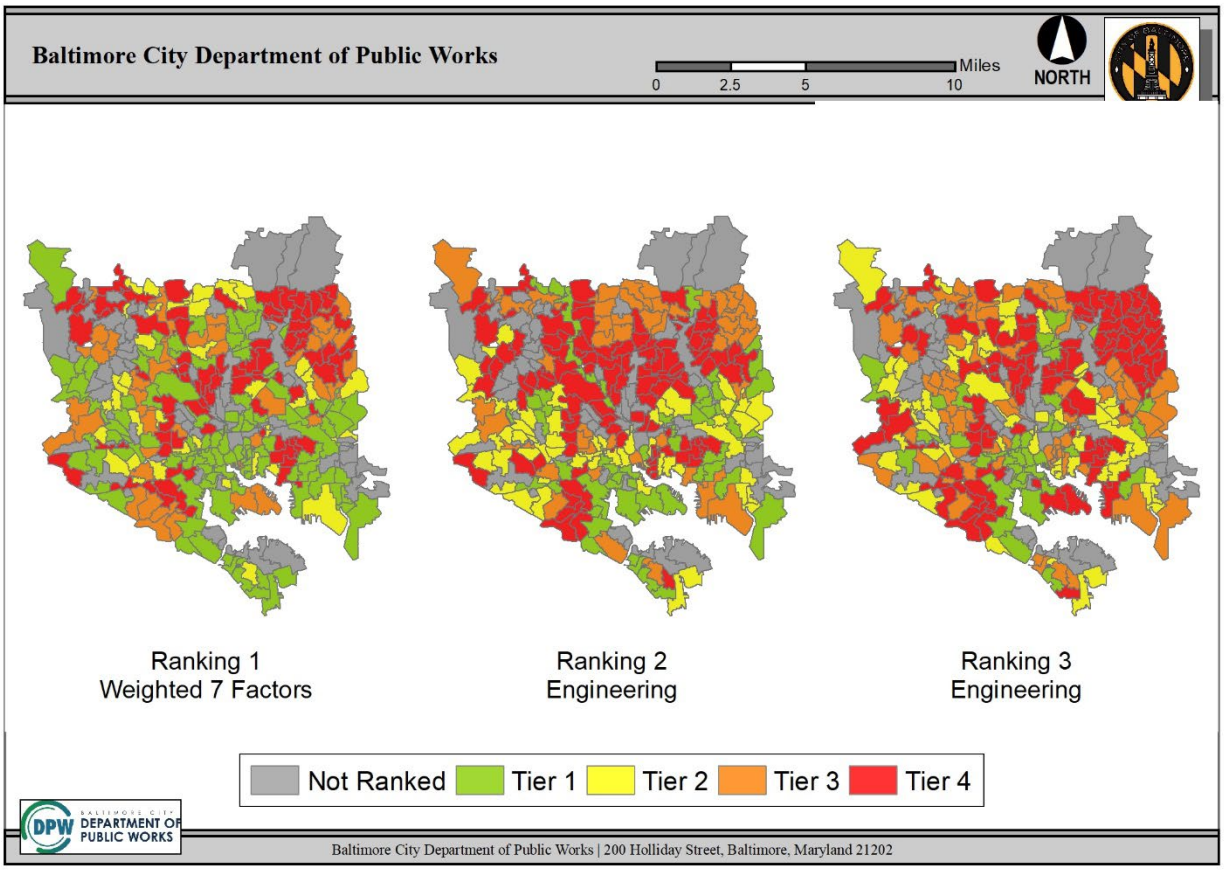


Figure 12. Basin Ranking by Method

The final ranking is shown in Figure 13, with the top two tiers (red and orange) highlighted in cyan.

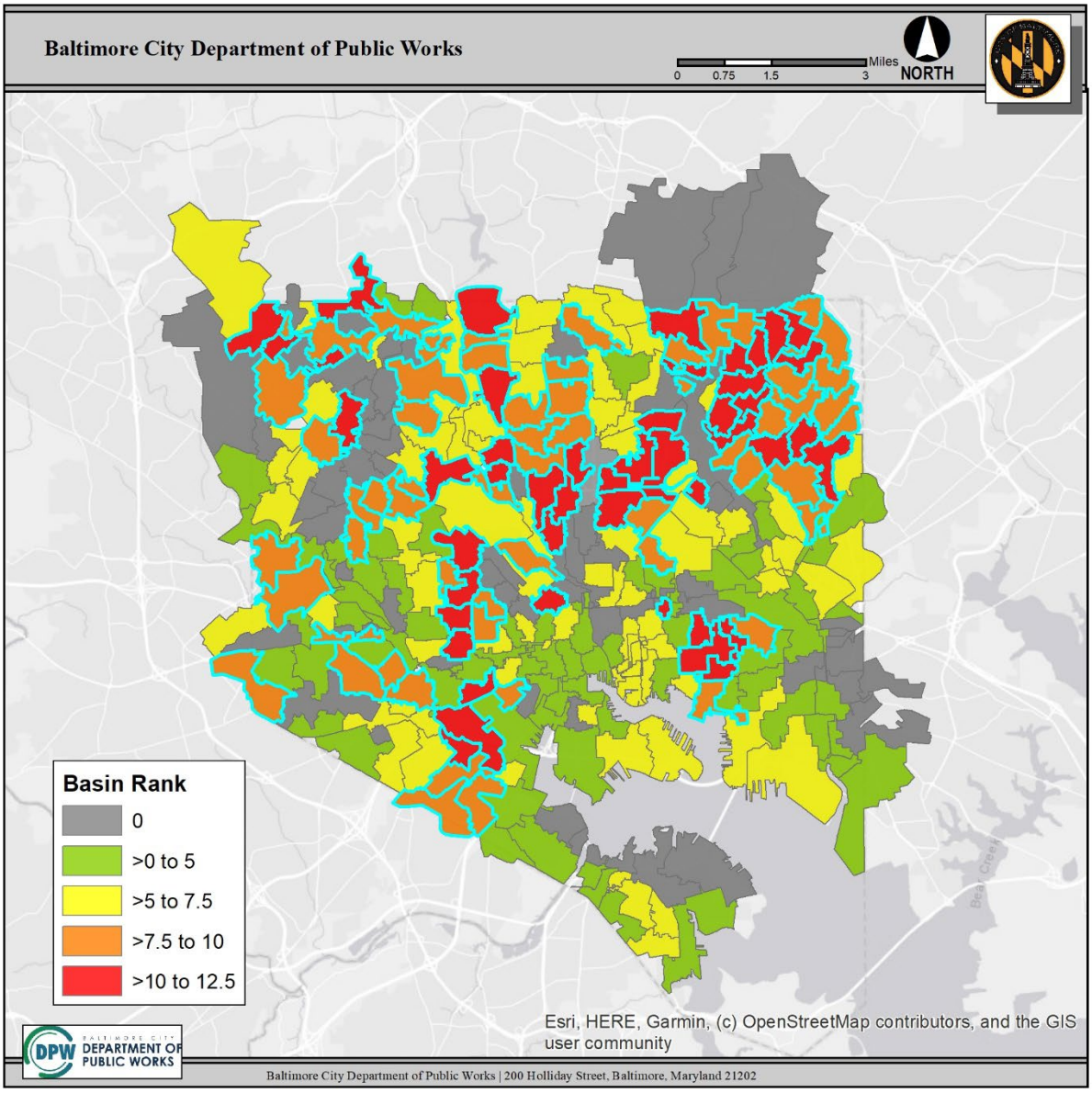


Figure 13. Overall Final Flow Basin Priority Ranking

The initial assessment of alternatives at the time involved running the model under I/I reduction in these basins (less than those assigned a conveyance intervention in engineering review #2) to ensure compliance.

9 Adaptive Management Approach

In several locations, the MCD pays tribute to the concept of adaptive management in relation to the overall long-term process of achieving the goal of reducing and eliminating SSOs. As a WHEREAS clause, the MCD states (MCD at p. 3, WHEREAS) that, *through a phased adaptive management approach, Baltimore will focus on rehabilitation projects [and correction actions] where they will most effectively address sanitary sewer overflows.* The literal intent of the adaptive management process is the two-step sequence of accomplishing the suite of projects identified in Paragraph 8 / Appendix A (plus newly discovered SSO structures), along with the Phase I projects identified in Paragraph 9 / Appendix B, followed by definition and the implementation of a Phase II Plan to accomplish what remains to achieve MCD LOP. However, the City has adopted a more figurative approach that seeks to continually gain as much knowledge as possible and, where new information or analysis contributes to improvement, adaptively implement. Several examples will clarify this point. Section 8 discusses assumptions that contribute to the City's estimate of how well Phase II I/I rehabilitation projects will perform: future condition sewer deterioration rates and I/I reduction. Should early Phase II activities perform below or above these estimates, the City will coordinate with regulators and stakeholders to propose an increase or decrease in the magnitude, sequence, or priority of Phase II activities. A similar variable that will provide insights to the Phase II Plan is the ultimate benefit of the multi-year large diameter interceptor cleaning project that is currently ongoing and will continue well into 2023.

10 Decision-Making Criteria for Potential Capital Projects [9.c.(v)(b)]

10.1 LOP Performance

Notwithstanding the city's forward-thinking and advanced approach to maintenance-related activities of the sewer system, the City may evaluate other possible system improvement needs to achieve MCD LOP, such as, rehabilitation projects. If so, the below key performance metrics are evaluated to make those decisions:

- Reduction in extraneous I/I
- Reduction in SSO frequency and/or volume. This could improve one or both of SSOs in proximity or those further downstream that are affected by upstream improvements
- Improved conveyance through relief of identified bottlenecks, such as insufficient pipe diameter or slope as well as instances where a small diameter pipe transitions into a larger diameter pipe and/or a steeper slope pipe transitions into a milder slope pipe

10.2 Cost

10.2.1 Basin Rehabilitation Costs

The City has a wealth of bid data for rehabilitation projects from Phase I and even before. This data was used as the basis for developing rehabilitation unit costs. In addition, the following assumptions were made to finalize the costs:

- Includes pre- and post-CCTV
- Lateral lining (up to 4 feet from connection with the main)
- Material testing
- Mobilization/demobilization costs at 2%
- Local sales and use tax at 6%
- Small tools, equipment, and consumables at 3.5%
- General conditions at 8%
- GC Overhead and Profit at 10%
- Permits, insurance, and bonds at 2.2%
- Wage rates are based on prevailing wage rate
- Contingency, liquidated damages, and other fees are excluded.

Table 10 displays the costs used for CIPP per size pipe. Manhole rehabilitation costs are estimated at $3,820 per manhole.

Table 10. CIPP Rehabilitation Costs

Pipe Diameter (Inch)	Cost $/LF
8	$53.83
10	$64.38
12	$81.28
15	$101.33
18	$130.88
20	$137.22
24	$147.78
30	$229.04
33	$268.10
36	$291.33
42	$310.33
48	$374.52
54	$421.33
60	$468.14
66	$514.96
72	$585.18
78	$633.95
84	$710.02
90	$760.73

10.3 Equity

The City has developed a robust equity-based analysis and prioritization tool based on key principles adopted by the City. This tool is a decision-support system that incorporates social, environmental, economic, and operational aspects applied to viable performance-based alternatives to assess and prioritize water, stormwater, and wastewater projects through a social equity lens. It facilitates project prioritization frameworks that includes studying the social, environmental, economic, and project implementation dimensions of a water/stormwater/wastewater project through the social equity lens necessary to enhance the current evaluation of such projects.

The tool incorporates all components included in the recently promulgated Infrastructure Investment and Jobs Act (IIJA) as well as new guidance on equity considerations based on the Justice40 Initiative required for projects to be eligible for funding from IIJA and other Federal sources.

10.4 Implementation Challenges

Implementing Phase II planned projects could result in various inconveniences to local communities, agencies, and businesses. The City maintains a Communication and Coordination Plan, designed to identify those who are impacted and outline a strategy to communicate and coordinate activities to minimize inconveniences and maintain daily operations where possible. In particular, the City strives to work with specific communities, such as those that observe specific and unique holidays, and ensure that they are minimally inconvenienced by infrastructure improvement activities.

10.4.1 Alignment/Routing Conflicts/Impediments

10.4.1.1 Infrastructure

Phase II projects will include a variety of different construction activities that will impact infrastructure throughout the City on varying levels. During the early stages of planning, the project team will identify impacted infrastructure and the level of impact. This will allow the team to develop a strategy to mitigate and avoid any interruption on daily operations and access, particularly for critical businesses such as hospitals, schools, clinics, police and fire stations, and assisted living/retirement homes.

The strategy will also identify points of contact for each infrastructure and outline a communication plan throughout the design and construction.

10.4.1.2 Transportation

Most Phase II projects will take place in public Right-of-Ways (ROW), which include City streets, roadways, alleyways, and sidewalks. This means a higher level of coordination is needed to streamline design reviews, permitting, access, and contractors operating in the public ROW.

The DPW will establish a plan and a vehicle to streamline a plans and specs review process between DPW project teams and various Department of Transportation (DOT) departments, divisions, and sectors. This will achieve multiple goals:

- Start the review early
- Coordinate a transparent review where comments can be reviewed and addressed between various parties
- Streamline responses, approvals, and permits

The project team will start the process early, especially for pipeline corridors where work is taking place in emergency, evacuation, and snow routes, as well as major roadways. This will allow the project team to discuss potential alternatives and develop an adequate Maintenance of Traffic (MOT) plan to minimize impacts on travelers.

10.4.1.3 Environmental

The DPW will work diligently and prioritize minimizing environmental impacts of Phase II projects. The impact and disturbances associated with pipelines crossing waterways, wetlands, and streams will be mitigated and avoided. If any Phase II pipeline corridor includes such an impact, it will be identified during the early planning state and the project team will work on two parallel paths:

- Identify ways to mitigate:
    - Trenchless technologies
    - Alternative route
- Communicate with the City or State permitting agency to:
    - Identify any applicable permits that need to be obtained
    - Identify ROE and land acquisition, if necessary
    - Identify stakeholders and start the process early

10.4.1.4 Cultural

The DPW does not foresee Phase II implementation to have any impact on cultural or historical assets and infrastructure. During the planning phase, if it appears that any cultural or historical assets will be impacted by a Phase II project, the City will identify possible alternatives and a way to avoid any impact through trenchless pipeline installation. If alternatives are not feasible, the City will communicate with the Maryland Historic Trust very early in the planning stages to discuss and identify actions required to mitigate impact and acquire any necessary permits.

11 Phase II Corrective Actions and/or Potential Rehabilitation Projects to Meet LOP [9.c.(v)]

11.1 Phase II Plan

11.1.1 Progressive Maintenance Activities

The City will advance its maintenance-related activities in order to proactively reduce the potential for blockages through a forward-thinking and a superior preventative maintenance program. An intensive analysis of observed SSO events recorded between 2003 and 2022, categorized as wet-weather derived, found that 81% of them were in fact related to blockage issues. Also, 97% of the blockage-related SSOs were on pipes 20" and less. This focused approach on O&M, especially on smaller pipes, will lead to substantial reductions in SSOs, will inform further enhancements to the City's asset management risk-based improvement prioritization program, and will identify instances of needed repair or rehabilitation that will be incorporated into capital projects.

The City is fully compliant with MCD paragraph 13 requirements. However, in light of recent findings related to the number and type of blockage-related SSOs, the City is re-evaluating and refining its overall maintenance program. The City will engage more proactively with regular CCTV and manhole inspection, acoustic inspection, chemical root control, and targeted cleaning. The City will also focus, as part of its inspection program, more comprehensively on the extent to which laterals are or may be contributing to I/I.

In addition to its regular maintenance activities, the City is reviewing and updating its risk-based asset management program. Asset management is not a one-time activity but rather a program for integrating detailed asset information and data to enhance asset-related decision-making at all levels of the organization. It is an integrated process that combines the skills, expertise, and activities of people with information about a community's physical assets and finances so that informed decisions are made to support sustainable service delivery. The program identifies the City's current practices and assures that an appropriate approach is in place for achieving desired outcomes.

11.1.2 Potential Other Projects

In parallel with the advance maintenance and related activities, there may be other projects needed as part of the Phase II Plan to meet the MCD LOP requirements.

The Phase II Plan presented in this report identifies projects contributing to achieving MCD LOP that will begin immediately. These projects will invest in rehabilitation and replacement of sewerage assets in basins that are most prone to extraneous I/I that contributes the most to SSOs. However, the City will continue to assess these possible projects to ensure they are needed, or whether the purpose of the possible projecs will bring added value to the wastewater collection system. Strategically and cost-effectively, performing advanced maintenance is the most optimal solution for reducing separate sanitary sewer wastewater collection system SSOs given the 90% reductions in SSOs the City has achieved. This advanced approach will remove the cause of the problem rather than store and/or

directly move the problem downstream to contribute to additional challenges, as well as incur energy and treatment costs.

11.1.3 LOP Challenges

There are several challenges that preclude the City from estimating all activities that may be needed to achieve full LOP compliance. Most prominent is the fact that the County has not yet fully established the characteristics of its future flows (and the population growth) that will need to be considered in relation to the impact that such flows will have on City conveyance infrastructure needs for 2030. While the City embarks on appropriate and high return on investment I/I rehab projects, it will in parallel continue the effective dialogue with the County to determine the most appropriate plan to manage their estimated flows as they progress their planning. The City's optimal and forward-thinking activities will be the maximum achievable given City resources, the County's uncertain forecasts, and local/regional contractor capacity that is constrained because of the amount of work to service other regional consent decrees and the infusion of federal and state funds for infrastructure replacement and renewal.

11.1.4 I/I Rehabilitation

Using the methodology laid out in section 8.9.3 of this report, the City identified the top 48 basins for rehabilitation as part of Phase II. These 48 basins represent the highest return on investment in terms of I/I volume reduction per dollar spent. The resulting rehabilitation projects are broken down per sewershed area in Table 11. The linear footages shown below represent a worst case scenario. The City will be reducing I/I through a targeted approach by rehabbing or replacing assets which have been identified with a defect through the City's O&M program.

Table 11. Top Priority Basins Identified for Rehabilitation by Sewershed

Sewershed	# of Basins for Rehab	Rehab Length (LF)
Gwynns Falls	1	36,596
Herring Run	19	474,109
High Level	5	140,921
Jones Falls	16	391,131
Low Level	6	162,053
Outfall	1	8,633
Grand Total	48	1,213,442

11.1.5 I/I Rehabilitation Performance

The 2030 baseline model results are shown in Table 12 in terms of frequency and volume of SSOs.

Table 12. Pre-Rehab Baseline 2030 Scenario Frequency and Volume of Estimated SSOs

	Baseline 2030 Conditions Model - Sensitive > 2 Before Rehab	Baseline 2030 Conditions Model - Non-Sensitive Area > 4 Before Rehab	Total
Number of Manholes Overflowing	74	50	124
Overflow Vol (mg)	148	66	214

There will be two types of construction rehab contracts, Accelerated Design (AD) and Design-Bid-Build (DBB). AD contracts are for areas with minimum permitting, private property encroachment, and environmental impact. These contracts will require minimum plans and design work while DBB contracts require full design plans, specifications, and lengthy permitting.

The proposed Phase II construction projects are planned to be procured in three groupings. The first group of projects to be procured and constructed will consist of AD areas. The performance for these projects is shown in Table 13 in terms of count and volume of SSOs.

Table 13. Group 1 Baseline 2030 Scenario Frequency and Volume of Estimated SSOs

	Baseline 2030 Conditions Model - Sensitive > 2 After Rehab	Baseline 2030 Conditions Model - Non-Sensitive Area > 4 After Rehab	Total
Number of Manholes Overflowing	63	37	**100**
Overflow Vol (mg)	120	50	**170**

The results above indicate a 15% reduction in the number of SSOs and an 19% reduction in the SSO volume in the sensitive areas, and a 26% reduction in the number of SSOs and a 24% reduction in the SSO volume in the non-sensitive areas. Figure 14 displays a map of remaining SSOs in sensitive and non-sensitive areas.

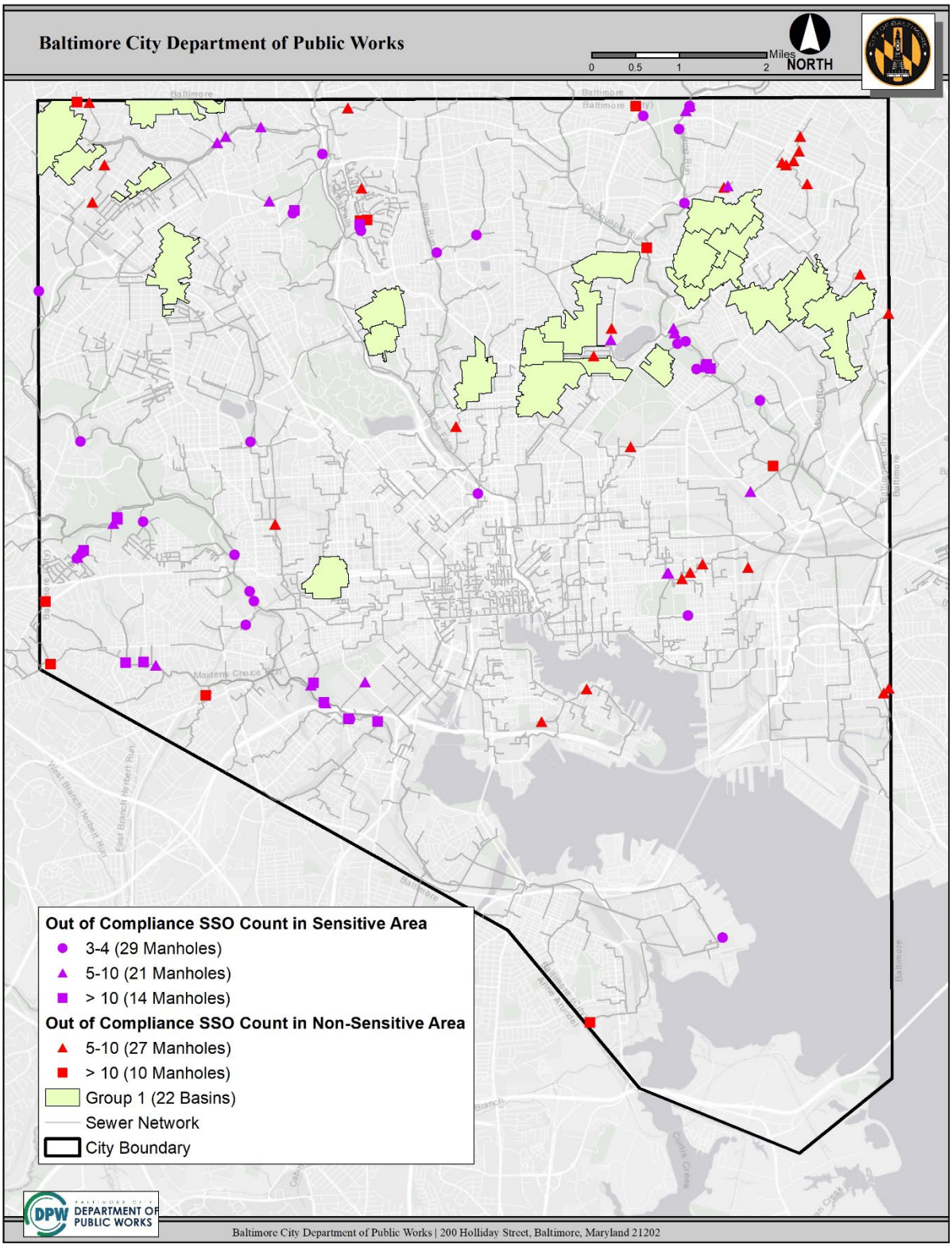


Figure 14. Group 1 Baseline 2030 Scenario Post Rehabilitation Remaining SSOs

The next group of projects to be procured are DBB areas and the performance for these projects are shown in Table 14. The performance assumes both Group 1 and Group 2 projects have been completed.

Table 14. Group 2 Baseline 2030 Scenario Frequency and Volume of Estimated SSOs

	Baseline 2030 Conditions Model - Sensitive > 2 After Rehab	Baseline 2030 Conditions Model - Non-Sensitive Area > 4 After Rehab	Total
Number of Manholes Overflowing	54	30	**84**
Overflow Vol (mg)	82	42	**124**

The results above indicate a 27% reduction in the number of SSOs and a 45% reduction in the SSO volume in the sensitive areas, and a 40% reduction in the number of SSOs and a 36% reduction in the SSO volume in the non-sensitive areas. Figure 15 displays a map of remaining SSOs in sensitive and non-sensitive areas.

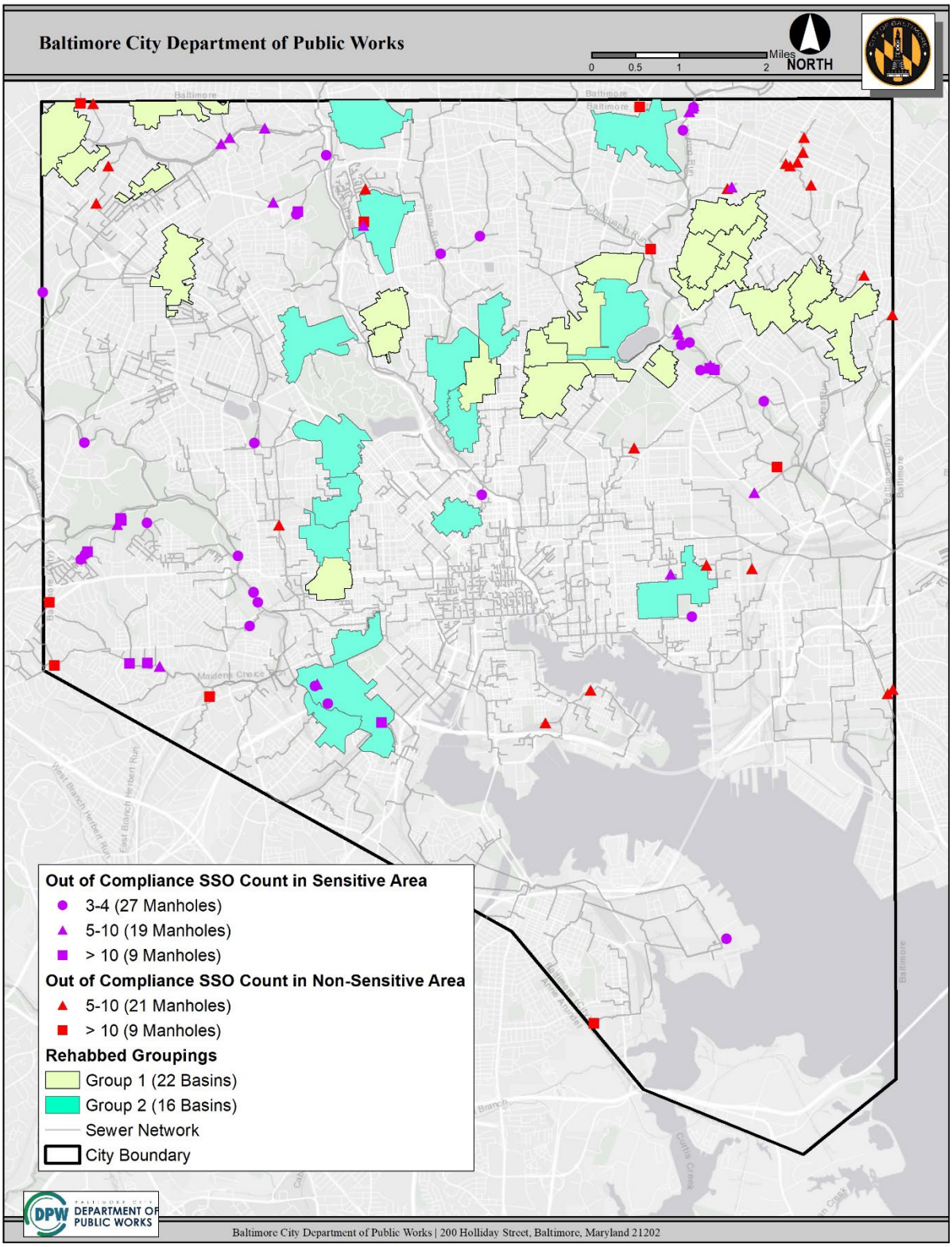


Figure 15. Group 2 Cumulative Baseline 2030 Scenario Post Rehabilitation Remaining SSOs

The third and final group of projects to be procured are the remaining AD areas. The performance of these projects (Group 3) and all the previous projects (Groups 1 and 2) is shown in Table 15.

Table 15. Group 3 Baseline 2030 Scenario Frequency and Volume of

	Baseline 2030 Conditions Model - Sensitive > 2 After Rehab	Baseline 2030 Conditions Model - Non-Sensitive Area > 4 After Rehab	Total
Number of Manholes Overflowing	49	22	**71**
Overflow Vol (mg)	76	38	**114**

The results above indicate an accumulative reduction from the 2030 baseline as follows:

- A 34% reduction in the number of SSOs and a 49% reduction in the SSO volume in the sensitive areas
- A 56% reduction in the number of SSOs and a 42% reduction in the SSO volume in the non-sensitive areas

Figure 16 displays a map of remaining SSOs in sensitive and non-sensitive areas.

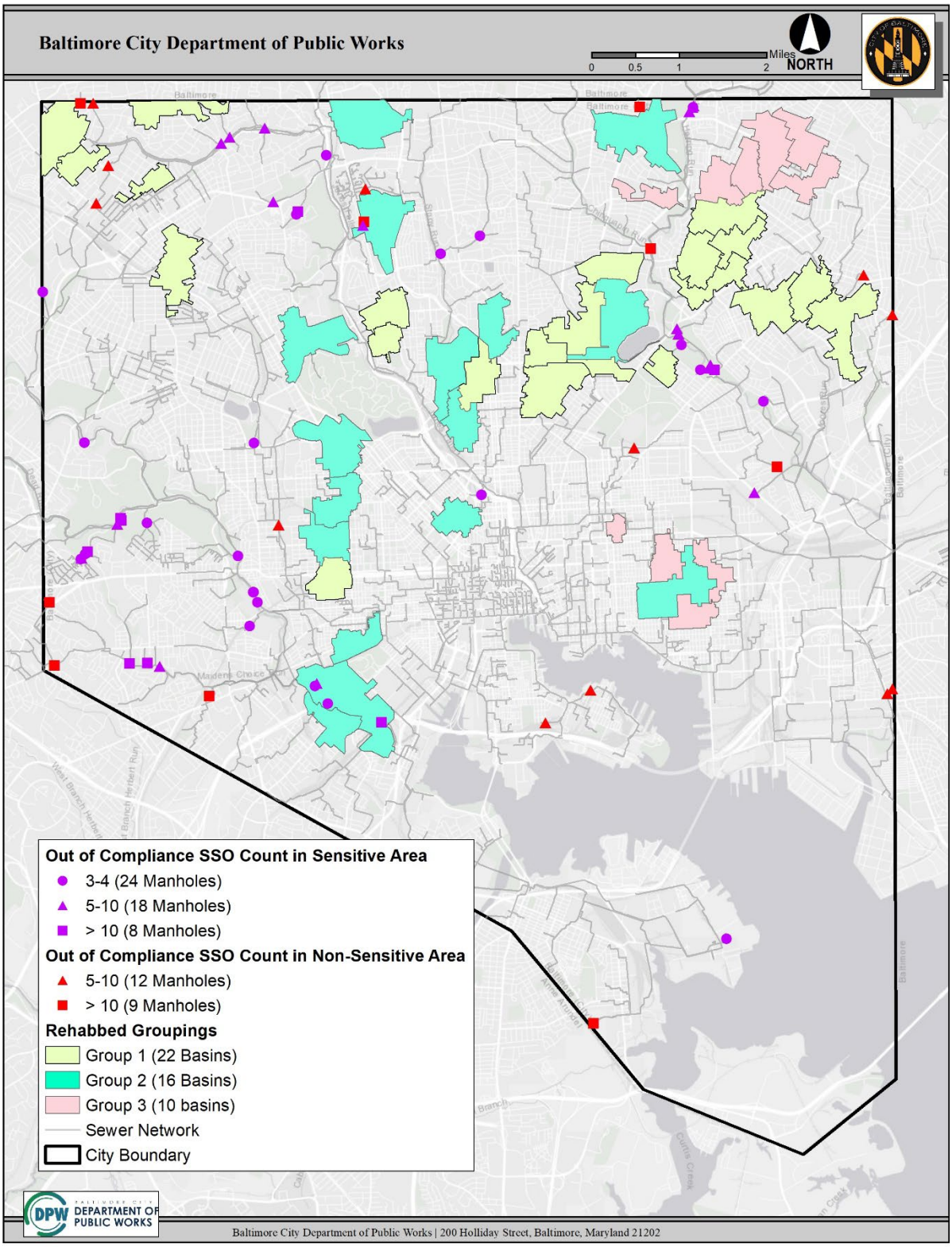


Figure 16. Group 3 Cumulative Baseline 2030 Scenario Post Rehabilitation Remaining SSOs

11.1.6 Sensitive Areas

The MCD [9.b.(ii)] requires that "*Baltimore will submit in the Phase II Plan a revised list of Sensitive Areas to which the 10-year LOP will apply, in accordance with sub-paragraph 9.c(v)(g)*." The City updated the sensitive areas following the MCD's definition of, "*designated Outstanding National Resource Waters, National Marine Sanctuaries, waters with threatened or endangered species and their habitat, waters where primary contact recreation is common, public drinking water intakes or their designated protection areas, shellfish beds, and areas within one hundred (100) feet from a public recreation area, a school, a day care center, a hospital or a similar establishment with potentially sensitive populations*."

Multiple City and State databases were used to update the different lists. The City prepared a report of the revised Sensitive Areas. The report is dated October 10, 2022, and is available under separate cover and by reference. The revised Sensitive Areas is used to determine what areas of the City are susceptible to more stringent SSO frequency criteria.

11.1.7 Map of Sensitive Areas

A map of the revised Sensitive Areas is shown in Figure 17.

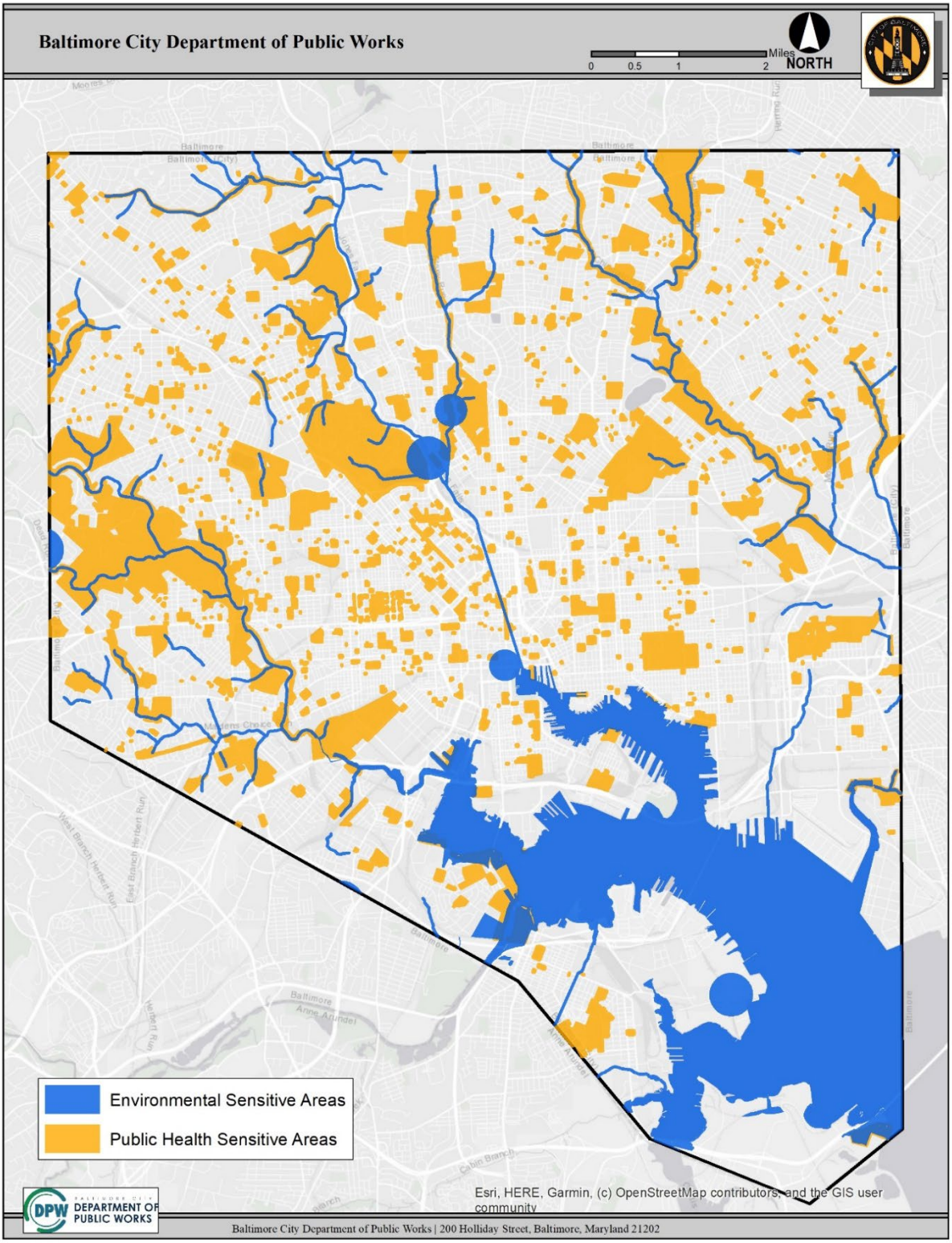


Figure 17. Revised (2022) List of Sensitive Areas

11.2 Location of all Actions [9.c.(v)(a)]

The 48 basins described in Section 11.1.4 are located throughout the City. Figure 18 identifies the location of the I/I rehabilitation basins that comprise the Phase II Plan.

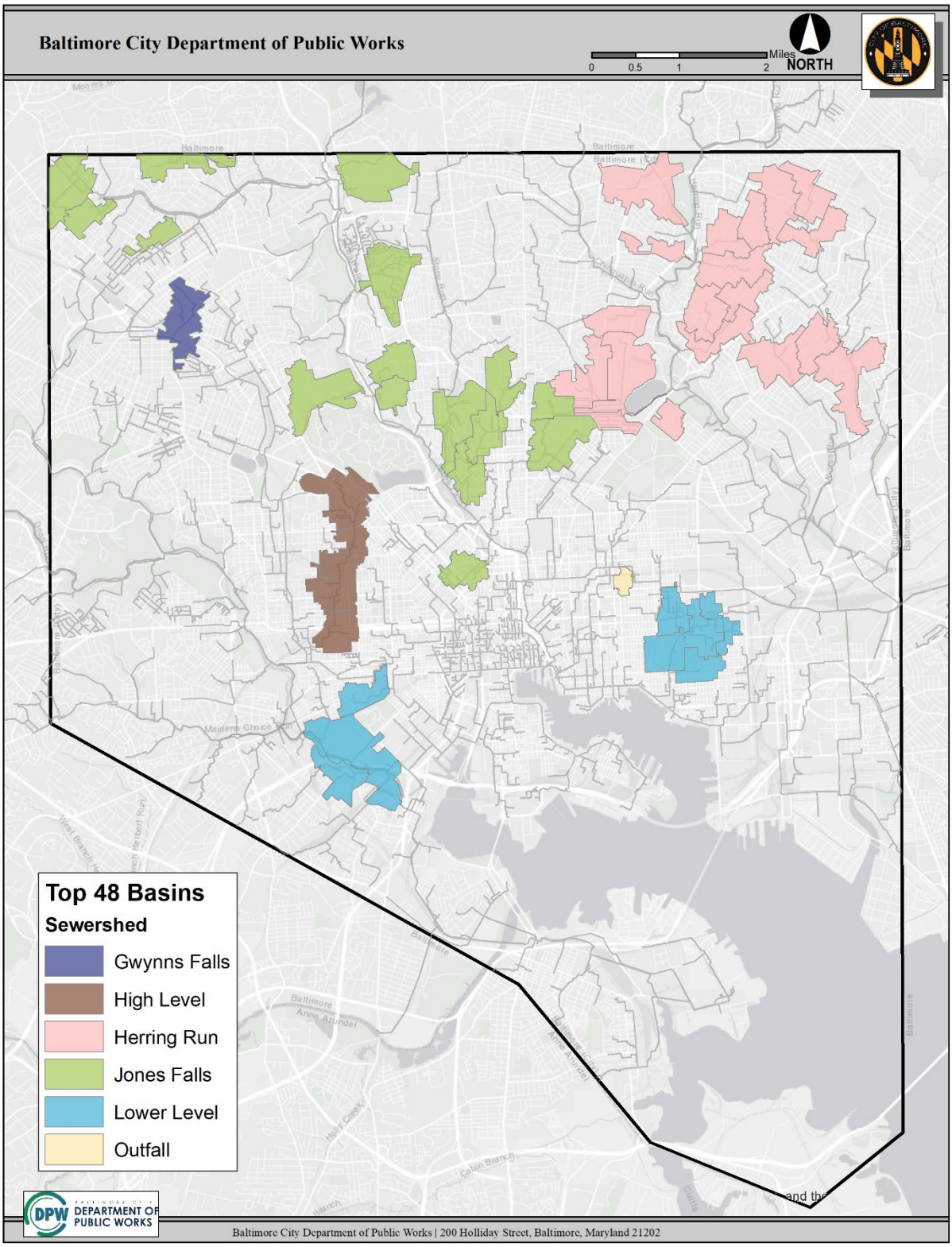


Figure 18. Phase II I/I Plan Rehabilitation Basins by Sewershed

11.3 Sequencing and Schedule [9.c.(v)]

The initial projects within Phase II will be to inspect the basins identified for rehabilitation through CCTV and manhole inspection. From there, design will begin on the rehabilitation work needed within these basins followed by construction implementation.

As described previously, there will be two types of construction rehab contracts, AD and DBB. These contracts will be procured in three phases. The initial contracts to be procured will address the AD areas while the design for the DBB areas is ongoing concurrently. After design is complete, the DBB rehab contracts will be procured as part of the second phase. When the initial batch of AD contracts near completion, another round of AD contracts will be procured as part of the third and final phase.

11.4 Prioritization Scheme [9.c.(v)(c)]

The 48 basins were prioritized and grouped into the three phases of contracts using the following criteria:

- Basin ranking described in 8.9.3 of this report
- AD/DBB designation
- Geographic location

Using this criteria, the highest ranked AD basins were grouped by geographic location and will be procured as part of the first phase. The highest ranked DBB basins were also grouped by geographic location and will be procured as part of the second phase. A similar exercise was done to group the AD basins as part of the last group of contracts.

11.5 Cost Estimates [9.c(v)(d)]

11.5.1 Design and Construction Management Cost

The breakdown for design and construction management cost is shown below as percentages of construction cost:

- 10% for design and post-award services
- 15% for construction management and inspection
- 5% for project management and administration

The total costs estimated per prioritized project area are shown in Table 16:

Table 16. Total Design and Construction Management Costs per Sewershed

Sewershed	Design, PAS, and CM Cost
Gwynns Falls	$1,494,000

Sewershed	Design, PAS, and CM Cost
Herring Run	$20,226,000
High Level	$6,356,000
Jones Falls	$19,718,000
Low Level	$7,513,000
Outfall	$373,000
Grand Total	$55,677,000

11.5.2 Communication and Public Outreach Costs

Communication and Public Outreach is an integral part of DPW's protocols for all capital projects. The DPW communications and outreach team maintains and updates project fact sheets in coordination with the Office of Engineering and Construction (OEC). These fact sheets are available to the public via the City's website. Furthermore, these fact sheets and other specific as-needed collateral are distributed at public meetings. Specific costs related to these internal DPW efforts are not estimated in relation to Phase II projects.

11.5.3 Construction Capital Costs

Construction costs are broken down in the following table. Construction costs consists of using the unit prices shown in 10.2 plus 35% contingency. The final construction costs consist of the pipe cost plus 25% surface restoration for rehabilitation projects, as shown in Table 17.

Table 17. Pipe Rehabilitation Costs per Sewershed

Sewershed	Rehab Pipe Cost	Final Construction Cost
Gwynns Falls	$2,199,000	$4,980,000
Herring Run	$30,967,000	$67,419,000
High Level	$9,356,000	$21,184,000
Jones Falls	$30,365,000	$65,725,000
Low Level	$11,264,000	$25,041,000

Sewershed	Rehab Pipe Cost	Final Construction Cost
Outfall	$495,000	$1,242,000
Grand Total	$84,644,000	$185,589,000

11.5.4 Operation & Maintenance

O&M Costs can play a significant role in determining the life cycle cost of each asset type. It was assumed the rehabilitation projects will have negligible effect due to renewal of the existing pipe with no additional relief sewer installed.

11.5.5 Total Life Cycle Cost

The total capital costs include the asset installation cost, additional contingency, surface restoration and beautification, and design and construction management costs. The percentages of each are summarized below and are reflected in Table 18.

- 35% contingency applied to rehab pipe costs
- 25% surface restoration costs applied to the rehabilitation basins construction cost (pipe + contingency)
- 10% design and post award services cost applied to final construction cost
- 20% construction management and city administration cost applied to final construction cost

Table 18. Total Life Cycle Costs per Sewershed

Project Area	Final Construction Cost	Design/CM Cost	Total Cost
Gwynns Falls	$4,980,000	$1,494,000	$6,474,000
Herring Run	$67,419,000	$20,226,000	$87,645,000
High Level	$21,184,000	$6,356,000	$27,540,000
Jones Falls	$65,725,000	$19,718,000	$85,443,000
Low Level	$25,041,000	$7,513,000	$32,554,000
Outfall	$1,242,000	$373,000	$1,615,000
Grand Total	$185,589,000	$55,677,000	$241,266,000

This total cost of $241M assumes all assets within the chosen basins will require rehabilitation. The City anticipates only approximately 80% of the assets will require rehabilitation at a cost of approximately $200M. This reflects the City's targeted approach of only fixing assets which show defects.

11.6 Non-MCD Related City Expenditures (In competition for limited budgets)

DPW faces many constraints (regulatory, policy driven, and budgetary) on future capital and operating spending for the MCD and other non-MCD initiatives. These limit what the agency can responsibly take on over the next decade due to limited resources and the need to preserve the utility's fiscal health over the long-term.

11.6.1 Capital Spending Within Existing Framework

Existing Debt: DPW's annual debt as a percent of operating revenue is approximately 33% for both the water and wastewater utilities. This is moderately higher than peer utilities in other jurisdictions, which range from 14% to 28% for water and 8% to 31% for wastewater. In addition, DPW's debt service coverage is below average for its AA2 rating and interest rates are rising nationally, so the City's capacity for additional debt to finance capital projects is diminished. Debt usage will be reduced going forward.

Pay-As-You-Go (PAYGO): Utility fund revenues are mostly used for the operating budget, but DPW allocates a certain amount for PAYGO capital each year to minimize debt financing. The intent of PAYGO is to fund smaller, discrete portions of projects, such as studies and design, and to use revenue bonds for construction phase work. For several fiscal years, the City did not include PAYGO in its operating budget but is now increasing its PAYGO capacity. This is necessary to complement the borrowing to maintain the future borrowing capacity in an inflationary macroeconomic environment with higher interest rates. PAYGO spending is intended to be largely focused on study and design work and construction as available.

Customer Rates: Since 1998, DPW's ratepayers have borne rate increases averaging 9.9% per year for water and wastewater. The historical rates are not sustainable. For Fiscal Years (FY) 2023-2025, rates were increased 3.0% for water, 3.5% for wastewater, and 3.0% for stormwater. The most recent rate adjustments represent a 67% reduction from previous water rate increases. The City intended for future rate increases to be inflationary and maintain water affordability.

Other Regulatory Requirements: DPW works to meet several regulatory requirements in addition to the MCD, such as Lead and Copper Rule Revisions (LCRR) for the water utility, Municipal Separate Storm Sewer System (MS4) for the stormwater utility, the Long Term 2 Enhanced Surface Water Treatment Rule (LT2) for drinking water storage, upcoming consent decree for wastewater facilities, and potential mandates in reference to emerging contaminants (e.g., PFAS).

- The EPA finalized the LCRR, which includes requirements to be completed by water systems prior to the compliance date of October 16, 2024. DPW is required to finalize the inventory through field investigation on both public and private infrastructure. This program adds a financial burden in a magnitude of up to $50 million. EPA plans to release further revisions in the form of Lead and Copper Rule Improvements (LCRI) in October 2024, which DPW is anticipating will require spending in a magnitude of up to $400 million for replacements of Lead and Galvanized pipes in the system and facilitate other compliance requirements.
- The existing MS4 permit is effective November 5, 2021, through November 4, 2026. Permit compliance will require an estimated average annual operations budget of $21.6 million to comply with the management and watershed assessment conditions of the permit, plus provide

approximately 8,876 acres of equivalent impervious area restoration from street sweeping, inlet cleaning, elimination of illicit discharges, and redevelopment. Additionally, a capital budget of $126.7M will be required to achieve 1,184 acres of equivalent impervious area restoration by stream restoration, shoreline management, outfall stabilization, bioretention facility installation, land cover conversion, and urban soil restoration.

- To comply with LT2, the City continues to execute two large projects to cover drinking water reservoirs at Druid Lake and Lake Ashburton. These projects are critical to compliance with a federal mandate designed to ensure public health protection. When complete, the City will have spent close to $500M.
- The City is currently in negotiations with MDE to establish a consent decree for improvements to the Back River and Patapsco Wastewater Treatment Plants (WWTP). Although the mandate has not been finalized, the City may need to accelerate its capital expenditures on various improvement projects at the WWTPs.
- The City continues to work with regulators on monitoring and assessment of PFAS in both the drinking water system as well as wastewater/biosolids. Upon finalization of federal regulations, there may be new mandates requiring significant investments on the part of the City to comply with regular sampling, monitoring, and abatement initiatives.

Nonregulatory Requirements: DPW has committed to fully addressing health and safety issues at aging facilities, as well as making proactive investments in infrastructure. For example, DPW is committed to replacing at least 15 miles of water mains each year, which costs at least $2M per mile. DPW also faces unplanned emergencies due to sinkholes (e.g., Montebello I sinkhole in November 2022; North Avenue sinkhole in July 2022) and other weather, emergency, and infrastructure failure events that require significant agency responses.

11.6.2 Alternative Funding Sources

City: The City's charter requires that the water, sewer, and stormwater utilities must be maintained as a self-sustaining operation. The utility does not have readily available access to the City's bond capacity, which is also limited. In FY 2023, DPW revenue bond appropriations were approximately double the City's GO bond and general fund appropriations for capital projects ($314M vs. $157M).

State and Federal: DPW has been successful in leveraging Federal and State programs, such as the Water Infrastructure Finance and Innovation Act (WIFIA) and State Revolving Fund (SRF), to fund capital investments. However, these funding sources are already assumed to be fully utilized in existing agency capital planning. New federal government programs, IIJA and the Inflation Reduction Act (IRA), represent new opportunities for support for DPW, but it is not possible to forecast exactly how much DPW will receive in future years and most of these awards are expected to be competitive.

11.6.3 Conclusion

DPW must be thoughtful and strategic in deciding which capital projects are implemented to maintain long-term fiscal health and sustainability. Multiple constraints, as outlined in this document, demonstrate a great demand on future capital and operating spending combined with limited ability to raise capital sustainably.

11.7 Affordability

11.7.1 Equity and Financial Capability

The City has invested in developing a support tool to evaluate the equity aspects of capital project financial planning. This tool enables a comprehensive and thorough estimate of equity considerations across the City and the impacts that capital projects may have. The City intends to use this tool to further evaluate the financial and social aspects of the MCD Phase II Plan, especially in the context of EPA's evolving efforts to update and refine their Financial Capability Assessment Guidance, a synopsis of which is provided below:

EPA prepared guidance in 1997 entitled "Guidance for Financial Capability Assessment and Schedule Development." The 1997 EPA Guidance contains a two-phased assessment approach. Phase I examines affordability in terms of impacts to residential households. This analysis applies the Residential Indicator (RI), which examines the average cost of household water pollution costs (wastewater and stormwater) relative to a benchmark of two percent of service area-wide Median Household Income (MHI). The results of this preliminary screening analysis are assessed by placing the community in one of three categories:

1. Low economic impact: Average wastewater annual costs are less than one percent of MHI
2. Mid-range economic impact: Average wastewater annual costs are between one percent and two percent of MHI
3. High economic impact: Average wastewater annual costs are greater than two percent of MHI.

The second phase develops the Permittee Financial Capability Indicators, which examine several metrics related to the financial health and capabilities of the impacted community. The indicators are compared to national benchmarks and are used to generate a score that is the average of six economic indicators: bond rating; net debt; MHI; local unemployment; property tax burden; and property tax collection rate within a service area. Lower Financial Capability Indicators (FCI) scores imply weaker economic conditions, and thus the increased likelihood that additional controls would cause substantial economic impact.

The results of the RI and the FCI are then combined in a Financial Capability Matrix to give an overall assessment of the permittee's financial capability. The result of this combined assessment can be used to establish an appropriate CSO control implementation schedule.

In November of 2014, EPA released its "Financial Capability Assessment Framework" (2014 EPA Framework), clarifying the flexibility within its CSO guidance. Although EPA did not modify the metrics established in the 1997 EPA Guidance, the 2014 EPA Framework reiterates that permittees are encouraged to supplement the core metrics with additional information that would "create a more accurate and complete picture of their financial capability" that may "affect the conclusion" of the analysis.

The Proposed 2022 Financial Capability Assessment (FCA) incorporates aspects of the 1997 Guidance and the 2014 FCA and is intended to standardize what EPA plans to consider when determining a community's financial capability to implement control measures needed to meet CWA obligations.

Objections by Municipalities and Utilities to the 2022 FCA generally revolve around the following four points:

1. The 2022 Proposed FCA Guidance eliminates most of the substantive policy and methodological improvements included in the Proposed 2020 FCA Guidance (withdrawn in January of 2021) that were called for by a broad array of stakeholders – not just utilities – and by the congressionally mandated, independent review of the 1997 guidance by the National Academy of Public Administrators (NAPA)
2. The 2022 Proposed FCA guidance no longer considers financial impacts on low-income households and suggests that consideration of low-income households should be limited to amplifying measures of the prevalence of poverty
3. The 2022 Proposed FCA guidance imposes a new requirement on utilities to conduct a Financial Alternatives Analysis. The EPA states that it does not intend to approve extended compliance schedules or water quality standard relief unless the community demonstrates it has taken all feasible steps to reduce or mitigate financial impacts on low-income households. This demonstration is to be accomplished through completion of a Financial Alternatives Analysis checklist composed of over 25 questions broken into four categories:

    - Financing options for capital costs
    - Rate design
    - Ratepayer support options for lower income residential customers
    - Financial and utility management

4. The 2022 Proposed FCA guidance also reverts to the use of arbitrary scheduling boundaries, notwithstanding the fact that these scheduling boundaries are at odds with several noteworthy CDs that are straining permittees' financial capabilities despite the extended schedules granted in those instances. For good reasons, the prescribed benchmarks in the 1997 FCA Guidance have been set aside in numerous CD negotiations where agreed compliance schedules exceed 20 and even up to 25 years

11.8 Community Benefits

The City is aware that major infrastructure investments can provide "spin-off" benefit to the community. In particular, the City's Small Business Development (SBD) initiative described in Section 13 promotes, trains, and supports local contractor and workforce development. Other endeavors that seek to indirectly capitalize on City infrastructure improvement expenditures include the following.

11.8.1 Investing in Neighborhoods and Schools to Promote Improvement, Revitalization, and Excellence (INSPIRE) Program

The Baltimore City Public School System, State of Maryland, and Baltimore City are investing nearly one billion dollars to renovate or replace 28 public schools. These modernized schools will help transform student opportunities and achievement, provide resources to families, and help revitalize neighborhoods.

To leverage this investment, and to enhance the connection between the schools and the surrounding neighborhood, the Department of Planning (DP) launched a program called "Investing in Neighborhoods and Schools to Promote Improvement, Revitalization, and Excellence (INSPIRE)." This program focuses on the neighborhoods immediately surrounding each of the modernized schools that are part of the 21st Century program, specifically the quarter mile surrounding each school. The INSPIRE processes are facilitated by the DP and created and implemented through many City agencies and community partners. For more information, please refer to one of the following links:

- https://planning.baltimorecity.gov/sites/default/files/INSPIRE%20Intro%20Flier_1.pdf
- https://baltimore21stcenturyschools.org/more/inspire

11.8.2 YH20

The Baltimore City Mayor's Office of Employment Development (MOED) and DPW partner with the Chesapeake Water Environment Association (CWEA) to design and operate the YH20 Career Mentoring Program, which prepares young adults for full-time jobs in the water industry.

This program is open to Baltimore City residents, ages 18-24, who have a high school diploma or GED, are unemployed or underemployed, and are not currently enrolled in a job training program or post-secondary education. The City is proud of the 156 young men and women who have successfully completed YH20 since its inception in 2015. For more information, please visit https://publicworks.baltimorecity.gov/water-mentoring-program.

11.8.3 B'More Wise Program

B'More WISE – the Baltimore Water Infrastructure Strategic Education Program welcomed its first cohort in December 2022 during an event in City Hall held on December 8, 2022. B'More WISE provides technical-based training to Baltimore residents dedicated to pursuing long-term careers in the water and wastewater industries as licensed water and wastewater operators. B'More WISE will help DPW build its own homegrown pipeline of qualified talent in the water and wastewater industry. DPW has been working with strategic partners to introduce the program to the Baltimore City School System and area nonprofits to develop the program.

12 Intra- and Inter-Agency Jurisdictional Agreements to Facilitate Phase II Planning and Implementation

This section describes other agencies, either within or external to the City, that the City may need to coordinate with in the planning, design, and implementation of Phase II projects.

12.1 Intra-Baltimore City Agency Agreements and/or Memorandums of Understanding

12.1.1 Intra-DPW

The following DPW divisions will be involved at various levels in the application of Phase II Plan projects.

- Office of Research and Environmental Protection (OREP)
- Office of Engineering and Construction (OEC)
- Office of Asset Management (OAM)
- Utility Maintenance Division (UMD)
- Bureau of Solid Waste (to resolve potential conflicts with Solid Waste routes)
- Office of Communications and Strategic Alliances (OCSA)

12.1.2 Baltimore City Department of Recreation and Parks (BCRP)

BCRP is the City's leading provider of affordable, year-round leisure and recreational activities for all residents, including:

- 51 recreation centers
- 23 public pools
- 120,000 trees
- 4,700+ acres of parkland
- 262 public parks
- 133 athletic fields
- 104 tennis/pickleball courts
- 116 basketball courts
- 32 historic structures
- 25+ miles of biking/hiking trails
- 18 picnic groves
- 12 pavilion groves
- Four dog parks
- Three skate parks

DPW engages with BCRP in the planning and implementation of wastewater collection system infrastructure projects, specifically in relation to:

- Design standards (street cuts, resurfacing, landscaping, bus pads, etc.)

- Project costs estimates
- Project timeline
- Project stakeholder coordination

Phase II projects will impact one or more BCRP properties. When this occurs, BCRP is a critical project stakeholder, and their permit is a crucial piece for projects to move forward.

As part of OEC's practices and procedures, BCRP receives OEC's project design packages and provides comments to be addressed in the next design package. The current permit(s) process involves sending the projects design documents at various design stages to BCRP for review and comments. The process is time-consuming and is vulnerable to inconsistencies due to staff changes or missing documentation between the different design stages and design and construction stages.

The City is evaluating options to:

- Improve the current processes by utilizing communication and document sharing technologies such as SharePoint
- Improve the design process by reviewing lessons learned from previous and current projects and develop a design guideline for the project design team to use

12.1.3 Baltimore City Department of Planning (BCDP)

BCDP is the City agency entrusted with guiding the physical development of Baltimore City. The Department staffs three Mayoral-appointed City commissions:

- Planning Commission
- Commission for Historical & Architectural Preservation (CHAP)
- Sustainability Commission

BCDP has five divisions within the Department, in addition to the Office of the Director and the Office of Sustainability, each with its special focus in support of the mission and the Commissions we serve. Cross-division collaboration is essential to the mission of BCDP:

- Office of the Director
- Office of Sustainability
- Food Policy & Planning
- Community Planning and Revitalization (CPR)
- Land Use and Urban Design
- Policy and Data Analysis
- Historical and Architectural Preservation

BCDP participation in the MCD Phase II CIP projects will be limited to providing the latest plans such as:

- Comprehensive Master Plan
- Department of Housing and Community Development (DHCD) Framework for Community Development
- Neighborhood Plans

- Urban Renewal Plans

The documents will include current and forecasted populations, zoning changes, and planned developments that will be used in the planning and design stages of the Phase II CIP projects.

12.1.4 Baltimore City Department of Transportation (BCDOT)

The BCDOT's mission is to maintain and improve the transportation infrastructure to produce a safe, reliable, accessible, and efficient system for everyone that provides for multiple and sustainable modes of transportation for residents, businesses, and visitors – thereby promoting habitable and vibrant communities across Baltimore City. The BCDOT is responsible for the planning, designing, building, and maintenance of:

- 2,000 miles of roadways
- Seven miles of interstate highways
- 298 bridges and culverts
- 3,600 miles of sidewalks, curbing, and gutters
- 456 miles of alleys
- 72,000 streetlights
- 1,300 signalized intersections
- 250,000 traffic and informational signs

Currently, BCDOT, BCDPW, and Baltimore Gas and Electric (BGE) meet regularly and as needed to discuss ongoing and future construction activities and identify conflict areas where coordination is needed. Those areas are highlighted and communicated with the impacted agencies to further coordinate. Currently, BCDOT is facilitating the meeting.

Additionally, in 2018, Baltimore adopted a new Complete Streets Ordinance (CSO) that will enhance the transportation landscape of the city. The Complete Streets approach will elevate the priority of pedestrians, bicyclists, and transit users in planning and roadway design to increase quality of life and mobility in Baltimore City.

The Complete Streets Advisory Committee (CSAC) meets a minimum of four times per year to discuss the development of the Complete Streets Manual (CSM), propose complete streets projects, and encourage interagency collaboration. The Advisory Committee is comprised of five major city agencies that work within the public Right of Way (ROW):

- DOT
- DPW
- DP
- DHCD
- Fire Department

It is critical to follow up and understand the impact of the CSO on Phase II projects, specifically:

- Design standards (street cuts, resurfacing, landscaping, bus pads, etc.)

- Projects cost estimates
- Project timeline
- Project stakeholder coordination

12.1.4.1 Capital Projects (Resurfacing and Management of Traffic)

Phase II project assets are mostly buried infrastructure under the pavement or sidewalk; therefore, coordinating Phase II projects with BCDOT future capital projects, especially resurfacing, is critically important to achieve two main objectives:

- Limit the impact on City neighborhoods
- Reduce expenses associated with cutting and resurfacing

Additionally, as part of OEC's practices and procedures, BCDOT receives OEC's project design packages. BCDOT reviews the design packages and provides comments to be addressed in the next design package. This allows BCDOT to take notice of OECs upcoming capital projects and their impact on their assets.

Currently, the City is evaluating options to:

- Expand and utilize the monthly coordination meeting currently facilitated by BCDOT to discuss OEC Phase II projects
- Conduct more detailed and specific coordination meetings on Phase II with impacted agencies
- Improve the current processes by utilizing available communication and document sharing tools such as SharePoint
- Improve the design process by reviewing lessons learned from previous and current projects and develop a design guideline for the project design team to use

12.1.4.2 Right of Way

BCDOT requires anyone who is planning on working in the City's ROW to obtain a permit from the Permit Section.

The Permit Section is responsible for issuing temporary Use of ROW permits, New Water Service permits, and the selling of plans and specifications to bidders for City Capital projects. Permits are issued for:

- Driveways and curb cuts
- Curb repairs
- Access to pull wires
- Cranes
- Storage containers
- Street, alley, or lane closures
- Footway permits
- Hauling
- Scaffold
- Dumpsters

- Fences
- Test pits
- Moving trucks
- Film and media equipment
- Street/utility cuts

The permit can be obtained by completing and submitting a ROW permit application to row.permit.documents@baltimorecity.gov.

DPW will follow this procedure for all Phase II projects where such permit is required.

12.1.5 Baltimore County DPW

The County's sewage collection system successfully handles approximately one billion gallons per year through its network of 3,000 miles of pipeline, 116 pumping stations, and 60,000 manholes.

12.1.5.1 Wastewater Coordination

It is not unlikely that a Phase II CIP project may cross City limits to involve County assets. In such events, the City will schedule workshops with the appropriate County staff during the early stages of project scope development. The workshop will be aimed at defining project scope, responsibilities, alternatives, communication protocols, and next steps. If the project scope continues to include work on County assets, the City will continue coordinating with the County throughout all phases and until the work on the County's assets is complete.

12.1.5.2 Future Flow Projections

The City receives and treats wastewater flowing from the County. The City will continue to try to obtain the County's latest flow projections on which the Phase II plan and Phase II projects' design will be based. The flow projection numbers provided by the County will be used during the planning phase and confirmed/updated during the design phase. Those numbers will be critical to adequately size the Phase II conveyance and facilities CIP projects to accommodate the correct future flow projections.

12.1.6 Anne Arundel County

Anne Arundel County operates and maintains nearly 1,800 miles of sewer lines and treats approximately 33.7 MGD of wastewater.

12.1.6.1 Future Flow Projections

The City receives and treats wastewater flowing from northern Anne Arundel County. The City will continue to try to obtain the County's latest flow projections on which the Phase II Plan and Phase II projects will be based. The flow projection numbers provided by the County will be used during the planning phase and confirmed/updated during the design phase. Those numbers will be critical to adequately size the Phase II conveyance and facilities CIP projects to accommodate the correct future flow projections.

12.1.7 Maryland Department of Transportation (MDOT) / Maryland Transit Administration (MTA)

For Phase II pipeline projects that cross or go under MTA's Light Rail tracks or disturb MTA's operations, an MTA permit will be required. The permit review and approval is a lengthy process and requires extensive coordination.

The DPW project team will identify such projects during the planning process and develop alternatives to avoid the need for an MTA work permit. If none of the alternatives are feasible, the team will coordinate with MTA from early stages of design to ensure permits are acquired in a timely manner.

12.1.8 United States Army Corps of Engineers (USACE) Baltimore District – Potential construction in wetlands/floodplains

A USACE Joint Permit Application (JPA) will be required for MCD Phase II projects that involves working in Maryland waterways. The JPA process and forms are used by the USACE for permitting purposes involving tidal and/or non-tidal water, tidal and/or non-tidal wetlands, and/or dune/beach resources including, but not limited to, construction, dredging, filling, or excavation.

There are two different JPAs available depending on the type of activities proposed in the project scope of work:

- If the project impacts tidal waters, wetlands, or dunes/beaches in the tidewater area of Maryland, it may be eligible to use the Tidewater JPA, an abbreviated version of the JPA. Activities eligible to use the Tidewater JPA include piers, boathouses, boat ramps, moorings, marinas, aquaculture facilities, riprap revetments, bulkheads, marsh toe stabilizations, breakwaters, beach nourishment, groins, jetties, road crossing over tidal waterways, and utility lines over or under tidal waterways
- Dredging and excavation projects in tidal waterways/wetlands MUST use the Standard JPA

The project team will apply and secure the appropriate JPA permit during the design stage.

12.2 Third Party Private Entities (Utilities)

12.2.1 Baltimore Gas and Electric (BGE)

BGE is Maryland's largest natural gas and electric utility, delivering power to more than 1.3 million electric customers and more than 680,000 natural gas customers in central Maryland.

BGE has an ongoing rehabilitation program throughout the City to rehabilitate their aging natural gas infrastructure. BGE is planning on expanding the program to rehabilitate 1% of their natural gas assets every year.

BGE's programs impact streets and sidewalks throughout the City. Therefore, coordinating capital/construction activities between the City agencies and BGE is crucial to limit the impact on residents, customers, businesses, and neighborhoods.

Additionally, as part of OEC's practices and procedures, all impacted agencies internally to the City (BCDOT, Department of General Services [DGS], BCRP etc.) and externally (BGE, Verizon, Amtrak, etc.) receive OEC's project design packages. The agencies review the design packages and provide comments to be addressed in the next design package. This allows the agencies to take notice of OEC's upcoming capital projects and their impact on their assets. To understand BGE's capital program and current operations, and to specifically talk about the DPW's OEC future planned projects and the need to coordinate early on those, Baltimore City and BGE met on February 22nd, 2021.

Representatives from the OEC and BGE met and discussed:

- Capital Improvement Cycle
- Capital projects
- The use of Envista platform to share project information
    - Envista Corporation is the exclusive provider of web-based software for infrastructure project coordination
- Current and future coordination opportunities

At the end of the meeting, it was noted that a thorough review of the projects currently in Envista is needed, as well as a good understanding of platform limitations and the current process to update and upload project information.

Both parties agreed that identifying and coordinating future overlapping capital projects is important to both agencies and to the impacted neighborhood(s).

Currently, the City is evaluating three options:

- Expand and utilize the monthly coordination meeting currently facilitated by BCDOT to discuss OEC Phase II projects
- Conduct more detailed and specific coordination meetings on Phase II with impacted agencies
- DPW is developing a Conveyance Planning tool that allows the project team to identify conflicts with BGE during the planning stages. DPW requested BGE's GIS network to be incorporated into the tool. This will allow the team to identify and potentially avoid time-consuming and budget-inflating conflicts with natural gas pipelines.

12.2.2 Private Communication

There are multiple private communication utility assets in the City streets, roadways, sidewalks, and alleyways such as Verizon, Comcast, and others. The DPW project team will typically identify and locate private utility assets buried in the project's limit of disturbance during the design phase. Those assets will be included in the project design documents with detailed instruction on avoiding, relocating, or replacing the assets.

The project team will then coordinate with the private utility and provide the design documents for review, comments, and confirmation.

12.2.3 Amtrak and CSX

There are DPW assets within the Amtrak and CSX ROW or assets that cross underneath the rail tracks. For any work within Amtrak and CSX ROW, the DPW project team will coordinate with Amtrak and CSX to acquire the appropriate permits.

For projects that involve constructing pipelines or working under the rail tracks, the conflict will be identified early on during the route studies. The DPW will work diligently to identify possible alternatives to avoid crossing underneath or within Amtrak and/or CSX ROW to mitigate the need for permitting and construction complications. If the route selected does pass through Amtrak and/or CSX ROW, the project team will coordinate with Amtrak and/or CSX early in the design phase. Design documents specific to crossing rail tracks will be sent to either or both agencies for their review, comments, and approval. Early coordination will allow the team to mitigate any potential delays and maintain project schedule and budget.

13 Economic Development Opportunities

While not required by the MCD, the City is going above and beyond to prepare local workforce and contractor capacity to engage in projects that are being procured in response to the MCD.

13.1 Small Business Development Program (SBDP)

The DPW SBDP is an 11-week training program developed and administered by DPW to increase and enhance the ability for small, local, Minority/Woman/Disadvantaged Business Enterprises (MBE/WBE/DBEs) to participate in City contracting opportunities. In particular, the SBDP focuses on topics such as pre-qualification and certification as an MBE/WBE/DBE company, contract administration, estimating and bidding, scheduling, and more. The program is designed to assist local MBE/WBE/DBEs in becoming contract-ready for opportunities in utility construction work, including MCD sewer rehabilitation and replacement, and capital improvements under drinking water, stormwater, and wastewater programs. The training program is tailored primarily for MBE/WBE/DBEs and provides technical support in areas such as:

- Concrete construction
- Construction program/project management
- Excavating
- Landscaping
- Pipeline installation
- Post-construction cleanup
- Scheduling
- Sediment and erosion control
- Sewer construction
- Site work
- Traffic control
- Underground utilities

DPW charges a nominal fee for attendance to cover the cost of materials and meals and then delivers 11 modules of training valued at over 10 times the fee.

In 2022, DPW held its seventh SBDP cohort. Due to the COVID-19 pandemic, the 2020 and 2021 cohorts were held virtually. The 2022 cohort was held in person. Each year, DPW rigorously seeks and evaluates feedback to improve and better serve participants. For example, based on feedback from prior years, a class was included this year to introduce blueprint reading. The 2022 cohort was able to share full-size plans and use scales in the course to better understand how to read blueprints.

The 2022 training curriculum included the following topics:

- Basic Blueprint Reading
- Bonding
- Business Plan Development
- Construction Cost Accounting

- Construction Best Practices
- Contract Administration
- Engineering Best Practices
- Estimating & Bidding
- MBE/WBE Certification
- Prequalification
- Project Management
- Proven Marketing Strategies
- Occupational Safety and Health Administration (OSHA) 10 Hour Certification

In addition to the courses delivered as part of the SPDP, DPW facilitates a weekly networking session. The SBDP incorporated opportunities for the cohort to network by hosting Thursday business pitch and networking sessions. Firms used this time to hone their business pitch presentations, network, and share useful business tips.

The SPDP also facilitates and hosts a virtual General Contractor Roundtable featuring local prime contractors. Each general contractor provides a presentation including:

- What they look for in selecting subcontractors
- Lessons learned and advice for subcontractors
- Upcoming contracting opportunities for subcontractors

Concluding with a Question and Answer (Q&A) period, attendees can engage with the general contractors and gain invaluable insight into doing business with their respective firms.

The ongoing DPW SBDP has been a tremendous success for the City by growing additional local and MBE/WBE/DBE capacity for the tremendous amount of MCD Phase II Plan sewerage work. Program accomplishments to date include:

- 329 total graduates
- 35 currently enrolled (Fall 2022)
- Over $3M in contract awards

As a testament to the success of the DPW SBDP, one graduate shared this sentiment:

“We truly believe that your network is your net worth. Under these unprecedented health and economic crises, it is imperative that we expand our network to grow and create opportunities for economic development. Thank you for creating such an effective program for us.”

14 Phase II Post-Construction Efficacy Evaluation [9.c.(v)(e)] and Estimates of Remaining SSO and Building Backups [9.c.(v)(f)]

The City will continue to gauge the success of its Phase II Plan relative to three criteria in addition to the construction contractual substantial and final completion checklists, protocols, and warranties.

First and foremost is the reduction in SSO frequency and volume. While the MCD focuses LOP on frequency, the City recognizes that volume reduction is also a key success factor. The City has developed dashboard-style internal activation and volume reporting to maintain a real-time summary of all SSOs by type.

Second is continued review of flow monitors deployed throughout the City. PCFM results will be compared to pre-construction monitoring for all projects. All monitors will be reviewed for trends relative to response to rainfall. Flow monitoring hydrograph wet-weather flow escalation will be evaluated and compared against various rainfall components such as antecedent moisture, duration, peak intensity, average intensity, and volume. The expected trend will be that as Phase II projects progress, the flow response to similar storms will decrease over time.

Finally, the City will monitor the success of Phase II Plan in relation to the observed reductions in building backups. Section 7.1.2 described the City's SOS program that is being implemented in parallel to the MCD Appendix E Building Backup Expedited Reimbursement Plan (BBERP). The City has proposed to EPA and MDE that the SOS program supersede the BBERP. Regardless of the decision on the long-term Appendix E program, the City has put in place a robust notification system to track and respond to building backups. Trends associated with decreasing wet weather related building backups in response to similar rainfall characteristics will be tracked thoroughly and meticulously.

15 Adequacy of Collection System Long-Term Transmission Capacity [9.f.(i)]

All hydrologic and hydraulic aspects, characteristics, and performance of the City's wastewater collection system will continue to be evaluated and reported on using the City's state-of-the-art, advanced, hydrologic, and hydraulic model described in Section 8. The City will meticulously maintain the model by integrating all changes including those manifested through projects, those identified through discovery or notification, as well as those associated with continued flow monitoring and calibration refinements.

The City will periodically evaluate the 20-year simulation to determine positive SSO reduction trends. For informational purposes, not compliance purposes, the City will use the model to simulate alternate 20-year periods that include greater magnitudes of rainfall, for example later periods that show effects of climate induced rainfall changes. A value in this exercise will be to show that as the City continues to rehabilitate and improve its system, the correlation between rainfall and elevated sewer flow will continue to decrease, ultimately to a point where much larger magnitude rainfall events are needed to induce SSO activations.

16 Phase II Implementation Progress Compliance Reporting

16.1 Quarterly Reporting [9.h.(ii)]

The City will comply with the MCD [9.h.(ii)] quarterly reporting requirements as stated:

> *Beginning with the first quarterly report following EPA's and MDE's approval of the Phase II Plan or part of the Phase II Plan, and thirty (30) days after the end of each calendar quarter thereafter, Baltimore shall certify and report to EPA and MDE Baltimore's progress implementing and completing the Phase II Plan. The progress report shall include the percentage completed for each multi-year project approved for Phase II.*

16.2 Annual Reporting [9.h(ii)]

The City will comply with the MCD [9.h.(ii)] annual reporting requirements as stated:

> *Baltimore shall certify and report to EPA and MDE Baltimore's progress implementing and completing the Phase II Plan. The progress report shall include the percentage completed for each multi-year project approved for Phase II. Annually the progress report shall include a table of ongoing cost of each project approved for Phase II*.

The first annual report will be sent to EPA and MDE by January 31, 2024.

17 Post-Phase II Implementation Compliance Reporting

17.1 Quarterly Reporting for Two Years Post-Phase II Completion and until Termination of CD [9.i]

The City will comply with the MCD [9.h.i] post-implementation compliance monitoring quarterly reporting requirements as stated:

Beginning thirty (30) days after the end of the first full calendar quarter following the completion of the implementation of the Phase I and Phase II Plans, and thirty (30) days after the end of each calendar quarter thereafter for a period of at least two (2) years after the completion of the implementation of all Phase I and Phase II Plans and until termination of the Consent Decree, Baltimore shall certify and report to EPA and MDE Baltimore's progress in achieving compliance with this Consent Decree. The progress report shall provide the following information: (i) A summary tabulation of the data collected to assess the efficacy of the rehabilitation and corrective actions implemented as provided in the Sewershed Phase II Plan and, in accordance with the data collection, activities established pursuant to sub-paragraph 9.c(v)(e) of this Consent Decree; (ii) A summary of rainfall and flow monitoring data for the three-month period ending thirty (30) days before the end of the calendar quarter (organized by sewershed and sewershed service area where appropriate), which shall, at a minimum, provide daily rainfall amounts, peak hourly rainfall intensity, daily flow volumes, and peak flow rates for each location at which flow monitoring is carried out. Baltimore shall submit this information in Excel both in paper and in electronic format.

The schedule will be as follows, shown in Table 19:

Table 19. Schedule of Compliance Monitoring Reporting

Post-Implementation Compliance Monitoring Quarterly Report #	Due Date
1	4/30/2031
2	7/31/2031
3	10/31/2031
4	1/31/2032
5	4/30/2032
6	7/31/2032
7	10/31/2032
8	1/31/2033

17.2 Closeout Report [9.1.(iii)]

The City will comply with the MCD [9.i.(iii)] post-implementation compliance monitoring close-out reporting requirements as stated:

Baltimore shall submit a close-out report containing a summary of the Phase II post-construction rainfall and flow monitoring data within six (6) months of the completion of Phase II post-construction flow monitoring. The close-out report shall be submitted no later than July 31, 2033.

18 Acronyms

Acronym	Definition
AD	Accelerated Design
ADS	Advanced Drainage Systems
AHP	Analytical Hierarchy Process
AI	Artificial Intelligence
ARPA	American Rescue Plan Act
AS	Ammonia Screening
B	Billion
BaSES	Baltimore Sewer Evaluation Standards
BBERP	Building Backup Expedited Reimbursement Program
BCCD	Baltimore County Consent Decree
BCDOT	Baltimore City Department of Transportation
BCDP	Baltimore City Department of Planning
BCDPW	Baltimore City Department of Public Works
BCRP	Baltimore City Department of Recreation & Parks
BG	Billion Gallons
BGE	Baltimore Gas and Electric
BR	Back River
BRTB	Baltimore Regional Transportation Board
BWI	Baltimore/Washington International
CCTV	Closed-Circuit Television

Acronym	Definition
CD	Consent Decree
CHAP	Commission for Historical & Architectural Preservation
CIP	Capital Improvement Plan
COMAR	Code of Maryland Regulations
COVID-19	Coronavirus Disease of 2019
CMMS	Computerized Maintenance Management System
CPR	Community Planning and Revitalization
CSAC	Complete Streets Advisory Committee
CSM	Complete Streets Manual
CSO	Complete Streets Ordinance
CSO	Combined Sewer Overflow
CWA	Clean Water Act
CWEA	Chesapeake Water Environment Association
CY	Calendar Year
DBB	Design-Bid-Build
DBE	Disadvantaged Business Enterprise
DHCD	Department of Housing & Community Development
DGS	Department of General Services
DOJ	Department of Justice
DOT	Department of Transportation
DP	Department of Planning
DPW	Department of Public Works

Acronym	Definition
DU	Dundalk
DWF	Dry Weather Flow
E. coli	Escherichia coli
ENS	Event Notification System
EPA	Environmental Protection Agency
FCA	Financial Capability Assessment
FCI	Financial Capability Indicator
FOG	Fats, Oils, and Grease
FY	Fiscal Year
GARR	Gauge-Adjusted Radar Rainfall
GF	Gwynns Falls
GIS	Geographic Information System
HGL	Hydraulic Grade Line
H&H	Hydrologic and Hydraulic
HL	High Level
HR	Herring Run
I/I	Infiltration and Inflow
IIJA	Infrastructure Investment and Jobs Act
INSPIRE	Investing in Neighborhoods and Schools to Promote Improvement, Revitalization, and Excellence
JF	Jones Falls
JPA	Joint Permit Application

Acronym	Definition
LCRI	Lead and Copper Improvements
LCRR	Lead and Copper Rule Revisions
LF	Linear Feet
LL	Low Level
LOP	Level of Protection
LTC/PFMP	Long Term Capacity/Peak Flow Management Plan
M	Million
MBE	Minority Business Enterprise
MCD	Modified Consent Decree
MDE	Maryland Department of the Environment
MG	Million Gallons
MGD	Million Gallons per Day
MHI	Median Household Income
ML	Machine Learning
MOED	Mayor's Office of Employment Development
MOT	Maintenance of Traffic
MS4	Municipal Separate Storm Sewer System
MTA	Maryland Transit Administration
NAPA	National Academy of Public Administrators
NPDES	National Pollutant Discharge Elimination System
O&M	Operation and Maintenance
OAM	Office of Asset Management

Acronym	Definition
OCR	Office of Compliance and Research
OEC	Office of Engineering and Construction
OSHA	Occupational Safety and Health Administration
OUT	Outfall
PA	Patapsco
PCFM	Post-Construction Flow Monitoring
Q&A	Question and Answer
QA	Quality Assurance
QC	Quality Check
RDII	Rainfall-Derived Infiltration and Inflow
RI	Residential Indicator
ROW	Right-of-Way
RT-DSS	Real-Time Decision Support System
SBD	Small Business Development
SBDP	Small Business Development Program
SIS	Stream Impact Sampling
SRF	State Revolving Fund
SOS	Sewage Onsite Support
SSO	Sanitary Sewer Overflow
TAZ	Transportation Analysis Zone
UMD	Utility Maintenance Division
U.S.	United States

Acronym	Definition
USACE	United States Army Corps of Engineers
WBE	Woman Business Enterprise
WIC	Water in Cellar
WIFIA	Water Infrastructure Finance and Innovation Act
WISE	Water Infrastructure Strategic Educational Program
WSO	Weather Service Office
WWTP	Wastewater Treatment Plant