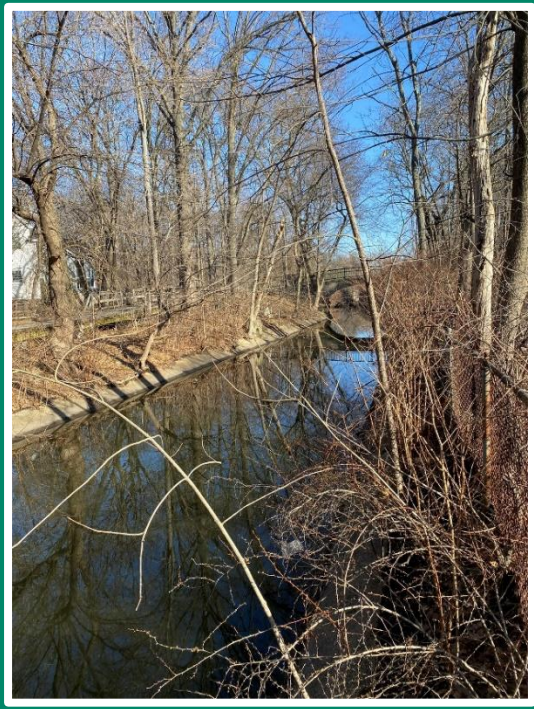
# Draft Updated Combined Sewer Overflow Control Plan for Alewife Brook, Upper Mystic River, and Charles River



Charles River



Alewife Brook



Upper Mystic River

**Submitted by City of Cambridge, City of Somerville, and Massachusetts Water Resources Authority in accordance with the requirements of the 2024 Final Determinations to Adopt a Water Quality Standards Variance for Combined Sewer Overflow (CSO) Discharges to the Alewife Brook/Upper Mystic River Basin and to the Lower Charles River/Charles Basin**

**April 30, 2026**

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# Acronyms and Abbreviations

| | |
|---|---|
| 1989 EPA CSO Strategy | *EPA National Combined Sewer Overflow Control Strategy (1989)* |
| 1992 TY | 1992 Typical Year |
| 1997 Plan | *CSO Facilities Plan and Environmental Impact Report* |
| 2006 LTCP | Long-Term Control Plan (LTCP) defined in the Second Stipulation that includes 35 projects |
| 2050 TY | 2050 Typical Year |
| AB | Alewife Brook |
| ABBS | Alewife Brook Branch Sewer |
| ABC | Alewife Brook Conduit |
| ABPS | Alewife Brook Pump Station |
| ACS | American Community Survey |
| ATTAINS | Assessment, Total Maximum Daily Load (TMDL) Tracking and Implementation System |
| BHC | Boston Harbor Case (U.S. v. M.D.C., et al., No. 85-0489 MA) |
| BMC | Boston Marginal Conduit |
| BMP | Best Management Practice |
| BOH | Boards of Health |
| BOS### | Boston Water and Sewer Commission CSO Outfall |
| BPHC | Boston Public Health Commission |
| BWSC | Boston Water and Sewer Commission |
| °C | Degrees Celsius |
| CAM### | Cambridge CSO Outfall |
| CBI | Consensus Building Institute |
| CBS | Cambridge Branch Sewer |
| CCVA | Climate Change Vulnerability Assessment |
| CET | Community Engagement Team |
| CFR | Code of Federal Regulations |
| CIP | Capital Improvement Plan |
| CMIP5 | Coupled Model Intercomparison Project Phase 5 |
| CMR | Code of Massachusetts Regulations |
| CPH | Cost Per Household |
| CR | Charles River |
| CRWA | Charlies River Watershed Association |
| CSO | Combined Sewer Overflow |
| CWA | Clean Water Act |
| DCR | Department of Conservation and Recreation |
| DITP | Deer Island Treatment Plant |
| DPW | Department of Public Works |
| DSGA | Designated Shellfish Growing Area |
| DWO | Dry Weather Overflow |

| | |
|---|---|
| *E. coli* | *Escherichia Coli* |
| EEA | Massachusetts Executive Office of Energy and Environmental Affairs |
| EIR | Environmental Impact Report |
| EJ | Environmental Justice |
| ENF | Environmental Notification Form |
| EPA | United States Environmental Protection Agency |
| FAA | Financial Alternatives Analysis |
| Final Assessment Report | *Final CSO Post Construction Monitoring Program and Performance Assessment Report* |
| FCA | Financial Capability Assessment |
| FCI | Financial Capability Indicator |
| FOG | Fat, Oil, and Grease |
| FMPV | Full Market Property Value |
| GCMs | Global Climate Models |
| GHG | Greenhouse Gas |
| GIS | Geographic Information System |
| GPD | Gallons Per Day |
| GSI | Green Stormwater Infrastructure |
| H&H | Hydrologic and Hydraulic |
| ICM | Integrated Catchment Modeling |
| IDF | Intensity Duration Frequency |
| I/I | Inflow and Infiltration |
| LA | Load Allocations |
| LID | Low Impact Development |
| LOC | Level of Control |
| LQPI | Lowest Quintile Poverty Indicator |
| LTCP | Long-Term Control Plan |
| MACA | Multivariate Adaptive Constructed Analogs |
| MassDEP, DEP | Massachusetts Department of Environmental Protection |
| MBTA | Massachusetts Bay Transportation Authority |
| MDC | Metropolitan District Commission |
| MEPA | Massachusetts Environmental Protection Act |
| MG, MGD | Million Gallons, Million Gallons per Day |
| mg | Milligram |
| MHI | Median Household Income |
| mL, L | Milliliter, Liter |
| MOU | Memoranda of Understanding |
| MR | Mystic River |
| MS4 | Municipal Separate Storm Sewer System |
| MyRWA | Mystic River Watershed Association |
| MWR### | MWRA CSO Outfall |

| | |
|---|---|
| MWRA | Massachusetts Water Resources Authority |
| N/A | Not Applicable |
| NACWA | National Association of Clean Water Agencies |
| NHESP | National Heritage and Endangered Species Program |
| NLC | National League of Cities |
| NMCs | Nine Minimum Controls |
| NMPS | North Main Pump Station |
| NOAA | National Oceanic and Atmospheric Administration |
| NPC | Notice of Project Change |
| NPDES | National Pollutant Discharge Elimination System |
| O&M | Operations and Maintenance |
| ORW | Outstanding Resource Waters |
| PCBs | Polychlorinated Biphenyls |
| PCCMP | Post Construction Monitoring Program |
| PFAS | Per- and Polyfluoroalkyl Substances |
| PI | Poverty Indicators |
| Plan | *Updated CSO Control Plan* |
| POTW | Publicly Owned Treatment Works |
| RCP | Representative Concentration Pathway |
| RE### | CSO Regulator |
| RI | Residential Indicator |
| ROW | Right-of-way |
| SAUSI | Sommerville Ave Utility and Streetscape Improvements Project |
| SCADA | Supervisory Control and Data Acquisition |
| SCP | Stormwater Control Permit |
| SCS | Soil Conservation Service |
| SMBS | Somerville Medford Branch Sewer |
| SOP | System Optimization Plan |
| SSO | Sanitary Sewer Overflow |
| StAB | Save the Alewife Brook |
| SOIA | Somerville Office of Immigrant Affairs |
| SOM### | Somerville CSO Outfall |
| STV | Statical Threshold Value |
| Supplemental Assessment Report | *Supplement to the 2021 Final Combined Sewer Overflow Post Construction Monitoring Program and Performance Assessment Report* |
| SWMM | USGS Storm Water Management Model |
| SWQS | Massachusetts Surface Water Quality Standards |
| TBC | Tannery Brook Conduit |
| TBM | Tunnel Boring Machine |
| TMDLs | Total Maximum Daily Loads |

| | |
|---|---|
| TP | Total Phosphorus |
| The Partners | City of Cambridge, City of Somerville, MWRA |
| The Regulators | MassDEP, EPA |
| TSS | Total Suspended Solids |
| TY | Typical Year |
| UAA | Use Attainability Analysis |
| Unified Model | Unified Hydrologic and Hydraulic Model |
| USFWS | United States Fish and Wildlife Service |
| USGS | United States Geological Survey |
| Variances | *2024 Final Determinations to Adopt a Water Quality Standards Variance for Combined Sewer Overflow Discharges to the Alewife Brook/Upper Mystic River Basin and to the Lower Charles River/Charles Basin* |
| WLA | Wasteload Allocations |
| WSCAC | Water Supply Citizens Advisory Committee |
| WSHW | Ward Street Headworks |
| WWTP | Wastewater Treatment Plant |

# Definitions

**1997 Plan:** Refers to the *CSO Facilities Plan and Environmental Impact Report* issued in 1997. The 1997 Plan received initial federal and state approvals in early 1998, allowing MWRA to move the projects into design and construction.

**2006 LTCP:** Refers to the final Long-Term Control Plan (LTCP) defined in the Second Stipulation that includes 35 projects.

**Alewife Brook (AB):** Stream that runs along the boundary between the town of Arlington and the cities of Cambridge and Somerville and discharges into the Upper Mystic River. There are six combined sewer outfalls that discharge into Alewife Brook subject to the Variances. The Alewife Brook Branch Sewer (ABBS) and Alewife Brook Conduit (ABC) run along Alewife Brook and flow to the Alewife Brook Pump Station (ABPS), Chelsea Creek Headworks, and North Main Pump Station to DITP. Refer to Figure 9-9 for a schematic of the Alewife Brook Combined Sewer System.

**Baseline Conditions Model:** Represents the expected configurations of the combined sewer system at the start of the Plan's implementation. This differs from the 2022 System Conditions Model, used at the start of this Plan's development, because it incorporates projects anticipated to be finalized between 2022 and 2027.

**Boston Harbor Case (BHC, U.S. v. M.D.C., et al., No. 85-0489 MA):** Landmark 1985 federal lawsuit initiated by the EPA and Conservation Law Foundation against the Metropolitan District Commission for violating clean water statutes by dumping sewage into the Boston Harbor. The ruling led to the creation of the MWRA and set schedules of activities to achieve compliance with the law.

**Boston Marginal Conduit (BMC):** Runs along the Boston side of the Charles River, beneath Storrow Drive. During current overflow conditions, flow is diverted from the BMC to MWR018, MWR019, and MWR020 through large weir structures.

**Best Management Practices (BMPs):** Practical, effective measures designed to prevent or reduce environmental impacts, including water pollution, energy use, and resource waste. In the context of this report, they are applied to stormwater management and surface water quality. BMPs can include both preventative and mitigation measures.

**Boston Water and Sewer Commission (BWSC):** Utility that provides drinking water and sewer services for the City of Boston to more than one million people daily.

**Cambridge Branch Sewer (CBS):** Runs along the Cambridge side of the Charles River, beneath Albany Street collecting flow from local sewer systems to the North Metropolitan Sewer System, making its way to Deer Island.

**Charles River (CR):** A hub for recreational aquatic activities and passive recreation for the cities of Boston, Cambridge, and Watertown. CR refers to the Lower Basin of the Charles River, which extends from the Waterdown Dam to the New Charles River Dam. The nine outfalls located in the CR area are subject to the 2024 Variance. Refer to Figure 9-53 for a schematic of the Charles River Combined Sewer System.

**Class B (CSO) Designation (B(CSO)):** The SWQS Classifications include qualifiers for freshwaters and saline waters, B(CSO) and SB(CSO), that are impacted by CSOs. A determination to change the water quality designation is within MassDEP's jurisdiction.

**Class B Waters:** Classification under the Massachusetts Surface WQS. Class B waters are designated as a habitat for wildlife and primary and secondary contact recreation, and they shall be suitable for agricultural uses and compatible with industrial cooling and process uses.

**Clean Water Act (CWA):** Federal legislation that established the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters.

**Combined Sewer:** A sewer that conveys stormwater and wastewater of domestic, commercial, and industrial origin.

**Combined Sewer Overflow (CSO):** Discharge of untreated or treated mixture of stormwater and wastewater from a combined sewer directly into nearby water bodies at CSO outfalls. The name of each outfall begins with an abbreviation of the Partner that is responsible for operating and maintaining it (MWR, CAM, SOM).

**Cost Per Household (CPH):** Annual residential share of current and projected CWA program costs.

**Cottage Farm CSO Facility (MWR201):** Treated CSO facility located on the Cambridge side of the Charles River, located at 660 Memorial Drive. It consists of two buildings a main building containing pump and screening equipment and a chemical building, which contains tanks and pump systems for the addition of sodium hypochlorite and sodium bisulfite to disinfect and dechlorinate combined flows prior to discharge to the Charles River.

**CSO Control Policy:** EPA's national framework for controlling CSOs, established in 1994 through the NPDES program. Provides guidance on how communities can achieve CWA goals of reducing and controlling CSOs in a flexible, cost-effective manner. Mandates that communities develop and implement the Nine Minimum Controls (NMCs) and a Long-Term Control Plan (LTCP) and monitor to verify compliance with water quality standards.

**CSO Control Program:** Timeline of activities relevant to the waterbodies listed in the Variances beginning with the First Stipulation in 1987 through the deadline for the final Updated CSO Control Plan in January 2027.

**Department of Conservation and Recreation (DCR):** The Massachusetts Department of Conservation and Recreation (DCR) oversees nearly half a million acres of land, making up one of the largest and most diverse state park systems in the country. DCR nurtures the vital connection between people and the environment by protecting, promoting, and enhancing natural, cultural, and recreational resources for the well-being of all. The Partners have kept DCR informed throughout the process and worked to understand the feasibility of using DCR-owned land for project sites.

**Deer Island Treatment Plant (DITP):** MWRA's wastewater treatment plant that removes human, household, business and industrial pollutants from wastewater that originates in homes and businesses in 43 greater Boston communities. In compliance with all federal and state environmental standards and subject to the precedent-setting discharge permit issued for the

**Department of Public Works (DPW):** A municipal or regional government agency responsible for managing, building, and maintaining essential public infrastructure. DPWs ensure the safety and functionality of daily life by managing services like road repairs, snow removal, water/sewer systems, waste disposal, and urban forestry.

**Dry Weather Overflows (DWOs):** Combined sewer overflows that occur during dry weather. DWOs are not permitted under NPDES CSO permits.

**Massachusetts Executive Office of Energy and Environment (EEA):** State agency that seeks to protect, preserve, and enhance the Commonwealth's environmental resources while ensuring a clean energy future for the state's residents. Through the stewardship of open space, protection of environmental resources, and enhancement of clean energy, the EEA works tirelessly to make Massachusetts a wonderful place to live, work, and raise a family. Codified at M.G.L. c. 30, §§ 61–62H and implemented through 301 CMR 11.00.

**Environmental Justice (EJ):** EJ and vulnerable populations are at a higher risk of experiencing disproportionate environmental burdens, while having limited access to environmental benefits and decision-making processes. Key characteristics of EJ populations include race, limited English proficiency, and lower income. The Partners identified EJ populations and made efforts to enable participation by translating materials and providing interpreter services during public meetings.

**United States Environmental Protection Agency (EPA):** Federal agency tasked with protecting human and environmental health. Implements the Clean Water Act with NPDES and MS4 permits and TMDLs.

**Final Assessment Report:** Refers to the *Final CSO Post Construction Monitoring Program and Performance Assessment Report* submitted to EPA and MassDEP in December 2021 on the results of a three-year performance assessment including post-construction monitoring to determine whether MWRA achieved the levels of CSO control in the LTCP.

**Financial Alternatives Analysis (FAA):** Analysis of whether a community has considered feasible steps to reduce costs and address impacts to low-income households, including use of variable rate structures, customer assistance programs (CAPs), and applications for grants or subsidies from the Clean Water State Revolving Fund. The community should provide a list of the programs or steps considered, the actions that would be necessary to put such measures into place, and the plan for taking those actions. Where available tools are not included in the community's plans, the requester should provide a written explanation of why those approaches are not being pursued.

**Financial Capability Assessment (FCA):** Developed after pollution controls have been selected to meet CWA requirements to aid in assessing a community's financial capability as a part of negotiating implementation schedules under both permits and enforcement agreements. Elements of the same methodology can also be used to understand the economic impacts of installing the pollution controls needed to meet CWA requirements to determine if a variance can be granted, if degradation of high-quality water is warranted, or, in some cases, if a designated use cannot be attained.

**Financial Capability Indicators (FCI):** Six indicators used to evaluate the debt, socioeconomic, and financial conditions that affect a community's financial capability to implement CWA controls. These indicators help characterize the community's financial capability as "weak," "midrange," or "strong."

**First Stipulation:** Stipulation in the Boston Harbor Case where MWRA accepted responsibility for developing and implementing a region-wide plan to control CSOs hydraulically related to its wastewater system. MWRA's CSO Control Program formally began in 1987.

**Global Climate Models (GCMs):** Complex mathematical representations of the major climate system components and their interactions. Eleven GCMs were analyzed in developing the 2050 TY, representing two greenhouse gas (GHG) emissions scenarios: Representative Concentration Pathway (RCP) 4.5 and RCP 8.5. The same GCMs are adopted by the EEA for the Statewide Climate Resilience Design Standards and Guidance.

**Green Stormwater Infrastructure (GSI):** Approach to stormwater management by mimicking the natural environment. GSI intercepts stormwater and allows for infiltration, reducing stormwater inputs to the sewer system and filtering out pollutants.

**Headworks Facility:** Provides preliminary treatment for raw wastewater. Screens out large debris and removes grit from sewage before it is conveyed to DITP. The MWRA system includes five headworks facilities. The Ward Street Headworks (WSHW), Chelsea Creek Headworks, and Columbus Park Headworks facilities are referenced in this Plan.

**Hydraulic Grade Line (HGL):** Total hydraulic head, or the sum of pressure head and elevation head, along a pipe.

**Inflow and Infiltration (I/I):** Stormwater (inflow) and groundwater (infiltration) that improperly enter sewer systems through broken pipes, defects, or illegal connections. This excess water overloads treatment facilities, increases treatment costs, and can cause sewage backups.

**Integrated List of Waters (303(d) List):** The CWA requires that states establish a list of waters that are assessed and identified as impaired or threatened by pollutants. TMDLs must be developed for the 303(d) List. Assessment Unit codes (AU-ID) are assigned to defined segments of the waterbody, and Assessment, TMDL Tracking and Implementation System (ATTAINS) Action IDs are assigned to impairments.

**Intensity-Duration-Frequency (IDF) Curve**: A mathematical function that relates the rainfall intensity with its duration and frequency of occurrence. These curves are commonly used in hydrology for flood forecasting and civil engineering for urban drainage design. IDF curves are also analyzed in hydrometeorology because of the interest in the time-structure of rainfall.

**Level of Control (LOC):** The extent to which CSOs are reduced or eliminated by a specific system configuration or intervention under specific rainfall events. The LOCs evaluated in this report are Limited CSOs in the 2050 TY, Zero CSOs in the 2050 TY, Zero CSOs during the 2050 5-year Storm, and Zero CSOs during the 2050 25-year Storm.

**Lowest Quintile Poverty Indicator (LQPI):** Evaluates the economic impact on low-income households by assessing the prevalence and severity of poverty in a community or service area using U.S. Census Bureau American Community Survey (ACS) data. Consists of six indicators: Upper limit of the lowest income quintile (50% weight), percentage of population with income below 200% of the Federal Poverty Level (10% weight), percentage of households receiving food stamps/SNAP benefits (10% weight), percentage of vacant housing units (10% weight), trend in household growth (10% weight), and percentage of unemployed population 16 and over in civilian labor force (10% weight).

**Long-Term Control Plan (LTCP):** A phased approach required under the Environmental Protection Agency's CSO Control Policy and part of the strategy to control CSOs. LTCPs aim to reduce the frequency, duration, and volume of CSO events through system characterization, development and evaluation of alternatives, and selection and implementation of controls. For this report, the term LTCP refers to the plan developed by MWRA in the 1990s to reduce CSO volumes in the cities of Boston, Cambridge, Somerville, and Chelsea.

**Multivariate Adaptive Constructed Analogs (MACA):** A statistical method for downscaling Global Climate Models (GCMs) from their native coarse resolution to a higher spatial resolution that captures observed patterns of daily near-surface meteorology and simulated changes in GCMs experiments.

**Massachusetts Department of Environmental Protection (MassDEP, DEP):** State agency that protects and enhances the natural resources of Massachusetts. Overseas Massachusetts State WQS, develops TMDLs, and issues Variances and MS4 permits with the EPA.

**Massachusetts Bay Transportation Authority (MBTA):** Provides public transit for the Greater Boston region. Ther Partners met with MBTA, and MBTA land was considered in Alternatives Development.

**Metropolitan District Commission (MDC):** Predecessor agency to the MWRA.

**Massachusetts Environmental Protection Act (MEPA):** Requires state agencies to evaluate the environmental impacts of projects requiring state action (permits, financial assistance, or land disposition). For large-scale or phased CSO control programs, MEPA review is often conducted through the submission of an Environmental Notification Form (ENF) and, if required, a Draft and Final Environmental Impact Report (EIR). MEPA may also require a Notice of Project Change (NPC) if significant modifications are made to a previously reviewed CSO plan or schedule.

**Median Household Income (MHI):** Income where half of households in a county earn more and half of households earn less within a service area.

**Mystic River (MR):** Supports habitat and recreational activities on the water and its shoreline. The outfall in the Upper Mystic River is subject to the Variances. The Upper Mystic River begins at the outlet of the Lower Mystic Lake, converges with Alewife Brook and Malden River, and ends upstream of the Amelia Earhart Dam. Refer to Figure 9-32 for a schematic of the Mystic River Combined Sewer System.

**Municipal Separate Storm Sewer System (MS4) Permits:** 5-year permit jointly issued by EPA and MassDEP that requires towns create a Stormwater Management Program (SWMP) to meet six minimum control measures: Pollution Prevention/Good Housekeeping for Municipal Operations, Illicit Discharge Detection and Elimination (IDDE) Program, Construction Site Runoff Control, Post Construction Runoff Control, Public Education and Outreach, Public Participation and Involvement. Towns report their

progress by sending in Annual Reports each May 1 to EPA and MassDEP. MS4 Permits are a component of the NPDES program.

**Massachusetts Water Resources Authority (MWRA):** The regional water and sewer authority in central and eastern Massachusetts, providing forty-three (43) communities sewer services.

**National Oceanic and Atmospheric Administration (NOAA):** Federal agency that works to understand and predict changes in climate, weather, ocean, and coasts, to share that knowledge and information with others, and to conserve and manage coastal and marine ecosystems and resources. Develops NOAA Atlas 14 precipitation frequency estimates The NOAA Atlas 14 and the NOAA Section 7 Mapper were that were used in preparing the Plan.

**Nine Minimum Controls (NMCs):** Technology-based controls that address CSOs without extensive engineering studies or significant construction costs. Required by the EPA under the terms of CSO Control Policy.

**National Pollution Discharge Elimination System (NPDES):** Permitting mechanism established under the Clean Water Act, authorizing the EPA to regulate the discharge of pollutants from point sources to waters of the United States. MWRA's NPDES permit includes both the Deer Island Treatment Plant outfalls and CSO outfalls owned by MWRA. Cambridge and Somerville have separate NPDES permits for their CSO discharges (NPDES CSO Permits) and separate NPDES permits for their stormwater discharges (NPDES MS4 Permits).

**Operations and Maintenance (O&M):** Continuous activities required to operate infrastructure effectively and to maintain its condition over time. It includes routine system operation, monitoring, cleaning, inspection, repair, and asset upkeep to ensure reliable service, regulatory compliance, and long-term system performance. BMPs and NMCs both address regular and comprehensive operations and maintenance programs for the sewer system and CSO outfalls.

**Plan:** Refers to this Updated CSO Control Plan.

**Poverty Indicators (PI):** Five indicators used to benchmark the prevalence of poverty throughout the service area from the 2020 proposed FCA Guidance.

**Prison Point CSO Facility (SOM009):** The facility provides screening and pumping of dry weather wastewater flows from portions of Cambridge and Boston to the Charlestown Branch Sewer and on to the Chelsea Creek Headworks. During wet weather, the facility provides screening, chlorination, detention, and dechlorination of combined sewer flows.

**Publicly Owned Treatment Works (POTWs):** Wastewater treatment facilities that treat sewage and industrial wastewater, owned and operated by a public authority. POTWs are subject to discharge permits issued by the EPA and state agencies (MassDEP). DITP is the downstream POTW.

**Recurrence Interval:** A hydrological statistical measure used to describe how often a storm of a given size or intensity will occur. The recurrence interval is the inverse of the annual exceedance probability: a 25-year storm has a 4% chance of being equaled or exceeded each year.

**Representative Concentration Pathway (RCP):** Greenhouse gas emissions scenarios used for resilience planning and climate design applications. They range from low emissions (RCP2.6) to high emissions (RCP8.5) scenarios. The 2050 TY development relies on using the high (RCP 8.5) emissions scenario, following the Statewide Climate Resilience Design Standards and Guidance by the Massachusetts EEA.

**Residential Indicator (RI):** Cost per household as a percentage of MHI**.**

**Supplemental Assessment Report:** Refers to *Supplement to the 2021 Final Combined Sewer Overflow Post Construction Monitoring Program and Performance Assessment Report* submitted in December 2024 to document the progress made towards meeting the LTCP goals at 16 outfalls that did not meet the LTCP goals in the Final Assessment Report.

**Soil Conservation Service (SCS):** Now the Natural Resources Conservation Service (NRCS). Produces 24-hour rainfall distributions used to model storm hyetographs for runoff estimation. The four primary types (I, IA, II, III) represent different geographic regions and storm intensities, allowing 24-hour rainfall depths to be converted into temporal distribution patterns for modeling.

**Somerville Marginal CSO Facility (MWR205A/SOM007A):** The sole outfall discharging to the Upper Mystic River, located above the Amelia Earhart Dam. When the capacity of the Somerville-Medford Branch Sewer (SMBS) and Cambridge Branch Sewer (CBS) are exceeded, the Somerville Marginal CSO Facility is activated and provides screening and disinfection. Treated effluent is conveyed to the Somerville Marginal Conduit (SMC) and discharged through outfall MWR205 to the tidal waters of the Lower Mystic River or outfall MWR205A/SOM007A to the Upper Mystic River when relief in the SMC is needed due to high flows or tide elevation. Due to its downstream location, MWR205 is not subject to the Variances and is not a part of this Plan.

**Schedule Seven:** Court-ordered schedule of more than 180 completed CSO-related milestones.

**Second Stipulation:** Replaced the First Stipulation in 2006. Resulted in a final LTCP, comprising 35 wastewater system projects, approved by EPA and MassDEP in March 2006 and accepted by the Federal Court in April 2006.

**Sanitary Sewer Overflow (SSO):** Discharge of raw sewage from a sanitary sewer when its capacity is exceeded. Sanitary sewers collect and transport domestic, commercial, and industrial wastewater and are separated from storm sewers. SSOs can discharge into nearby waterbodies, streets, or basements.

**Statistical Threshold Value (STV):** Used to determine the significance of observations. No more than ten (10) percent of all samples collected within that interval shall exceed the STV for that indicator. MassDEP recommended that the Partners assess attainment with a single sample maximum value based on the ninetieth ($90^{th}$) percentile statistical threshold values (STV) for E. coli and Enterococcus.

**Massachusetts Surface Water Quality Standards (SWQS):** Implements provisions of the CWA, designates the most sensitive uses for Massachusetts waters, and provides criteria for evaluating water quality to support those uses. The SWQS identifies classifications for different types of waters, including Class B, inland waters, and Class SB, coastal and marine waters. Codified at 314 CMR 4.00 and developed by MassDEP.

**Tannery Brook Conduit (TBC):** Currently directs flow to the SOM001A CSO regulator into Alewife Brook and will be repurposed as a storm drain following complete sewer separation.

**The Partners:** The City of Cambridge, the City of Somerville, and the Massachusetts Water Resources Authority (MWRA).

**The Regulators:** The Massachusetts Department of Environmental Protection (MassDEP) and the U.S. Environmental Protection Agency (EPA).

**Total Maximum Daily Loads (TMDLs):** The CWA requires states (MassDEP) to identify water bodies that do not meet health standards and develop TMDLs to restore water quality. Each TMDL must identify the pollutant(s) causing the impairment, determine the waterbody's assimilative capacity, and allocate allowable loads to contributing sources. These loads include wasteload allocations (WLAs) for point sources—such as CSO outfalls, permitted stormwater outfalls, and wastewater treatment plant discharges—and load allocations (LAs) for nonpoint sources, such as overland stormwater runoff or failing septic systems.

**Tunnel Boring Machine (TBM):** A specialized machine used to excavate tunnels through various ground conditions while minimizing surface disturbance.

**Typical Year (TY):** A full year of rainfall data best representing rainfall conditions over 365 days. The EPA CSO Control Policy requires the development and use of a "Typical Year" to plan and assess the performance of CSO control as part of the Updated CSO Control Plan. The 1992 TY served as the

benchmark for the MWRA LTCP. This Updated CSO Control Plan develops and adopts a 2050 TY to evaluate system performance over projected climate conditions.

**Unified Hydrologic and Hydraulic Model (Unified Model):** Collection system model used to address the hydrologic and hydraulic system performance and generate estimates of CSO flows and volumes under various conditions. It is composed of individual collection system models developed by the Partners, aligned together. The model is continuously updated with new information about the collection system.

**United States Fish and Wildlife Service (USFWS):** Federal agency responsible for managing and conserving wildlife and their habitats. Information from the USFWS was used to determine the presence of endangered species habitats in the Charles River, Alewife Brook, and Upper Mystic River as a part of the UAA.

**United States Geological Survey (USGS):** Boundary conditions for the Unified and the Water Quality Models were developed with inputs from USGS flow data and from the USGS and BWSC stormwater models.

**Units:** The volume capacity of the alternatives is measured in million gallons (MG). Flow measurements are reported in the unit of gallons per day (gpd) and million gallons per day (MGD). Bacteria concentrations are recorded in #/ 100 mL, or number per one-hundred milliliters, and precipitation depths are recorded in inches.

**Use Attainability Analysis (UAA):** Variance Condition F Item 5 requires that the Updated CSO Control Plan includes documentation needed to support the issuance of a Variance or for changing the classification of any CSO-impacted receiving waters. The UAA includes documentation of the existing uses, the attainability of the designated use, stressors, feasible activities and controls and the extent to which they would lead to attainment, the factor(s) listed in 40 CFR 131.10(g) that precludes attainment, and the determination of the highest attainable use.

**Variances:** Refers to the *2024 Final Determinations to Adopt a Water Quality Standards Variance for Combined Sewer Overflow (CSO) Discharges to the Alewife Brook/Upper Mystic River Basin and to the Lower Charles River/Charles Basin*. The Variances are short-term modifications of the SWQS, issued by MassDEP and approved by EPA Region 1, that allow limited discharges from permitted CSO outfalls, subject to specific conditions. were issued by MassDEP and approved by EPA Region 1. They require the preparation of an Updated CSO Control Plan.

**Water Quality Parameters:** Total Phosphorus (TP) and Total Suspended Solids (TSS) are common water quality parameters that are monitored and used in regulatory requirements. The Water Quality Model projected attainment for *Escherichia Coli* (*E. coli)* and *Enterococcus*.

**Water Supply Citizens Advisory Committee (WSCAC):** Advises the MWRA and DCR on water conservation and watershed protection strategies, providing ongoing public input.

**Watershed Advocacy Groups:** The Partners engaged three watershed advocacy groups during the Updated CSO Control Plan development effort: the Charles River Watershed Association (CRWA), the Mystic River Watershed Association (MyRWA), and Save the Alewife Brook (StAB). The watershed advocacy groups provided input and conducted outreach to their constituents.

**Weir:** Flow control structure places across the width of a sewer pipe to regulate, measure, or divert flow.

## Executive Summary

The City of Cambridge, the City of Somerville, and the Massachusetts Water Resource Authority (MWRA), collectively known as the Partners, are pleased to submit this Draft Updated Combined Sewer Overflow (CSO) Control Plan (Updated CSO Control Plan or Plan). This effort focuses on projects that target the remaining CSO outfalls that can discharge to the Alewife Brook, Mystic River, and Charles River as shown in the "Study Area" in **Figure 1.**

***See Section 2: Regulatory and Policy Drivers for CSO Control for discussion on the Variances and other regulatory requirements***

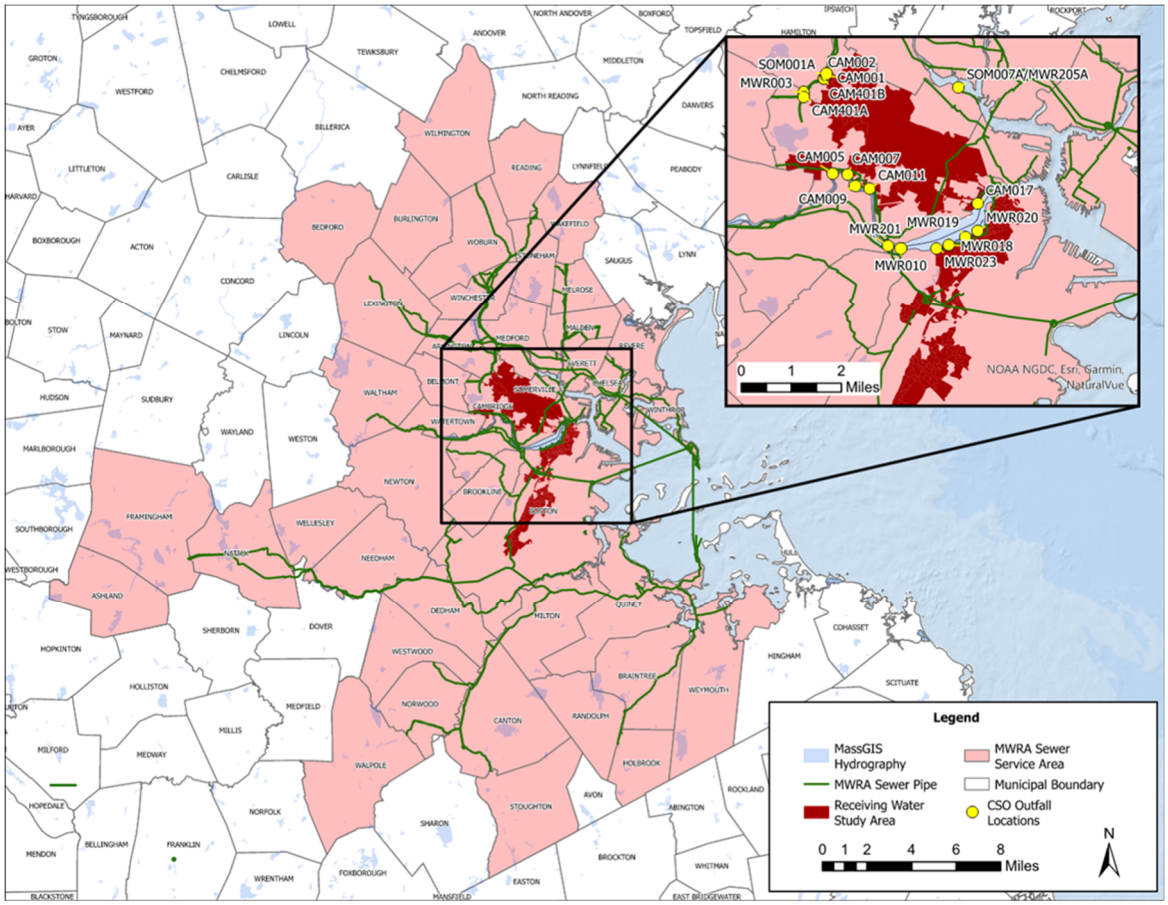



**Figure 1. Updated CSO Control Plan Area and MWRA Service Area**

Advised by a team of dedicated experts, the Partners spent several years developing a CSO Control Plan that builds on work completed by the MWRA and its member communities over the past four decades. This prior work reduced CSO discharges within the region by 88% from conditions in the late 1980s at a total cost of over $900 million.

***See Section 3: History of CSO Planning and Implementation***

This Plan, with an estimated design and construction cost of $1.3 billion (in 2026 dollars), has the following characteristics:

- Utilizes a forward-thinking approach to CSO control that incorporates future climate conditions, was informed by robust water quality analyses, and engaged stakeholders and the public;
- Balances water quality concerns, construction impacts, preservation of public open space, and projects timelines, while considering financial impacts across Cambridge, Somerville, and the other 41 MWRA sewer communities; and
- Recommends projects that are predicted to eliminate CSOs in a future year that accounts for a changing climate—this is referred to as the 2050 Typical Year.

***See Section 12: Draft Recommended Plan for characteristics of the Recommended Plan***

### A Plan Resilient to the Impacts of Climate Change

Given the year-to-year variability of rainfall and therefore CSO discharges, a key building block of any CSO Control Plan is to control CSOs based on a defined Typical Year. The Typical Year has always been backwards looking and selected based on historical rainfall trends in the region. The Partners broke from convention by evaluating future-looking rainfall patterns centered on the year 2050***.***

***See Section 6: Planning Components for the Updated CSO Control Plan for background on the historic Typical Year, development of the 2050 Typical Year, and development of 2050 design storms***

This represents a unique, believed to be first-in-the-nation approach that integrates CSO control and climate mitigation into one singular strategy. Using this approach, the 2050 Typical Year contains a greater number of storms, with higher rainfall volumes and intensities, in comparison to the storms that are included in traditional historically based Typical Year development methodologies. **With both treated and untreated CSOs predicted to be eliminated with the recommended Plan in the more robust 2050 Typical Year, there will be huge improvements over current CSO controls.**

### A Plan Grounded in Water Quality Data Analysis

The Partners have analyzed water quality samples, which were collected in dry and wet conditions with and without CSO activations for more than a decade. This informed the water quality modeling performed by the Partners to better understand both the sources of water quality impairments, and the scope of added benefits of controlling CSOs in the 2050 Typical Year and infrequent larger storms than those forecasted in the 2050 Typical Year. In addition to CSO, there are other water quality impacts, and **the water quality modeling demonstrates that the influence of other sources, mainly stormwater and upstream sources, continue to be the primary cause of water quality impacts during most storm events with or without CSOs.**

***See Section 7.6: Baseline Assessment of Attainment of Current Water quality Criteria for pollutant contributions by source***

Given that pollutants from other sources (stormwater, etc.) will continue within these waterbodies for the foreseeable future, even additional CSO control will not result in water quality improvements that allow for more days of swimmable or fishable waters.

Addressing stormwater impacts to these waterbodies is a watershed-scale problem that extends beyond the limits of this Updated CSO Control Plan. With this understanding in mind, the Draft Recommended Plan provides CSO controls that are effective, feasible, evidence based, and aligned with water quality

benefits while acknowledging the level of achievable water quality when considering other factors. **This balanced, data-driven approach reflects the Partners' dedication to achieving a cleaner, healthier future for the receiving waters and the communities that use and enjoy them.**

### A Robust Alternative Development and Evaluation Framework

Many of the remaining CSOs in this region persist due to complex system challenges: limited available space to locate new infrastructure in dense urban areas, challenges to ensuring stormwater discharges from sewer separation do not negatively impact water quality in the receiving waterbodies or flood Alewife Book during extreme storms, and downstream sewer capacity limitations that can be further hampered by regional infiltration/inflow (e.g., groundwater infiltration and leaking sewer pipes) sources during larger storm events, to name a few.

The Partners developed 39 distinct alternatives across the three waterbodies and four levels of control: limited CSOs in a 2050 Typical Year, 0 CSOs in a 2050 Typical Year, 0 CSOs in a 2050 5-year storm, and 0 CSOs in a 2050 25-year storm. CSO control tools reviewed included: sewer separation, green stormwater infrastructure, inflow/infiltration reduction, storage, and conveyance. **39 alternatives were developed based on performance against future climate (2050)**; the intent behind this approach was to guarantee that any selected alternative would provide meaningful CSO reductions that are resilient to a future climate.

***See Section 7: Levels of CSO Control and System Baseline Conditions for details on the levels of control, and Section 9. Development of CSO Control Alternatives for the alternative development process***

Selecting the recommended alternatives focused on balancing numerous considerations, including CSO control, timeline to CSO reduction benefits, cost, implementation, overall impacts (neighborhood disruption and temporary and permanent loss of recreational areas), operational impacts, community and regional flooding, and water quality improvements.

***See Section 10: Evaluation of CSO Control Alternatives for the evaluation process and results***

This multi-layered evaluation methodology aimed to be protective of the environment, responsible with ratepayer dollars, mindful of construction impacts, provide opportunities for earlier benefits, and not preclude adaptability/expandability in the future. This is especially pertinent when considering other needs: climate change initiatives to prevent widespread flooding, projects to meet other stormwater regulatory requirements, and maintaining existing sewer and drinking water infrastructure to ensure continued access to safe drinking water and reliable wastewater services.

### A Plan Developed with Significant Public Engagement

The Partners carried out public and targeted engagement to capture perspectives from varied groups including community, environmental, regulatory, and municipal interests. Through this engagement, the Partners received varied feedback that informed all stages of the process. Although the Partners heard a strong desire from advocacy groups for the Charles River, Mystic River and Alewife Brook to eliminate any and all CSOs to these water bodies, as documented in this Plan, that approach comes at a sizeable expenditure of limited regional resources that would be more prudently applied to reduce other pollutant sources and address the climate change challenges ahead.

***See Section 5: Outreach and Engagement for all engagement and a summary of how feedback was incorporated into the Plan***

Since 2022, the Partners have been committed to engaging impacted stakeholders and clearly sharing critical information through the Joint Project Website and other approaches, as summarized in **Figure 2**.




**Figure 2. Summary of Engagement and Outreach Activities**

### The Recommended Plan

After the Partners completed their extensive, multi-layered evaluation of all 39 alternatives, one alternative was selected for each waterbody. **Table 1** presents the Draft Recommended Plan. **The selected alternatives for each of the three waterbodies are all predicted to achieve 0 CSOs in the 2050 Typical Year, meaning that projected increases in precipitation due to climate change are accounted for, offset, and largely mitigated through the implementation of the recommended alternatives.**

**Table 1. Draft Recommended Plan**

| Waterbody | Alternative Description | Cost | Estimated Duration |
|---|---|---|---|
| Alewife Brook | 2 storage tanks (3 MG) + 8 acres of sewer separation + 0.75-mile-long conveyance pipe + 1 mile-long microtunnel | $340M | 13-18 years |
| Mystic River | 1 storage tank (7.4 MG) + 95 acres of sewer separation | $260M | 5-7 years |
| Charles River | 2 storage tanks (12.6 MG) + 446 acres of sewer separation + 2 storage conduits | $690M | 28-33 years |

When compared to alternatives achieving higher levels of control, the recommended projects have additional benefits, including:

- Earlier reductions in CSO discharges as several projects can be completed and come online more quickly;
- Less disruptive construction impacts, including less truck traffic; and
- Reduced temporary and permanent loss of valuable open space, including park land.

The Recommended Plan builds upon four years of robust technical analysis and collaboration undertaken by the Partners. It aims to be an implementable and feasible plan that will achieve meaningful water quality benefits, be grounded in climate resilience, and recognize where factors outside of CSO control may drive remaining water quality impacts. It will lead the nation in the next round of CSO control that contemplates the difficult and technically challenging questions around CSO elimination, climate resilience, and other drivers of regional water quality.

This Plan concludes that the significantly larger capital expenditure, local construction impacts, sewer system operational and capacity impacts, and forfeiture of park lands for further CSO control in large and infrequent rain events beyond those forecast in a future 2050 Typical Year, is not a responsible ratepayer investment. Allocating additional resources to further CSO control will result in minimal water quality improvements due to the continued influence of other water quality drivers as noted above.

### Next Steps

Over the next five months, concluding at the end of September 2026, the Partners are seeking feedback on this proposed Draft Updated CSO Control Plan. The key to a successful Final Updated CSO Control Plan is the incorporation of feedback from all impacted stakeholders. During the public comment period, people will have the opportunity to submit comments on the draft Plan in a variety of ways including public hearings, local office hours, and electronically on the Joint Project Website (https://voice.somervillema.gov/joint-cso-planning).

# 1. Introduction

The City of Cambridge, the City of Somerville, and the Massachusetts Water Resources Authority (MWRA), henceforth known as the Partners, have jointly prepared this Draft Updated Combined Sewer Overflow (CSO) Control Plan (Updated CSO Control Plan or Plan) for their respective outfalls, in accordance with the requirements of the 2024 Final Determinations to Adopt a Water Quality Standards Variance (Variances) for CSO Discharges to the Alewife Brook/Upper Mystic River Basin and to the Lower Charles River/Charles Basin (**Appendix A**).

The Variances are short-term modifications of the Massachusetts Surface Water Quality Standards (SWQS) that allow limited discharges from permitted CSO outfalls, subject to specific conditions. The overarching goal of the Variances is to further improve water quality in the Alewife Brook, the Mystic River, and Charles River through elimination or reduction of CSOs.

The Variances require that the Updated CSO Control Plan(s) should be developed conforming to the United States Environmental Protection Agency (EPA) CSO Policy[1] and Massachusetts Department of Environmental Protection (MassDEP) 1997 *Guidance for Abatement of Pollution from CSO Discharges.*[2] The EPA CSO Policy states that "permittees with CSOs are responsible for developing and implementing long-term CSO control plans (LTCP) that will ultimately result in compliance with the requirements of the Clean Water Act (CWA)". LTCPs generally include large capital projects that require robust engineering studies, significant design, permitting and construction work, and complex public funding.

The Variances are an acknowledgement by MassDEP and EPA Region 1 that CSO control in the region needs to continue. MWRA's first LTCP resulted in significant reductions to CSOs and improvements to water quality. This Updated CSO Control Plan lays out the implementation strategy to continue CSO control in alignment with the Variances and other regulatory requirements. The Partners have committed to a close collaboration starting in 2022 by holding interagency meetings, sharing data, developing and maintaining unified modeling tools, coordinating technical analyses, and engaging with the public throughout the process.

## 1.1 Combined Sewer Overflow Control Background

### 1.1.1 Defining the Problem

Like many older European and U.S. cities with 19th century infrastructure, the Greater Boston area still contains numerous combined sewer systems where both sanitary sewage and stormwater travel through a single pipe network. In combined sewer systems, a CSO outfall functions as a hydraulic relief point that helps prevent sewage backups into streets, homes, and businesses, and protects downstream wastewater treatment facilities from overload. During dry weather (no rain or snow) and minor storms, these single-pipe systems convey all flow to regional treatment plants. However, during significant rain events, stormwater volumes can exceed the capacity in the system. To prevent backups into homes, businesses, and streets, excess flows during these significant events are diverted through CSO outfalls to nearby waterways—resulting in a CSO event (see **Figure 1-1**).

[1] EPA Combined Sewer Overflow Control Policy
[2] State of MA - Combined Sewer Overflow Policies & Guidance | Mass.gov

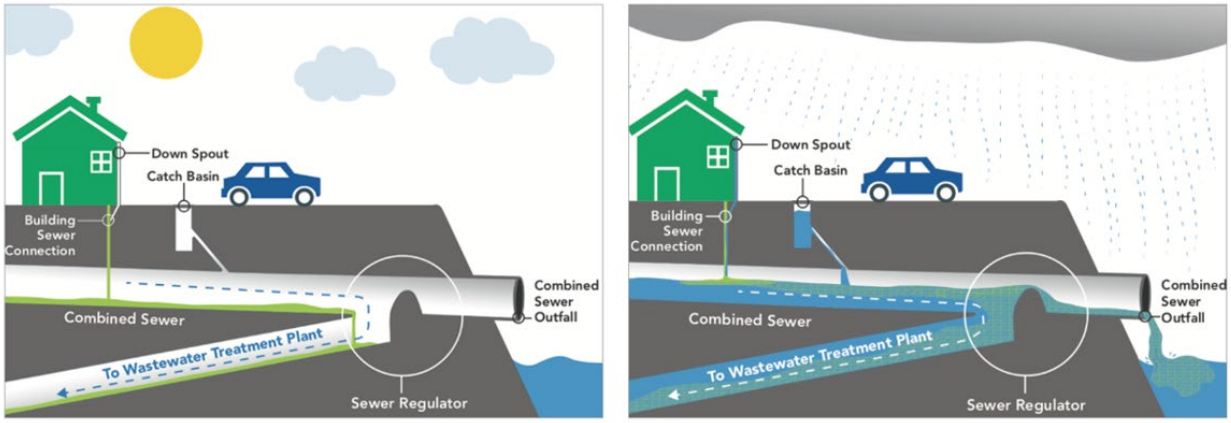



**Figure 1-1. Illustration of a Combined Sewer System and Overflow Event**

### 1.1.2 History of CSO Control

The history of CSO control in the Greater Boston area dates back to the early 1970s, shortly after passage of the CWA. Pursuant to its Enabling Act, MWRA is authorized to provide wholesale water and sewer services in service areas encompassing, in whole or in part, 61 communities located primarily in eastern Massachusetts. Approximately 3 million people, or 44% of the total population of the Commonwealth, live in the MWRA's service areas. Over the last four decades, MWRA has significantly invested in its system and the region to improve water quality and protect public health within Massachusetts and in Boston Harbor. Early investments resulted in the construction of the Deer Island Treatment Plant (DITP), New England's largest wastewater treatment facility, centralization of sewer infrastructure, and the reduction of sanitary sewer overflows (SSOs) and CSOs. MWRA's sewer collection system now includes a network of 274 miles of sewer pipelines (19 miles of cross-harbor tunnels, 226 miles of gravity sewers, 18 miles of force mains, seven miles of siphons, and four miles of CSO and emergency outfalls); 13 pump stations; one screening facility; six CSO treatment/storage facilities; and four remote headworks facilities.

MWRA's DITP was the centerpiece of the $3.8 billion construction program to alleviate pollution in Boston Harbor. DITP provides primary and secondary treatment of wastewater collected in the sewer service area. Treated wastewater effluent is carried by a 9.4-mile, 24-foot diameter outfall tunnel and discharged into the 100-foot-deep waters of Massachusetts Bay. Components of the DITP include influent pumps, primary treatment, secondary treatment, disinfection, dechlorination, the outfall tunnel, sludge digesters, odor control, and on-site power generation. Extensive monitoring of wastewater effluent and Massachusetts Bay ensures protection of the environment.

The MWRA and its member communities have also completed extensive work to improve their sanitary and combined sewer systems to provide redundancy, improve safety, and reduce their systemic reliance on CSOs as a hydraulic relief tool for sewage conveyance. Moreover, MWRA has provided over $574.6 million in grants and zero interest loans to its member communities for inflow and infiltration reduction projects. CSO volumes across the region have decreased by nearly 88% since the late 1980s.

In addition to the over $900 million in projects specified in the MWRA's first LTCP, Cambridge, Somerville, and the Boston Water and Sewer Commission (BWSC) have independently implemented projects that have also resulted in further reductions of CSOs to the Alewife Brook, Mystic River, and the Charles River. Overall, the region has invested billions of dollars to reduce CSOs and improve overall system performance. As a result, 19 of 33 CSO outfalls within the areas subject to the Variances have been closed, and 2 Cambridge CSO outfalls have been temporarily closed (CAM009 and CAM011), as shown in **Figure 1-3.** The two Cambridge regulators have been bulkheaded since 2008. For this reason, these two CSO outfalls have not been included in the evaluations for this Plan.

### 1.1.3 Challenge of Remaining CSOs

Continued CSO reductions at the remaining outfalls require complex solutions. CSOs were purposely built into the system as a hydraulic relief tool for sewage conveyance and to protect the public from sewage discharging directly into people's homes or city streets; reducing and/or eliminating them is a difficult balance to ensure that the risk and consequence is not just moved downstream.

The Alewife Brook, the Mystic River, and the Charles River all flow through highly developed, mostly urbanized lands. Pollution sources include stormwater, dry weather inputs (illicit connections), upstream inputs, and CSOs. All these inputs contribute bacteria and other pollutants loads that can make the three waterbodies unsafe for recreation, like swimming and boating.

Cambridge and Somerville are only two of the 43 communities that contribute to MWRA's regional conveyance network and the DITP, but they are at the downstream end of the MWRA network. Although the broader contributing area spans nearly 500 square miles, the 16 remaining CSO outfalls subject to the Variances are concentrated within a compact area—less than 10 square miles—across Cambridge, Somerville, and Boston. **Figure 1-2** depicts the CSO tributary areas (or sewersheds) contributing to the receiving waters within the broader MWRA service area. These sewersheds contain some of the most low-lying and densely populated neighborhoods in the system, and its residents come into direct contact with the affected waterbodies: Alewife Brook, the Mystic River, and the Charles River.

On a typical day, approximately 365 million gallons of sewage are treated at the DITP, but flows can increase to more than 3.5 times that amount during major storm events. The contributing combined sewers were intentionally designed with hydraulic relief points—CSO outfalls—to prevent system overload and basement or street flooding. Although the Partners no longer permit construction of combined sewer and manage new development to limit inflow increases when new impervious areas are created, decades of prior development have left large inflow volumes and rates to contend with. Combined with more intense precipitation driven by changing climate patterns, CSOs can continue to occur and affect water quality and public health in the receiving water particularly during heavy rain events.

Importantly, these CSO outfalls also provide hydraulic relief that protects adjacent communities, such as Medford, Arlington, Everett and Boston, from sewer backups and flooding, given their proximity to CSO outfalls in the Alewife Brook, the Mystic River, and the Charles River. As part of this Updated CSO Control Plan, analyses were undertaken to identify situations where eliminating a CSO in one location could inadvertently increase water quality or public health risks elsewhere. The goal was to avoid potentially shifting water quality issues from one community or waterway to another. This delicate balance highlights why many conventional CSO control approaches are not feasible in the uniquely constrained environment surrounding these remaining outfalls.

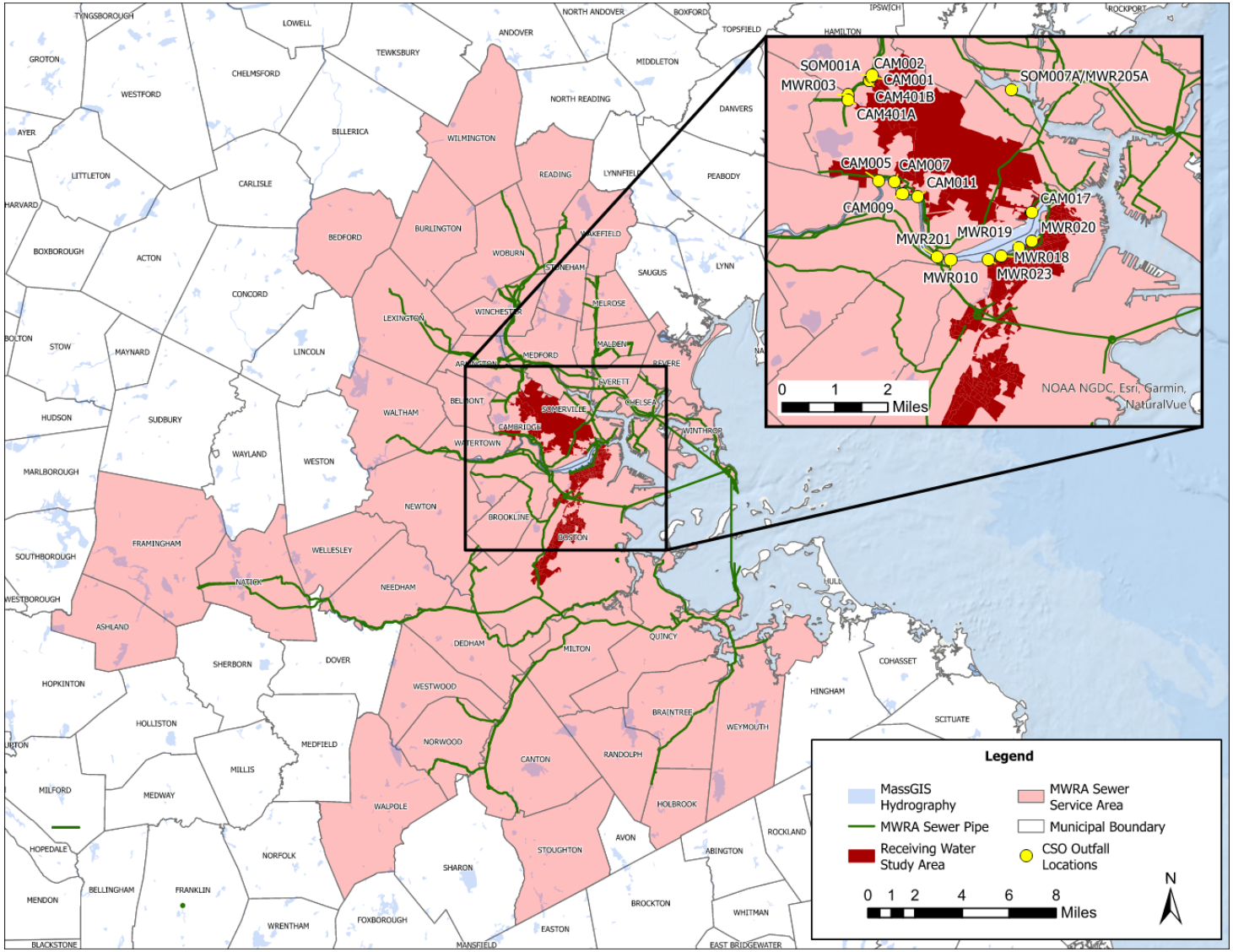



**Figure 1-2. Comparison of the Receiving Water Sewersheds with the Entire MWRA Sewer Service Area**

## 1.2 The CSO Outfalls Subject to This Plan

The CSO outfalls subject to this Updated CSO Control Plan are each regulated pursuant to National Pollutant Discharge Elimination System (NPDES) permits issued to MWRA, Cambridge, and Somerville, for their respective outfalls. Through the NPDES program, EPA established a national framework for controlling CSOs, called the CSO Control Policy. Communities with CSOs must comply with the CSO Control Policy and have a permit to discharge.

Under its NPDES permit, MWRA maintains and operates facilities that collect, convey, and treat combined wastewater from its member communities for treatment at the DITP with ultimate discharge into Massachusetts Bay. Within the area subject to this Updated CSO Control Plan, MWRA is authorized to discharge from eight (8) CSO outfalls:

- MWR003 in the Alewife Brook.
- SOM007A/MWR205A, which is downstream of the Somerville Marginal CSO Treatment Facility, is in the Upper Mystic River. This single CSO outfall is permitted to both Somerville and MWRA.
- MWR201, which corresponds to Cottage Farm CSO Treatment Facility, and MWR010, MWR018, MWR019, MWR020, and MWR023 in the Charles River.

Cambridge's NPDES CSO Permit authorizes discharges from eleven (11) CSO outfalls, only 7 of which are open:

- CAM001, CAM002, CAM401A and CAM401B in the Alewife Brook
- CAM005, CAM007 and CAM017 in the Charles River. Two CSO outfalls in the Charles River are temporarily closed: CAM009 and CAM011.

Somerville's NPDES CSO Permit authorizes CSOs from

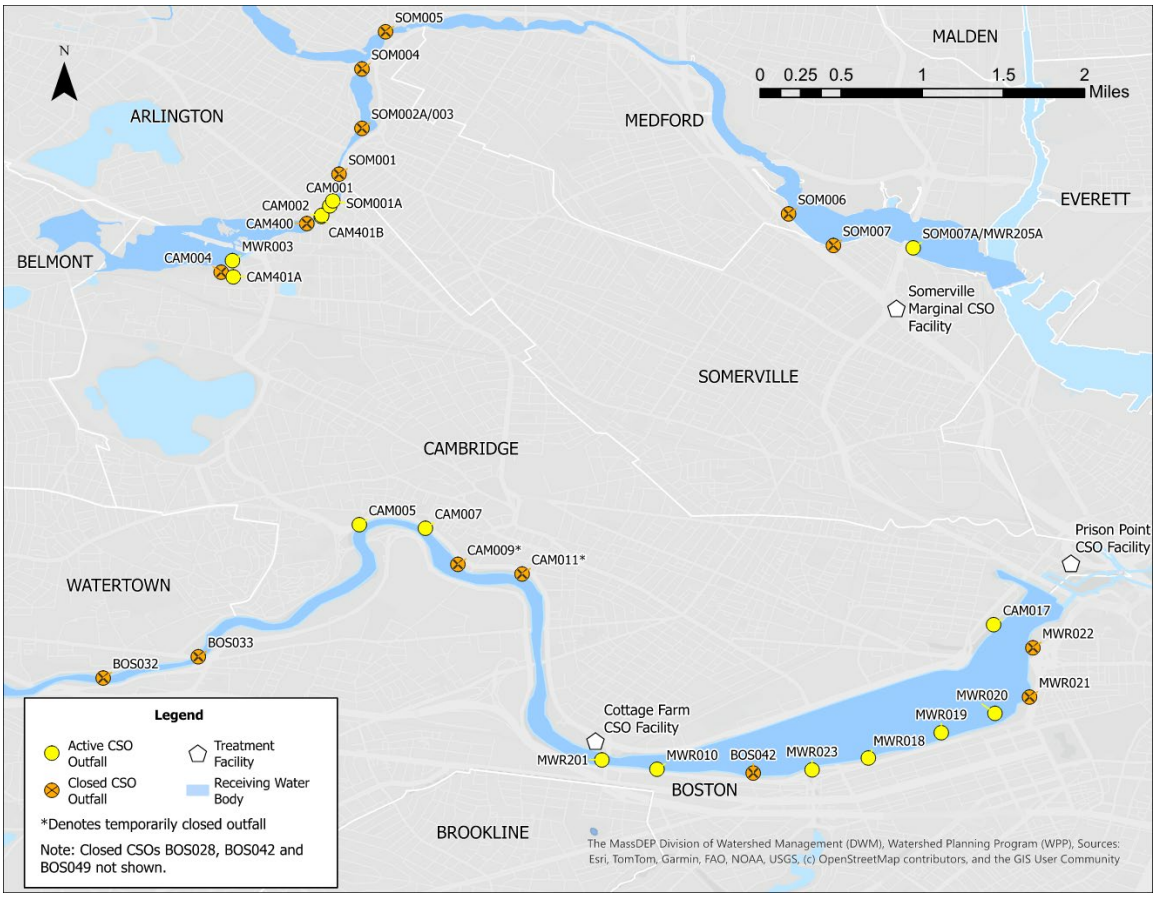
- SOM001A to the Alewife Brook.
- SOM007A/MWR205A into the Mystic River. This single CSO outfall is permitted to both Somerville and MWRA.

As of 2024, approximately 60% of Cambridge's sewer system and 10% of Somerville's sewer system has been separated, and the two cities continue sewer separation and optimization work that contributes to improving the conveyance system and the natural and built environment. Sixteen (16) CSO outfalls remain open in these three waterbodies, as summarized in **Table 1-1** and shown in **Figure 1-3**.

## Table 1-1. Open CSO Outfalls Subject to the 2024 Variance and this Plan

| CSO Name | Permittee | Description | Permit No. |
|---|---|---|---|
| **Alewife Brook** | | | |
| CAM001 | Cambridge | Untreated | MA0101974 |
| CAM002 | Cambridge | Untreated | MA0101974 |
| MWR003 | MWRA | Untreated | MA0103284 |
| CAM401A | Cambridge | Untreated | MA0101974 |
| CAM401B | Cambridge | Untreated | MA0101974 |
| SOM001A | Somerville | Untreated | MA0101982 |
| **Mystic River** | | | |
| SOM007A / MWR205A | Somerville/MWRA | Treated | MA0101982/MA0103284 |
| **Charles River** | | | |
| CAM005 | Cambridge | Untreated | MA0101974 |
| CAM007 | Cambridge | Untreated | MA0101974 |
| CAM017 | Cambridge | Untreated | MA0101974 |
| MWR010 | MWRA | Untreated | MA0103284 |
| MWR018 | MWRA | Untreated | MA0103284 |
| MWR019 | MWRA | Untreated | MA0103284 |
| MWR020 | MWRA | Untreated | MA0103284 |
| MWR 201 (Cottage Farm) | MWRA | Treated | MA0103284 |
| MWR023 | MWRA | Untreated | MA0103284 |

**Note:**
CAM009 and CAM011 are temporarily closed and not included in this table.




## Figure 1-3. Permitted CSOs Discharging in the Alewife Brook, Mystic River, and Charles River

## 1.3 Impact of Stormwater on Water Quality

Stormwater continues to be one of the major contributors to impairments in local waterways. Total Maximum Daily Loads (TMDLs) established under the CWA play an important role in efforts to improve regional water quality. While the development of TMDLs requires consideration of a wide range of pollutants and sources, stormwater runoff—carrying nutrients, bacteria, solids, and other pollutants from streets, rooftops, and illicit connections from sanitary sources, and other sources typical to developed areas—has been repeatedly identified as a significant driver of water quality challenges across the region.

It is also critical to underscore that stormwater impacts extend far beyond the about ten square mile area covered by this Updated CSO Control Plan. Stormwater is a watershed-based issue by nature, generated across multiple municipalities and drainage systems, and it cannot be fully managed or mitigated within the boundaries of this Plan. The watershed's hydrology does not align neatly with jurisdictional lines, and water quality outcomes depend on actions taken by numerous entities across the impaired watersheds. **Figure 1-4** depicts the watershed boundaries contributing to the receiving waters within the broader MWRA service area.

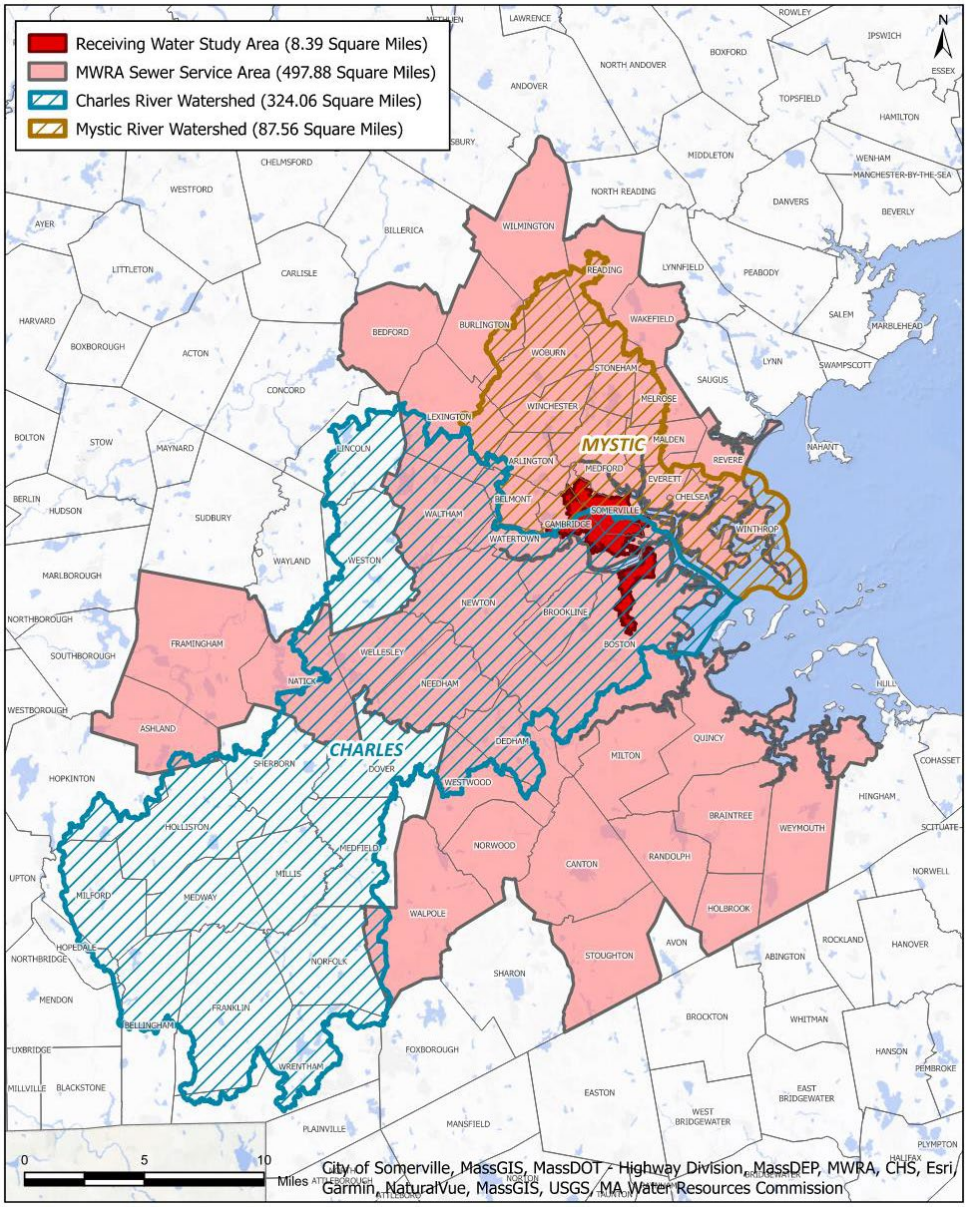



**Figure 1-4. Map of MWRA Service Area and Receiving Water Watersheds**

In many other CSO communities, the same agencies that are responsible for CSO control also oversee municipal separate storm sewer system (MS4) programs and broader stormwater management efforts. In contrast, stormwater responsibilities in this region are distributed to the municipalities, and MWRA, per its Enabling Act, is not directly involved in municipal MS4 or stormwater operations. As a result, as the Partners are coordinating in developing this Updated CSO Control Plan to reduce CSOs, the Cities of Somerville and Cambridge also must balance the recommendations here with the significant technical challenges and financial investments required in their stormwater systems to achieve the best overall water quality improvements.

As we consider CSO control alternatives for larger very infrequent storm events, we must also consider the impact of increases in flows resulting from stormwater entering MWRA's interceptor system outside of the study area. Although remaining combined areas within Cambridge, Somerville, and Boston are a primary contributor to remaining CSOs, large storms of the magnitude considered in this study, particularly when coupled with extended wet periods, can contribute extraneous stormwater flows from the upper reaches of the MWRA service area outside the boundaries of Cambridge and Somerville of magnitude that can influence existing CSO discharges. MWRA continues to support its 43 wastewater communities in their efforts to reduce these upstream inflow sources through its inflow/infiltration (I/I) financial assistance program. Through December 2025, a total of $596 million has been distributed to member communities to fund 708 local sewer rehabilitation projects. An additional $489 million is approved for distribution through FY35. MWRA also works to reduce I/I entering directly to the MWRA's interceptor system through ongoing interceptor renewal programs and recently awarded Phase 1 Siphon Rehabilitation project. The capacity constraints of the downstream MWRA conveyance system including DITP represent fixed systemwide limitations—factors that fall outside the scope of this Updated CSO Control Plan.

### 1.3.1 Commitment to Water Quality

The Partners remain deeply committed to improving water quality within the Alewife Brook, the Mystic River, and the Charles River, while recognizing that multiple sources contribute to the conditions observed today. CSOs continue to play a role in these challenges; however, they are neither the sole cause nor necessarily the primary driver of the impairments identified in regional TMDL analyses. While CSOs do have real impacts on public health and the environment, the broader stormwater system—spread across many communities and multiple complex watersheds—delivers substantial pollutant loads that must be addressed alongside CSO controls to achieve meaningful and lasting improvements.

Within this broader context, the Partners reaffirm their longstanding commitment to reducing CSOs. Significant progress has been made over decades of investment, and the Partners remain focused on advancing further reductions. At the same time, the next phase of CSO abatement presents increasingly difficult, costly, and technically complex challenges. As new controls are evaluated, it is essential that future investments result in measurable gains in water quality within the receiving waters. Ensuring that each additional project meaningfully improves water quality is critical to supporting both environmental protection and responsible stewardship of ratepayer resources.

The continued presence of CSOs contributes to both human health and ecological integrity concerns for the region. Addressing both remains central to the Partners' commitment.

Together, the Partners will continue to pursue CSO controls that are effective, feasible, evidence based, and aligned with measurable water quality benefits. However, it is important that watershed-wide stormwater impacts are acknowledged by communities and stakeholders within the larger watersheds. This balanced, data-driven approach reflects the Partners' dedication to achieving a cleaner, healthier future for the receiving waters and the communities that rely on them.

## 1.4 Updated CSO Control Plan Scope and Objectives

### 1.4.1 Plan Scope

The Partners have committed to a close collaboration that included holding interagency meetings, sharing data, developing and maintaining unified modeling tools, coordinating technical analyses, and preparing a

single joint Updated CSO Control Plan (Plan). The purpose of this Plan is to identify projects that can be implemented to further reduce or eliminate CSOs and continue improving the water quality in the Alewife Brook, Mystic River, and Charles River. This Plan builds on decades of planning and construction activities to date, and the Partners have prepared this Plan in accordance with existing decades-old state and federal policies and guidelines that center on CSO control. At the time of writing this report, no state or federal policies and guidelines that focus on updated long-term control plans have been issued.

Our region faces numerous challenges due to increased stormwater and flooding from projected increased precipitation, sea level rise, and storm surge; a changing regulatory environment; and the competing infrastructure and financial needs of the communities. As much as possible, these impacts are addressed in this Updated CSO Control Plan as part of evaluating the proposed projects and alternatives. However, many of these regional issues require collaboration with other communities and local and state agencies that are outside the jurisdiction of the Variances and scope of a CSO control plan, as defined by EPA's CSO Control Policy.

### 1.4.2 Plan Objectives

As the Partners embarked on this process, they understood the urgency of finding solutions to issues of CSOs. Most directly, the MWRA's mission statement directly includes the protection of public health and the promotion of environmental stewardship, and the Cities of Cambridge and Somerville have proven track records of stewarding the same values.

With the aim of identifying innovative strategies and solutions, the Partners assembled a technical team of industry leaders to perform the analyses described within this Plan. This work remains grounded in the following guiding principles:

- **Collaboration**: the Partners collaboratively developed this singular Updated CSO Control Plan in hopes that it will achieve more than what each entity working in a silo could.
- **Learn from Peer Communities**: communities across the country are grappling with CSO control, and this Plan aims to leverage their experience to learn what has and has not worked for others.
- **Integrate Climate Change**: be forward looking and respond proactively to climate change, rather than developing a plan that may become obsolete in the near future due to changing conditions.
- **Driven by Water Quality:** review water quality drivers in the region and consider multiple sources impacting overall water quality within affected receiving water bodies, not just CSOs.
- **Emphasize Feasibility:** recommend a plan that is technically implementable within the constrained local environment.
- **Measurable and Near-Term Improvements**: prioritize near-term CSO benefits that have significant impact on water quality and public health; and
- **Consider Financial Impacts:** understand the impact of CSO improvements on our rate payers, particularly those of lower socio-economic status.

These objectives are woven into each stage of the Updated CSO Control Plan development to ensure that real water quality and public health improvements would be realized with the recommended alternatives.

## 1.5 Structure

The following sections detail the activities associated with the Updated CSO Control Plan, including:

- Section 2: Regulatory and Policy Drivers for CSO Control outlines the regulatory and policy drivers for CSO control, including overarching federal and state regulatory framework for water quality standards as well as the CSO control policies, permitting, and notifications.

- Section 3: History of CSO Planning and Implementation summarizes the history of MWRA's CSO accomplishments and investments over time along with its ongoing post construction monitoring to continue to quantify the water quality benefits of past CSO efforts.
- Section 4: Related CSO Control Efforts presents an overview of the Partners' work following the Nine Minimum Controls guidance in system operation, along with summaries of each entity's additional CSO-related work, public notifications and public health advisory, and water quality monitoring.
- Section 5: Public Outreach and Engagement summarizes the many outreach and engagement activities the Partners undertook to educate, inform, and gather input from the public and stakeholder groups.
- Section 6: Planning Components for the Updated CSO Control Plan characterizes key analytical tools of the plan, including definition of the 'typical year', the unified hydrologic and hydraulic (H&H) model development as well as the receiving water quality model development.
- Section 7: Levels of CSO Control and System Baseline Condition defines level of control and presents the levels of CSO control evaluated. This section summarizes the system baseline conditions as well as the level of CSO control provided under those baseline conditions. Additionally, this section presents the baseline water quality assessments for the receiving waters.
- Section 8: CSO Control Technologies reviews the various CSO control technologies considered, including sewer separation, green stormwater infrastructure, I/I controls, storage and conveyance controls, and treatment technologies.
- Section 9: Development of CSO Control Alternatives presents the development of CSO control alternatives to meet various CSO levels of control, including an initial screening of the preliminary CSO technologies to rule out those strategies that were infeasible or not viable to move forward for further development.
- Section 10: Evaluation of CSO Control Alternatives details the methodology developed to prioritize alternatives and assess their potential to provide water quality and community benefits.
- Section 11: Financial Capability Assessment summarizes the three Financial Capability Assessments (FCAs) each Partner performed to understand their ability to fund the projects. The FCA represents the 'capability' but not necessarily the affordability of the Plan. Affordability considerations of the preferred alternatives as determined from expected rate impacts are also outlined within this section.
- Section 12: Draft Recommended Plan presents the recommended alternative for each waterbody.
- Section 13: Use Attainability Supporting Data and Information includes data that MassDEP can use for a Use Attainability Analysis (UAA). The UAA is a structured scientific assessment of the factors affecting the attainment of uses specified in CWA and MassDEP regulations.

# 2. Regulatory and Policy Drivers for CSO Control

CSO control is tied to multiple regulatory frameworks that aim to improve water quality and protect public health. The applicable laws and regulations establish goals and prescribe steps that regulated parties must take to achieve those goals. This section reviews those frameworks, including water quality drivers, national and state CSO policies, and permitting. CSOs are just one contributor to water quality issues; therefore, the frameworks presented here (except for the EPA CSO Control Policy) extend to other pollutant sources such as stormwater. Thus, it is important to keep in mind that CSO control may not achieve end goals if other pollutant sources are not also addressed.

## 2.1 Water Quality Drivers

### 2.1.1 Clean Water Act

The Federal Clean Water Act (CWA or the Act), originally enacted as the Federal Water Pollution Control Act Amendments of 1972 and subsequently amended, is the foundational statute for protecting water quality in the United States. The Act's stated objective is

> *"to restore and maintain the chemical, physical, and biological integrity of the Nation's waters"* [33 U.S.C. §1251(a)],

with the national goal that all waters be "fishable and swimmable" wherever attainable. The Act recognizes that waters have been impacted to varying degrees. It requires ongoing assessment of water quality, identification of uses and restoration goals, and specific steps to reach these goals.

The CWA prohibits the discharge of pollutants from any point source to navigable waters unless authorized by a permit issued under the NPDES program, as established in Section 402 of the Act. CSO outfalls are classified as point source discharges under the Act and are permitted accordingly.

The Act further requires states to adopt and periodically review water quality standards for all navigable waters within their jurisdiction under Section 303(c). These standards are based on designated uses (e.g., recreation, aquatic habitat), narrative and numeric water quality criteria to protect those uses, and an antidegradation policy. Section 303(d) requires each state to assess its waters, identify waterbodies that are impaired or threatened by pollutants, and establish a list of those waters (known as the 303(d) List, described in **Section 2.1.3**. For each impaired waterbody, a TMDL must be developed that calculates and allocates pollutant load reductions among point and nonpoint sources to meet water quality standards. Refer to **Section 2.1.3** for further details on the impairments listed for Alewife Brook, the Upper Mystic River and the Charles River, and **Section 2.1.4** for the TMDLs applicable to those waterbodies.

In the context of CSO control, the 303(d) listings and associated TMDLs have significant implications. Waterbodies impaired due to pathogens or bacteria may be influenced by wet-weather discharges, including discharges from CSO outfalls and stormwater. In such cases, CSO controls are often one component of the TMDL implementation strategy to achieve water quality objectives.

The CWA does not prescribe a one-size-fits-all solution to attaining water quality standards. Rather, it allows for flexibility in addressing CSO and other water quality impacts, provided that water quality standards are ultimately attained or that progress toward attainment can be demonstrated. This framework supports site-specific planning based on the receiving water's sensitivity, the frequency and volume of CSO discharges, and the community's financial capability.

By regulating CSO outfalls as point source discharges and by linking their control to the achievement of water quality standards, the CWA is the principal federal authority underpinning all CSO permitting, planning, enforcement, and compliance activities nationwide. The specific requirements of the CWA

pertaining to the control of CSO discharges are spelled out in the EPA CSO Control Policy, as described in **Section 2.2**.

### 2.1.2 Massachusetts Surface Water Quality Standards

Massachusetts Surface Water Quality Standards, codified at 314 CMR 4.00, are the regulatory basis for protecting the quality of the Commonwealth's surface waters. These standards implement the requirements of the CWA and are developed by MassDEP to designate uses for each waterbody, prescribe minimum criteria to protect those uses, and provide an antidegradation policy to prevent the deterioration of existing water quality. The standards are enforceable by the Commonwealth, but federal CWA regulations (40 CFR 131) require that revisions to state water quality standards be approved by EPA.

Each waterbody in Massachusetts is assigned one or more classifications based on its intended uses.

Under 314 CMR 4.05(3)(b), Class B waters are described as:

> *"designated as a habitat for fish, other aquatic life, and wildlife, including for their reproduction, migration, growth and other critical functions, and for primary and secondary contact recreation… Class B waters shall be suitable for irrigation and other agricultural uses and for compatible industrial cooling and process uses. These waters shall have consistently good aesthetic value."*

The numeric and narrative water quality criteria that support Class B uses are summarized in **Table 2-1**.

**Table 2-1. Water Quality Criteria and Summary Descriptions for Class B Waterbodies**

| Water Quality Criteria | Summary Description (further detail in 314 CMR 4.05(3)(b)) |
|---|---|
| Dissolved Oxygen | Shall not be less than 6.0 mg/L in cold water fisheries and not less than 5.0 mg/L in warm water fisheries. |
| Temperature | Shall not exceed 68°F (20°C). |
| pH | Shall be in the range of 6.5 through 8.3. |
| Bacteria | For protection of primary contact recreation, surface waters shall meet the minimum criteria for bacteria set forth in 314 CMR 4.05(5)(f)1. and 3 (See **Table *2-2*** below). |
| Solids | These waters shall be free from floating, suspended and settleable solids in concentrations and combinations that would impair any use assigned to this Class, that would cause aesthetically objectionable conditions, or that would impair the benthic biota or degrade the chemical composition of the bottom. |
| Color and Turbidity | These waters shall be free from color and turbidity in concentrations or combinations that are aesthetically objectionable or would impair any use assigned to this Class. |
| Oil and Grease | These waters shall be free from oil, grease and petrochemicals that produce a visible film on the surface of the water, impart an oily taste to the water or an oily or other undesirable taste to the edible portions of aquatic life, coat the banks or bottom of the water course, or are deleterious or become toxic to aquatic life. |
| Taste and Odor | None in such concentrations or combinations that are aesthetically objectionable, that would impair any use assigned to this Class, or that would cause tainting or undesirable flavors in the edible portions of aquatic life. |

The criterion most closely tied to attainment of recreational uses in a waterbody is bacteria. Alewife Brook, Upper Mystic River, and Charles River are designated in 314 CMR 4.06 as Class B waterbodies and have been denoted with a CSO qualifier, indicating the waterbodies are "impacted by the discharge of combined sewer overflows; however, a long term control plan has not been approved or fully implemented for the CSO discharges" (314 CMR 4.06(1)(d)(10)). This CSO qualifier acknowledges that it may not be practical to eliminate CSO discharges and reinforces the requirement to control CSOs to the maximum extent practicable consistent with the CWA and approved long-term control plans (as discussed in **Section 2.2.2**). **Table 2-2** summarizes the requirements for bacteria for inland waters impacted by CSO, which includes the Alewife Brook, the Upper Mystic River and the Charles River.

**Table 2-2. Criteria for Bacteria Concentrations for Inland Waters Impacted by CSO**

| Bacterial Indicator | Bacterial Criteria for Inland Waters Impacted by CSO (#/100mL) | |
|---|---|---|
| | Geometric Mean(1) | Statistical Threshold Value(2) |
| *E. coli* | ≤ 126 | ≤ 410 |
| *Enterococci* | ≤ 35 | ≤ 130 |

**Notes:**
(1) The geometric mean for at least one indicator shall not be exceeded in any 30-day or smaller interval.
(2) No more than 10% of all samples collected within that interval shall exceed the statistical threshold value for that indicator.

While the criteria expressed in **Table 2-2** (from 314 CMR 4.05) require an average (geometric mean) concentration and do not require that all bacteria concentrations fall under maximum value ("single sample maximum"), MassDEP recommended that the Partners, in this Updated CSO Control Plan, assess attainment with a single sample maximum value based on the 90$^{th}$ percentile statistical threshold values (STV) for *E. coli* and *Enterococcus*. The water quality evaluations presented in Section 7 therefore also include assessments of attainment of the single sample maximum criteria to align with both the CWA water quality assessments and the latest guidance from MassDEP.

### 2.1.3 Integrated List of Waters ("303(d) List")

MassDEP is required to report on the water quality status of its waters on a biennial basis in accordance with a range of CWA requirements. The State meets this requirement by publishing the "Integrated List" report approximately every two years. The latest approved Integrated List is from 2022 and was approved by EPA in May 2023. As described in the 2023 *Final Massachusetts Integrated List of Waters for the Clean Water Act 2022 Reporting Cycle:*[1]

> *"Section 305(b) of the CWA requires states to assess waters with respect to their attainment of designated uses such as habitat for fish, other aquatic life and wildlife, fish and shellfish consumption, and primary (e.g., swimming) and secondary (e.g., boating) contact recreation. Under Section 314 states report on the trophic status of their lakes and ponds. Section 303(d) requires states to identify those waterbodies that are not expected to meet surface water quality standards after the implementation of technology-based controls and to prioritize and schedule them for the derivation of total maximum daily load (TMDL) restoration plans."* (MassDEP, 2023)

Thus, each listed waterbody is assigned one or more "causes of impairment" and placed into a category reflecting the status of assessment and progress toward restoration.

- Category 1: "Waters attaining all designated uses";
- Category 2: "Attaining some uses; other uses not assessed";
- Category 3: "No uses assessed";

[1] https://www.mass.gov/doc/final-massachusetts-integrated-list-of-waters-for-the-clean-water-act-2022-reporting-cycle/download

- Category 4a: “All TMDLs are completed”;
- Category 4b: “Impairment controlled by alternative pollution control requirements”;
- Category 4c: “Impairment not caused by a pollutant – TMDL not required”;
- Category 5: “Waters requiring one or more TMDL(s)” (i.e., the 303(d) List); and
- Category 5a: “303(d)-listed waters for which Alternative Restoration Plans have been completed”.

Waters under Category 5 constitute “the 303(d) List” and are reviewed and approved by EPA.

The Alewife Brook, Upper Mystic River, and the Charles River downstream of the Watertown Dam have all been assigned Category 5 and are therefore included on the 303(d) List. **Table 2-3** presents the pollutant impairments for these three waterbodies.

## Table 2-3. Category 5 waters (303(d) List) - "Waters requiring a TMDL"

| Waterbody | AU_ID[1] | Description | Size | Units | Impairment | ATTAINS[(2)] Action ID |
|---|---|---|---|---|---|---|
| Alewife Brook | MA71-20 | From emergence of Cambridgepark Drive, Cambridge to mouth at confluence with Mystic River, Arlington/Somerville (formerly part of 2016 segment: Alewife Brook MA71-04). | 1.6 | Miles | (Debris[(3)]) | |
| | | | | | (Water Chestnut[(3)]) | |
| | | | | | Chloride | |
| | | | | | Copper in Sediment | |
| | | | | | Dissolved Oxygen | R1_MA_2020_5a |
| | | | | | *Enterococcus* | |
| | | | | | *Escherichia Coli (E. Coli)* | R1_MA_2019_01 |
| | | | | | Flocculant Masses | |
| | | | | | Lead in Sediment | |
| | | | | | Odor | |
| | | | | | Oil and Grease | |
| | | | | | PCBs in Fish Tissue | |
| | | | | | Phosphorus, Total | R1_MA_2020_5a |
| | | | | | Scum/Foam | |
| | | | | | Sediment Bioassay [Chronic Toxicity Freshwater] | |
| | | | | | Transparency / Clarity | R1_MA_2020_5a |
| | | | | | Trash | |
| Mystic River | MA71-02 | Outlet Lower Mystic Lake, Arlington/Medford to Amelia Earhart Dam, Somerville/Everett | 5 | Miles | (Eurasian Water Milfoil, Myriophyllum Spicatum[(3)]) | |
| | | | | | (Water Chestnut[(3)]) | |
| | | | | | Arsenic | |
| | | | | | Chlordane in Fish Tissue | |
| | | | | | Chlorophyll-a | R1_MA_2020_5a |
| | | | | | DDT in Fish Tissue | |
| | | | | | Dissolved Oxygen | R1_MA_2020_5a |
| | | | | | Dissolved Oxygen Supersaturation | R1_MA_2020_5a |
| | | | | | *Enterococcus* | |
| | | | | | *Escherichia Coli (E. Coli)* | R1_MA_2019_01 |
| | | | | | Harmful Algal Blooms | |

**Table 2-3. Category 5 waters (303(d) List) - "Waters requiring a TMDL"**

| Waterbody | AU_ID[1] | Description | Size | Units | Impairment | ATTAINS[(2)] Action ID |
|---|---|---|---|---|---|---|
| | | | | | PCBs in Fish Tissue | |
| | | | | | pH, High | |
| | | | | | Phosphorus, Total | R1_MA_2020_5a |
| | | | | | Sediment Bioassay [Chronic Toxicity Freshwater] | |
| | | | | | Transparency / Clarity | R1_MA_2020_5a |
| Charles River | MA72-36 | From Watertown Dam (NATID: MA00456), Watertown to the Boston University Bridge, Boston/Cambridge (formerly part of 2006 segment: Charles River MA 72-08). | 6.1 | Miles | (Fish Passage Barrier[(3)]) | |
| | | | | | (Flow Regime Modification[(3)]) | |
| | | | | | (Non-Native Fish/Shellfish/Zooplankton[(3)]) | |
| | | | | | (Water Chestnut[(3)]) | |
| | | | | | Chlorophyll-a | 33826 |
| | | | | | DDT in Fish Tissue | |
| | | | | | Dissolved Oxygen | |
| | | | | | *Escherichia Coli (E. Coli)* | 32371 |
| | | | | | Fish Bioassessments | |
| | | | | | Harmful Algal Blooms | 33826 |
| | | | | | Nutrient/Eutrophication Biological Indicators | 33826 |
| | | | | | Oil and Grease | |
| | | | | | PCBs in Fish Tissue | |
| | | | | | pH, High | |
| | | | | | Phosphorus, Total | 33826 |
| | | | | | Sediment Bioassay [Acute Toxicity Freshwater] | |
| | | | | | Transparency / Clarity | 33826 |
| | | | | | Unspecified Metals in Sediment | |
| Charles River | MA72-38 | From Boston University Bridge, Boston/Cambridge to mouth at the New Charles River Dam (NATID: MA01092), Boston (formerly part of 2006 segment: Charles River MA72-08) | 3.1 | Miles | (Fish Passage Barrier[(3)]) | |
| | | | | | (Flow Regime Modification[(3)]) | |
| | | | | | Cause Unknown [Sediment Screening Value (Exceedance)] | |
| | | | | | Chlorophyll-a | 33826 |
| | | | | | Combined Biota/Habitat Bioassessments | |

## Table 2-3. Category 5 waters (303(d) List) - "Waters requiring a TMDL"

| Waterbody | AU_ID[1] | Description | Size | Units | Impairment | ATTAINS[(2)] Action ID |
|---|---|---|---|---|---|---|
| | | | | | DDT in Fish Tissue | |
| | | | | | Dissolved Oxygen | |
| | | | | | Dissolved Oxygen Supersaturation | 33826 |
| | | | | | Escherichia Coli (E. Coli) | 32371 |
| | | | | | Harmful Algal Blooms | 33826 |
| | | | | | Nutrient/Eutrophication Biological Indicators | 33826 |
| | | | | | Odor | 33826 |
| | | | | | Oil and Grease | |
| | | | | | PCBs in Fish Tissue | |
| | | | | | Phosphorus, Total | 33826 |
| | | | | | Salinity | |
| | | | | | Temperature | |
| | | | | | Transparency / Clarity | 33826 |

**Notes:**

(1) "AU-ID" is an "Assessment Unit" code assigned to the defined segment of the waterbody

(2) Assessment, Total Maximum Daily Load (TMDL) Tracking and Implementation System (ATTAINS) system - https://www.epa.gov/waterdata/attains

(3) TMDL not required (Non-pollutant)

As indicated in **Table 2-3**, wide ranges of pollutants have been identified as causing water quality impairments in Alewife Brook, the Upper Mystic River, and the relevant segments of the Charles River. The 303(d) List does not identify or quantify the sources of the pollutants causing the impairments, nor is it intended to identify a path to compliance with the SWQS.

In the context of CSO planning, the presence of a receiving waterbody on the 303(d) List affects regulatory compliance and control strategy development. Because CSOs contribute to certain impairments, control measures implemented under long-term control plans (discussed in **Section 2.2**) are often coordinated with or integrated into TMDL implementation plans. For NPDES permittees (discussed in **Section 2.4**), discharges to Category 5 waters may also trigger enhanced monitoring, stricter effluent limits, or additional planning requirements.

### 2.1.4 Total Maximum Daily Loads (TMDLs)

After a waterbody is listed on the 303(d) List, the state must then develop a TMDL, which is a regulatory tool under Section 303(d) of the CWA that establishes the maximum amount of a pollutant that a waterbody can receive while still meeting applicable water quality standards. The state is required to prepare TMDLs for all impaired waters listed in Category 5 of the Integrated List.

Each TMDL must identify the pollutant(s) causing the impairment, determine the waterbody's assimilative capacity, and allocate allowable loads to contributing sources. These allocations include wasteload allocations (WLAs) for point sources—such as CSO outfalls, permitted stormwater outfalls, and wastewater treatment plant discharges—and load allocations (LAs) for nonpoint sources, such as overland stormwater runoff or failing septic systems.

TMDLs are especially relevant for aligning CSO control strategies with broader watershed restoration objectives. Often, the implementation of CSO controls through a long-term CSO control plan (LTCP, discussed in **Section 2.2.2**) serves as a mechanism to achieve the pollutant reductions allocated to CSO discharges by a TMDL. At the same time, TMDLs can limit the available CSO control alternatives, or create additional CSO requirements. For example, as described in later sections, sewer separation would result in increased stormwater discharge, and the impact of the potential increase in stormwater loadings would need to be assessed in the context of the applicable TMDL.

TMDLs relevant to this Updated CSO Control Plan include the following:

- Final Pathogen TMDL for the Charles River Watershed (MassDEP/EPA 2007b);[2]
- Final Pathogen TMDL for the Boston Harbor, Weymouth-Weir, and Mystic Watersheds (MassDEP/EPA 2018);[3]
- Final Total Maximum Daily Load for Nutrients in the Lower Charles River Basin, Massachusetts (MassDEP/EPA 2007a);[4]
- Mystic River Watershed Alternative TMDL Development for Phosphorus Management - Final Report (EPA 2020); and[5]
- Each of these TMDLs is described briefly in the subsections below. Section 12 describes how the recommendations in this Updated CSO Control Plan support the water quality objectives of these TMDLs.

[2] https://www.mass.gov/doc/final-pathogen-tmdl-reports-for-the-charles-river-watershed-0/download
[3] https://www.mass.gov/doc/final-pathogen-tmdl-report-for-the-boston-harbor-weymouth-weir-and-mystic-watersheds/download
[4] https://www.mass.gov/doc/final-phosphorus-tmdl-report-for-the-lower-charles-river-basin/download
[5] https://www.epa.gov/sites/default/files/2020-05/documents/mystic-phosphorus-tmdl-development.pdf

#### 2.1.4.1 Final Pathogen TMDL for the Charles River Watershed

This report assessed bacterial loadings for the entire Charles River, broken down by defined river segments, including segment 72-08, which covers the Charles River downstream of the Watertown Dam. As described in this report,

> *"For this TMDL the MassDEP developed three types of daily TMDL targets. First, MassDEP set daily concentration TMDL (WLA/LA) targets for each one of the Charles River discharge sources by category (i.e., storm water, CSO, etc.). MassDEP recommends that the concentration targets be used as the primary guide for implementation. Second, MassDEP provided an estimate of the necessary percent reductions needed in each segment using a conservative analysis based on comparing ambient bacteria concentrations to water quality criteria. Third, maximum daily loads were developed as a function of streamflow and percentage of time a given streamflow is expected to occur using a flow duration approach."* (MassDEP/EPA, 2007b)

Table 7-2 from this report indicated that for segment 72-08, a 99.3% reduction in fecal coliform loading would be required to meet the bacterial water quality criteria that were in place at the time of the report (the fecal coliform geometric mean of 200 #/100mL and no more than 10% of the samples exceed 400 #/100mL). Because of the complexity and variability of bacterial loading, the TMDL did not establish separate, unique targets for CSO versus stormwater loadings.

#### 2.1.4.2 Final Pathogen TMDL for the Boston Harbor, Weymouth-Weir, and Mystic Watersheds

This report establishes indicator bacteria loadings and limits for the Boston Harbor, Weymouth-Weir, and Mystic Watersheds. Within the Mystic River Sub-basin, segments 71-04 (Alewife Brook), 71-02 (Mystic River from the Lower Mystic Lake to the Amelia Earhart Dam), and 71-03 (Mystic River from the Amelia Earhart Dam to the confluence with the Boston Inner Harbor and Chelsea River) are included. As described in the report,

> *"Sources of indicator bacteria in the Boston Harbor watershed were found to be many and varied. Most of the bacteria sources are believed to be stormwater related. [...]*
>
> *Since accurate estimates of existing sources are generally unavailable, it is difficult to estimate the pollutant reductions for specific sources. For the illicit sources, the goal is complete elimination (100% reduction). However, overall wet weather indicator bacteria load reductions can be estimated using typical stormwater bacteria concentrations. These data indicate that in general two to three orders of magnitude (i.e., greater than 90%) reductions in stormwater bacteria loading will be necessary, especially in developed areas. This goal is expected to be accomplished through stepwise implementation of illicit discharge detection and elimination programs (IDDE), best management practices, such as those associated with the Phase I and Phase II control program for stormwater."*

Table ES 1-4 from this report includes the waste load and load allocations based on water quality standards. The Alewife Brook (segment 71-04) and Upper Mystic River (segment 71-02) are surface water classifications B/CSO variance in this Table, with the WLA tied to the CSO Typical Year activations and volumes included in the MWRA LTCP (see Section 3 for more information on the MWRA LTCP).

#### 2.1.4.3 Final Total Maximum Daily Load for Nutrients in the Lower Charles River Basin

This report establishes allocations for phosphorus loadings for the Charles River downstream of the Watertown Dam. The TMDL was intended to address the nutrient and noxious aquatic plant impairments noted on the 303(d) List along with water clarity impairments such as turbidity and taste, odor and color (MassDEP/EPA, 2007a).

As described in the TMDL report,

> *"Regular occurrences of severe algal blooms during the summer months reduce water clarity and contribute to anoxic bottom waters that do not support aquatic life. Water quality data indicate the Lower Charles River is undergoing cultural eutrophication, which is the process of producing excessive plant life because of excessive pollutant inputs from human activities. The algal blooms in the Lower Charles are directly responsible for degrading the aesthetic quality of the river, reducing water clarity, and impairing the designated uses. Additionally, eutrophication of the Lower Charles River has led to the occurrence of a very severe toxic algal bloom in the downstream portion of the Lower Charles during the summer of 2006."* (MassDEP/EPA, 2007a)

The TMDL developed waste load allocations for sources within three broad categories:

(1) upstream watershed at the Watertown Dam;

(2) non-CSO drainage areas that discharge directly to the Lower Charles River; and

(3) CSO discharges.

Individual waste load allocations were provided for CSO discharges to the Lower Charles River and the wastewater treatment facilities in the upstream watershed. The phosphorus waste load allocations for the CSO discharges to the Charles River were based on the CSO Typical Year performance included in the MWRA LTCP (see Section 3 for more information on the MWRA LTCP).

#### 2.1.4.4 Mystic River Watershed Alternative TMDL Development for Phosphorus Management - Final Report

In January 2020, an alternative restoration plan for the Mystic River was released, titled "*Mystic River Watershed Alternative TMDL Development for Phosphorus Management - Final Report.*" This "Alternative TMDL" was developed in accordance with a 2013 EPA framework for prioritizing and implementing TMDLs and pollution control strategies. The framework:

> *"…acknowledge[d] that alternative restoration approaches may be more immediately beneficial or practical in achieving water quality standards than a traditional TMDL … [and] call[ed] on states to strategically focus efforts and demonstrate progress over time…This 'adaptive management' approach for the Mystic will be an iterative process of implementing control actions over an extended period of time while progress is monitored, and new information is gathered to further inform management needs for attaining water quality standards...These studies as well as other efforts have determined that effective nutrient management will likely go a long way towards addressing sources of other impairments in the watershed such as bacteria and sediment-bound contaminants."* (EPA 2020)

Findings from the 2020 Alternative TMDL included the following (wording taken from the report, EPA 2020):

- Nutrients and pathogens are the primary causes of "use impairment" in the freshwater portion of Mystic River watershed.
- Cultural eutrophication–the degradation of aquatic environments by nutrient pollution caused by human activity and urban development–is a major cause of impairments in the watershed as evidenced by excessive algal and macrophyte growth and harmful cyanobacteria blooms.
- Regular occurrences of severe algal blooms during the summer months reduce water clarity and contribute to anoxic bottom waters that do not support aquatic life. Algal blooms and macrophyte growth degrade the aesthetic quality of the river, reduce water clarity, and impair designated uses such as fishing and boating.

- Watershed analyses conducted during this study demonstrate that inadequately controlled stormwater runoff from developed landscapes are the predominant source of nutrient loads–specifically phosphorus loads–to the surface waters of the Mystic River watershed.
- The stormwater load reductions required to meet water quality targets under future conditions (which account for baseline stormwater management, combined sewer overflows/sanitary sewer overflows controls and an estimate of associated reductions in internal loads) were between 59 and 62 percent.

Elimination of combined sewer overflows and sanitary sewer overflows had minimal impact compared to reducing stormwater loads and internal loads released from bottom sediments of the river system. The difference between wet vs. dry years is significant, with much greater difficulty meeting water quality targets during dry years.

The report also noted that in the lower watershed (including Mystic River and Alewife Brook), between 2000 and 2016, "CSO mitigation projects by the MWRA and the cities of Cambridge and Somerville have reduced annual CSO discharge volumes to the freshwater portion of the Mystic River by approximately 88 percent (59 to 7 million gallons) for the typical rainfall year."

## 2.2 EPA CSO Control Policy (1994)

In April 1994, EPA issued the CSO Control Policy (59 Fed. Reg. 18688) (CSO Control Policy), establishing a national framework to guide CSO operators toward attaining the goals established through the CWA and the water quality drivers established in **Section 2.1**. The CSO Control Policy contains both short- and long-term measures to control CSO discharges. The CSO Control Policy was subsequently incorporated into Section 402(q) of the CWA, requiring that each permit for a discharge from a municipal combined sewer system issued after December 21, 2000, must conform to the CSO Control Policy.

The CSO Control Policy provides a flexible structure that allows tailoring controls to local situations. Through coordination with NPDES permitting authorities and state water quality standards authorities, the CSO control strategies developed under the CSO Control Policy become part of NPDES CSO Permit requirements, with the ultimate goal of enabling permittees to meet CWA requirements.

The following subsections describe key elements of the CSO Control Policy: (1) Nine Minimum Controls; (2) Long-Term Control Plan; (3) Coordination with State Water Quality Standards; and (4) Financial Capability Assessment. While the following discussion is generic, each of these elements were part of the original MWRA LTCP (detailed in Section 3) and also make up the foundation of this Updated CSO Control Plan.

### 2.2.1 Nine Minimum Controls

The CSO Control Policy defines nine minimum controls (NMCs) that permittees must implement. These technology-based controls are designed to be implementable without extensive engineering studies, thus reducing the frequency and impact of CSO discharges using practical and cost-effective measures. The NMCs are:

(1) Proper operation and regular maintenance programs for the sewer system and CSO outfalls

(2) Maximum use of the collection system for storage

(3) Review and modification of pretreatment requirements to ensure that CSO impacts are minimized

(4) Maximization of flow to the publicly owned treatment works (POTW) for treatment

(5) Elimination of CSOs during dry weather

(6) Control of solid and floatable materials in CSOs

(7) Pollution prevention programs to reduce contaminants in CSOs

(8) Public notifications to ensure that the public receives adequate notification of CSO occurrences and CSO impacts

(9) Monitoring to effectively characterize CSO impacts and the efficacy of CSO controls

Implementation of the NMCs is typically required as a condition of the NPDES Permit, and CSO communities typically prepare annual reports documenting their activities related to implementing the NMC. Refer to Section 4 for additional details on the ongoing NMC efforts by Cambridge, Somerville, and MWRA.

Through the implementation of the NMCs over the past 30 years, permittees have improved their understanding and optimized the functionality of their collection systems. These enhancements have resulted in improvements in CSO control while also supporting a permittee's ability to accommodate growing and thriving communities. It is recognized, however, that in most cases, implementing the NMCs would not achieve a level of CSO control sufficient to meet SWQS, and that further control measures would be required.

### 2.2.2 Long-Term Control Plan

Recognizing that the NMCs alone are not enough to achieve SWQS in most cases, the CSO Control Policy states that "permittees with CSOs are responsible for developing and implementing long-term CSO control plans that will ultimately result in compliance with the requirements of the CWA" (Policy at II.C). These LTCPs generally include large capital projects that require robust engineering studies, design, and construction to achieve. The CSO Control Policy identifies the following "minimum elements" to be included in an LTCP: (1) characterization, monitoring, and modeling of the combined sewer system; (2) public participation; (3) consideration of sensitive areas; (4) evaluation of alternatives; (5) cost/performance considerations; (6) operational plan; (7) maximizing treatment at existing POTWs; (8) implementation schedule; and post-construction compliance monitoring program.

The CSO Control Policy emphasizes flexibility, allowing for site-specific LTCPs based on receiving water impacts, system characteristics, and community financial capability. The CSO Policy suggests that communities adopt one of two alternative approaches to develop targets for CSO controls that achieve compliance with the Act: the *presumption approach*, under which control levels are "presumed" to be sufficient to meet SWQS if certain minimum performance criteria are met (e.g., ≤4-6 overflow events per year); and the *demonstration approach*, under which the permittee demonstrates that its selected controls are "adequate to meet the water quality-based requirements of the CWA".

Choosing an approach for evaluation of alternatives is a key decision point in the development of an LTCP. The approaches are described in the subsections below, followed by a discussion of the recommended approach for this Updated CSO Control Plan.

#### 2.2.2.1 Presumption Approach

- Under the presumption approach, if the selected control program meets at least one of three specified performance criteria, the program is presumed to provide an adequate level of control to meet SWQS:
    i. Limiting CSO discharges to no more than four to six overflow events per year
    ii. Eliminating or treating at least 85% of the combined sewage volume collected in the system during precipitation events on an annual average basis
    iii. Eliminating or removing no less than the mass of the pollutants identified as causing water quality impairment through the sewer system characterization, monitoring and modeling

effort, for the volumes that would be eliminated or captured for treatment under paragraph ii. above.

Where criteria (i) or (ii) are applied and combined sewer flows remain after implementation of the nine minimum controls, flows should receive a minimum of:

- Primary clarification (using any combination of treatment technologies or methods that are shown to be equivalent to primary clarification for removing floatables and settleable solids);
- Solids and floatables disposal; and
- Disinfection of effluent, if necessary, to meet SWQS, protect designated uses and protect human health, including removal of harmful disinfection chemical residuals, where necessary.

EPA developed the criteria for the presumption approach because "data and modeling of wet weather events often do not give a clear picture of the level of CSO controls necessary to protect SWQS" (Policy at II.C.4.a). The presumption approach further requires that "the permitting authority determines that such presumption is reasonable in light of the data and analysis conducted in the characterization, monitoring, and modeling of the system and the consideration of sensitive areas …" (Policy at II.C.4.a).

#### 2.2.2.2 Demonstration Approach

The demonstration approach allows a permittee to select a level of CSO control that can be demonstrated to meet the water-quality based requirements of the CWA, even if the criteria for the presumption approach are not met. A successful demonstration approach should show:

- The CSO control program will meet SWQS "unless SWQS or uses cannot be met as a result of natural background conditions or pollution sources other than CSOs" (Policy at II.C.4.b.i);
- "The CSO discharges remaining after implementation of the planned control program will not preclude the attainment of SWQS or the receiving waters' designated uses or contribute to their impairment…a [TMDL]…should be used to apportion pollutant loads" (Policy at II.C.4.b.ii);
- "The planned control program will provide the maximum pollution reduction benefits reasonably attainable" (Policy at II.C.4.b.iii); and
- "The planned control program is designed to allow cost effective expansion or cost-effective retrofitting if additional controls are subsequently determined to be necessary to meet SWQS or designated uses" (Policy at II.C.4.b.iv).

The demonstration approach offers flexibility for communities where the presumption approach may be impractical or inappropriate due to unique system or receiving water conditions. The demonstration approach requires substantially greater effort in identifying different sources of pollutants, quantifying those sources, and assessing the impacts of those sources on water quality in the receiving waters, compared to the presumption approach.

#### 2.2.2.3 Approach for Updated CSO Control Plan

As described in more detail in Section 7, water quality modeling, supported by water quality sampling data, has shown that due to the impacts of non-CSO sources (stormwater, baseflow, and upstream boundary flow; see Sections 6 and 7 for more detail), applicable bacterial water quality criteria in Alewife Brook, Upper Mystic River, and the Charles River would not be fully met even if CSO loadings to these waterbodies were eliminated. Given that zero CSO events per year would not meet the water quality-based requirements of the CWA, a presumption that four CSO events per year (the first presumption criterion) or the elimination or capture of no less than 85% of the combined sewage volume (second criterion) or the mass of pollutants causing impairment (third criterion) would provide an adequate level of

control to meet SWQS is not supported. “[T]the data and analysis conducted in the characterization, monitoring and modeling of the system” have shown that the overwhelming impact of the non-CSO sources would preclude attainment of the SWQS and thus the presumption would not be reasonable.

As a result, this Updated CSO Control Plan has been developed under the demonstration approach, wherein the impact of remaining CSO discharges can be isolated from the impacts of the non-CSO sources. This approach allows the Partners to assess whether remaining CSO discharges would preclude attainment of SWQS if the non-CSO sources were controlled.

### 2.2.3 Coordination with Water Quality Standards

Part III of the CSO Control Policy focuses on coordination of the LTCP with state water quality standards. In particular, the Policy states that “development of the long-term plan should be coordinated with the review and appropriate revision of SWQS and implementation procedures on CSO-impacted waters to ensure that the long-term controls will be sufficient to meet water quality standards” (Policy at III.A). The CSO Control Policy indicates that “EPA regulations and guidance provide states with the flexibility to adapt their SWQS, and implementation procedures to reflect site-specific conditions including those related to CSOs” (Policy at III.B). In addition to potentially modifying the criteria that protect designated uses, the CSO Control Policy notes that states may adopt partial use designations and short-term SWQS modifications called variances.

States can “adopt partial uses by defining when primary contact recreation such as swimming does not exist, such as during certain seasons of the year in northern climates or during a particular type of storm event” (Policy at III.B).

These options are discussed in more detail in **Section 2.3**.

### 2.2.4 Financial Capability Assessment

The CSO Control Policy requires that LTCPs include an implementation schedule for the recommended CSO controls (Policy at II.C.8). The CSO Control Policy explicitly allows consideration of a community’s financial capability, stating “schedules for implementation of the CSO controls may be phased based on the relative importance of adverse impacts upon SWQS and designated uses, priority projects identified in the long-term plan, and on a permittee’s financial capability” (Policy at II.C.8).

In March 1997, EPA issued the *Combined Sewer Overflows – Guidance for Financial Capability Assessment and Schedule Development* (EPA 832-B-97-004) (1997 Financial Guidance). This document provided a framework to evaluate the financial resources of CSO communities and determine reasonable LTCP implementation schedules.

The 1997 Financial Guidance was intended to help permittees and regulators establish schedules that balance environmental objectives with the community’s ability to pay. It introduced two core metrics for assessing financial capability: (1) *Residential Indicator (RI)*: Based on the estimated per-household cost of implementing CSO controls as a percentage median household income; and (2) *Financial Capability Indicator (FCI)*: A composite measure of community-specific economic and financial factors, including unemployment rate, bond ratings, and existing debt burden.

The 1997 Financial Guidance provided a matrix that used the RI and FCI to determine whether the impact of the CSO program costs is considered “low,” “medium,” or “high.” This designation informed whether a CSO implementation schedule should be shorter (e.g., 10 years) or longer (e.g., up to 25 years or more). In 2023, EPA published the *CWA Financial Capability Assessment Guidance* (FCA Guidance) to replace the 1997 Financial Guidance. Final revisions were made in March 2024. The FCA Guidance continued the use of RI and FCI and added the Lowest Quintile Poverty Indicator (LQPI) as a new critical metric for an Expanded FCA Matrix. The FCA Guidance also provides a Financial Alternatives Analysis that walks communities through considerations for construction phasing, such as funding mechanisms, described in the CSO Control Policy (II.C.8).

Although not binding regulations, the 1997 Financial Guidance and the subsequent FCA Guidance have played an important role in the negotiation of enforcement actions, consent orders, and schedule extensions under the CWA. The guidance documents are also frequently cited in support of requests for CSO-related water quality variances under 40 CFR 131.14 and 314 CMR 4.03. The continued use of and recent enhancements to this financial guidance demonstrate its importance as a key reference for developing LTCP implementation schedules that are both legally defensible and practically achievable.

For this Updated CSO Control Plan, the Partners each developed their own financial capability assessments in accordance with the EPA guidance documents. The findings from these assessments are presented in Section 11.

## 2.3 Use Attainability Analysis and Regulatory Options if SWQS Cannot be Met

The CSO Control Policy says "EPA regulations and guidance provide States with the flexibility to adapt their SWQS, and implementation procedures to reflect site-specific conditions including those related to CSOs" (Policy at III.B). In particular, the CWA recognizes that in some cases, SWQS and designated uses cannot be met due to physical conditions or sources out of the CSO municipality's control, or due to economic hardship that would occur as a result of compliance costs. In those cases, the CWA spells out the process states must follow to modify SWQS or designated uses, and EPA guidance details the information needed to support modifications.

The EPA provides step-by-step guidance[6] to help states, authorized tribes, and territories establish or revise designated uses by addressing the steps and questions they should consider while conducting a Use Attainability Analysis (UAA). The Partners are required to submit relevant documentation to MassDEP to complete the UAA. The guidance notes that "in general, a UAA is required when revising designated uses related to protecting aquatic life, wildlife, and recreation in and on the water specified in CWA section 101(a)(2). [...] 40 CFR 131.10 details when a UAA is required and the specific requirements for establishing and revising designated uses."

40 CFR 131.10(g) states:

> *"States may designate a use, or remove a use that is not an existing use, if the State conducts a use attainability analysis as specified in paragraph (j) of this section that demonstrates attaining the use is not feasible because of one of the six factors in this paragraph. If a State adopts a new or revised water quality standard based on a required use attainability analysis, the State shall also adopt the highest attainable use, as defined in § 131.3(m).*
>
> 1. *Naturally occurring pollutants prevent the attainment of the use; or*
> 2. *Natural, ephemeral, intermittent, or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating State water conservation requirements to enable uses to be met; or*
> 3. *Human-caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or*
> 4. *Dams, diversions, or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in a way that would result in the attainment of the use; or*

[6] Use Attainability Analysis and the Use Revision Process | US EPA (https://www.epa.gov/wqs-tech/use-attainability-analysis-and-use-revision-process)

5. *Physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, pool, riffles, and the like, unrelated to water quality preclude the attainment of aquatic life protection uses; or*

6. *Controls more stringent than those required by sections 301(b) and 306 of the (Clean Water) Act would result in substantial and widespread economic and social impact."*

The Massachusetts Surface Water Quality Standards contain similar factors to justify changing a waterbody use at 314 CMR 4.03(4)(a).

When MassDEP issued the 2024 Water Quality Standards Variances to the Partners for their discharges to Alewife Brook/Upper Mystic River and the Charles River, it included a requirement that the Partners' Updated CSO Control Plan include "any documentation needed to support issuance of a Variance, or for changing the classification of any CSO-impacted receiving waters with Use Attainability Analyses" (Variance Condition F.5). Section 13 provides the UAA data as requested by MassDEP.

**Massachusetts CSO Policy and Guidance**

In August 1997, MassDEP published its *Policy for Abatement of Pollution from Combined Sewer Overflows*, and an accompanying *Guidance for Abatement of Pollution from CSO Discharges.* These documents presented information consistent with the EPA's CSO Control Policy and provided further guidance on potential regulatory pathways for SWQS compliance specific to Massachusetts. In particular, the documents presented five potential pathways for water quality determinations based on the findings of the approved LTCP. A simplified version of the flow chart included in MassDEP's Policy and Guidance Documents is presented in **Figure 2-1**. This figure has been modified for applicability to this Updated CSO Control Plan, where Alewife Brook, the Upper Mystic River and the Charles River are freshwater bodies (saltwater classification options would not apply).

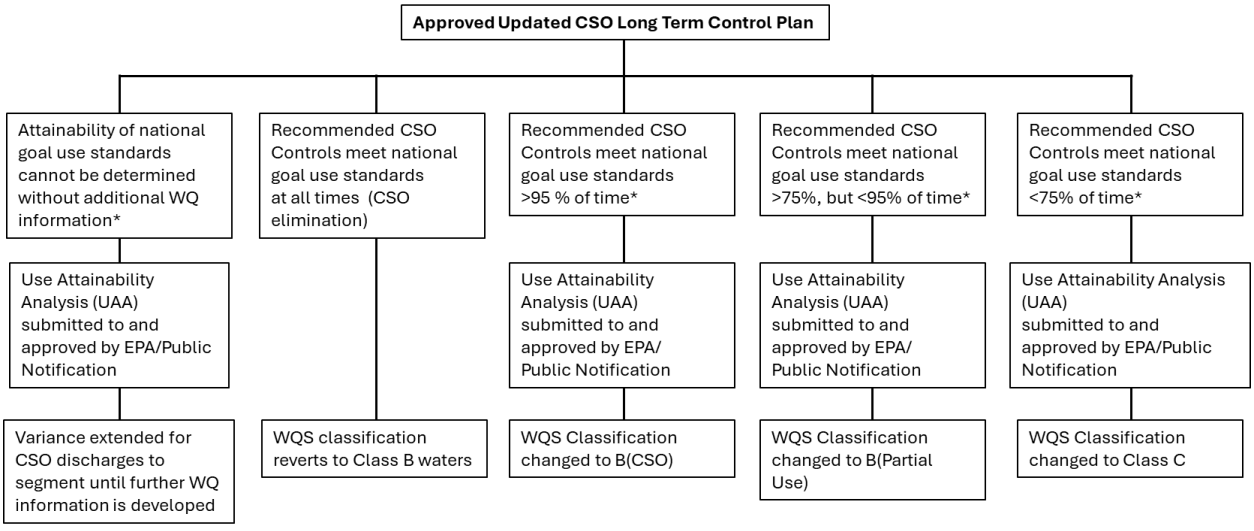



**Figure 2-1. SWQS Coordination Options**

If, through the UAA process, MassDEP finds that existing SWQS cannot be met in Alewife Brook, the Upper Mystic River, and/or the Charles River for one or more of the reasons specified in 40 CFR 131.10(g) and 314 CMR 4.03(4), the two likely options would be to either continue the issuance of water quality variances (additional WQ information is needed), or change the water quality classification from

Class B to Class B(CSO) (CSO controls will meet the national goal use standards >95% of the time). The regulatory implications of each of these options are described below.

### 2.3.1 Water Quality Variance

Variances are regulatory tools that allow a state to temporarily modify water quality standards where full attainment is not feasible under current conditions. A state may grant variances to discharge when achieving full compliance with applicable water quality criteria would impose substantial and widespread economic and social impacts or when natural, physical, or technical conditions preclude attainment. According to EPA[7], "[a] SWQS variance can be used when it is uncertain how much progress can be achieved, but it is known that some progress is possible, and states, territories and authorized tribes don't want to give up on working toward water quality improvement." In the context of CSO control planning, a state may grant variances to temporarily authorize discharges by CSO operators.

In Massachusetts, water quality variances are governed by 314 CMR 4.03 and must be consistent with federal regulations under 40 CFR 131.14. A variance does not remove the designated use of a waterbody or authorize any backsliding of current ambient water quality but instead authorizes a time-limited alternative standard, which may include less stringent numeric criteria or site-specific conditions, subject to EPA approval.

To obtain a variance, applicants must submit documentation demonstrating:

- The specific water quality standard(s) for which the variance is sought;
- The pollutant(s) and sources responsible for the standard not being met;
- A justification based on one or more of the six allowable factors under state and federal regulations (40 CFR 131.14(b)(2) and 314 CMR 4.03(4)(a)), such as substantial economic and social impact or natural background conditions; and
- A pollutant reduction plan showing progress toward eventual attainment of standards or maximized water quality improvement.

All variances receive public notice and comment. They are time-limited and are typically reviewed and renewed on a permit cycle basis. Variances do not exempt dischargers from CWA obligations, but rather they provide an adaptive regulatory mechanism for achieving incremental water quality improvements while considering site-specific constraints and/or community resources.

### 2.3.2 Class B(CSO) Designation

The Massachusetts Water Quality Classification options include qualifiers for freshwaters (B(CSO)) or saline waters (SB(CSO)) impacted by CSOs. These qualifiers

> *"…denote[ ] those waters occasionally subject to short-term impairment of swimming or other recreational uses due to untreated CSO discharges in a typical year, and the aquatic life community may suffer adverse impact yet is still generally viable. In these waters, the uses for Class B and Class SB waters are maintained after the implementation of long term control measures described in the approved CSO long term control plan, except as identified in such plan"* (314 CMR 4.06 (1)(d)(10).

MassDEP may designate a waterbody or segment thereof as partial use (B(CSO) or SB(CSO)), provided that:

[7] https://www.epa.gov/wqs-tech/water-quality-standards-variances

- A MassDEP-approved LTCP provides justification for the overflows;
- MassDEP finds through a use attainability analysis, and EPA concurs, that achieving a greater level of CSO control is not feasible for one of the reasons specified at 314 CMR 4.03(4);
- Existing uses and the level of water quality necessary to protect the existing uses shall be maintained and protected; and
- Public notice is provided in accordance with appropriate regulations and a notice is published in the Environmental Monitor.

As described in the 1997 MassDEP Policy for Abatement of Pollution from Combined Sewer Overflows[8],

> *"An identification of B(CSO) will be made only after the Department has approved a facilities plan showing that minor CSO discharges are the most environmentally protective and cost-effective option available. Generally, eligibility for Class B (CSO) status is limited to discharges which can meet national goal use standards more than 95% of the time, but the highest level of control must always be achieved for each case as determined in the facilities plan through a cost/benefit analysis."*

A determination to change the water quality designation to Class B(CSO) lies within MassDEP's jurisdiction.

## 2.4 Permitting Framework

Four types of permits govern the manner in which CSO operators implement applicable CWA requirements. This section summarizes the NPDES permitting components, for both CSO and stormwater, the existing Variances, and the role of the Massachusetts Environmental Protection Act (MEPA) in the CSO planning process.

The NPDES permitting mechanism established under Section 402 of the CWA authorized EPA to regulate the discharge of pollutants from point sources to waters of the United States. As point source discharges, CSO outfalls are subject to NPDES permitting requirements and must be explicitly authorized by permit conditions.

### 2.4.1 NPDES Permits (Governing CSO)

Massachusetts is one of three states without delegated authority to directly issue NPDES permits. This section discusses the NPDES CSO Permits for Cambridge and Somerville, and the MWRA NPDES Permit. Historically, in Massachusetts, NPDES permits, including those regulating CSO discharges, were issued jointly by EPA and MassDEP and serve as the primary regulatory mechanism for enforcing CSO control and compliance. As of June 20, 2020, the NPDES permit program is administered solely by EPA. In current practice, Massachusetts now certifies that the discharge will meet state standards (the 401 Water Quality Certification) and also issues the NPDES permittee a state Surface Water Discharge Permit. Under the CWA, NPDES permits regulating CSO discharges need to conform to the 1994 EPA CSO Control Policy. Further, state laws may introduce additional CSO permitting requirements (e.g., Massachusetts 2021 Public Notification Law).

**Table 2-4** lists the NPDES Permits issued to the Partners, along with the date of issuance.

[8] https://www.mass.gov/doc/pollution-abatement-from-combined-sewer-overflows-policy/download

**Table 2-4. MWRA, Cambridge and Somerville NPDES Permits**

| Entity | Permit No. | Date of Issuance |
|---|---|---|
| Cambridge | MA0101974 | September 30, 2009 |
| Somerville | MA0101982 | June 11, 2012 |
| MWRA | MA0103284 | May 20, 1999 (reissued August 10, 2000) |

A draft 2023 MWRA NPDES Permit (2023 Draft Permit) has been published by EPA[9], wherein it is envisioned that it will supersede the existing permits individually held by each entity. If finalized in the form proposed by EPA the 2023 Draft Permit will be issued to MWRA as the Permittee and Cambridge, Somerville, Chelsea and the Boston Water and Sewer Commission would be “CSO-Responsible Co-Permittees"; the 2023 Draft Permit also includes 43 communities within the MWRA service areas as additional “Co-permittees”.

NPDES regulations and permits require CSO communities to demonstrate both interim progress (e.g., NMC implementation and performance monitoring) and long-term outcomes (e.g., water quality improvements and use attainment). The CSO Permit may also incorporate adaptive provisions to allow for LTCP updates, phased implementation, and post-construction compliance monitoring. In this way, the NPDES program provides both regulatory accountability and procedural flexibility, ensuring that CSO controls are implemented in a manner that protects water quality while responding to local conditions.

### 2.4.2 NPDES MS4 Permits

Municipal Separate Storm Sewer System (MS4) Permits are a component of the NPDES program that regulates stormwater discharges through stormwater outfalls to surface waters. MS4 Permits are issued to municipalities and other entities that own or operate separate storm sewer systems. MS4 Permits are administered as “general permits” and follow a form that is periodically updated and typically issued for five-year terms. Communities operating MS4s are currently regulated through the 2016 MS4 Permit, which has been administratively extended. The one exception is that the City of Boston is regulated under an Individual Phase 1 MS4 Permit. A 2024 Draft MS4 Permit was made available for public comment on November 22, 2024.

Cambridge and Somerville both own and operate MS4 systems; MWRA, through its enabling act, is responsible for the regional water and wastewater systems, but does not manage or own separate stormwater systems. However, most communities within the MWRA service area also maintain their own MS4s. The MS4 Permit is organized into two major categories of requirements. The first includes six minimum control measures, which are outlined in **Table 2-5**. The second category covers requirements for waterbodies with impairments (both those with and without TMDLs) based on listings in the 303(d) List. For example, the Cities of Cambridge and Somerville must comply with enhanced requirements for (a) bacteria and pathogen impairments in these waterbodies (e.g., enhanced pet waste management messaging) and (b) total phosphorus impairments and TMDLs in the Mystic and Charles Rivers.

[9] https://www.epa.gov/npdes-permits/epas-permit-massachusetts-water-resources-authority-mwra-deer-island-treatment-plant

**Table 2-5. MS4 Permit Minimum Control Measure Summary from EPA**

| Minimum Control Measure | Description[10] |
|---|---|
| Public Education and Outreach | Municipalities are required to provide educational material about stormwater to four audiences (residents, industry, commercial, and construction). The purpose of the educational material is to provide the targeted audience information about stormwater and how their actions may impact it. The permit requires 2 messages for each audience during the five year permit term. |
| Public Involvement and Participation | Municipalities are required to at least annually provide an opportunity for the public to participate in the development/implementation of their Stormwater Management Program. Notices must comply with state public notice requirements. |
| Illicit Discharge Detection and Elimination Program | Municipalities are required to find and eliminate sources of non-stormwater from their storm sewer system. The permit requires a proactive rather than a reactive approach. Municipalities are expected to systematically look in their system for non-stormwater sources<br>and remove them. Part of this requirement includes development of system wide storm sewer system map. |
| Construction Site Stormwater Runoff Control | Municipalities are required to have an ordinance from management of stormwater discharges from construction sites that disturb one or more acres of land. Their ordinance should include requirements for projects to implement sediment and erosion control practices as well as requirements for site plan review. |
| Stormwater Management in New Development and Redevelopment (Post Construction Stormwater Management) | Municipalities are required to address stormwater runoff from new development and redevelopment that disturb one or more acres of land. The goal of this measure is to try to management stormwater where it falls and retain it on site. This control measure encourages the use of low impact design techniques and requires the retention or treatment of runoff on site using green infrastructure practices. |
| Good Housekeeping and Pollution prevention for Permittee Owned Operations | Municipalities are required to implement good housekeeping<br>practices in municipal operations such as vehicle maintenance, open space, buildings and infrastructure. The permit requires at least annual street sweeping and optimization of catch basin cleaning. Development of pollution prevention plans are required at waste management facilities and maintenance garages not already regulated by another NPDES permit. |

MS4 requirements can overlap with CSO planning goals, particularly in urban watersheds such as the Alewife Brook, Mystic River, and Charles River watersheds, where both wet weather CSO discharges and stormwater runoff from MS4 areas contribute to water quality impairments. Additionally, changes to the collection system configuration (i.e., sewer separation that adds new MS4 area) enacted through CSO control will directly impact MS4 compliance for these communities.

While the MS4 and CSO programs have separate NPDES frameworks, both aim to control wet weather pollution and support attainment of water quality standards. As such, collaboration across these programs, between MassDEP and EPA, is critical in the planning and implementation of effective, watershed-based solutions.

### 2.4.3 Variances Issued by MassDEP

MassDEP issued a series of SWQS variances to CSO dischargers to the Alewife Brook/Upper Mystic River and the Charles River, allowing temporary, wet weather impacts to the Class B waters, while making additional progress on CSO control. The latest EPA-approved variances are from August 2024, are included as part of the current SWQS (see 314 CMR 4.06, Table 2 and Table 5), and are effective for a five-year period ending August 31, 2029 (2024 Variances).[11]

[10] Descriptions from EPA Summary: https://www.epa.gov/system/files/documents/2025-11/six-minimum-control-measures.pdf
[11] The 2024 Variances supersede prior EPA-approved variances that took effect on August 30, 2019, and remained in effect through August 29, 2024.

Over the years, the variances have included certain requirements designed to improve the understanding of sources of pollution to the Alewife Brook, Mystic River, and Charles River, evaluate opportunities to improve the level of CSO control, and implement, where appropriate, projects and activities to further improve water quality in these impaired waterbodies.

Requirements in the variances included the following activities, many of which have since been completed, while others remain part of ongoing activities (the current status is indicated in square brackets):

- MWRA, Cambridge, and Somerville to continue implementation of the Nine Minimum Controls and to continue to assess/implement system optimization projects intended to further reduce CSO discharges [ongoing activity];
- MWRA to continue to evaluate I/I controls [ongoing activity];
- MWRA to coordinate with MWRA member communities in Alewife/Upper Mystic River and Charles River Basins on Best Management Practices, system mapping, illicit connection detection and pollution prevention [ongoing activity];
- MWRA to conduct additional sampling to support additional evaluations of CSO control for Alewife Brook/Upper Mystic River and the Charles River required per earlier variances [completed];
- MWRA to work with EPA and MassDEP to attempt to identify triggers appropriate to act as a basis for determining when additional CSO controls would yield greater benefits for their respective costs [completed];
- MWRA to continue and expand its CSO receiving water quality monitoring program, including submission of an annual water quality report [ongoing activity];
- MWRA to submit the results of the CSO Performance Assessment to EPA and MassDEP, documenting the level of CSO control achieved through implementation of the LTCP throughout the CSO Planning area, in regard to CSO activations and volumes in the 1992 Typical Year, relative to the Second Stipulation levels of control [completed];
- MWRA to submit progress reports and conduct public meetings related to the CSO Performance Assessment [completed];
- MWRA to develop and calibrate receiving water quality models, use such models to present information on the water quality impacts of CSO and non-CSO discharges in the Alewife Brook/Upper Mystic River and Charles River Basins, and submit a CSO Water Quality Impact Report to EPA and MassDEP [completed];
- MWRA, Cambridge and Somerville (Alewife Brook/Upper Mystic River only) to maintain CSO outfall signs, and develop and implement a CSO subscriber-based notification system to provide CSO alert notifications to interested parties [ongoing activity];
- Cambridge and Somerville (Alewife Brook/Upper Mystic River only) shall consider use of green infrastructure technologies where feasible to increase stormwater filtration [ongoing activity];
- MWRA, Cambridge and Somerville shall each submit for MassDEP and EPA review and approval, a scope and schedule for an updated CSO control plan for the CSO outfalls that each permittee owns and operates that discharge to the Alewife Brook/Upper Mystic River and Charles River [completed]; and
- MWRA to complete the CSO System Optimization for Alewife Brook and Lower Charles River Basins Project Study and Preliminary Design (Notice to proceed December 2020. Study Report/Preliminary Design Submittal to MassDEP for review and approval December 2022) [completed].

**Conditions Applicable to Alewife Brook/Upper Mystic River Only**

- MWRA to prepare a report summarizing the findings from the activities conducted in accordance with the 1999 Variance, including a reassessment of the recommended CSO control plan included in the (1997) Final Facilities Plan for the Alewife/Upper Mystic Basin [completed];
- MWRA to complete the MWR205 & SOM007A/MWR205A Somerville Marginal CSO Reduction Project, Study and Preliminary Design (Notice to proceed December 2020. Study Report/Preliminary Design Submittal to MassDEP for review and approval December 2021) [completed]; and
- MWRA to complete the Alewife Brook Pump Station Optimization Evaluation Project (Notice to proceed April 2020. Study Report/Preliminary Design Submittal to MassDEP for review and approval April 2021) [completed].

**Conditions Applicable to Charles River Only**

- MWRA to prepare a report evaluating alternatives to provide additional storage at its Cottage Farm CSO Facility, evaluating chemical, physical and disinfection enhancements to the facility, and evaluating the performance of the facility based on sampling results [completed];
- MWRA to run its sewer system and receiving water models for a series of varying stormwater inputs and boundary conditions to assess the potential water quality benefits of additional and/or upgraded CSO controls and provide the results to EPA and MassDEP [completed]; and
- MWRA to work with EPA and MassDEP to evaluate the potential for pollution trading as a mechanism to improve water quality in the Charles River [completed].

Most recently, the 2024 Variances include the following required activities (applicable to MWRA, Cambridge and Somerville, except where noted (current status again indicated in brackets):

- Continuation of MWRA's water quality monitoring program and submission of an annual water quality report; (MWRA only) [ongoing activity];
- Submittal of a supplemental CSO performance assessment report (MWRA only) [completed];
- Submittal of annual reports presenting estimates of CSO activations and discharge volumes at each outfall, and rainfall data associated with the activation events [ongoing activity];
- Continued implementation of Public Notification Plans for CSO discharges ("activations") to the Charles River and to Alewife Brook or the Upper Mystic River which as of January 2022 are also required in MassDEP regulations set forth at 314 CMR 16.00: Notification Requirements to Promote Public Awareness of Sewage Pollution [ongoing activity];
- Evaluation of the feasibility of installing and implementing a real time, on site public notification system for CSO discharges, such as a warning light system [completed];
- Continued implementation of the Nine Minimum Controls (see Section 4 for a summary of activities undertaken by MWRA, Cambridge and Somerville to address the Nine Minimum Controls) [ongoing activity];
- Continue to provide technical as well as financial assistance to member communities related to the identification and removal of Infiltration/Inflow (I/I) (MWRA only) [ongoing activity];
- Evaluation of floatables control at the CSO outfalls [completed];
- Evaluation of odor issues at the CSO outfalls [completed];
- Implementation of the outfall CAM005 Weir Raising and Lengthening project, the Somerville Marginal CSO Facility - New Connection and gate structure, Somerville Marginal CSO Facility Rehab Design, and Further CAM401A Metering and Model Calibration (MWRA only) [CAM005 and Somerville

Marginal new connection and rehab design ongoing activities; Further CAM401A Metering and Model Calibration completed];

- Implementation of the Willard Street, River Street and Land Boulevard sewer separation projects and Tobin Stormwater Storage Tank (Cambridge only) [Willard Street, Land Boulevard and Tobin tank completed; River Street ongoing activity];
- Implementation of the Spring Hill Sewer Separation Phase 1 [completed] and Poplar St Pump Station Projects) [ongoing activity] (Somerville only); and
- Preparation of the Updated CSO Control Plans [ongoing activity].

### 2.4.4 Massachusetts Environmental Policy Act (MEPA)

The Massachusetts Environmental Policy Act (MEPA), codified at M.G.L. c. 30, §§ 61–62H and implemented through 301 CMR 11.00, requires state agencies to evaluate the environmental impacts of projects requiring state action (permits, financial assistance, or land disposition). While MEPA does not itself regulate discharges or approve projects, it requires that a broad range of environmental impacts are identified and considered early in project development.

The MEPA review process for the Plan is scheduled to start in 2027 upon submittal of the Final Updated CSO Control Plan and will include a public comment period. As individual CSO control projects are developed pursuant to this Updated Plan, they may trigger MEPA review when they involve:

- State agency action (e.g., funding through the Massachusetts Clean Water Trust);
- Construction requiring a state permit (e.g., wetlands or waterway permits);
- Significant alteration of environmental resources (e.g., wetlands, waterways, groundwater, or habitat); or
- Exceedance of defined Environmental Notification Form (ENF) thresholds listed under 301 CMR 11.03.

For large-scale or phased CSO control programs, MEPA review is often conducted through the submission of an ENF followed, if required, by a Draft and Final Environmental Impact Report (EIR). MEPA may also require a Notice of Project Change (NPC) if significant modifications are made to a previously reviewed CSO plan or schedule.

A key component of MEPA is public transparency and participation. Public comment periods are required for ENFs, EIRs, and NPCs, and MEPA encourages early coordination with stakeholders, including environmental justice (EJ) communities. Proposed updates to MEPA regulations may require additional EJ-focused outreach for projects located in or near designated EJ populations, including enhanced public noticing, translated materials, or in-language meetings.

The MEPA review process provides meaningful opportunities for public review of the environmental impacts of projects for which agency action is required. It requires agencies to study the environmental impacts of projects requiring agency permits or other approvals, financial assistance, or land transfers, and to use all feasible measures to avoid, minimize, and mitigate damage to the environment. As such, MEPA serves as an important procedural complement to regulatory requirements under the CWA and Massachusetts SWQS, particularly when CSO control projects involve significant capital investment, land disturbance, or cross-jurisdictional impacts.

# 3. History of CSO Planning and Implementation

This section provides a history of the CSO planning work conducted by the Partners to date. MWRA developed and implemented an LTCP in accordance with the requirements set forth in the CSO Control Policy (described in Section 2.2), and the Cities of Cambridge and Somerville have implemented projects both in concert with the LTCP and separately that have significantly reduced CSOs since the 1990s. The efforts conducted by the Partners as described below established the groundwork for the current conditions that will form the basis of the continued CSO work developed under this Updated CSO Control Plan.

## 3.1 MWRA's CSO Control Accomplishments To Date

This section focuses on the history of MWRA's CSO planning work that culminated in the implementation of an extensive series of projects to control CSOs to the waters in and around Boston Harbor, including Alewife Brook, the Upper Mystic River, and the Charles River.

### 3.1.1 History of CSO Control

MWRA's CSO Control Program formally began in 1987, when through a stipulation (the "First Stipulation") entered in the Boston Harbor Case (U.S. v. M.D.C., et al., No. 85-0489 MA), MWRA accepted responsibility for developing and implementing a region-wide plan to control CSOs hydraulically related to its wastewater system. CSOs were purpose-built into MWRA's original collection system to provide hydraulic relief and protection for both the Deer Island Treatment Plant (DITP) and sewer backups; however, the presence of CSOs contributes to water quality impairments in the receiving waters, as well as risks to public health. This region-wide plan included CSO discharges from both MWRA-owned outfalls as well as outfalls permitted to and operated by the Boston Water and Sewer Commission (BWSC) and the cities of Cambridge, Chelsea, and Somerville. This commitment was formalized through the development of a series of planning documents as described below and ultimately memorialized through a Second Stipulation to the Boston Harbor Case in 2006. Section 2 described the robust regulatory framework that municipalities and utilities must adhere to in developing plans and projects to reduce or eliminate CSOs. The series of planning activities and documents described below illustrates the iterative nature of CSO planning efforts and the regulatory process. This iterative process will continue through the development and ultimate implementation of this Updated CSO Control Plan.

MWRA, with the cooperation of the CSO communities, has completed more than 180 CSO related milestones in the court-ordered schedule. The court-ordered schedule evolved over time with the evolution of the planning work; the current version is "Schedule Seven". **Figure 3-1** below presents a timeline of selected events starting in 1985 with the establishment of the MWRA through January 2027 when the final Updated CSO Control Plan is due, focusing on activities relevant to the waterbodies listed in the Variances.

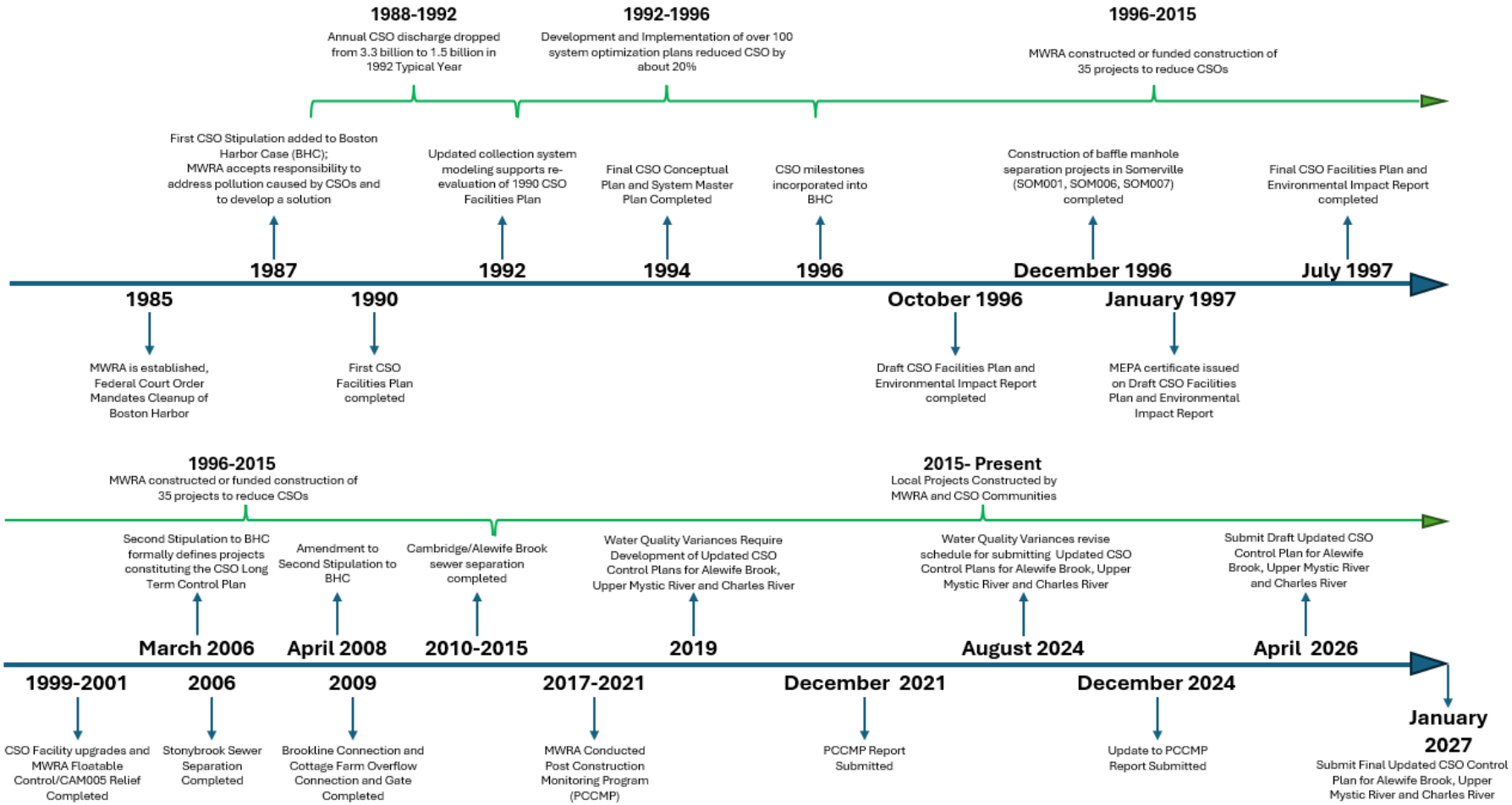



**Figure 3-1. MWRA CSO Control Program Timeline**

MWRA's CSO efforts began with the development and implementation of projects to eliminate dry weather overflows and the development of a first recommended CSO control plan. That plan, formalized in 1990 and conforming to the 1989 EPA CSO Strategy, recommended a Deep Rock Storage Tunnel for CSO control at an estimated capital cost of $1.2 billion in 1990 dollars (approximately $2.5 billion today). In 1992, MWRA began a new planning effort that culminated in the MWRA LTCP. This new effort leveraged improvements to the collection system modeling capabilities and was facilitated by the prospect of a more flexible EPA CSO policy (ultimately codified as the 1994 CSO Control Policy described in Section 2.1.2).

Development and implementation of the LTCP closely followed the requirements of the 1994 CSO Control Policy and EPA CSO-related guidelines, as well as MassDEP's CSO Policy and CSO Guidance, even as these federal and state CSO policies were evolving. Through extensive inspections, system monitoring, and modeling beginning in 1992-93, MWRA conducted a detailed characterization and performance assessment of its then-existing collection and treatment system, also incorporating major capital improvements already planned. The 1992 performance assessment incorporated major capital investments in the sewer system already underway or planned by MWRA, including upgrades to the transport system, pumping stations, headworks, and DITP. In the period 1988 through 1992, total annual CSO discharge predicted for the 1992 Typical Year[1] rainfall dropped from 3.3 billion gallons to 1.5 billion gallons, with approximately 51% of the remaining discharge treated at five MWRA CSO treatment facilities that were in operation at that time[2]. The Charles River especially benefited from these early system improvements.

As summarized in Section 2.2, the CSO Control Policy requires short- and long-term CSO reduction interventions. In 1993-1994, MWRA completed a System Optimization Plan, which recommended approximately 160 system modifications to maximize wet weather storage and conveyance. The System Optimization Plan projects, which were fully implemented by MWRA and the CSO communities by 1997, further reduced CSO discharges by about 20 percent from the 1992 levels.

Following the system optimization evaluations, MWRA's CSO iterative planning process involved the development and evaluation of an extensive set of projects covering a range of control technologies to achieve long-term, site-specific CSO control goals using watershed-based assessments of receiving water impacts and uses. MWRA first presented a conceptual plan of these improvements in the 1994 *CSO Conceptual Plan and System Master Plan*, then refined the recommendations in a *CSO Facilities Plan and Environmental Impact Report* (1997 Plan) issued in 1997. The 1997 Plan received initial federal and state approvals in early 1998, allowing MWRA to move the projects into design and construction.

As MWRA proceeded with implementation of the projects, it evaluated and recommended several adjustments and additions to the 1997 Plan in the period 1998 through 2006. These adjustments and additions responded to regulatory inquiries seeking higher levels of control for the Charles River or to new information about construction requirements, cost or CSO control performance (for North Dorchester Bay, Reserved Channel, East Boston, and Alewife Brook). A final LTCP, comprising 35 wastewater system projects, was approved by EPA and MassDEP in March 2006 and accepted by the Federal Court in April 2006 as part of the Second Stipulation, which replaced the First Stipulation. As commonly occurs in the CSO planning process, the evolution from the 1995 CSO Conceptual Plan to the final LTCP ("2006 LTCP" or "MWRA LTCP") defined in the 2006 Second Stipulation was driven by a combination of regulatory and stakeholder input, as well as new information developed as the planning work progressed. **Figure 3-2** shows the geographical distribution of the 35 projects in the 2006 LTCP. Descriptions of the 35 projects and their individual CSO control benefits were presented in Section 2.4 of *MWRA's Semiannual Report No. 1, November 30, 2018.*

[1] See Section 6 for a discussion of the 1992 Typical Year, and of the new Typical Year used for the current Updated CSO Control Plan for the Alewife Brook, Upper Mystic River and Charles River.
[2] Since that time, MWRA has decommissioned the Constitution Beach, Commercial Point and Fox Point CSO facilities following completion of sewer separation projects, upgraded the Cottage Farm, Prison Point and Somerville Marginal CSO facilities, and brought into operation the newly constructed Union Park Detention and Treatment facility.




**Figure 3-2. The Thirty-Five (35) 2006 Long-Term Control Plan Projects**

*Note: The City of Cambridge maintains CAM009 and CAM011 in a closed condition while it continues to evaluate hydraulic conditions in the local sewer system before making a decision to close them permanently. CAM004, CAM400, SOM001, SOM002, SOM002A, SOM003 & SOM004 CSO outfalls are closed.*

The approved MWRA LTCP and its recommended levels of CSO control were again updated by an amendment to the Second Stipulation in April 2008 that revised the long-term level of control at the Prison Point Facility. This update was based on hydraulic optimization MWRA incorporated into the operations of the facility in response to federal and state regulators' requests and in compliance with related milestones in Schedule Seven. The final approved plan called for reducing total annual CSO discharge in the 1992 Typical Year to 0.4 billion gallons (an 88% reduction from the 1988 level), with 93% of the remaining discharge to be treated at four MWRA CSO facilities: three CSO facilities providing detention/treatment with disinfection/dechlorination (Cottage Farm, Prison Point and Union Park), and one CSO facility providing screening and disinfection/dechlorination (Somerville Marginal).

In parallel with the approval processes described above, MWRA began design and construction of the CSO projects in 1996 in compliance with milestones in the federal court schedule. MWRA executed memoranda of understanding (MOUs) and financial assistance agreements with BWSC, the City of Cambridge, and the City of Somerville in 1996 by which each municipality agreed to implement the projects within the 2006 LTCP involving facilities that would be owned and operated by each community, such as the new storm drains that would be constructed as part of sewer separation projects. MWRA agreed to fund the "eligible" costs: the costs of work to construct the facilities necessary to attain the long-term levels of CSO control.

In compliance with strict design and construction milestones in the court schedule, and within a timeframe of only 20 years, MWRA and the CSO communities completed the design and construction of all 35 projects (see **Table 3-1**). The capital (design and construction) cost of these projects ranged from less than $100,000 (for Prison Point CSO Facility Optimization) to $228.4 million (for the North Dorchester Bay CSO Tunnel).

Most of the projects were major undertakings involving the construction of new wastewater facilities or extensive new storm drain or sewer systems, all in historical, densely developed residential and commercial areas. In addition to the design and construction work, the projects also required extensive coordination with landowners, permitting agencies, transportation authorities and neighborhood residents. In some of the project areas, construction impacts were significant and unavoidable, and the collaboration, support, and patience of residents and business owners should not be overlooked in understanding the effort borne by many parties to bring these projects to completion and achieve their benefits.

The MWRA and community CSO control efforts included the management of 125 contracts, including 82 construction contracts, 33 engineering contracts and 10 planning and technical support contracts, as well as financial assistance agreements with five communities that assisted in designing and constructing the plan (**Table 3-1**) with total award value of $423 million. The financial assistance agreements constituted just under half of the total $941 million budget (as of 2025) for CSO control in MWRA's Capital Improvement Program (CIP), with the remainder covering contracts and projects implemented directly by MWRA. MWRA, BWSC, the City of Cambridge, and the Town of Brookline installed nearly 100 miles of new storm drain and sewer pipe with the sewer separation, interceptor relief, hydraulic relief, and storage projects in the 2006 LTCP. The sewer separation projects involved street-by-street separate storm drain and/or sewer construction that removed more than 4,300 acres of stormwater runoff from sewer systems in Boston, Cambridge, and Brookline.

Prior to 1988, treated and untreated CSO discharges occurred in every rainfall event, approximately 100 times a year. **Figure 3-3** shows the total CSO volume reductions achieved by the CSO Control Program between 1988 and 2024. **Figure 3-4** shows the targeted CSO reduction for each of the receiving water segments addressed in the 2006 LTCP.

## Table 3-1. 2006 Long-Term CSO Control Plan Project Implementation Schedules

| Project | | Capital Cost ($ millions) | Commence Design | Commence Construction | Complete Construction |
|---|---|---|---|---|---|
| **North Dorchester Bay Storage Tunnel and Related Facilities** | | 228.4 | Aug-97 | Aug-06 | May-11 |
| **Pleasure Bay Storm Drain Improvements** | | 3.2 | Sep-04 | Sep-05 | Mar-06 |
| **Hydraulic Relief Projects** | **CAM005 Relief** | 1.1 | Aug-97 | Jul-99 | May-00 |
| | **BOS017 Relief** | 1.2 | | Jul-99 | Aug-00 |
| **East Boston Branch Sewer Relief** | | 85.7 | Mar-00 | Mar-03 | Jul-10 |
| **BOS019 CSO Storage Conduit** | | 14.3 | Jul-02 | Mar-05 | Mar-07 |
| **Chelsea Relief Sewers** | **Chelsea Trunk Sewer Relief** | 30 | Jun-97 | Sep-99 | Aug-00 |
| | **Chelsea Branch Sewer Relief** | | | Dec-99 | Jun-01 |
| | **CHE008 Outfall Repairs** | | | Dec-99 | Jun-01 |
| **Union Park Detention/Treatment Facility** | | 49.5 | Dec-99 | Mar-03 | Apr-07 |
| **CSO Facility Upgrades and MWRA Floatables Control** | **Cottage Farm Upgrade** | 22.4 | Jun-96 | Mar-98 | Jan-00 |
| | **Prison Point Upgrade** | | | May-99 | Sep-01 |
| | **Commercial Point Upgrade** | | | Nov-99 | Sep-01 |
| | **Fox Point Upgrade** | | | Nov-99 | Sep-01 |
| | **Somerville-Marginal Upgrade** | | | Nov-99 | Sep-01 |
| | **MWRA Floatables Control and Outfall Closings** | | | Mar-99 | Mar-00 |
| **Brookline Connection and Cottage Farm Overflow Interconnection and Gate** | | 3.0 | Sep-06 | Jun-08 | Jun-09 |
| **Optimization Study of Prison Point CSO Facility** | | 0.05 | Mar-06 | Mar-07 | Apr-08 |
| **South Dorchester Bay Sewer Separation** | | 118.8 | Jun-96 | Apr-99 | Jun-07 |
| **Stony Brook Sewer Separation** | | 44.2 | Jul-98 | Jul-00 | Sep-06 |
| **Neponset River Sewer Separation** | | 2.5 | Unk(1) | Apr-96 | Jun-00 |
| **Constitution Beach Sewer Separation** | | 3.7 | Jan-97 | Apr-99 | Oct-00 |
| **Fort Pt Channel Conduit Sewer Separation and System Optimization** | | 11.9 | Jul-02 | Mar-05 | Mar-07 |
| **Morrissey Boulevard Storm Drain** | | 32.3 | Jun-05 | Dec-06 | Jul-09 |
| **Reserved Channel Sewer Separation** | | 70.6 | Jul-06 | May-09 | Dec-15 |
| **Bulfinch Triangle Sewer Separation** | | 9.1 | Nov-06 | Sep-08 | Jul-10 |
| **Brookline Sewer Separation** | | 24.7 | Nov-06 | Nov-08 | Apr-13 |
| **Somerville Baffle Manhole Separation** | | 0.4 | Unk[1] | Apr-96 | Dec-96 |
| **Cambridge/Alewife Brook Sewer Separation** | **CAM004 Stormwater Outfall and Detention Basin** | 13.8 | 2001(2) | Apr-11 | Apr-13 |
| | **CAM004 Sewer Separation** | 54.0 | Jan-97 | Jul-98/Sep-12 | Dec-15 |
| | **CAM400 Manhole Separation** | 4.8 | Oct-08 | Jan-10 | Mar-11 |
| | **Interceptor Connection Relief/Floatables Control at Outfalls CAM002, CAM401B and CAM001** | 2.9 | Oct-08 | Jan-10 | Oct-10 |
| | **MWR003 Gate and Rindge Ave. Siphon Relief** | 3.8 | Mar-12 | Aug-14 | Oct-15 |
| | **Connection Relief/Floatables Control at SOM01A** | 0.8 | Mar-12 | Sep-13 | Dec-13 |
| **Region-wide Floatables Control and Outfall Closings** | | 1.2 | Sep-96 | Mar-99 | Dec-07 |

**Notes:**
(1) Unknown; these dates were not tracked.
(2) Approximate start; Notice of Intent for project was filed in Dec-03

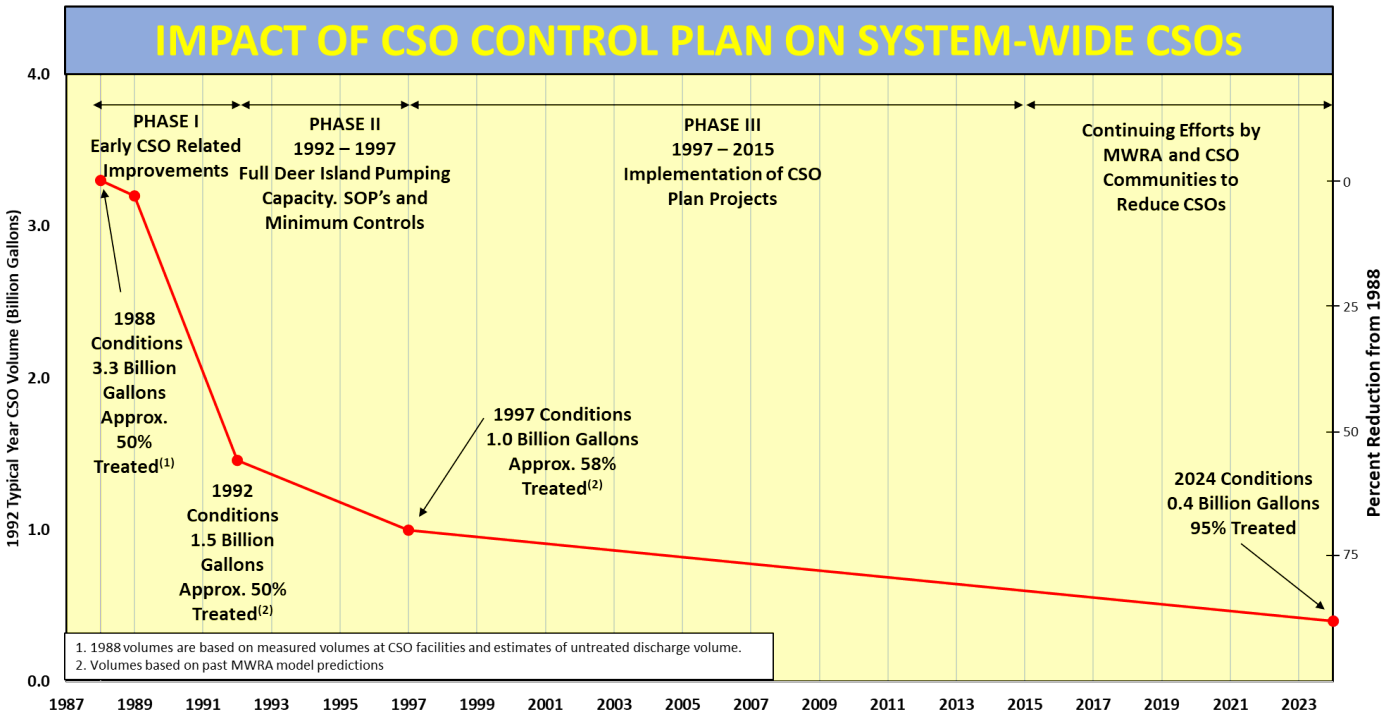



**Figure 3-3. Wastewater System Improvement Contributions to CSO Control**

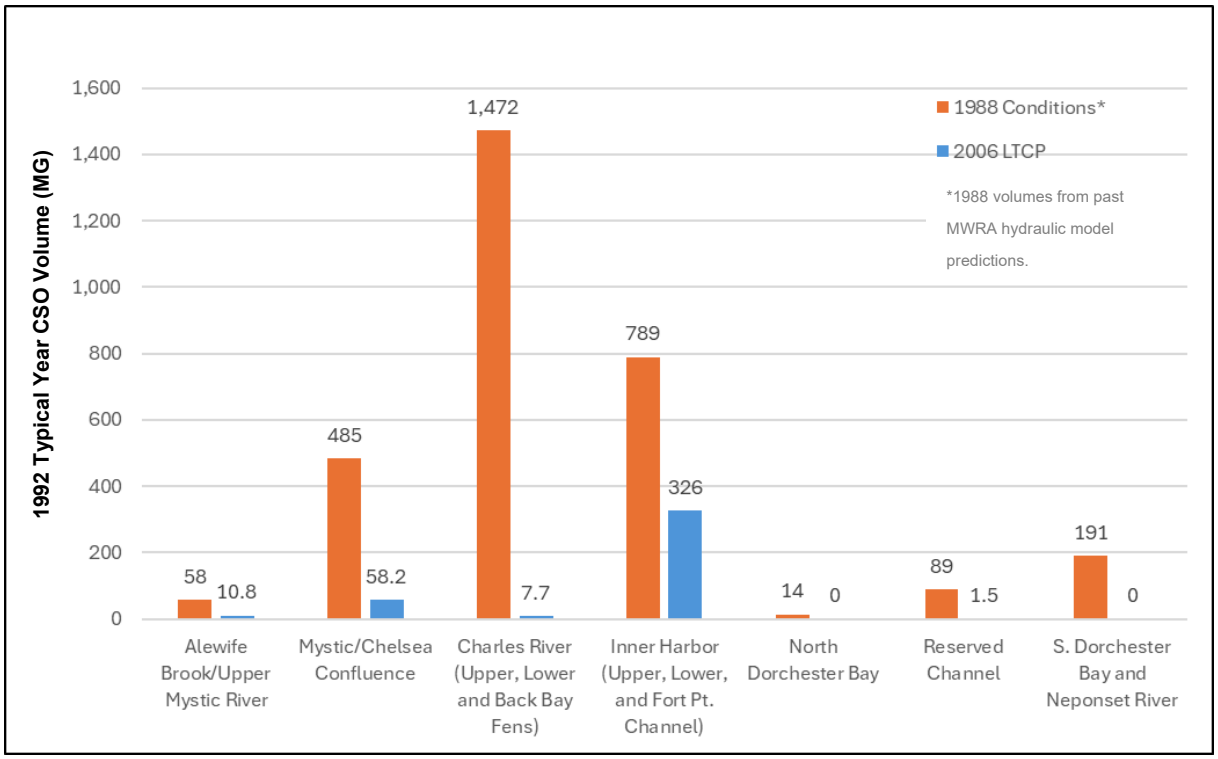



**Figure 3-4. Region-wide CSO Discharge Volume Reduction by Receiving Water**

### 3.1.2 MWRA Ratepayers' Investment in CSO Control

MWRA's CIP, as of 2025, includes $941 million for the CSO Control Program. This total includes past planning, MWRA design and construction, financial assistance to communities to implement the 2006 LTCP projects resulting in facilities the communities own and operate, and the CSO performance assessment. The allocation of these dollars to CSO control projects and activities for the various receiving waters is shown in **Figure 3-5**.

From 1987 through 2025, MWRA spent approximately $930 million (99%) of the $941 million CSO Control Program budget, including $858 million for design and construction of the 35 projects in the 2006 LTCP. The remaining $11 million of CSO spending is intended to cover the following scheduled activities:

- Development of the Updated CSO Control Plan;
- BSWC construction projects that will further reduce stormwater inflow from the Dorchester Interceptor system to minimize the risk of system flooding following the completion in 2007 of the South Dorchester Bay sewer separation project and the closing of related CSO outfalls;
- Construction of a new pipe connection to improve performance at MWRA's Somerville Marginal CSO Facility and outfall SOM007A/MWR205A discharging to the Upper Mystic River; and
- Implementation of a project to raise and lengthen the regulator weir at outfall CAM005 to the Charles River.

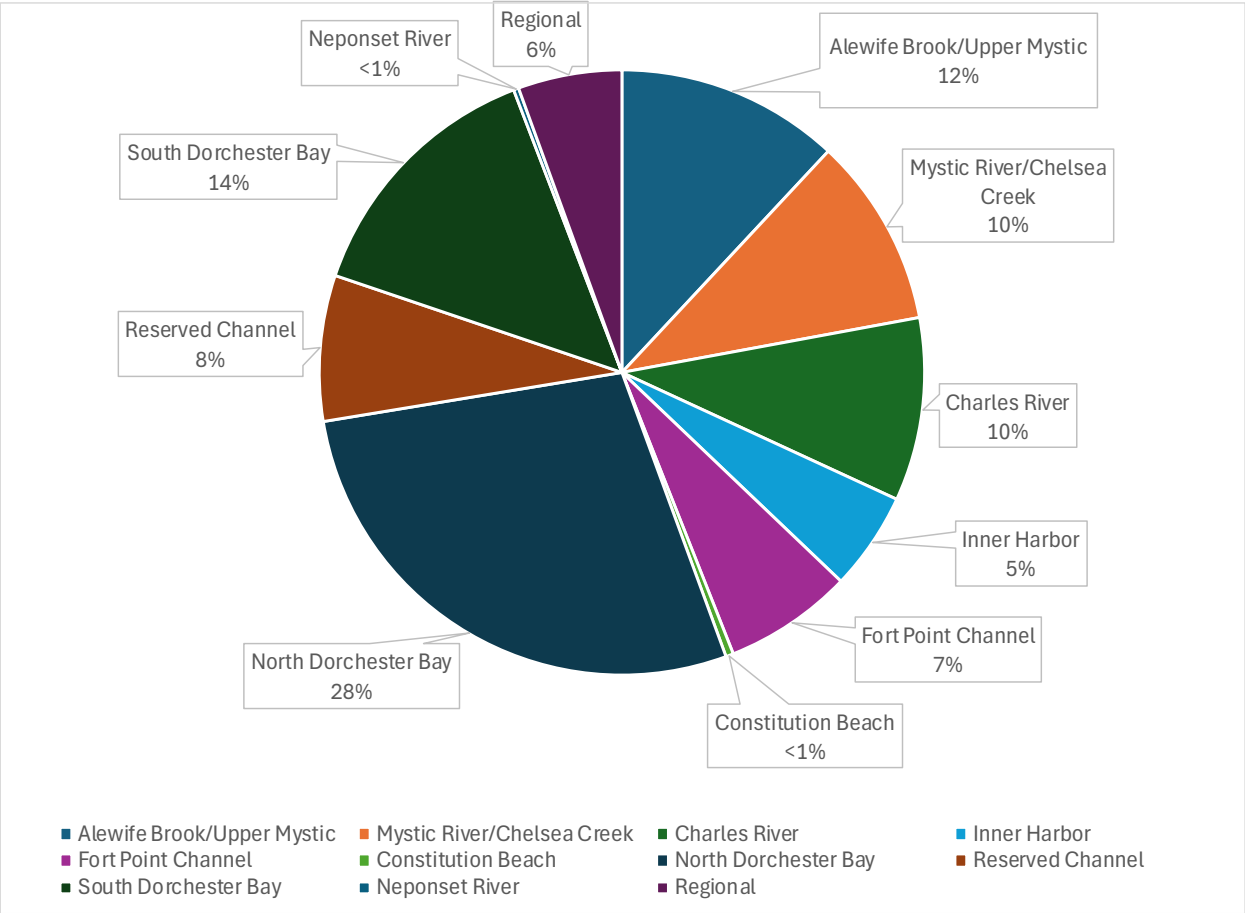



**Figure 3-5. CSO Cost Allocation by Receiving Water**

In addition to the $941 million cost to MWRA for CSO control, BWSC, the City of Cambridge, and the Town of Brookline incurred a total of more than $150 million of their own cost to successfully construct the 2006 LTCP projects they assumed responsibility for implementing pursuant to MOUs and financial assistance agreements with MWRA. These projects primarily involved the construction of miles of new storm drains and sewers in dense residential neighborhoods. The neighborhoods were greatly affected by construction, and it was necessary to leave the construction areas, primarily neighborhood streets, in an improved condition for the long term.

## 3.2 Evaluating Results of CSO Control from 2006 LTCP

Following completion of the projects included in the 2006 LTCP, MWRA implemented a post-construction monitoring program as required by the CSO Control Policy. This program included an evaluation of the effectiveness of the 2006 LTCP projects. The post-construction assessment was established as a court schedule milestone in the Boston Harbor Case. The following sections summarize the findings of the initial Post Construction Monitoring and Performance Assessment Report completed by MWRA, as well as a follow-up Supplemental Assessment Report.

### 3.2.1 Post Construction Monitoring and Performance Assessment Report (2017-2021)

MWRA's Post Construction Monitoring and Performance Assessment commenced on November 8, 2017. This performance assessment was intended to comply with the last two scheduled milestones in the 1987 Federal District Court Order in the Boston Harbor Case (U.S. v. M.D.C., et al, No. 85-0489 MA).

From 1987 through 2015, MWRA addressed 182 CSO-related court schedule milestones, including completing the construction of the 35 wastewater system projects that comprised the 2006 LTCP by December 2015. The last two court milestones required MWRA to:

- Commence by January 2018 a three-year performance assessment including post-construction monitoring in compliance with EPA's CSO Policy (59 Fed. Reg. 18688) (April 19, 1994); and
- Submit by December 2021 the results of its performance assessment to the EPA and MassDEP demonstrating that it has achieved the levels of CSO control specified in the 2006 LTCP.

These requirements were pursuant to the March 15, 2006, Second Stipulation noted above. On July 19, 2019, Federal District Court Judge Richard G. Stearns issued an order extending the milestone for submission of the final report by one year, from December 31, 2020 to December 31, 2021. MWRA had requested the extension to provide the time necessary to perform receiving water quality modeling to support water quality assessments for the Lower Charles River/Charles Basin and the Alewife Brook/Upper Mystic River. With submittal of the performance assessment report, all the court-imposed deadlines were met.

MWRA's CSO performance assessment included the following elements:

- Inspections at all CSO regulators addressed in the 2006 LTCP to confirm closed or active status and confirm or update physical conditions;
- Extensive overflow data collection at remaining active CSO regulators;
- Upgrading and improving calibration of MWRA's hydraulic model of the wastewater system using recent inspection information and overflow data;
- Assessments of system performance for CSO control and the consideration of performance improvements; and
- Assessment of the water quality impacts of remaining CSOs and compliance with Massachusetts SWQS.

In December 2021, MWRA submitted the *Final CSO Post Construction Monitoring Program and Performance Assessment Report*[3] (Final Assessment Report). The report documented that of the 46 CSO

[3] https://www.mwra.com/cso/pcmpa-reports/Final12302021.pdf

outfalls that remained active (i.e., were not physically closed or effectively closed as being associated with the North Dorchester Bay CSO Storage Tunnel[4]), 30 outfalls met the 2006 LTCP goals as of the end of 2021 (Q4-2021 conditions). Of the remaining 16 outfalls not meeting 2006 LTCP goals, six were projected to meet the 2006 LTCP goals after December 2021, and four had a concept plan in place to bring them into compliance after December 2021. The remaining six outfalls were found to present significant challenges in terms of identifying reasonable and effective alternatives to achieve the 2006 LTCP goals, and investigations for those outfalls were to continue.

Prior to the filing of the Final Assessment Report, the Parties in the Boston Harbor Case had engaged in discussions regarding a possible framework and path forward in the case. An agreement was ultimately reached, and upon an Assented-to Motion of the MWRA, the Court ordered that Schedule Seven be amended to include a new final compliance milestone requiring MWRA to file a supplement to the Final Assessment Report by December 2024.

### 3.2.2 Supplement to the 2021 Post Construction Monitoring and Performance Assessment Report

On December 27, 2024, MWRA submitted the *Supplement to the 2021 Final Combined Sewer Overflow Post Construction Monitoring Program and Performance Assessment Report* (Supplemental Assessment Report). The purpose of this Supplemental Assessment Report was to document the progress made towards meeting the 2006 LTCP goals at each of the 16 outfalls since the submittal of the Final Assessment Report. The work at these locations included field investigations, modeling assessments, and conceptual plan development. Ten outfalls also included final design, and construction of these improvements were completed at eight locations to date.

**Figure 3-6** presents a comparison of the treated discharge, untreated discharge and total discharge volume for 1988, 1992, 2021, and Q4-2024 conditions, as well as the 2006 LTCP goal. **Table 3-2** provides the same values in a tabular format. These results are based on the 1992 Typical Year. As a result of the projects implemented under the 2006 LTCP and the continued work by MWRA and the CSO communities, both treated and untreated CSO discharges have been reduced significantly. As indicated in **Figure 3-6** and **Table 3-2**, since 2021 the average annual CSO volume system wide has been reduced by an additional 13 million gallons (MG) from 414 MG in 2021 to 401 MG in 2024, meeting the overall 2006 LTCP goal of 404 MG. Since 1988, the overall CSO discharge volume has decreased by almost 2.9 billion gallons (an 88% reduction).

[4] See Section 7 for further discussion of the North Dorchester Bay project and the definition of CSO elimination.

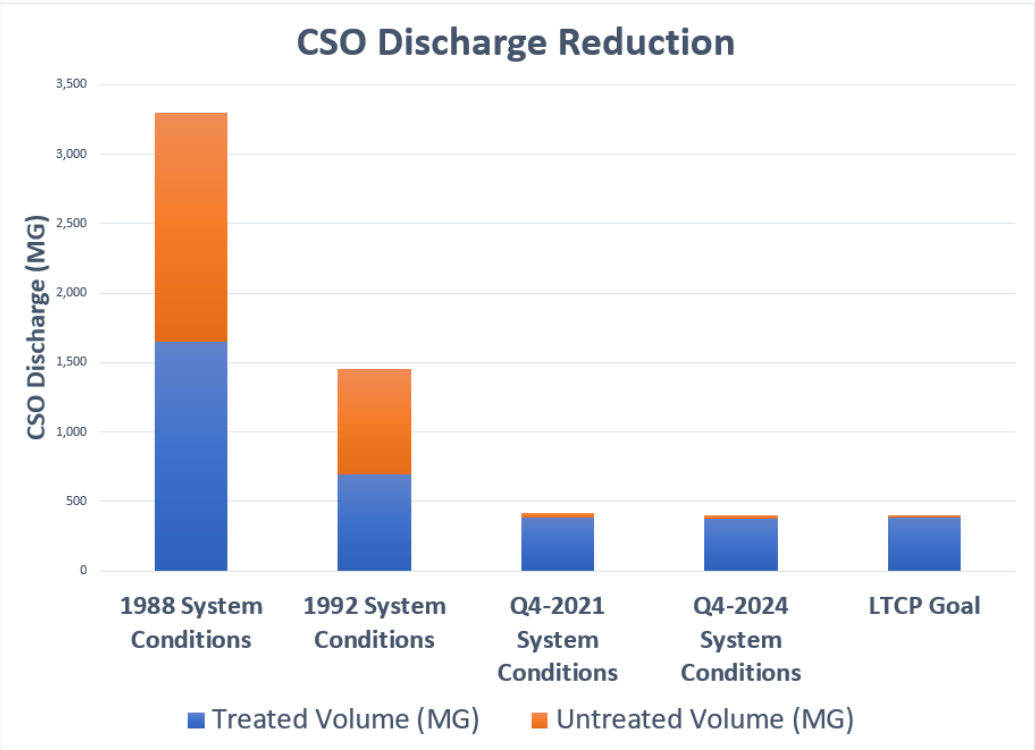



**Figure 3-6. CSO Discharge Reduction from 1988 to 2024 Conditions Compared to 2006 LTCP Goals**

**Table 3-2. CSO Discharge Reduction from 1988 to 2024 Conditions Compared to 2006 LTCP Goals**

| | 1992 Typical Year Rainfall | | | | |
|---|---|---|---|---|---|
| | 1988 System Conditions | 1992 System Conditions | Q4-2021 System Conditions | Q4-2024 System Conditions | LTCP Goal |
| **Treated Volume (MG)** | 1,650 | 698 | 384 | 379 | 381 |
| **Untreated Volume (MG)** | 1,650 | 759 | 30 | 22 | 23 |
| **Total (MG)** | 3,300 | 1,457 | 414 | 401 | 404 |

As of the end of 2024, the 2006 LTCP goals for average annual CSO activation and volume were met, or were materially met, at 78 of the 86 outfalls. This performance reflects eight more outfalls meeting or materially meeting 2006 LTCP performance targets than reported in 2021. Of the eight remaining outfalls not projected to meet 2006 LTCP goals by the end of 2024, projects are moving forward for three outfalls to meet 2006 LTCP goals after 2024.

These three outfalls include the MWR205 (Somerville Marginal CSO Facility), SOM007A/MWR205A (Upper Mystic River), and BOS003. For Somerville Marginal CSO Facility (MWR205) and SOM007A/MWR205A, the project involves constructing a new connection from the facility influent conduit to the interceptor. The construction contract was awarded in September 2024 and substantial completion is anticipated in December 2026. Upon completion of this work, outfalls MWR205 and SOM007A/MWR205A are projected to materially meet the 2006 LTCP goals.

For outfall BOS003, BWSC has a plan in place to construct the East Boston Phase 4 Sewer Separation project which includes five contracts to be constructed between 2025 and 2030. With completion of this

sewer separation work, the model predicts that outfall BOS003 will have 0 activations in the 1992 Typical Year, thus meeting the 2006 LTCP goals.

For the remaining five outfalls (SOM001A and CAM401A, which discharge to Alewife Brook, and CAM005, MWR018, and MWR019, which discharge to the Charles River), additional projects to meet 2006 LTCP goals were evaluated, but feasible and cost-effective projects were not identified. Although further reductions at CAM005 are expected with the design and construction of a higher and longer weir wall, these further adjustments are not predicted to fully meet 2006 LTCP goals. The project may be considered to materially meet when complete. New alternatives to achieve higher levels of control at these outfalls have been evaluated as part of this Updated CSO Control Plan as described in Section 9.

## 3.3 Activities Related to Alewife Brook/Upper Mystic River and Charles River Variances

As described in Section 2.4.3, MassDEP has issued water quality Variances to the Partners since the approval of the MWRA LTCP in 2006. Since that time, the Partners have complied with the requirements of the Variances to expand water quality monitoring, perform model calibrations, establish CSO notification programs, develop and implement optimization and design projects, and more. The discreet requirements of the past and current Variances were presented in Section 2.4.3.

The extension of the Variances over time also provided opportunities for work by others to contribute to the understanding of pollutant impacts to the Alewife Brook, Upper Mystic River, and the Charles River. This work included water quality sampling programs by the Charles River Watershed Association (CRWA), the collection and evaluation of water quality data by the United States Geological Survey (USGS) in 1999-2002 on the effectiveness of stormwater pollution controls, and the implementation of stormwater pollution control measures by municipalities along the Charles River.

## 3.4 Other Work Conducted by the CSO Communities and MWRA Impacting the Alewife Brook, Mystic River, and Charles River

In addition to the projects specified in the MWRA's 2006 LTCP and in the Variance Conditions, MWRA, the cities of Cambridge and Somerville, and BWSC have independently implemented projects over time that have also resulted in reduced CSO impacts to the Alewife Brook, Mystic River, and the Charles River. **Table 3-3** provides a summary of these projects, organized by completion date. Additional details on programs in both the Cities of Cambridge and Somerville that impact water quality and CSOs are presented in Section 4.

**Table 3-3. Other Projects Implemented by MWRA, Cambridge, Somerville and BWSC with CSO Reduction Benefits**

| Impacted CSO | Project Description | Construction Completed |
|---|---|---|
| MWR201 (Cottage Farm CSO Facility) | BWSC completed Roxbury Phase I, II, and III sewer separation, covering approximately 116 acres of combined sewer area. This work reduced wet weather flows to Ward Street Headworks, which in turn reduced treated discharge volume at the Cottage Farm CSO Facility | 2024 |
| MWR205A/SOM007A | MWRA replaced a leaky tide gate on outfall MWR205, downstream of the overflow weir to outfall MWR205A. | 2023 |
| CAM017 | The City of Cambridge completed the PL6 Stormwater Tank and Separation, a project with local sewer separation and pumping of stormwater to the South Massachusetts Avenue drain during larger typical year events. This work reduced untreated discharges at the CAM017 outfall. | 2021 |
| CAM017 | The City of Cambridge completed the Rogers Park area separation and green stormwater infrastructure (storage/infiltration) project. This work reduced untreated discharges at the CAM017 outfall. | 2021 |

## Table 3-3. Other Projects Implemented by MWRA, Cambridge, Somerville and BWSC with CSO Reduction Benefits

| Impacted CSO | Project Description | Construction Completed |
|---|---|---|
| CAM017 | The City of Cambridge completed the 9 A/B Separation project, a separation of approximately 40 acres. This work reduced untreated discharges at the CAM017 outfall. | 2020 |
| MWR201 (Cottage Farm CSO Facility) | City of Cambridge completed partial separation of 220-acres of combined sewer area in the Cambridgeport neighborhood tributary to the MWRA interceptor and Cottage Farm CSO Facility. This work reduced flows to the MWRA's interceptor, which resulted in reduced treated discharges at Cottage Farm CSO Facility Massachusetts Avenue | 2019 |
| MWR201 (Cottage Farm CSO Facility) | The City of Cambridge completed the Newport/Roseland Infrastructure Improvements to remove private property inflow and construct green stormwater infrastructure (infiltration). This work reduced flows to the MWRA's interceptor, which resulted in reduced treated discharges at Cottage Farm CSO Facility | 2017 |
| MWR201 (Cottage Farm CSO Facility) | The City of Cambridge completed Phase 1 of the Western Avenue area separation that included over 3,000 feet of new 36-inch RCP/FRP storm drain along Western Avenue (~10 acres) and a new outfall to the Charles River was installed for current and future area to be separated. This work reduced flows to the MWRA's interceptor, which resulted in reduced treated discharges at Cottage Farm CSO Facility | 2016 |
| CAM017, Prison Point | The City of Cambridge completed the CAM017 Bending Weirs project; a unique three-weir approach was constructed to reduce overflows as well as improve the level of service (flooding potential) in the area. | 2015 |

# 4. Related CSO Control Efforts

This section summarizes the ongoing programs and systemwide initiatives undertaken by the Partners that provide measurable CSO reductions beyond the MWRA LTCP projects described in Section 3. These efforts operate in parallel with the history presented in Section 3 and represent the additional investments to support system performance, regulatory compliance, and long-term water quality improvement.

The initiatives described here include implementation of the NMC, coordinated public notification and health advisory programs, MWRA's water quality monitoring activities, and the CSO related work advanced independently by Cambridge and Somerville. Collectively, these programs reduce hydraulic loading, improve system reliability, enhance monitoring and communication, and strengthen the overall framework within which CSO control is achieved. The section concludes with a summary of the 2024 Variance evaluations. These initiatives form the supporting pillars for the region's CSO control strategy and provide essential context for the Updated CSO Control Plan.

## 4.1 Nine Minimum Controls and work by Partners

The NMCs are part of EPA's 1994 CSO Control Policy as summarized in Section 2.2. EPA defines the NMCs as "…minimum technology-based controls that can be used to address CSO problems without extensive engineering studies or significant construction costs, prior to the implementation of long-term control measures."[1] The NMCs are written to be site-specific and not "one size fits all".

Each of the NMCs are summarized in the following sections, including how each of the Partners continue to implement the requirements. BWSC and the City of Boston also implement NMCs within their jurisdiction as well, but those details are not included here.

### 4.1.1 NMC #1- Proper operation and regular maintenance programs for the sewer system and CSO outfalls

The first NMC involves having proper operations, maintenance (O&M), and inspection programs for the collection system and treatment facilities, ensuring both function to maximize treatment. This includes not only obvious items like O&M manuals, identification of critical facilities and structures, and proper staffing, but also elements like adequate budgetary resources for O&M, emergency response procedures, and proper training for the relevant staff.

#### 4.1.1.1 MWRA

MWRA has cataloged CSO outfalls and associated parts of the collection and treatment system. Inspection and O&M plans exist for all the above, as well as staffing plans as required by Massachusetts regulations. To meet the requirements of MWRA's NPDES Permit, both a status report on O&M efforts and a certification that all CSO outfalls and regulators are inspected every year are submitted annually.

#### 4.1.1.2 City of Cambridge

As part of its NPDES MS4 Permit, the City of Cambridge adopted pollution prevention and good housekeeping controls intended to ensure that City operations and activities conducted at City-owned facilities do not contribute to stormwater pollution.

Although CSOs and the combined sewer system are not technically part of the MS4, the City applies these Best Management Practices (BMPs) comprehensively throughout the City. The Good Housekeeping Manual was first published in 2007 and is updated periodically.

In addition to the BMPs included in the Good Housekeeping Manual, the City has developed a Sanitary Sewer System cleaning program and maintenance schedule that specifically targets problematic catchments, such as those that service a greater density of restaurants or other food establishments. This

[1] USEPA. May 1995. Combined Sewer Overflows: Guidance for NMCs. EPA 832-B-95-003. https://www.epa.gov/sites/default/files/2015-10/documents/owm0030_2.pdf

proactive effort mitigates grease or detritus build-ups that contribute to potential contaminant introduction to the combined sewer system.

The City has created routine inspection form templates that obligate trained inspectors to complete all required permit reporting data fields. The City's work order system can automatically generate work orders for monthly inspections, institutionalizing the procedures and contributing to the proactive system management the City has pursued. This will ensure that unintended lapses exceeding one month will be eliminated and allocate appropriate resources to the task.

#### 4.1.1.3 City of Somerville

Somerville's Water and Sewer Department oversees system operation, supported by the Department of Infrastructure and Asset Management for planning, budgeting, and asset management. Together, the two departments ensure that routine maintenance activities, including sewer cleaning, catch basin cleaning, and inspection of the SOM001A CSO outfall, are performed.

As part of Somerville's NPDES MS4 Permit, the City engages in pollution prevention and good housekeeping policies which are applied to both MS4 and non-MS4 areas of the City to reduce pollution. Cleaning and inspection of combined and separated sewer pipes is performed on a five-year frequency. Inspection programs additionally include quarterly regulator inspections, and continuous monitoring of SOM001A through flow meters. System assets are tracked in a GIS database, which supports condition assessments and maintenance planning.

Emergency response is managed through the City's 311 Service Center and SSO Emergency Response Plan. Reports of blockages, sinkholes, or system failures trigger immediate investigation and response by City crews or an on-call emergency contractor.

### 4.1.2 NMC #2- Maximum use of the collection system for storage

The second NMC aims to use the collection system as storage to minimize the amount of CSO discharged. Examples of this NMC include collection system inspections to identify (and clear) debris and sediment buildups, maintenance of outfall tide gates, changes to pump station operational strategies, and adjustments to regulator weir heights.

#### 4.1.2.1 MWRA

MWRA has maximized collection system storage through the implementation of projects in the 2006 LTCP. Some examples are the South Boston CSO Storage Tunnel (2.1 miles long / 17-foot diameter connected to a 15 million gallons per day (MGD) dewatering pump station) and modifications to CSO regulators on the Fort Point Channel. Additional optimization projects are being examined through the requirements in the 2024 Variances. Two examples are now being implemented include weir raising at CAM005 and a gate at the Somerville Marginal CSO Facility to take advantage of available MWRA interceptor capacity in smaller storm events.

#### 4.1.2.2 City of Cambridge

The City of Cambridge has used relatively simple modifications to the combined sewer system to enable the system to store wet weather flows until downstream facilities can handle them. The City has undertaken multiple projects that address sewer solids and collection system storage to increase collection of combined sewage.

The City has incorporated BMPs that specifically address system storage optimization including: integration of infiltration basins; sanitary and storm system flushing; provision of storage tanks; installation of bending weirs; ongoing sewer separation; use of swales; and implementation of a development ordinance that requires new developments to provide storage of excess runoff between the 2-year existing storm and the 2070 25-year storm event.

#### 4.1.2.3 City of Somerville

Existing activities performed by the City of Somerville serve to reduce the volume and frequency of overflows by storing wet weather volume within the collection system to the greatest extent possible. The City removes debris from its collection system through annual inspection and cleaning programs as well

as ad hoc removal. Additionally, the City has increasingly included deep sump catch basins and permeable pavement in its own infrastructure projects. New and redevelopment projects are subject to the City's zoning ordinance and the City's Construction Site Stormwater Runoff Control program, both of which require and incentivize additional stormwater infiltration and retention. As part of Somerville's Engineering Site Permit Rules & Regulations, large projects are required to provide storage of excess runoff between the pre-development 2-year storm and the post-development 10-year storm peak flow.

Somerville also completed construction of a new stormwater culvert along Somerville Avenue which stores 0.8 million gallons and has started construction of a 4-million-gallon stormwater Storage Tank and Pump Station on Poplar Street.

### 4.1.3 NMC #3 - Review and modification of pretreatment requirements to ensure that CSO impacts are minimized

The goal of NMC #3 is to catalog and minimize the discharge of industrial and commercial effluent into the combined sewer system, thereby minimizing the amount of pollutants discharged when a CSO regulator structure does activate.

#### 4.1.3.1 MWRA

As required by Massachusetts regulations, MWRA maintains sewer use regulations which regulate the discharge of pollutants to the system. Per federal regulations, MWRA's approved pretreatment program, including Cambridge and Somerville's industrial discharges, also identifies 177 Significant Industrial Users who discharge to the combined system, as well as thousands of smaller industrial users. MWRA issues an annual Industrial Pretreatment Program Report to comply with the MWRA NPDES Permit.

#### 4.1.3.2 City of Cambridge

Cambridge's Department of Public Works (DPW) developed and administers a program specifically targeting fats, oil and grease (FOG) discharges into its system. The DPW provides business owners and residents with information regarding FOG on their website. Compliance officers review plans and perform inspections at new food facilities or facilities undergoing renovations. The City's Inspectional Services Department requires that the facilities notify and submit kitchen and plumbing plans to DPW prior to obtaining signatures on building permits. The DPW requires the use of liquid grease digesting bacteria where grease is found to be problematic in the sanitary system.

#### 4.1.3.3 City of Somerville

The City of Somerville works with the MWRA to identify non-domestic users of the collection system. The City's Board of Health maintains pretreatment regulations for FOG, which require all permitted establishments to provide the Inspectional Services Division with a comprehensive FOG Management Plan and limit FOG concentrations for wastewater discharges.

### 4.1.4 NMC #4 – Maximization of flow to the POTW for treatment

The core principle of NMC #4 is that the more flow that can be conveyed to a POTW, the less likely a CSO is to occur. Even if CSOs continue, greater conveyance to the POTW is likely to lessen the number of CSO activations and the volume of CSO discharged.

#### 4.1.4.1 MWRA

In the early 1990s, one of the first upgrades to the DITP was additional pumping to get more combined flows to DITP for treatment. Much of the early reductions in CSO discharge volume in the early 1990s were due to increased pumping capacity at DITP.

#### 4.1.4.2 City of Cambridge

The City of Cambridge employs specific BMPs that address flow including sanitary and storm system flushing, and integration of storage tanks to contain wet weather flows which can be conveyed to the to the DITP for treatment following the storm when system capacity is available.

The City also engages remediation contractors annually to conduct television camera inspections, cleaning and remedial reconstruction or repair of portions of the sanitary sewers, combined sewers and MS4.

#### 4.1.4.3 City of Somerville

Annual rehabilitation, cleaning, and inspection programs performed by the City of Somerville and its contractors on the combined sewer and sanitary portions of the collection system serve to optimize the existing capacity of pipes that convey flow to DITP for treatment. The City has established policies that help reduce the amount of inflow and infiltration into the combined sewer system.

### 4.1.5 NMC #5 – Elimination of CSOs during dry weather

NMC #5 aims to eliminate CSOs during dry weather, also known as dry weather overflows (DWOs). Cambridge and Somerville's NPDES CSO Permits and MWRA's NPDES Permit also prohibit DWOs. They can be eliminated through the identification of structures that could overflow in dry weather through normal O&M inspections (see NMC #1 and #2) and then taking corrective action, such as regulator and tidegate maintenance. Part of this NMC also includes notification to the proper regulatory authorities.

#### 4.1.5.1 MWRA

MWRA implemented a DWO Control Program in 1988 and documented the findings in a 1989 Final DWO Control Program document as well as the 1997 MWRA NMC document. The Massachusetts Operation, Maintenance and Pretreatment Standards for Wastewater Treatment Works (314 CMR 12.00)[2], as well as MWRA's NPDES Permit, requires reporting of DWOs. Since 2000, MWRA has not had any DWOs to the Alewife Brook, Mystic River, or Charles River. No further actions, apart from those outlined through other control measures, are planned at this time.

#### 4.1.5.2 City of Cambridge

Cambridge has successfully eliminated discharges during dry weather conditions. No further actions, apart from those outlined through other control measures, are planned at this time.

#### 4.1.5.3 City of Somerville

Somerville has not had a DWO since 1989. No further actions, apart from those outlined through other control measures, are planned at this time.

### 4.1.6 NMC #6 – Control of Solid and Floatable Materials in CSOs

NMC #6 is intended to reduce or eliminate visible floatable material and solids in CSO discharges. This is typically accomplished through mechanical devices such as screens or baffles.

#### 4.1.6.1 MWRA

MWRA operates two CSO treatment facilities that are predicted to treat 97% of the CSO to the Charles and all of the CSO discharging to the Upper Mystic River in a 2050 Typical Year. Both of these facilities have fine mechanical screens (½-inch opening) to remove floatable and other objectional material. The Cottage Farm CSO facility, also has 1.3 MG of detention basins with underflow baffles and a fine mesh up-flow screen to further remove objectional materials and settleable solids before discharging the Charles River. Both methods capture floatables before they might otherwise be discharged during a CSO event.

#### 4.1.6.2 City of Cambridge

The City of Cambridge's solid and floatable program has included considerable technical evaluation of alternatives, both in terms of capital costs and O&M considerations.

BMPs that specifically target control of solids and floatables include floatables control baffles and installation of floatables control brush screens. Baffles have been installed at all active CSO regulator

[2] Operation, Maintenance and Pretreatment Standards for Wastewater Treatment Works: https://www.mass.gov/doc/314-cmr-1200-wastewater-treatment-plants/download

structures except for CAM001. At CAM001, a hood was installed on the outfall pipe to prevent overflow of floatables. In addition, brush screens were installed on the concrete weir at CAM401A to further control floatables.

#### 4.1.6.3 City of Somerville

The City of Somerville implements strategies to control and prevent floatables at the source, including public outreach and enforcement of pollution ordinances. Catch basin hoods throughout the City trap floatables and prevent them from discharging through the outfalls and CSO regulator structures.

Somerville's SOM001A outfall is equipped with a steel underflow baffle designed to prevent floatables from discharging to the Alewife Brook. SOM007A/MWR205A is located downstream of MWRA's Somerville Marginal CSO Facility which provides screening, disinfection, and dechlorination of combined sewer flows prior to discharge at SOM007A/MWR205A. These CSO treatment processes are managed by MWRA on behalf of the City of Somerville.

### 4.1.7 NMC #7 – Pollution Prevention Programs to Reduce Contaminants in CSOs

NMC #7 covers several initiatives that aim to reduce pollutants from entering the combined, storm, and sanitary sewer collection systems and then potentially being discharged in CSO effluent. One of the key components of this NMC is based on the Pollution Prevention Act of 1990, which states that pollution being removed or prevented at the source is a top priority. Examples given in the NMC document include street sweeping, public education programs, additional trash collection and/or receptacles, enforcement of illegal dumping ordinances, hazardous waste collection, and preventing pollution from non-residential sources (see NMC #3).

#### 4.1.7.1 MWRA

MWRA has BMPs to fulfill NMC #7 in three areas. First, MWRA has provided guidance to communities on how to reduce stormwater pollution and/or flow in the stormwater portion of CSO in the MWRA Sewer Use Regulations[3]. Second, each MWRA facility has a Best Management Practices Plan to reduce and control pollution from runoff, spills, and leaks. Finally, MWRA's groundskeeping contract requires that application of fertilizer and weed control chemicals adhere to best practice industry standards. MWRA also has a Pollution Prevention Plan[4] which is required by their NPDES Permit. This plan addresses preventative measures that can be taken by households and industries to avoid pollutants entering into the collection system. Finally, MWRA has Spill Prevention Control and Countermeasure plans for facilities with more than 1,320 gallons of oil products stored aboveground. These plans aim to prevent oil spills and lay out response plans in case a spill does occur.

#### 4.1.7.2 City of Cambridge

Through its MS4 program, the City has instituted public information campaigns that aim to help reduce the household use of potential contaminants and illegal dumping. The City has developed a suite of educational materials highlighting actions to minimize stormwater pollution tailored to residential, commercial, and industrial properties. These materials are distributed through online campaigns, neighborhood and City events, and mailings. The Storm Stewards program, where residents pledge to keep storm drains clear of debris, is available citywide. Residents may also report illegal dumping through Commonwealth Connect and City staff prioritize cleaning of reported structures.

The City's effort to reduce potential surface water contaminants also include robust and intensive curbside recycling, yard waste, and composting programs, as well as household hazardous waste drop-offs implemented by the Sanitation Department. Litter barrels in City squares are emptied daily on weekdays and three times daily on weekends.

Cambridge's street sweeping program is frequently cited by other cities and towns as a model for other communities. The major street sweeping operation runs from April through December each year and covers each side of residential streets monthly. Bike lanes and primary corridors are swept weekly, and City squares are swept daily. During the months of April, July, and November the City completes a

[3] MWRA Sewer Use Regulations https://www.mwra.com/your-sewer-system/toxic-reduction-and-control-trac/sewer-use-and-discharge-regulations
[4] https://www.mwra.com/media/file/pollution-prevention-households-and-permitted-industries-svc-area-2000-ms-63

tandem street sweeping operation combining a vacuum sweeping operation following mechanical sweeping operation. Hand crews assist in the removal of materials during all sweeping operations, and there are street-cleaning crews working throughout the year.

Pollution prevention BMPs have been adopted by the City, including deep sump catch basins (sumps and hoods), which entails the replacement of shallow or no-sump catch basins with catch basins constructed with a six-foot minimum sump. City maintenance facilities and DPW yards also have Stormwater Pollution Prevention Plans and are inspected quarterly for potential sources of pollution. The DPW Maintenance Garage and Recycling Center has a Spill Prevention Control and Countermeasure Plan to contain materials in the case of a spill.

In addition, the City has adopted an integrated pest management approach for maintenance of passive and active recreation areas and open space. This policy allows the City to reduce contributions of pesticides, fungicides and herbicides as well as fertilizers to stormwater runoff.

#### 4.1.7.3 City of Somerville

The City of Somerville utilizes a series of structured pollution prevention and good housekeeping practices to minimize contaminant discharge into the collection system. From April through December, the DPW conducts weekly street sweeping on main streets and biweekly street sweeping on side streets. DPW also inspects and cleans catch basins to maintain a target of less than 50% debris capacity.

Public education supports pollution prevention through the City's website, social media, and annual mailers. The City distributes custom messaging tailored to residential, commercial, and industrial audiences. The Somerville Waste Wizard provides disposal instructions and pickup schedules, while materials such as the Environmental Service Guide and Recycle Smart Postcard inform residents about waste reduction, recycling, and stormwater protection. Educational content covers topics such as proper disposal of non-dispersible items, hazardous waste management, and pollution that may be contained within the CSO discharges.

Other pollution prevention and good housekeeping elements employed by Somerville include adopting a standard detail for deep sump catch basins with a six-foot minimum sump depth. The City also operates an Adopt-a-Drain program, which is a city-wide program where residents can volunteer to keep catch basins clear of debris.

The City enforces waste handling and product regulations to minimize pollutant sources. Trash and dumpsters must remain covered and clean, and the DPW Yard accepts drop-offs for yard waste, electronics, tires, and hazardous materials. Curbside services are provided for bulk and recyclable items. Somerville has enacted bans on polystyrene food containers, plastic bags, and plastic straws and stirrers to reduce non-biodegradable waste from contributing to stormwater runoff.

### 4.1.8 NMC #8 – Public notifications to ensure that the public receives adequate notification of CSO occurrences and CSO impacts

NMC #8 addresses notification of CSO discharges along with possible health risks of the discharge and potential curtailment of activities resulting from a discharge. This NMC also recommends the labeling of outfalls.

#### 4.1.8.1 MWRA

MWRA's work to comply with the public notification and signage requirements of the Variances and the Massachusetts Sewage Notification Law are covered in **Section 4.2.** MWRA has installed visible signs at all MWRA CSO outfalls and CSO regulator structures to comply with requirements in the MWRA NPDES Permit. For CSO discharges that may impact swimming beaches and shellfishing areas, MWRA informs the Massachusetts Department of Conservation and Recreation (DCR) and Massachusetts Division of Marine Fisheries, respectively.

#### 4.1.8.2 City of Cambridge

In addition to following the signage and notification requirements in the Cambridge Public Notification Plan per 314 CMR 16.00, the City maintains identification signs for all CSO outfall structures. The signs

are readable both from the shore and from waterways. In collaboration with the MWRA and the City of Somerville, Cambridge maintains an informational sign at John Wald Park. The City also collaborated with MWRA in the development of printed posters to be distributed to boat houses and other locations where residents access the Charles River.

Cambridge works with MWRA and Somerville to implement a system for rapid reporting of CSO discharges to the Alewife Brook and the Charles River. These subscriber-based systems provide timely information regarding a CSO activation, including the start time and location of the discharge. The City also collaborates with MWRA and Somerville to distribute an annual press release to stakeholders on the information on CSOs within the Alewife Brook.

#### 4.1.8.3 City of Somerville

In accordance with 314 CMR 16.00 and Somerville's CSO Public Notification Plan, the City issues public notifications after any CSO, discharge of partially treated wastewater, and any SSO. The City collaborates with the MWRA and City of Cambridge to implement a system for rapid reporting of CSO discharges to the Alewife Brook and the Upper Mystic River. These subscriber-based systems provide timely information regarding a CSO activation, including the start time and location of the discharge. The City also collaborates with the MWRA and the City of Cambridge to distribute an annual press release to stakeholders on the information on CSOs within the Alewife Brook.

The City maintains signage at SOM001A as well as three points of public access downstream of CSOs: Blessing of the Bay Park, Draw 7 Park, and the Patrick O'Sullivan Fishing Hole.

### 4.1.9 NMC #9 – Monitoring to effectively characterize CSO impacts and the efficacy of CSO controls

NMC #9 involves determining when CSOs occur and examining their potential impacts. The EPA guidance document stresses this NMC is about "visual inspections and other simple methods" such as documenting CSO occurrences.

#### 4.1.9.1 MWRA

The MWRA NPDES Permit requires submission of monthly Discharge Monitoring Reports for the CSO treatment facilities which report effluent quality as well as some basic information such as when the facility discharged. On an annual basis, as required by the Variances, MWRA submits a water quality report for the Charles River and Mystic River/Alewife Brook basins based on MWRA's in-house water quality monitoring results. A report on estimates of previous year CSO discharges and rainfall analyses is also issued annually.

The CSO Post-Construction Monitoring and Performance Assessment as required by the Boston Harbor Case (U.S. v. M.D.C., et al, No. 85-0489 MA) could also fall under NMC #9, although on a more sophisticated level. The Performance Assessment aims to measure the performance of the work done under the 2006 LTCP, and has included updated hydraulic and water quality modeling. NMC #9 also includes additional ongoing CSO control work done under the Variances (see NMC #2).

#### 4.1.9.2 City of Cambridge

In addition to the required real-time notifications and the monthly reporting that the City does, Cambridge's CSO Annual Report documents the CSOs during the calendar year and updated meter/modeling results. The report also provides an evaluation of the existing CSO monitoring plan, and recommendations for improvements relative to quantification of effluent volumes and model calibration.

#### 4.1.9.3 City of Somerville

The City of Somerville maintains a flow meter at the SOM001A outfall, which provides real-time information about CSOs discharging from this outfall into the Alewife Brook. This data is used to report real-time notifications to the public and the monthly reporting. The City's CSO Annual Report documents and reports the combined sewer overflows during the calendar year and updated meter/modeling results. The report also provides an evaluation of the existing CSO monitoring plan, and recommendations for improvements relative to quantification of effluent volumes and model calibration.

## 4.2 Public Notifications and Public Health Advisory Coordination and Implementation

Massachusetts adopted the CSO Public Notification Law[5] in 2021, which requires permittees to notify state agencies, local boards of health, and the public when CSO discharges occur. This section details how the Partners are complying with the CSO Public Notification Law.

### 4.2.1 MWRA

MWRA has been sending rapid public notifications for discharges from its CSO treatment facilities since April 2016 and untreated CSOs since July 2020. The program was updated again in July 2022 in accordance with 314 CMR 16.00: Notification Requirements to Promote Public Awareness of Sewage Pollution[6].

Within two hours of a confirmed CSO activation, MWRA notifies the public in two ways: through a subscriber-based email and text messaging system and by updating the CSO Notification page[7] on MWRA's website. The notifications provide preliminary details for discharges including location and start time, as well as a link to MWRA's website for additional details. MWRA is responsible for sending public notifications for four treated and five untreated MWRA CSO outfalls, as well as the BWSC outfalls associated with the South Boston beaches (BOS081-BOS086).

**Table 4-1** identifies the CSO outfalls that MWRA monitors and that are part of the CSO notification program. An example of the CSO notification website is shown in **Figure 4-1** with the locations monitored (see **Table 4-1** for letter key).

Prior to July 2022, three additional outfalls were included in MWRA's public notification program: MWR010, MWR215, and BOS019. On July 1, 2022, MWRA received a waiver from some of the public notification requirements from MassDEP for the infrequently discharging MWR010 – the last CSO discharge from the outfall was in March 2010. Activations at the nearby Cottage Farm CSO Facility (MWR201) and MWR023 would occur before an activation at MWR010. MWRA's notifications for those two outfalls would already alert the public to potential public health risk in this stretch of the Charles River. MWRA's Union Park CSO Treatment Facility (MWR215), is co-permitted with BWSC and discharges to Fort Point Channel through an outfall permitted to BWSC (BOS070). Public notifications for activations of Union Park are handled by BWSC. Public notifications for discharges associated with the MWRA storage facility at Little Mystic Channel which discharges through a BWSC outfall (BOS019) are also sent by BWSC.

**Table 4-1. MWRA Monitored CSOs in the MWRA Notification Program**

| CSO Outfall | Outfall Location | Potentially Affected Area | Location (Figure 4-1. ) |
|---|---|---|---|
| SOM007A/ MWR205A (Somerville Marginal) | Treated CSO; Baxter Park/Assembly Row, just downstream of Rte. 28 Bridge | Mystic River | A |
| MWR205 (Somerville Marginal) | Treated CSO; Draw Seven Park | Lower Mystic River (marine) | B |
| MWR203 (Prison Point) | Treated CSO; Upper Inner Harbor, upstream of N. Washington St. bridge | Boston Inner Harbor | D |
| BOS081-086 | South Boston beaches along Day Boulevard | South Boston beaches, North Dorchester Bay | F |
| MWR020 | Downstream end of Charles R. Esplanade | Charles River between Esplanade and Science Museum | G |

[5] Chapter 322 of the Acts of 2020, *An Act Promoting Awareness Of Sewage Pollution In Public Waters*
[6] https://www.mwra.com/sites/default/files/2023-11/final_cso_notif_plan.pdf
[7] https://www.mwra.com/harbor/html/cso_reporting.htm

**Table 4-1. MWRA Monitored CSOs in the MWRA Notification Program**

| CSO Outfall | Outfall Location | Potentially Affected Area | Location (Figure 4-1. ) |
|---|---|---|---|
| MWR019 | Middle of Charles River Esplanade | Charles River between Esplanade and Science Museum | H |
| MWR018 | Upstream end of Charles R. Esplanade | Charles River between Esplanade and Science Museum | I |
| MWR023 | Boston side of river, near Fenway exit from Storrow Drive | Charles River from just upstream of Harvard Bridge (Mass. Ave.) to Science Museum | J |
| MWR010 | Charles River near Boston University | Charles River between the Boston University Bridge and Science Museum | K |
| MWR201 (Cottage Farm) | Treated CSO; Cottage Farm CSO Storage and Treatment Facility, Between Magazine Park and BU Bridge | Charles River from just upstream of the Boston University Bridge to Science Museum | L |
| MWR003 | Alewife Brook Reservation near Alewife T station | Little River and Alewife Brook | M |

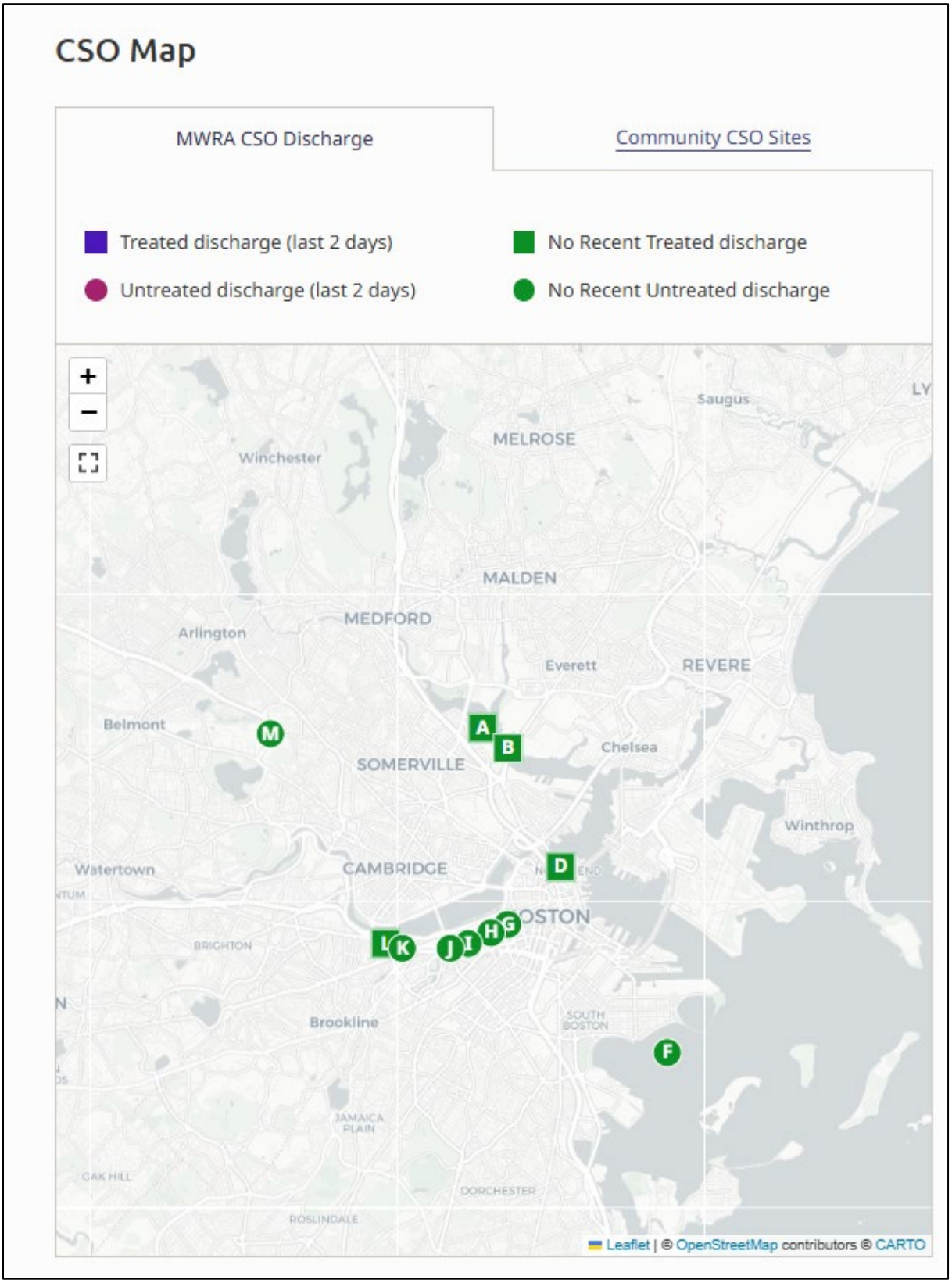



**Figure 4-1. MWRA CSO Notification Reporting Example**

Notification signage is also required by 314 CMR 16.00. In the spring of 2023, MWRA, along with the four CSO communities, installed signage at public access points to waters potentially affected by CSO discharges. Included on the signs is information about weather events that may cause a discharge, a warning of the potential threat to public health after a CSO discharge, and information for the public to subscribe to discharge notifications. Local Boards of Health (BOH) are also required to post temporary public health warnings if a CSO has discharged for at least two hours. Space has been allocated on each sign to accommodate the BOH temporary warnings. An example of the public access signage is shown in **Figure 4-2**, and the locations of these signs are presented graphically and tabularly in **Figure 4-3** and **Table 4-2**, respectively.

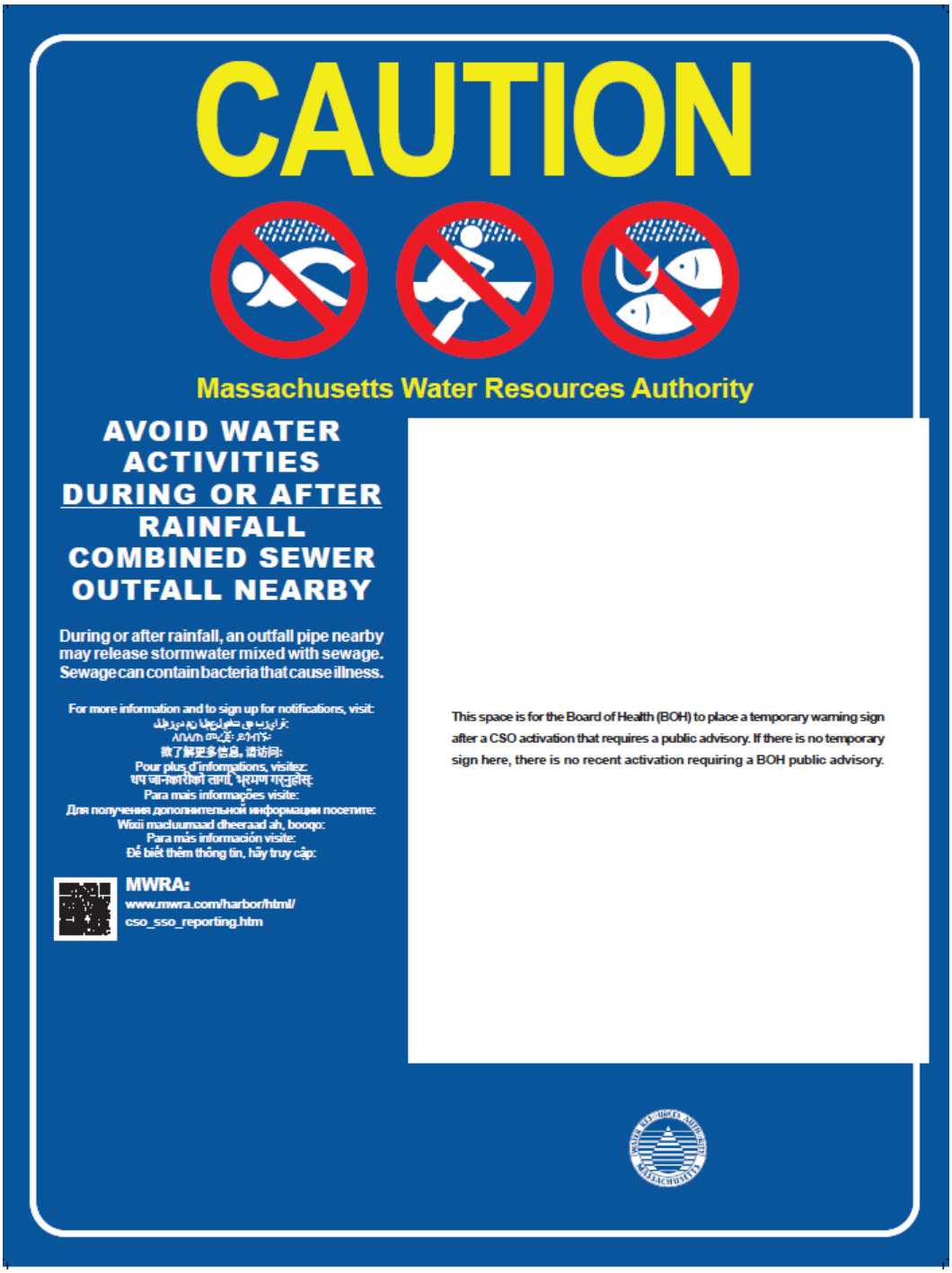



**Figure 4-2. Example Public Access Sign**

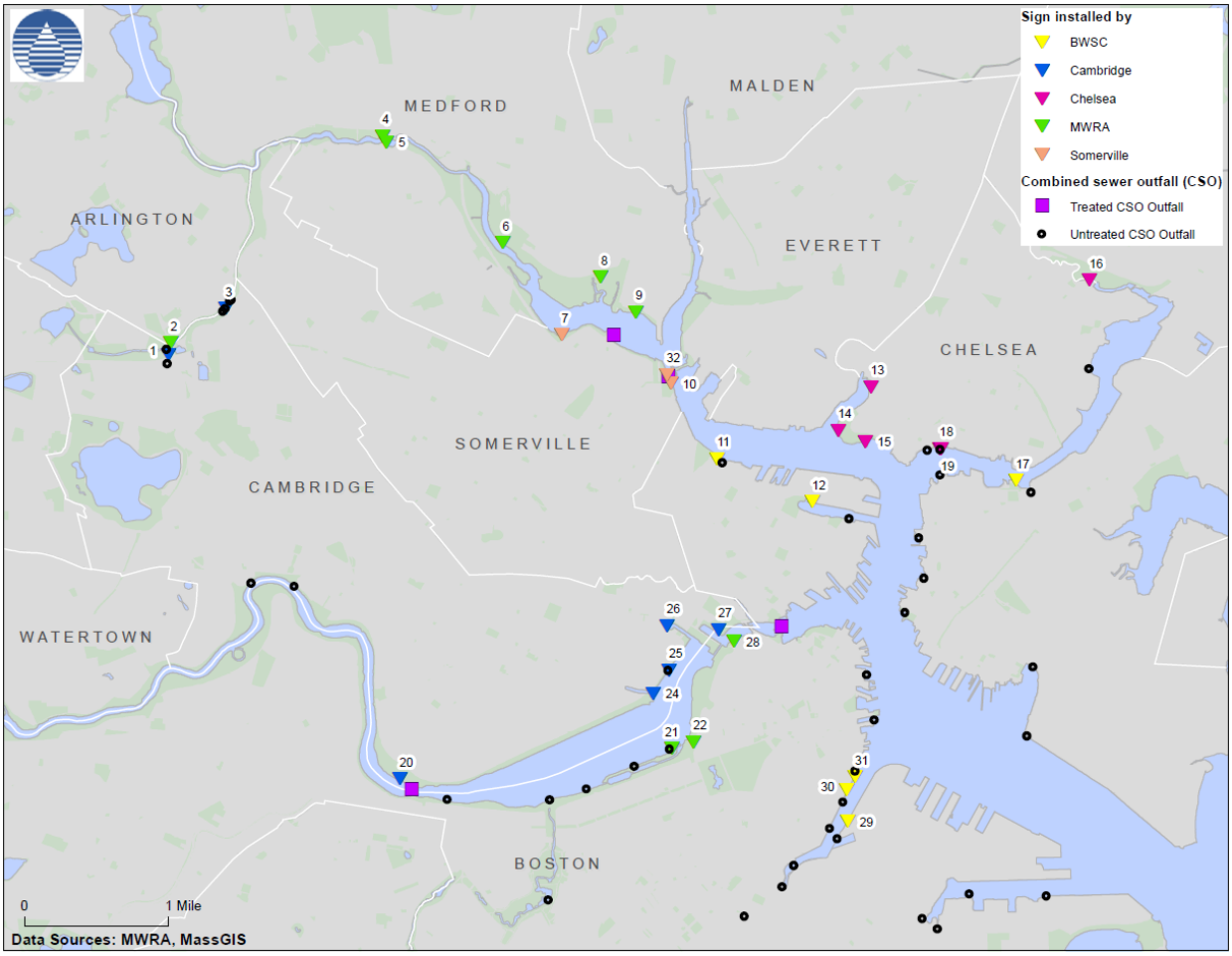



**Figure 4-3. Public Access Signage Locations**

**Table 4-2. Public Access Signage Locations**

| Map # | Public access | BOH | Latitude | Longitude | Street Address | Landowner | Installed by |
|---|---|---|---|---|---|---|---|
| 1 | Fitchburg cutoff bike path | Cambridge | 42.39658589 | -71.1438 | Fitchburg cutoff bike path near Steel Place | DCR | Cambridge |
| 2 | John Wald Park | Arlington | 42.39771 | -71.14351 | Thorndike Street Extension | DCR | MWRA |
| 3 | Mass Ave at Rte 16 | Cambridge | 42.401195 | -71.136045 | Mass Ave at Rte 16 | DCR | Cambridge |
| 4 | Paddle Boston/Condon Shell | Medford | 42.41842059 | -71.1146478 | 2501 Mystic Valley Parkway | DCR | MWRA |
| 5 | South St. - public boat launch site | Medford | 42.417779 | -71.11414 | 69 South Street | DCR | MWRA |
| 6 | McGlynn School - public kayak/canoe boat launch | Medford | 42.407614 | -71.098415 | 90 Locust Street | City of Medford | MWRA |
| 7 | Blessing of the Bay boathouse and park | Somerville | 42.39836475 | -71.09047664 | 32 Shore Drive | DCR | Somerville |

## Table 4-2. Public Access Signage Locations

| Map # | Public access | BOH | Latitude | Longitude | Street Address | Landowner | Installed by |
|---|---|---|---|---|---|---|---|
| 8 | MacDonald Park fishing dock | Medford | 42.40414598 | -71.08516321 | 3920 Mystic Valley Parkway | DCR | MWRA |
| 9 | DCR boat ramp at Wellington Yacht Club | Medford | 42.40063186 | -71.08043585 | 451 Fellsway | DCR | MWRA |
| 10 | Draw Seven Park Fishing Pier | Somerville | 42.393461 | -71.075714 | Noonan Place | DCR | Somerville |
| 11 | Harborwalk Floating Dock/Ramp at Schrafft Center | BPHC | 42.385861 | -71.069528 | 529 Main Street | Schrafft Center LLC | BWSC |
| 12 | Little Mystic Access Area (boat launch) | BPHC | 42.38156504 | -71.05662587 | 300 Terminal Street | Boston Redevelopment Authority | BWSC |
| 13 | Island End River/Marina at Admiral's Hill | Chelsea | 42.39302778 | -71.04861111 | 2-704 Justin Drive | One Amco South LLC | Chelsea |
| 14 | Mary O'Malley State Park | Chelsea | 42.388648 | -71.053089 | 141 Commandants Way | DCR | Chelsea |
| 15 | Mary O'Malley Pavillion | Chelsea | 42.387501 | -71.049404 | 141 Commandants Way | DCR | Chelsea |
| 16 | Mill Creek Walkway | Chelsea | 42.40361111 | -71.01894444 | 1012 Broadway | Broadway Hotel LLC | Chelsea |
| 17 | Condor Street Urban Wilds | BPHC | 42.38351746 | -71.02903736 | 300 Condor Street | City of Boston | BWSC |
| 18 | Andrew McArdle Bridge #1 | Chelsea | 42.38677778 | -71.03936111 | 35 Winnisimmet Street | Belam Realty LLC | Chelsea |
| 19 | Andrew McArdle Bridge #2 | Chelsea | 42.38677778 | -71.03919444 | 13 Marginal Street | Mahoney Marine Terminal LLC | Chelsea |
| 20 | Magazine Beach cartop launch | Cambridge | 42.35390667 | -71.11272179 | 668 Memorial Drive | DCR | Cambridge |
| 21 | Boston Public Dock on the Esplanade | BPHC | 42.35681137 | -71.07581131 | Esplanade | DCR | MWRA |
| 22 | Union Boat House on the Esplanade (Back Bay) | BPHC | 42.3574837 | -71.0729247 | Esplanade | DCR | MWRA |
| 23 | Community Boating Boathouse | BPHC | 42.36001836 | -71.07325016 | Esplanade | DCR | MWRA |
| 24 | Poor Man's Dock | Cambridge | 42.3623223 | -71.07832514 | Memorial Drive at Broad Canal | DCR | Cambridge |
| 25 | Public docks across from Front Park | Cambridge | 42.36472 | -71.076195 | Cambridge Parkway | DCR | Cambridge |
| 26 | Lechmere Canal | Cambridge | 42.369135 | -71.076436 | 6 Canal Park | City of Cambridge | Cambridge |
| 27 | North Point Park (Cambridge) | Cambridge | 42.36868912 | -71.06949713 | 1 North Point Boulevard | DCR | Cambridge |
| 28 | Nashua Street Park (Boston Proper) | BPHC | 42.36753213 | -71.06736557 | Nashua Street | DCR | MWRA |

**Table 4-2. Public Access Signage Locations**

| Map # | Public access | BOH | Latitude | Longitude | Street Address | Landowner | Installed by |
|---|---|---|---|---|---|---|---|
| 29 | Fort Point Pier | BPHC | 42.34941858 | -71.0520717 | End of Necco Court | MassDevelop-ment/NECCO | BWSC |
| 30 | Atlantic Wharf Docks (near Summer Street Bridge) | BPHC | 42.3525892 | -71.0521802 | 300 Congress Street | various private | BWSC |
| 31 | Harborwalk Floating Dock at Independence Wharf (near Atlantic Avenue Bridge) | BPHC | 42.353889 | -71.051028 | 470 Atlantic Avenue | C Srefi Independence Wharf Boston Inc. | BWSC |
| 32 | Patrick Sullivan Memorial Fishing Hole | Somerville | 42.394314 | -71.076289 | Noonan Place | DCR | Somerville |

### 4.2.2 City of Cambridge

The City of Cambridge follows a comprehensive, state-approved system for notifying the public when a CSO occurs at one of its outfalls. The program complies with the 2021 state law *An Act Promoting Awareness of Sewage in Public Waters* and the plan was approved by MassDEP on June 16, 2023. Cambridge's system is designed to detect, confirm, and communicate CSO events quickly to protect public health and keep residents informed.

Cambridge continuously monitors its CSO outfalls using flow meters connected to SCADA and FLOWLINK software. These systems measure water elevation and velocity and automatically alert City Engineering and Sewer Division staff by email and text when water levels rise high enough to indicate an overflow. Staff have four hours from when the CSO alert is received to verify the CSO and send the public advisory notification.

Once a CSO is confirmed, or cannot be confirmed but must still be reported, the City issues public notifications through its subscriber email system. Community members can sign up to receive these alerts at cambridgema.gov/subscribe, and notifications are also posted on the City's CSO Reporting webpage. This website provides maps, outfall numbers, discharge information, as well as links to annual reports.

When required, public health advisories are posted on the Cambridge Public Health Department's News & Events page. These advisories are issued for discharges that may pose health risks, including any that last two or more hours. Residents are advised to avoid contact with the Charles River or Alewife Brook during storm events and for 48 hours afterward due to potential contamination.

To provide real-time access to information, Cambridge has also coordinated with MWRA and Somerville to install permanent public access signs at waterfront locations. These signs direct residents to online resources, which can be translated into multiple languages using built-in web tools.

As part of its state reporting obligations, Cambridge also issues notifications also to a broad list of agencies and media outlets. These include MassDEP, EPA, the Massachusetts Department of Public Health, local health departments in Cambridge and neighboring municipalities, and watershed associations for the Charles and Mystic Rivers. To reach non-English speaking communities, Cambridge also distributes notifications to media outlets serving Chinese, Portuguese, Spanish, and Vietnamese readers.

### 4.2.3 City of Somerville

The City of Somerville also maintains a public notification system for CSO discharges at the SOM001A CSO outfall. Somerville continuously monitors the outfall using flow meters and a real-time data reporting platform. The system measures water depth and velocity and automatically alerts City Engineering staff

by email and text when water levels rise high enough to indicate an overflow. The City has four hours from when the CSO alert is received to verify the CSO and send the public advisory notification, and this email notification has been automated to trigger after that first notification is received. The automatic email informs citizens and staff that an overflow has occurred, the timing and location of the occurrence, the affected waterbodies, as well as the expected volume based on historical CSO events. An additional email is sent out to the community once the activation has ended, detailing the duration and the estimated CSO volume. This follow-up notification/email is required to be sent no later than eight hours after the CSO begins.

The public is also notified on the City's website, on the *Combined and Sanitary Sewer Overflow Control*[8] page, where a banner-style, large text banner indicates the last CSO event. Additionally, the information also informs them of the date, time, location, and affected water body. Adjacent to the banner is an interactive map, showing the outfall locations, and the outfall is colored based on CSO timeline (no overflows in the last 48 hours, overflow in the last 48 hours, overflow actively occurring, and data not received). The website is typically updated during normal City business hours, and if an event were to occur during off hours, on a holiday, or over the weekend, it will be updated on the next business day.

For any CSO lasting longer than two hours in locations upstream of Somerville points of public waterbody access, Somerville DPW staff place temporary signage alerting the public to a prolonged discharge event and the public health warning associated with the waterbodies. These weatherproof frames are placed at three locations at each corresponding to public access points nearby: the Blessing of the Bay Boathouse, Patrick O'Sullican Fishing Hole, and Draw Seven State Park. DPW staff removes the printed signage for CSO discharge notice 48 hours after the event has ended.

## 4.3 MWRA Water Quality Monitoring

The MWRA has operated an extensive water quality monitoring program for CSO receiving waters since 1989. The program covers Boston Harbor and tributary areas affected by CSOs in Boston, Chelsea, Cambridge, and Somerville, including the receiving waters of the Variances of the Lower Charles River/Charles Basin and the Alewife Brook/Upper Mystic River. MWRA also conducts water quality monitoring for stations in the Neponset River, Dorchester Bay, and Inner and Outer Boston Harbor. The sampling locations are shown in **Figure 4-4**.

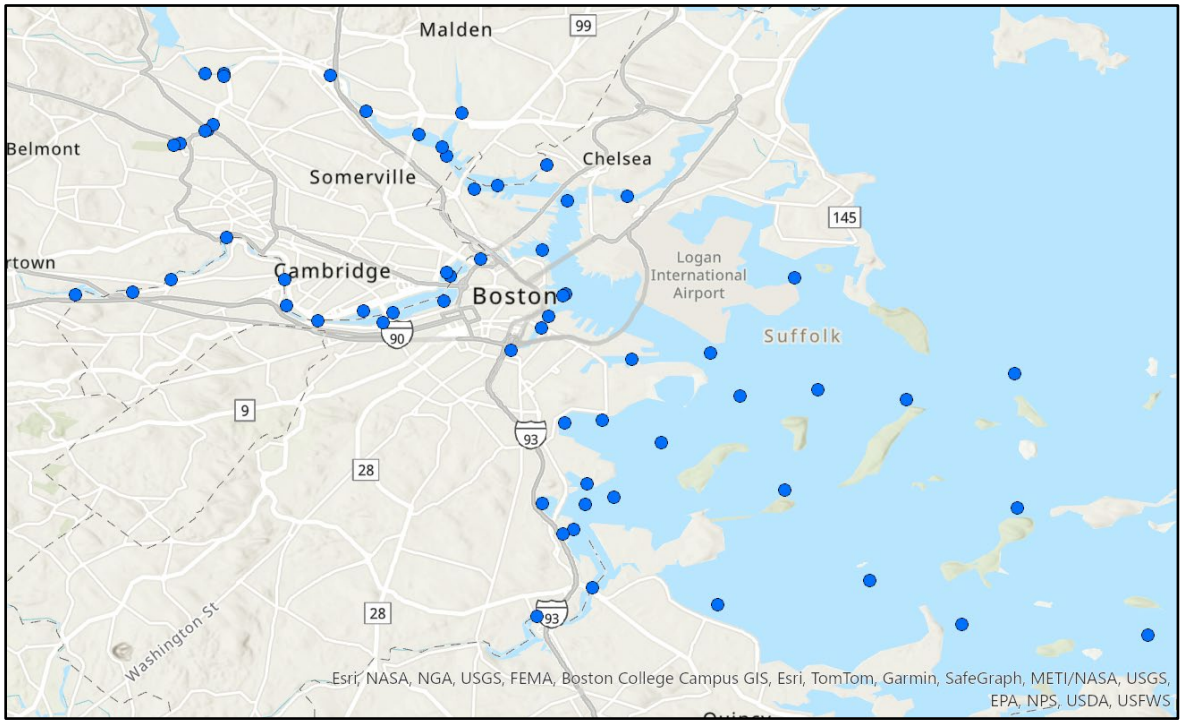



**Figure 4-4. MWRA Boston Harbor and Rivers Sampling Locations**

[8] https://www.somervillema.gov/cso

MWRA collects approximately 20 samples per station each year within the Alewife Brook, Mystic River, and Charles River. Sampling locations were selected both for their proximity to CSO discharge points and to provide representative water quality measurements for a given area. Sampling is scheduled with the goal of assessing water quality in dry weather, and after a variety of storm events, both with and without CSO discharges. Grab samples are collected near the surface at all locations, and near the bottom at sites with water depth greater than 3 meters. These samples are analyzed in the laboratory for bacteria, as well as nutrients, chlorophyll-*a*, and solids at select stations. Physical parameters, including temperature, salinity, dissolved oxygen, and pH, are measured in the field using calibrated instruments. MWRA publishes an annual summary of the receiving water sampling data, as part of the Variance requirements.[9]

Additionally, MWRA's NPDES Permit requires monitoring of the sewage effluent before discharge from the DITP as well as monitoring of the water column, sea floor, and marine communities in Massachusetts and Cape Cod Bays. Results from those monitoring efforts are regularly published online and are also available by request.[10]

## 4.4 Cambridge CSO Related Work

### 4.4.1 Overview of CSO Related Work in Cambridge

The City of Cambridge recognizes that CSOs are part of a broader set of interconnected challenges within the municipal collection system. Beyond O&M efforts as described in **Section 4.1**, the City invests in infrastructure improvements to ensure that the community benefits from a modern collection system based on progressive ideals. Accordingly, the City's planning and infrastructure improvement efforts extend beyond CSO control to address SSOs, hydraulic surcharging and basement backups, street flooding, and the overall quality of stormwater runoff; these issues are inherently linked. Recognizing these linkages, the City has adopted an integrated approach that manages the sewer and drainage systems holistically—enhancing system capacity, improving water quality, and strengthening climate resilience. Cambridge has been advancing these initiatives over several decades, often ahead of regulatory requirements, demonstrating a longstanding commitment to proactive system management. Through initiatives such as the Ten-Year Sewer and Drain Infrastructure Plan[11], the *FloodViewer*[12] Flood Resilience Zoning programs[13], and the implementation of green stormwater infrastructure (GSI), the City continues to adopt a comprehensive, system-wide approach that integrates ongoing refinement of modeling tools, technical guidance, and design standards in response to new data and emerging trends. This proactive and adaptive strategy ensures that infrastructure investments achieve multiple environmental and regulatory objectives while enhancing the long-term reliability and resilience of the collection system. The following sub-sections provide a detailed discussion of the proactive initiatives undertaken by the City over the years to advance these goals.

### 4.4.2 Climate Resiliency Efforts

As part of its ongoing climate resiliency and flood preparedness initiatives, the City of Cambridge continues to refine its technical tools and design standards to reflect the most current climate science and state guidance. These efforts are guided by the Resilient Cambridge Plan[14] (2021), which serves as the City's roadmap to reduce climate-related risks and prepare the community for impacts that cannot be avoided. The plan focuses on the major threats posed by increasing temperatures, heavier precipitation, and sea level rise, and it builds upon the Climate Change Vulnerability Assessment (CCVA)—a citywide "climate stress test" that projects potential impacts through 2030 and 2070 under future climate scenarios. Starting with the CCVA as the technical foundation, neighborhood-scale resilience planning efforts in Alewife and The Port were developed. The City developed an integrated framework organized around four key focus areas: (1) Closer Neighborhoods, (2) Better Buildings, (3) Stronger Infrastructure, and (4) Greener City. These strategies are designed to complement one another and be implemented

[9] The most recent report, *Summary of CSO Receiving Water Monitoring in Upper Mystic River/Alewife Brook and Charles River, 2024*, is available here: https://www.mwra.com/media/file/2025-02.pdf
[10] For additional reports, visit: https://www.mwra.com/our-environment/water-quality-reports
[11] Ten-Year Sewer and Drain Infrastructure Plan, April 2022- *sewer10yp_v2_final_accesible.pdf*
[12] Cambridge Flood Viewer 2025 - *Flood Viewer 2025*
[13] Climate Resilience Zoning 2023 - *https://www.cambridgema.gov/Services/climateresiliencezoning*
[14] Resilient Cambridge Plan 2021 - *Resilient Cambridge*

collaboratively across all levels of the community—residents, institutions, government, and businesses—to build a resilient and adaptive urban environment.

### 4.4.3 Stormwater Management

To strengthen the regulatory framework for water quality protection, the City of Cambridge adopted the Wastewater and Stormwater Drainage System Ordinance[15] (Title 13, Chapter 13.16) on January 28, 2008. This ordinance established a regulatory foundation for managing discharges to the municipal drainage system. Building on this, the City enacted the Wastewater and Stormwater Drainage Use Regulations on March 31, 2008 to protect public health and the environment by regulating the discharge of waste and pollutants. These regulations require DPW approval for certain drainage discharge related activities to ensure that stormwater management practices align with established standards and support the City's broader infrastructure and environmental goals. As an extension of this regulatory framework, the City introduced the Stormwater Control Permit program[16] which is applicable for certain new development and redevelopment projects. To facilitate implementation, the City developed a Wastewater and Stormwater Management Guidance Document (May 2008) [17], which provides detailed instructions for private construction, development, and redevelopment projects subject to the Stormwater Control Permit program. The Wastewater and Stormwater Management Guidance Document outlines best practices and requirements to ensure appropriate measures are taken throughout the project to address erosion, nonpoint source pollution, and flood control.

These foundational regulations and guidance documents laid the groundwork for the City's long-term infrastructure planning. Expanding upon this foundation, the City of Cambridge has outlined comprehensive strategies in their Ten-Year Sewer and Drain Infrastructure Plan[18] to improve water quality, reduce flooding, and increase system resilience. A key objective of this plan is to address high-risk infrastructure, remove inflow and infiltration, and eliminate sanitary sewer overflows. The plan emphasizes the importance of managing stormwater to mitigate flooding risks and enhance the city's resilience to climate change. Additionally, the plan includes measures to reduce combined sewer overflows and improve the overall efficiency of the sewer and drain systems.

Stormwater Requirements for Private Development:

The City of Cambridge has long been a leader in proactive stormwater management, implementing programs and standards ahead of state and federal regulatory requirements. While the City's Stormwater Control Permit program was revised in 2021 to meet the 2016 MS4 Permit requirements for phosphorus control, its foundation dates back to 2008, when the City first developed its stormwater regulations (formerly known as Land Disturbance Permits), and the Wastewater and Stormwater Management Guidance Document.

The Stormwater Control Permit applies to new development and redevelopment projects that meet one or more thresholds: disturbance of one acre or more, development exceeding 50,000 square feet of gross floor area, parcels one acre or larger, construction of parking for ten or more vehicles, or projects requiring a Planning Board Special Permit. The Stormwater Control Permit may also apply if the City Engineer determines that a project could adversely affect the municipal sewer, combined sewer, stormwater system, or nearby water resources, including high-risk sites with increased impervious area or a history of stormwater issues.

Projects below Stormwater Control Permit thresholds are still reviewed by DPW through the Building Permit site plan review process. Depending on potential impacts, the City may encourage stormwater best management practices, including Low Impact Development measures such as green infrastructure, permeable pavement, infiltration systems, and vegetated open spaces to increase natural storage, reduce impervious cover, and improve pollutant removal.

[15] Wastewater and Stormwater Drainage System Ordinance - *Chapter 13.16 - WASTEWATER AND STORMWATER DRAINAGE SYSTEM | Code of Ordinances | Cambridge, MA | Municode Library*
[16] Stormwater Control Permit Program Application Module- *Stormwater Control Permit - City of Cambridge, MA*
[17] Wastewater and Stormwater Management Guidance Document, Drafted on May 2008- *Document* & 2021*Supplemental Directive*
[18] Ten-Year Sewer and Drain Infrastructure Plan, April 2022- *sewer10yp_v2_final_accesible.pdf*

While the existing stormwater system is designed to convey a 2-year design storm, the City continues to address localized flooding and water quality concerns by requiring the use of advanced design criteria and future climate projections**.** All development and re-development projects subject to the Stormwater Control Permit must comply with both MassDEP's Stormwater Management Standards and City-specific standards. In some cases, the City's standards are more stringent due to the use of future climate-adjusted rainfall data and expanded design requirements.

For example, under Standard 2 of the MassDEP Stormwater Handbook (2008), stormwater systems must be designed so that post-development peak discharge rates do not exceed pre-development rates for the 2-, 10-, and 100-year, 24-hour storms. Cambridge's Draft Stormwater Handbook (2023) updates this by requiring precipitation values based on NOAA Atlas 14 (Volume 10) rainfall data (Version 3.0 or later), using the upper confidence interval multiplied by 0.9 to account for variability.

Cambridge revised its Stormwater Control Permit program in 2021 and implemented ahead of the Draft 2023 MassDEP Stormwater Handbook to adopt more stringent climate-adaptive standards. The City of Cambridge mandates that stormwater systems be designed using projected rainfall data for the year 2070, which incorporates anticipated increases in storm intensity due to climate change. Additionally, this Cambridge-specific standard requires on-site storage for the difference between the 2-year pre-construction runoff volume and the 25-year post-construction runoff volume, providing an additional safety margin beyond MassDEP's baseline requirements (**Figure 4-5**).

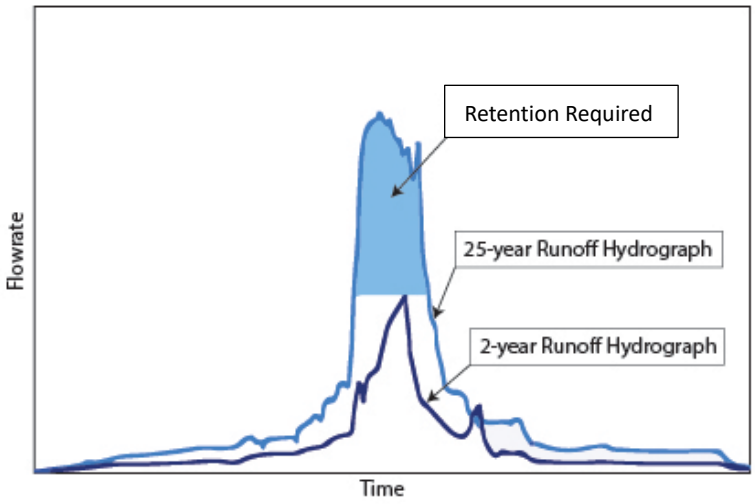



**Figure 4-5. Onsite Retention Requirements**

Moreover, this Cambridge-specific standard requires the rainfall data used for design to be based on the Cambridge projected rainfall data for 2070. As shown in **Table 4-3**, the projected rainfall depths for Cambridge in 2070 exceed both the current MassDEP Stormwater Handbook (TP-40) and anticipated Draft MassDEP Stormwater Handbook (NOAA Atlas 14) values across various design storms:

**Table 4-3. Rainfall Data for Various Design Storms**

| | Current City Standards | | Anticipated MassDEP Standards | Current City Standards vs Anticipated MassDEP Standards | |
|---|---|---|---|---|---|
| Design Storm | Cambridge Present (in) (Current Cornell[19]) | Cambridge 2070 (in) | TP-40 (in) | NOAA Atlas 14 (in) [20] | % Increase (Cambridge 2070 vs NOAA Atlas 14) |
| **2-year** | 3.25 | 3.65 | - | 3.53 | +3.4% |
| **10-year** | 4.90 | 6.40 | 4.70 | 5.62 | +13.9% |
| **25-year** | 6.21 | 8.22 | - | 7.33 | +12.1% |
| **100-year** | 8.90 | 11.70 | 6.80 | 10.17 | +15.1% |

Stormwater Runoff Pollutant Control Requirements:

The 2008 MassDEP Stormwater Handbook established the requirements for stormwater management systems for new developments and redevelopments to achieve 80% removal of the average annual post-construction load of Total Suspended Solids (TSS). There was no Total Phosphorus (TP) reduction requirement, only the requirement that in cases where there was a TMDL for TP, BMPs must be selected to address it. The 2016 MS4 Permit instituted a Cambridge specific 62% TP load reduction in accordance with the Final Phosphorus TMDL for the Lower Charles River. In 2021, the City issued the Supplemental Directive as an Appendix to the 2008 Draft Stormwater and Wastewater Guidance, in part to address the TP reduction requirements. The Supplemental Directive requires stormwater management systems to achieve a 65% TP reduction in separated sewer areas and a 100% TP reduction in combined sewer areas. By doing so, the City exceeds the 62% TP load reduction requirement under the MS4 Permit, as well as the proposed 60% TP load reduction requirement under the Draft 2023 MassDEP Stormwater Handbook. This demonstrates the City's commitment to achieving greater phosphorus reduction than currently mandated.

Operation & Maintenance Plan for Construction Site (Temporary) and Permanent BMPs:

Cambridge has established a comprehensive and structured O&M program that exceeds standard practice. Under this program, submission of a detailed O&M Plan is required for both temporary BMPs implemented during construction and permanent BMPs installed post-construction. A Stormwater Control Permit will not be issued in the absence of a complete O&M Plan, ensuring that all stormwater management measures are properly maintained and effective over their operational lifespan. This approach reflects the City's proactive commitment to long-term water quality protection, pollution prevention, and regulatory compliance, and underscores the rigor with which Cambridge oversees stormwater system performance.

### 4.4.4 Inflow & Infiltration Reduction

Infiltration and inflow (I/I) is excess water that flows into sewer pipes from both groundwater and stormwater. The highest infiltration flows are often observed following significant storm events or following prolonged periods of precipitation. Similarly, peak inflows typically occur during heavy storm events. I/I takes up sewer system capacity and can peak when a combined system is at its most stressed—during a rain event. The City of Cambridge recognizes the importance of addressing I/I through routine maintenance of the sewer system (detailed in **Section 4.1**), capital projects, and through policy.

Several recent capital projects have addressed I/I through sewer separation or through diverting and detaining stormwater flow. Sewer separation projects such as the CAM004 Infrastructure Improvements Project include the rehabilitation, replacement, or new construction of sewer and drainage infrastructure which addresses defects and eliminates cross connections. Stormwater diversion projects such as the

[19] Northeast Regional Climate Center, Cornell University.
[20] NOAA Atlas 14 Point Precipitation Frequency Estimates – *PF Map: Contiguous US (noaa.gov)*.

Sherman Street Drainage Improvement Project redirect drainage to a stormwater tank that can then be discharged at 'off peak' times after a rain event, reducing the load on the system during critical times.

Beyond City projects, Cambridge is also drafting an I/I Mitigation Policy that will require private developers with new sewer connections with design flows exceeding 15,000 gallons per day (gpd) to address I/I. These developers will be required to remove four (4) gallons of I/I for each new one (1) gallon of wastewater flow to mitigate the impacts of the development on the existing sewer system. This is in agreement with MassDEP's 2014 regulations [314 CMR 2.00, Section 12.04(2)(d)] related to communities that have a NPDES CSO Permit (like Cambridge). Under this policy, developers will coordinate with the City to comply either through removing sources of I/I or paying a fee. Compliance with this policy will be tied to the City's Occupancy Permit.

### 4.4.5 Flood Mitigation

To address the growing risks posed by climate change, including more frequent flooding and extreme heat, the City of Cambridge introduced Flood Resiliency Zoning requirements in early 2023. This set of regulations is grounded in the City's long-term climate projections, which centers on 2070 (i.e., using rainfall projections from 2060-2089), and is designed to evolve as new data becomes available. The zoning framework calls on developers to proactively incorporate flood mitigation strategies into their building designs, particularly in response to the increasing intensity of rainstorms and weather events. The goal is to ensure that new developments are structurally and functionally equipped to withstand future flood conditions, thereby enhancing community resilience.

Use of Modeling Tools to Predict Current and Future Flood Risk:

The City's hydraulic/hydrologic flood model and *FloodViewer* were developed as tools for the City and community to assess climate change threats from flooding and to prepare for it by implementing specific strategies. The model was used to inform the City's planning efforts including the Ten-Year Sewer and Drain Infrastructure Plan with the goals of reducing flooding and CSOs. Results from the City's flood model were published to the FloodViewer tool which provides projected flood extents and elevations for every property in the City for precipitation and storm surge/sea level rise flooding scenarios. The City continues to update their hydraulic/hydrologic flood model and the *FloodViewer* tool with Version 4.0, also called *FloodViewer 2025*, superseding the previous Version 3.0 published in 2022. The City's flood model has been improved and modified in *FloodViewer 2025* to better simulate the hydraulic performance of the City's drainage system including development of a unified hydraulic model that incorporates key regional waterways, model expansion and recalibration in several areas and updates to modeled operation of the Charles River Dam and Amelia Earhart Dam. The City has incorporated updated precipitation projections and modeling methodologies into its *FloodViewer 2025* tool to improve long-term flood risk assessment. The updated design parameters are based on Intensity Duration Frequency (IDF) projections developed by Cornell University as part of the Massachusetts Executive Office of Energy and Environmental Affairs (EEA) Climate and Hydrologic Risk Project, adopted statewide through the Climate Resilience Design Standards Tool.

To ensure long-term planning relevance, the *2030 planning horizon* (representing conditions through 2039) has been excluded from the *FloodViewer* update, as it closely resembles present-day conditions and offers limited value for future risk assessment. Instead, the *2050 planning horizon* (covering 2040–2069) has been incorporated to capture mid-century climate risks and inform infrastructure design and flood mitigation strategies. In addition, the rainfall distribution methodology for 24-hour design storms has been updated from the traditional SCS Type III to the NOAA Atlas 14 Type D distribution, aligning Cambridge's modeling approach with current state recommendations and ensuring consistency with current climate projections, regional planning models, and associated planning tools.

The *FloodViewer* is also integrated as part of the City's new zoning requirements that includes the Flood Resilience Standards, which references Long Term Flood Elevations associated with parcels that need to be assessed using the *FloodViewer* Tool. The Cambridge *FloodViewer 2025* has been posted online and regulations confirming *FloodViewer 2025* as jurisdictional were promulgated on November 4, 2025. The City continues to update the model and Floodviewer to maintain the best understanding of their infrastructure and climate projections and use the model to inform infrastructure improvements to reduce flooding and CSOs.

Nature-Based Solutions in Mitigating Flood Risk:

The City has always focused on implementing nature-based solutions to improve water quality and restore natural hydrology. Reflecting this priority, the City designed the *Alewife Reservation Constructed Wetland.* This project represents an innovative and unique opportunity to enhance flood management, water quality, and ecosystem functions within the Alewife watershed, given the location of the available open space and the downstream convergence of separated infrastructure. As a key component of Cambridge's sewer separation and stormwater management strategy under MWRA's LTCP, the wetland is intended to attenuate newly separated stormwater flows prior to discharging to the Alewife Brook/Little River system. The 3.5-acre facility treats urban runoff by slowing and storing storm flows, allowing sedimentation, nutrient uptake, and pollutant removal before water is discharged into downstream waters. The design integrates native vegetation, hydrologic control structures, and habitat enhancements to restore natural hydrology, protect wildlife, and buffer against flooding. The project was developed in coordination with DCR to align with the Alewife Reservation Master Plan, ensuring the wetland not only functions hydraulically but also delivers public, educational, and ecological benefits within the reservation.

Stormwater Storage as a Means to Reduce Neighborhood Flooding:

Furthermore, to address exacerbated flooding vulnerabilities associated with climate change in the Port Neighborhood, the City launched a comprehensive infrastructure initiative centered on underground stormwater storage. This effort includes the design and construction of a stormwater storage tank beneath Parking Lot 6 on Bishop Allen Drive and initially proposed stormwater and sewage storage tanks beneath Clement Morgan Park. These tanks are engineered to temporarily store excess water during peak rainfall, alleviating pressure on the drainage and sewer systems and reducing the risk of property damage and public health hazards. Phase 1 of the project featured a 390,000 gallon stormwater tank and pump station beneath Parking Lot 6, completed at a cost of $20 million, with the goal of protecting homes and improving climate resilience in The Port.

### 4.4.6 GSI Use in City Projects

Recognizing the interdependence of various water management challenges, the City of Cambridge has adopted a systems-based approach that aligns infrastructure improvements with climate resilience, regulatory compliance, and community well-being. A central component of this approach is the emphasis on co-benefit analyses—particularly through the implementation of GSI. GSI not only complements CSO reduction efforts, but it also supports urban heat island mitigation, improves stormwater quality, and enhances public realm aesthetics. These green interventions are often integrated into broader streetscaping and utility projects, demonstrating the City's commitment to multi-functional and sustainable design.

The City of Cambridge consistently implements a comprehensive and proactive approach to street and stormwater infrastructure improvements, exceeding standard requirements. For Chapter 90 and other projects, the City actively evaluates opportunities to integrate GSI elements—including bioretention systems, tree planters, and permeable pavements—into routine roadway, sidewalk, and utility upgrades. Recognizing the spatial constraints within the right-of-way, the City also strategically incorporates GSI into parks, open spaces, and other publicly accessible areas, maximizing stormwater management and urban greening benefits.

To further enhance system-wide performance, Cambridge supplements state-provided Chapter 90 funds to take a broader view of street improvements beyond resurfacing alone. This enables the City to coordinate utility upgrades, implement green and gray stormwater BMPs, plant trees, and improve infrastructure for all road users. The City of Cambridge's Green Streets Guidance[21] outlines the City's approach to incorporating stormwater management and green infrastructure into public right-of-way design. The primary purpose of this guidance is to capture, infiltrate, and treat stormwater runoff at its source to improve water quality, reduce pollutant loads to the Charles River, and support compliance with the phosphorus TMDL. In addition to water quality improvements, the Green Streets initiative aims to enhance urban livability by integrating vegetation, soils, and permeable surfaces into streetscapes, thereby improving aesthetics, supporting tree health, mitigating urban heat, and promoting climate

[21] Green Street Guidance- *CRWA Final Green Street Guidance Booklet- Cambridge 4.pdf*

resilience. The guidance emphasizes a collaborative and site-specific approach that balances stormwater management objectives with other public infrastructure needs, ensuring that designs maintain the functional use of streets while achieving hydrologic performance goals. Designers are required to consider soil and planting media specifications, drainage design, accessibility for maintenance, and long-term system performance to ensure that these green infrastructure systems remain effective and sustainable over time.

By integrating these measures at locations where separated infrastructure converges downstream, the City leverages available open space to support the reduction of CSO impacts, demonstrating a forward-looking and innovative approach to stormwater management.

The City also dedicates approximately $500,000 annually to support the implementation of GSI, reflecting its sustained commitment to integrating green infrastructure into municipal projects. Much of this work is also embedded within standard operating procedures and departmental budgets, ensuring that GSI is treated as a core component of infrastructure management rather than a standalone initiative. The City funds maintenance of existing biobasins and wetlands through ongoing contracts, while inspection and cleaning of existing stormwater BMPs are routinely performed by City staff. This integrated approach ensures the long-term performance, functionality, and sustainability of the City's GSI systems.

### 4.4.7 Relevance to CSO Planning

The City of Cambridge consistently prioritizes the enhancement of community well-being and environmental quality through its municipal initiatives. As part of its capital improvement strategy, the City actively advocates for the integration of progressive policies—particularly those focused on climate resiliency—into all projects involving the municipal collection system. By exceeding minimum regulatory standards and design protocols, Cambridge aims to achieve measurable benefits in flood mitigation, reduction of property damage, control of pollutant discharges, and protection of public health. These elevated performance goals also ensure that the collection system maintains the level of service necessary to support a growing and dynamic urban population.

In navigating a wide array of related but sometimes competing priorities, the City remains focused on maximizing co-benefits and ensuring the strategic, well-considered use of both public and private funds. This integrated planning model not only advances CSO control objectives but also aligns with the City's broader goals of climate adaptation, water quality improvement, and equitable infrastructure investment. Despite finite resources, Cambridge continues to incorporate these priorities into every capital project, reinforcing its commitment to resilient, sustainable, and community-centered infrastructure.

The City's planning efforts are further supported by robust technical analyses, updated climate projections, and progressive design standards. Tools like the *FloodViewer*, the Stormwater Control Permit program, and the Green Streets Guidance ensure that both public and private development projects contribute to long-term resilience and environmental performance. With a dedicated $500,000 annual allocation for GSI, Cambridge continues to invest in nature-based solutions that deliver measurable benefits across multiple domains. Collectively, these efforts demonstrate how Cambridge exceeds regulatory requirements by implementing projects that not only address targeted objectives but also provide co-benefits across the system, including improved water quality, system performance, and CSO mitigation.

## 4.5 Somerville CSO Related Work

### 4.5.1 Overview of CSO Related Work in Somerville

Like Cambridge, the City of Somerville understands that CSO control is related to and impacted by all facets of its collection system operation. This section summarizes plans, policies, and other efforts related both the separate and combined sewer systems that have impacts on CSO. It also documents Somerville's commitment to stewarding water quality and climate resilience for its constituency.

### 4.5.2 Climate Resiliency Efforts

In 2018, the City developed its *Climate Forward: City of Somerville Community Climate Action Plan*[22]. The plan was updated in April 2024 along with the accompanying webpage on SomerVoice[23]. This plan outlines various climate action goals to be achieved at or before 2030, 2040, and 2050 and progress to meet these goals can be seen on the Climate Forward Dashboard, Climate Forward Dashboard | City of Somerville[24]. These decade goals act as interim milestones to meet the ultimate target of becoming carbon net negative by 2050. The report also includes key information related to coastal flooding, stormwater flooding, and extreme heat, all of which are projected to increase in frequency and intensity. The data and scientific projections in this plan were forecasted through 2070. These efforts highlight the City's vision for a sustainable community while fortifying critical infrastructure.

Somerville is also actively involved in regional climate resilience partnerships within the Mystic River watershed, namely the *Resilient Mystic Collaborative*[25], which is a coalition of 21 municipalities within the Mystic River watershed organized by the Mystic River Watershed Association. The collaborative has performed modeling of risks associated with sea level rise throughout the watershed to understand flood risk across municipal boundaries and is working with member communities to develop plans, designs, and construct flood mitigation projects within these communities.

### 4.5.3 Stormwater Management

Stormwater Requirements for Private Development:

The City of Somerville's Engineering Site Permit Rules and Regulations[26] govern stormwater management requirements for private development, and these regulations were last updated in March 2023. These regulations generally build upon construction and post-construction requirements promulgated through the NPDES MS4 Permit, enhancing those requirements to stricter standards. Somerville's regulations capture many smaller developments than the one-acre land disturbance threshold in the MS4 Permit, with requirements for activities ranging from as small as 100 SF of constructed pavement or roof area to land disturbances of 10,000 SF or more. These regulations aim to facilitate Somerville's goals to steward water quality and mitigate localized flooding. The City's water quality requirements for post-development mandate TSS removal rates of 80% and TP removal rates of 62%. This is in alignment with the requirement under the MS4 Permit and is more stringent than the proposed 60% TP load reduction requirement under the Draft 2023 MassDEP Stormwater Handbook, illustrating the City's commitment to achieving water quality objectives. The regulations also promote the use of Low Impact Development and redirection of storm flows from the City's storm and combined sewer systems to infiltration into pervious areas on-site.

To address localized flooding and reduce peak flows into the sewer systems, Somerville requires on-site storage for the difference between the 2-year pre-construction runoff volume and the 10-year post-construction runoff volume, providing an additional safety margin beyond MassDEP's baseline requirements (**Figure 4-6**).

[22] Climate Forward: City of Somerville Community Climate Action Plan, Update April 2024 - *https://s3.amazonaws.com/somervillema-live/s3fs-public/Final_Somerville_ES_Onscreen.pdf*
[23] Climate Forward | City of Somerville - *https://www.somervillema.gov/departments/programs/climate-forward*
[24] Climate Forward Dashboard | City of Somerville - *https://www.somervillema.gov/climatedashboard*
[25] Resilient Mystic Collaborative - *https://resilient.mysticriver.org/*
[26] City of Somerville Engineering Site Permit Rules and Regulations - *engineering-site-permit-rules-regs.pdf*

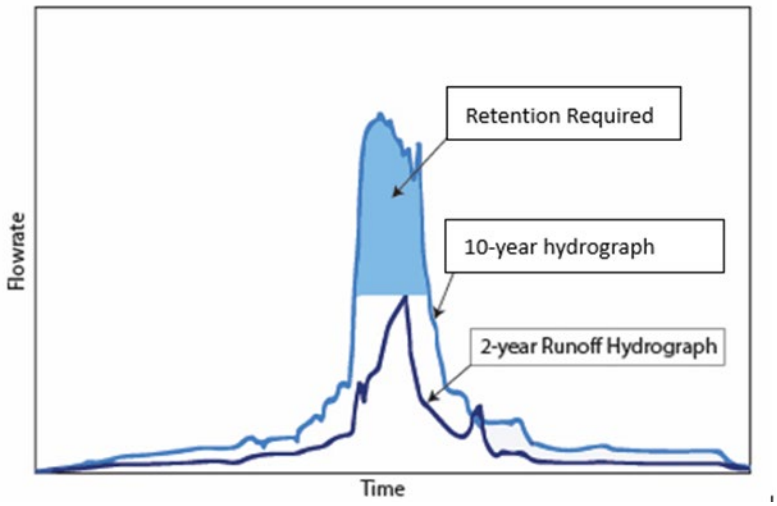



**Figure 4-6. Somerville Onsite Retention Requirements**

As shown in **Table 4-4**, the projected rainfall depths for Somerville exceeds the current MassDEP Stormwater Handbook (TP-40) but are slightly lower than The Draft Stormwater Handbook (2023) because MassDEP values are based on NOAA Atlas 14 data using the upper confidence interval multiplied by 0.9 to account for variability, while the City standards take the mid-range value in NOAA Atlas 14 data.

**Table 4-4. Design Rainfall Data for Various Design Storms (in inches)**

| Design Storm | Current City Standards (NOAA Atlas 14) | Current MassDEP Standards | Anticipated MassDEP Standards |
|---|---|---|---|
| **1-year 6-hour** | 1.71 | | 1.901 |
| **1-year 24-hr** | 2.64 | | 2.90 |
| **2-year 24-hr** | 3.28 | - | 3.53 |
| **5-year 24-hr** | 4.31 | | 4.74 |
| **10-year 24-hr** | 5.17 | 4.70 | 5.62 |
| **25-year 24-hr** | 6.35 | - | 7.33 |
| **100-year 24-hr** | 8.17 | 6.80 | 10.17 |

### 4.5.4 Inflow and Infiltration (I/I) Reduction

Somerville established an I/I reduction fee in 2014 to create dedicated funding streams for ongoing efforts to improve the collection system. The I/I fee of $14.35/gpd was determined in 2014 based on assumed construction costs and assumed effectiveness of sewer rehabilitation and sewer separation projects to remove stormwater from the system. In 2018, the City updated its Municipal Sewer Policy[27] and Code of Municipal Ordinances to meet these I/I requirements. The Ordinance and Policy require projects to pay an I/I fee based on gpd for wastewater added to the City sewer system. These funds help support the City's sewer rehabilitation and separation projects that reduce Infiltration and Inflow into the sewer system, thus reducing the severity of CSOs. The fee was revised to $32.00/gpd in 2025 to reflect current market conditions.

Somerville has addressed I/I through several large infrastructure projects throughout the City, primarily through sewer separation or diverting and detaining stormwater flows. Sewer separation projects such as the Spring Hill Sewer Separation Project (2022-2025) included the rehabilitation, replacement, or new construction of sewer and drainage infrastructure which addresses defects and eliminates cross connections. Stormwater diversion projects such as the Poplar Street Pump Station Project (2023-2027),

[27] Policy for New Connections to and Modifications to Existing Connections to the Municipal Sewer and Drain System, Stormwater Management, and Infiltration / Inflow Mitigation, Updated: 14 May 2018 - *Microsoft Word - Sewer Drain and II Policy 2018May14*

redirect drainage to a stormwater tank that then is discharged at 'off peak' times after a rain event which reduces the load on the system during critical times.

The City's ongoing capital improvement programs and projects have prioritized sewer rehabilitation, predominantly through cured-in-place pipe (CIPP). Beginning in 2019, the City began tracking and prioritizing annual rehabilitation projects for the mitigation of I/I.

### 4.5.5 Flood Mitigation

In November of 2022, Somerville published its Citywide Flood Mitigation and Water Quality Master Plan[28]. This plan systematically reviews causes and extents of flooding across the City and culminates in a portfolio of recommended projects to address flooding.

Somerville's collection system is very complex, with flow patterns across the City contributing to multiple MWRA interceptors based on antecedent conditions. The City evaluated each individual sewersheds to understand the local hydrology and water quality challenges, develop flood mitigation projects, recommend preliminary project sequencing, and assess water quality impacts. The Master Plan acknowledges the relationships between flooding and water quality and aimed to develop a comprehensive plan to address both within the City.

Projects were developed to address flooding using various tools, including increasing or adding additional infrastructure, sewer separation, storage tanks, and GSI. Tools were evaluated at each of the identified project sites and combined into larger projects. Many of these projects form the building blocks of continued work within Somerville; for example, two ongoing design projects ("New Mystic River Outfall & Foss Park Area Sewer Separation" and the "Morrison Ave Linear Storage & Greater Davis Square Area Sewer Separation") are projects that originated from this Master Plan. They have been further developed through the design process, and of these projects address localized flooding through sewer separation, new drains, and new outfalls or larger trunk drains, while having the co-benefit of reducing combined sewer flows in these areas.

The Master Plan developed over twenty projects to mitigate flooding within the City. Though these projects were not primarily designed to reduce CSOs, much of the City is served by a combined sewer system. Therefore, the flood mitigation projects developed through this effort will result in reductions in the number and volume of CSO activations to the downstream CSO outfalls.

### 4.5.6 GSI Use in City Projects

Somerville is committed to incorporating GSI within the City where possible. In 2018 and 2019, the City received a Municipal Vulnerability Preparedness Grant from the State to complete a GSI Feasibility Study. The City evaluated the feasibility of installing GSI within the public right-of-way in six Somerville neighborhoods. These neighborhoods included portions of West Somerville, Davis Square, East Somerville, Gilman Square, and Winter Hill. Various types of GSI were evaluated under the different neighborhood conditions, allowing for the most beneficial GSI type to be identified for each location. These findings were also integrated into the 2022 Citywide Flood Mitigation and Water Quality Master Plan described in **Section 4.5.5**. GSI was considered a multi-benefit tool that could provide both water quality benefits along with neighborhood beautification.

Somerville has also developed a public-facing webpage[29] to provide information regarding GSI practices within the City. The public can find general information about GSI practice types, including what they are, how they work, and diagrams or photos to visualize what the installed GSI looks like. The website hosts the GSI planning guidance developed through the 2018-2019 grant, which can be used citywide. This document outlines how to retrofit existing sidewalks, roadways, and publicly owned property with GSI, includes brief descriptions of different practices, design and siting guidelines and considerations, and details the associated benefits for each practice type. GSI practices covered in the document include stormwater bumpouts, subsurface infiltration trenches, planters, rain gardens, bioswales, permeable

[28] Citywide Flood Mitigation and Water Quality Master Plan - *11394d690a9269914f07d8bb49a4b868_Somerville_FloodMitigation_WQ_MasterPlan_Nov_2022_Final_wAppendices.pdf*
[29] City of Somerville Green Stormwater Infrastructure webpage Green Stormwater Infrastructure (GSI) | City of Somerville

pavement, and green roofs. This page also includes an interactive map that shows the existing locations of public GSI throughout Somerville.

### 4.5.7 Relevance to CSO Planning

The City of Somerville's commitment to maintaining its complex collection system results in enhancements to public health and environmental quality for its constituency. By exceeding minimum regulatory standards and design protocols, Somerville desires to achieve measurable benefits in flood mitigation, control of pollutant discharges, and protection of public health. Robust planning efforts like the Citywide Flood Mitigation and Water Quality Master Plan form the basis of continued infrastructure upgrades, and these projects free up system capacity, provide resilience, and bolster the same water quality objectives that CSO control planning aims to achieve. The City's planning efforts are further supported by robust technical analyses, updated climate projections, and right-sizing new infrastructure based on its design standards, policies, and practices.

## 4.6 MWRA CSO Related Work

MWRA's Capital Improvements Program continues to focus on projects to maintain and improve the conveyance systems which can impact CSOs. These projects include rehabilitating pump stations, headworks facilities and CSO facilities, maintenance and improvements to conveyance systems, and continuing to provide financial assistance to communities for I/I reduction.

**Table 4-5** provides a partial list of MWRA's recent and future efforts to maintain and improve conveyance systems which can impact CSOs. The table includes the project name, category, estimated cost, schedule, status, and key benefit.

Rehabilitating pump stations and headworks facilities improves reliability and in the case of the Alewife Brook PS Rehabilitation project completed in 2019, the wet weather capacity was increased, reducing CSOs. MWRA currently has projects to rehabilitate the Cottage Farm and Somerville Marginal CSO Facilities. MWRA's interceptor rehabilitation and renewal projects improve the reliability of the conveyance system and restore hydraulic capacity.

MWRA's I/I Financial Assistance Program has been providing financial assistance to communities since 1993. To date, MWRA has provided $596 million to 43 communities with the purpose of reducing inflow and infiltration within the regional wastewater system, thereby decreasing wet-weather flows, reducing CSO events, and improving overall system performance. This program is ongoing with approximately $498 million remaining in available funding.

**Table 4-5. Partial List of Recent and Future Projects in MWRAs Capital Improvements Program to Maintain and Improve Conveyance Systems**

| Project / Program | Category | Estimated Cost (Million) | Schedule | Status | Key Benefit |
|---|---|---|---|---|---|
| **Facility Rehabilitation** | | | | | |
| Alewife Brook PS Rehab | Pumping & Treatment | $13.5 | Complete (2019) | Complete | Increased wet-weather capacity; reduced CSOs |
| Cottage Farm PCB Abatement | Pumping & Treatment | $10.7 | 2026-2028 | Design Complete | Regulatory compliance; environmental remediation |
| Ward Street Headworks | Pumping & Treatment | $255 | 2027-2032 | Design | Major treatment reliability improvements |
| Somerville Marginal Facility Rehab | Pumping & Treatment | $12.5 | 2028-2030 | Procurement | Improved CSO treatment performance |
| DeLauri PS Rehab | Pumping & Treatment | $15 | TBD | Design | Improved pumping reliability |
| **Interceptor Rehabilitation and Renewal efforts** | | | | | |
| Somerville Marginal Bypass Pipe | Interceptor | $4.45 | 2024-2026 | Construction | Increased storm conveyance capacity |

**Table 4-5. Partial List of Recent and Future Projects in MWRAs Capital Improvements Program to Maintain and Improve Conveyance Systems**

| Project / Program | Category | Estimated Cost (Million) | Schedule | Status | Key Benefit |
|---|---|---|---|---|---|
| Siphon Rehabilitation | Interceptor | $7.2 | 2026-2027 | Construction | Restored hydraulic performance at 40 siphons within the collection system |
| Interceptor Renewal No. 7 (Malden- Melrose) | Interceptor | $11.96 | 2026-2028 | Design | Renewed aging infrastructure |
| North System Interceptor | Interceptor | $9.1 | TBD | Design | System reliability improvements |
| **I/I Financial Assistance Program** | | | | | |
| I/I Assistance Program | Systemwide | $1.086 | Ongoing | Active | Reduced I/I and CSO volumes |

## 4.7 CSO Variance Evaluation Summary

The 2024 Variances required Cambridge, Somerville, and the MWRA to conduct three evaluations (as stated in Section 2.4.3) related to:

- The effectiveness of existing floatables controls at CSO structures;
- The feasibility of implementing on site, real-time CSO public notifications; and
- The effectiveness of existing odor controls at CSO structures.

The following is a summary of each evaluation and a link to the evaluation report.

### 4.7.1 *Cambridge CSO Floatables Control Evaluation* (Link to Report)

The City of Cambridge has an existing source control program in place for floatables controls. There is no indication that the City's CSO regulators and outfalls are currently an appreciable source of floatables in the Alewife Brook or the Charles River. It is recommended that the City continue the public education program around stormwater management. In addition, the City should continue to investigate the presence of hoods on catch basins tributary to CSO outfalls through the catch basin inspection and cleaning program. The City should continue to respond to the SeeClickFix reports and complaints received and continue to conduct monthly inspections of the CSO regulators.

### 4.7.2 *Somerville CSO Floatables Control Evaluation* (Link to Report)

The City of Somerville maintains existing floatables control at its SOM001A outfall and through non-structural controls, including catch basin cleaning, street sweeping, and public education. There is no indication that the SOM001A outfall is currently a considerable source of floatables in the Alewife Brook. It is recommended that the City continue to install catch basin hoods throughout the City, including one immediately adjacent to SOM001A in coordination with DCR. Additionally, the City should continue its public education programs around trash and debris, and should perform additional monitoring of SOM001A to observe activity during overflows.

### 4.7.3 *MWRA CSO Floatables Control Evaluation* (Link to Report)

MWRA CSO treatment facilities are equipped with bar screens, and Cottage Farm also has fine mesh screens to further remove objectional materials and while all CSO outfalls anticipated to discharge in a 1992 Typical Year are equipped with underflow baffles. The MWRA maintains these floatables control structures and conducts monthly field observations. Based on these inspections, the existing floatables control structures appear to be working as intended. Monthly field inspections that are conducted by MWRA staff have not observed a buildup of floatables at any of the CSO regulators. As a result, it is recommended that the existing control measures remain, and that MWRA continue with monthly field

inspections to document that they remain in good working conditions. To document these conditions in future monthly inspections, MWRA staff will modify its monthly inspection log to include space to record any observed floatables within the chambers.

### 4.7.4 *Cambridge Real-time CSO Public Notification Evaluation* (Link to Report)

The City evaluated the implementation of a beacon light system for onsite CSO public notifications. It is recommended that the City should continue reviewing the City's existing SCADA infrastructure, software, and telemetry systems for opportunities to optimize the beacon light system's integration. The goal is to not rely on manual operation of these alerts, as the City does not have staff coverage 24/7. The City should write the scope of work and specifications for the beacon light systems to work with the existing operational systems for procurement. The City should continue to coordinate with MWRA, Somerville, and Chelsea to ensure any beacon light system operates with consistent aesthetics and functionality across jurisdictions. The City should collaborate with the public stakeholders to launch a public awareness and education campaign for the beacon light system. The City should continue engaging MassDEP to advocate for the development of standardized guidelines for any enhancements to CSO public notifications. Any future locations should be coordinated with public and private stakeholder groups.

### 4.7.5 *Somerville Real-time CSO Public Notification Evaluation* (Link to Report)

The City of Somerville determined that beacon light systems are a practical and implementable solution for real-time, onsite CSO public notifications. However, any beacon system put into use in Somerville should be optimized for consistency and integration with similar systems throughout the region. As next steps, it is recommended that the City coordinate with the City of Cambridge and the MWRA on the pilot installation of a beacon light at SOM007A/MWR205A. Additionally, Somerville should coordinate with the Cities of Cambridge and Chelsea and the MWRA for consistency across jurisdictions. Before any beacon system is installed, Somerville should launch a public awareness and education campaign. Lastly, it is recommended that the City continue engaging MassDEP to advocate for the development of standardized guidelines for enhancements to CSO public notifications.

### *4.7.6 MWRA Real-time CSO Public Notification Evaluation* (Link to Report)

MWRA concluded that based on the research conducted for this report, the most common technologies used for CSO warnings and notifications include indicator beacons, flagging systems, and informational signage. Some newer technologies like remote-controlled drones could be promising but currently have significant challenges that must be overcome.

Electronic notifications have proven to be effective avenues to reach the wider public. Nearly every notification system investigated in this feasibility study has an electronic notification component, providing updates to the public through website updates and/or social media posts. Each of them also utilizes an opt-in, subscription service, allowing the public to receive real-time CSO updates through emails, phone calls, or text messages. MWRA also uses electronic messaging, through Everbridge, to keep the public informed about CSO activations. Members of the public can sign up to receive near real-time CSO notifications through MWRA's website.

As part of further investigations into real time notification methods that could be implemented into the current CSO public notification program, MWRA is pilot testing an indicator beacon at the jointly permitted SOM007A/MWR205A outfall. MWRA will operate the recently installed pilot beacon at outfall SOM007A/MWR205A and assess its effectiveness based on feedback from the public. Pending the results of the pilot study, MWRA may evaluate the feasibility of similar installations at other MWRA-owned CSO outfalls. Additionally, the temporary sandwich boards manually placed and removed along Alewife Brook have proven to be popular. MWRA will continue this program and may consider partnering with other entities to assist in deploying the sandwich boards.

### 4.7.7 *Cambridge CSO Odor Control Evaluation* (Link to Report)

Cambridge has already implemented several odor control measures that reduce odor throughout the system. The City should continue to investigate and monitor for odors emanating from the CSO regulators and outfalls for six months. This should be incorporated into existing monthly inspections through a sniff test. The City should enhance the current cleaning schedule to include cleaning at the outfall pipes of

CAM002 and CAM401B, since these two outfalls are above the water line and therefore allow access for cleaning equipment. Cleaning should occur three times annually. In addition, the City should install manhole insert lids into seven manholes around the CAM005 structure area. Additionally, there are recent reports of deodorization activities in a catch basin located in the vicinity of the structure. This should be coordinated with MWRA as MWRA has a planned future improvement for the CAM005 regulator structure.

### 4.7.8 *Somerville CSO Odor Control Evaluation* (Link to Report)

The City of Somerville is committed to mitigating odors throughout their system including at CSO regulators and outfalls. The City evaluated a number of odor control measures including physical system modifications, system repair, mechanical cleaning, venting, catch basin hoods, sealed manholes, backflow controls, flap valves, air filtration, chemical addition, and bioaugmentation. The most feasible solution to odor control for SOM001A, based upon estimated implementation cost, operations and maintenance requirements and effectiveness, includes additional odor control monitoring for up to 6-months along with a pilot project of several improvements to seal SOM001A and prevent odors from escaping. These pilot elements include installing a PVC curtain barrier at the outfall, installing a catch basin hood on the catch basin connected to the outfall structure, and installing manhole insert lids in the two manholes associated with SOM001A. The City will continue to explore implementation of the odor control measures.

### 4.7.9 *MWRA CSO Odor Control Evaluation* (Link to Report)

This feasibility study included a review of the potential sources of odors in the MWRA's sewer collection system and at CSO locations, a review of odor complaints, the development and implementation of a sampling program, and a review of odor control technologies and best management practices. Dry weather sampling was conducted on March 19, 2025 at locations along the Alewife Brook and Upper Mystic River and on March 26, 2025 at locations along the Charles River. Wet weather sampling was conducted along the Alewife Brook and Upper Mystic River on May 6, 2025. Wet weather samples were not collected along the Charles River during this program due to insufficient rainfall to cause a CSO activation during the evaluation period.

During sampling events, odors were observed and/or hydrogen sulfide concentrations over 0.001 ppm were measured at seven locations. Based on sampling events, a series of targeted evaluation and monitoring measures are recommended across the system. These efforts include assessing the feasibility of installing gasketed metal covers at select structures to reduce odor emissions, and sealing or caulking certain manholes to minimize odor release. In addition, resampling is recommended at specific facilities to confirm the presence of hydrogen sulfide and investigate potential sources. Depending on the findings, at some locations consider extended monitoring for up to six months using an OdaLog meter or similar technology may be implemented to further evaluate odor generation and inform potential mitigation measures.

# 5. Public Outreach and Engagement

**The Partners carried out public and targeted engagement throughout the development of this Updated CSO Control Plan. Public feedback was one input in developing the Plan, and the engagement described in this section enabled the Partners to gather important feedback that influenced the Plan.**

The Variances require that this Updated CSO Control Plan include:

> *"a public participation plan sufficient to provide ample opportunities for the public to be informed about the development of the Plan at critical junctures, and to have opportunities to provide informed comments on the CSO abatement alternatives and recommendations."*

The Variances outline the schedule for the key public meetings and the importance of targeted outreach to Environmental Justice communities. This section describes the engagement process and the key input themes received leading up to the submission of the Draft Plan. Engagement will continue following the release of the Draft Plan, as described in **Section 5.5**, and the Partners will consider input received during the 2026 comment period as they revise the Draft and produce the Final Updated CSO Control Plan.

## 5.1 Approach to Community Engagement

The entities impacted by this Plan are not a singular homogenous group, and so the Partners sought to engage the public in multiple ways to get representation from a wide array of community interests and priorities. The process was designed to capture perspectives from varied stakeholder groups, including community, environmental, regulatory, and municipal interests. A summary overview of the outreach approach is shown in **Figure 5-1**.




**Figure 5-1. Outreach Summary**

The Partners designed a flexible, multilayered engagement strategy to reach a diverse cross-section of stakeholders during Plan development. Beyond the different interest groups, the Partners knew that project stakeholders would vary in their technical understanding of CSOs, the amount of time they were able to commit, and their ability to attend events. This multilayered approach allowed for interested and impacted community members to participate in ways that matched their availability, preferred formats, and depth of interest.

Outreach efforts focused on individuals and organizations connected to areas potentially affected by CSO activations or proposed infrastructure projects, including residents, rate payers concerned about financial impacts, those attentive to public health and recreational conditions in these waterbodies, and elected officials from surrounding communities. Engagement also included talking with advocacy groups dedicated to the health of the Alewife Brook, Mystic River, and Charles River, along with state and federal regulators responsible for overseeing CSO compliance. A summary of the types of stakeholders engaged in this process is presented in **Table 5-1.**

**Table 5-1. Summary of Stakeholders Invited into the Updated CSO Control Plan Process**

| Stakeholder Type | Description |
|---|---|
| **Members of the Public (including Environmental Justice communities)** | • Live, work, or own businesses near or within areas impacted by CSO activations<br>• Live, work, or own businesses near or within potential project areas<br>• Would be impacted by changes to water and sewer rates<br>• Concerned with health and recreation aspects of waterbodies<br>• Represent these areas in local government or on boards<br>• Represent disadvantages communities in these areas |
| **Watershed Advocacy Groups** | • Charles River Watershed Association<br>• Mystic River Watershed Association<br>• Save the Alewife Brook<br>• Green Cambridge<br>• The Esplanade Association<br>• Emerald Necklace Conservancy<br>• |
| **Federal and State Agencies** | • Environmental Protection Agency (EPA)<br>• Department of Environmental Protection (MassDEP)<br>• Department of Conservation and Recreation (DCR)<br>• Massachusetts Bay Transportation Authority (MBTA)<br>• Massachusetts Environmental Policy Act Office (MEPA)<br>• Massachusetts Department of Transportation (MassDOT)<br>• Executive Office of Energy and Environmental Affairs |
| **Municipalities and Representative Boards** | • Boards, councils, and committees representing constituencies<br>• MWRA Advisory Board and Wastewater Advisory Committee<br>• MWRA Water Supply Citizens Advisory Council<br>• Somerville City Council<br>• Cambridge City Council<br>• Cambridge Health and Environment Committee<br>• Cambridge Conservation Commission<br>• Impacted rate-payer communities (e.g., MWRA wastewater communities, neighboring communities) |

An equitable and effective engagement strategy necessitated a range of methods that could be tailored to the differing needs of these various stakeholder groups. These included in person participation at existing local events, dedicated online public meetings, focused meetings with targeted stakeholder groups, and opportunities for offline review of project materials with options to submit written comments. These engagement approaches were used at various frequencies, for different audiences, and achieved specific goals to support the Plan development process. **Table 5-2** summarizes these engagement types, and they are each further described in **Section 5.3.**

**Table 5-2. Summary of Engagement Types and Audiences Reached**

| Engagement Type | Event Cadence | Medium | General Public | Watershed Advocacy Groups | State and Federal Agencies | Municipalities and Representative Boards |
|---|---|---|---|---|---|---|
| **Public Meetings** | 7 total | Virtual | X | X | X | X |
| **Targeted Meetings** | As Needed | Virtual and/or in person | | X | X | X |
| **Existing Events (Tabling)** | Ongoing | In person | X | | | |
| **Website** | Ongoing | Online | X | X | X | X |
| **Written Feedback** | Ongoing | Online | X | X | X | X |

To support productive and inclusive dialogue throughout this process, the Partners worked with the Consensus Building Institute (CBI), an experienced, local, non-profit facilitation firm. Working collaboratively with technical and communications staff from the Partner communities, the CBI facilitators guided a series of outreach activities designed to inform, consult, and involve community members as appropriate in shaping elements of the planning process. The input received through these channels resulted in direct impacts to Plan development, including influencing technical analyses like the Typical Year development and informing the evaluation criteria used to compare alternatives. Details on how this information influenced the Plan are included in **Section 5.4**

## 5.2 Priority Populations – Environmental Justice (EJ) and Vulnerable Populations

The Partners identified and engaged priority populations, or those populations designated as EJ and/or vulnerable, within each of their communities. The Partners, in accordance with MEPA Environmental Justice Protocols, consider EJ and vulnerable populations as neighborhoods or groups that are at higher risk of experiencing disproportionate environmental burdens, such as pollution, while having limited access to environmental benefits and decision-making processes.

Key characteristics of EJ populations, including race, limited English proficiency, and lower income, can significantly reduce a community's capacity to withstand and recover from environmental risks. These vulnerabilities are often intensified by additional stressors such as age (both young and elderly), existing physical or mental health conditions, type of employment, housing conditions, and the distance or difficulty involved in traveling to schools, workplaces, services, and sources of food.

EEA defines an EJ population as a census block group where one or more of the following criteria are true[1]:

1. The annual median household income is 54% or less of the statewide annual median household income.
2. Minorities make up 40% or more of the population.
3. 24% or more of households identify as speaking English less than "very well".
4. Minorities make up 25% or more of the population and the annual median household income of the municipality in which the block group is located does not exceed 150% of the statewide annual median household income.

[1] https://www.mass.gov/doc/february-2024-environmental-justice-strategy-english/download

EJ status for each community is determined at the Census block group level within Massachusetts, and the data is available through EEA's Environmental Justice Viewer (EJ Viewer)[2]. **Figure 5-2** shows the most current version of the map of EJ Viewer released in November 2022. EEA is in the process of updating EJ viewer and map, planned for renewal in 2026.

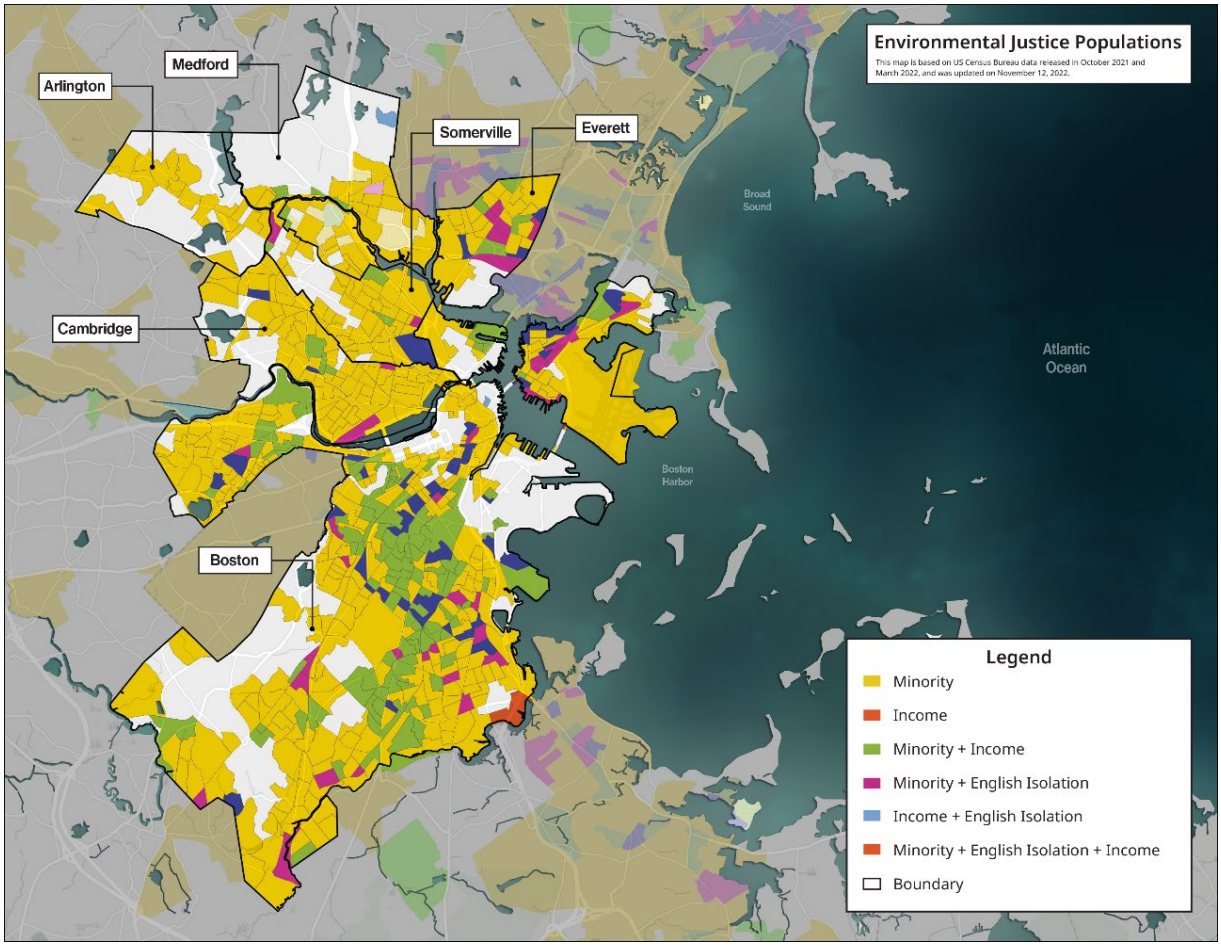



**Figure 5-2. 2022 EJ Viewer showing the US Census Blocks for Cambridge and Somerville, Somerville, Boston, Arlington, Medford, and Everett**

Because significant portions of the CSO-impacted communities contain EJ designations, the Partners prioritized identifying community-based organizations that serve these populations as a foundational step in the public engagement strategy. MWRA maintains contacts for state, local, and EJ representatives throughout their impacted communities who were sent all public meeting invitations. The Partners also sent invitations for the public meetings and listening session to relevant contacts on the MEPA EJ Reference List. Cambridge and Somerville each have dedicated municipal departments dedicated to supporting robust and well-rounded engagement on projects across both cities. The Cambridge Community Engagement Team (CET) and Somerville Office of Immigrant Affairs (SOIA) shaped the engagement strategies for this Plan so that they would be both meaningful and accessible for EJ residents. The Partners were in constant communication with staff from these teams throughout the development of the Draft Plan. Both engagement departments emphasized the importance of ensuring open access to the planning process for all community members by prioritizing translation and interpretation services. However, they also advised that engagement expectations in the earliest stages

[2] https://mass-eoeea.maps.arcgis.com/apps/webappviewer/index.html?id=1d6f63e7762a48e5930de84ed4849212

should remain measured, noting that many residents from disadvantaged communities were unlikely to participate meaningfully until concrete proposals were available for review. CET and SOIA recommended that targeted outreach to specific EJ communities occur following release of the Draft Plan, where residents can react to tangible projects and strategies.

Language access was identified as a critical component of early inclusive engagement. Using the January 1, 2022 MEPA Enhanced Public Participation Policy, the Partners identified the languages indicated in the "Languages Spoken in Massachusetts" table of the EJ Viewer to determine those languages spoken by 5% or more of the residents in the Partner and adjacent communities, i.e., Cambridge, Somerville, Boston, Arlington, and Medford. **Table 5-3** summarizes the predominant languages (besides English) spoken within the Partner and adjacent communities.

**Table 5-3. Summary of Languages Spoken by 5% or more of Residents within Stakeholder Communities**

| Partner / Adjacent Community | Languages Spoken (besides English)(1) |
|---|---|
| Cambridge | Amharic<br>Haitian Creole<br>Spanish<br>Portuguese |
| Somerville | Spanish<br>Portuguese<br>Nepali |
| Boston | Chinese<br>Spanish<br>Russian<br>Vietnamese<br>Haitian Creole<br>Portuguese |
| Arlington | N/A - none |
| Medford | Arabic<br>Spanish<br>Portuguese |

Note:

(1) From https://mass-eoeea.maps.arcgis.com/apps/webappviewer/index.html?id=dffdbf9c109647fc9601f7524c1fd9f4

To support broad participation, the Partners developed a language access plan that included translation of all public meeting notices, general project flyers, surveys and other printed project material. The languages shown in **Table 5-3** were further augmented and later finalized based on the guidance from CET and SOIA, who maintain a more granular inventory of the languages spoken in Cambridge and Somerville. The final list of eight translation languages is presented below based on the insights from **Table 5-3** and the local guidance from CET and SOIA:

- Amharic;
- Haitian Creole;
- Spanish;
- Portuguese;
- Nepali;
- Chinese;

- Arabic; and
- Bengali.

The initial public meeting (held on June 29, 2022, detailed in **Section 5.3.2.1**) included interpretation into five languages. In addition, translated presentations were posted on the website. For public meeting #2, the Partners opted to expand interpretation to eight languages to broaden outreach. Post-meeting analysis showed that only two participants used interpretation services. To allocate resources more effectively while maintaining accessibility, the Partners agreed to provide interpretation upon request for future meetings and provided clear instructions in multiple languages for requesting interpretation.

Following submission of the Draft Plan, the Partners will re-engage CET, SOIA, and additional community-based organizations to ensure EJ and vulnerable communities are meaningfully included in the 2026 public comment period for the Draft Plan. These communities have been historically underrepresented in the decision-making process. Robust, targeted outreach and expanded engagement opportunities are essential for ensuring that all voices are represented throughout the remainder of the planning process.

## 5.3 Engagement Strategies

**Table 5-2** summarized the major engagement types used to inform this Plan. Each component served to reach specific stakeholder audience groups and facilitate either active or passive communication strategies. Each type is described in more detail below.

### 5.3.1 Project Website

Early in the project, each of the Partners developed individual project websites. Over time, as part of synchronizing and coordinating this outreach effort, the Partners created a single shared project webpage. This webpage, https://voice.somervillema.gov/joint-cso-planning, is hosted by the City of Somerville and is now the single source for information about the project's engagement activities. This consolidation ensured that information provided to the public was consistent and readily accessible to anyone who wanted to know about and track the project and related engagement opportunities.

The project webpage is used to share project information and updates, including the following:

- Project overview;
- Timeline of Plan development;
- Subscription link for those who want to receive project updates;
- Public meetings announcements (in multiple languages);
- Materials from all public meetings, including meeting agendas, meeting recordings, and meeting slides;
- Frequently asked questions;
- Variance evaluation studies; and
- Contact information for each of the Partners.

The City of Somerville manages the project website, and it serves as a repository for major Plan components.

### 5.3.2 Meetings

The project timeline initially submitted to and approved by EPA and MassDEP included six public meetings: five of which would be held during the Plan development phase, and one to be held after the

submission of the Draft Plan. After this timeline was approved, it became clear to the Partners that further engagement was warranted to adequately communicate the dense technical work underpinning the Plan. To this end, the Partners made the following changes to the original public meeting framework:

- Add a dedicated listening session to hear public feedback on the Plan development;
- Add more focused engagement with the watershed advocacy groups, agencies, and municipal entities; and
- Add one additional public meeting during the Plan development phase.

The watershed advocacy groups suggested the incorporation of the listening session, and then the additional public meeting was added to the schedule when the Partners filed for an extension to the deadline to submit the draft Updated CSO Control Plan. Focused meetings became a central tenant of the engagement strategy, as it became clear that many stakeholder groups had specific interests and expertise, and that these meetings would bolster the public meetings and public engagement efforts.

**Figure 5-3** reflects the final major engagement meetings that took place during the development of the draft Updated CSO Control Plan.

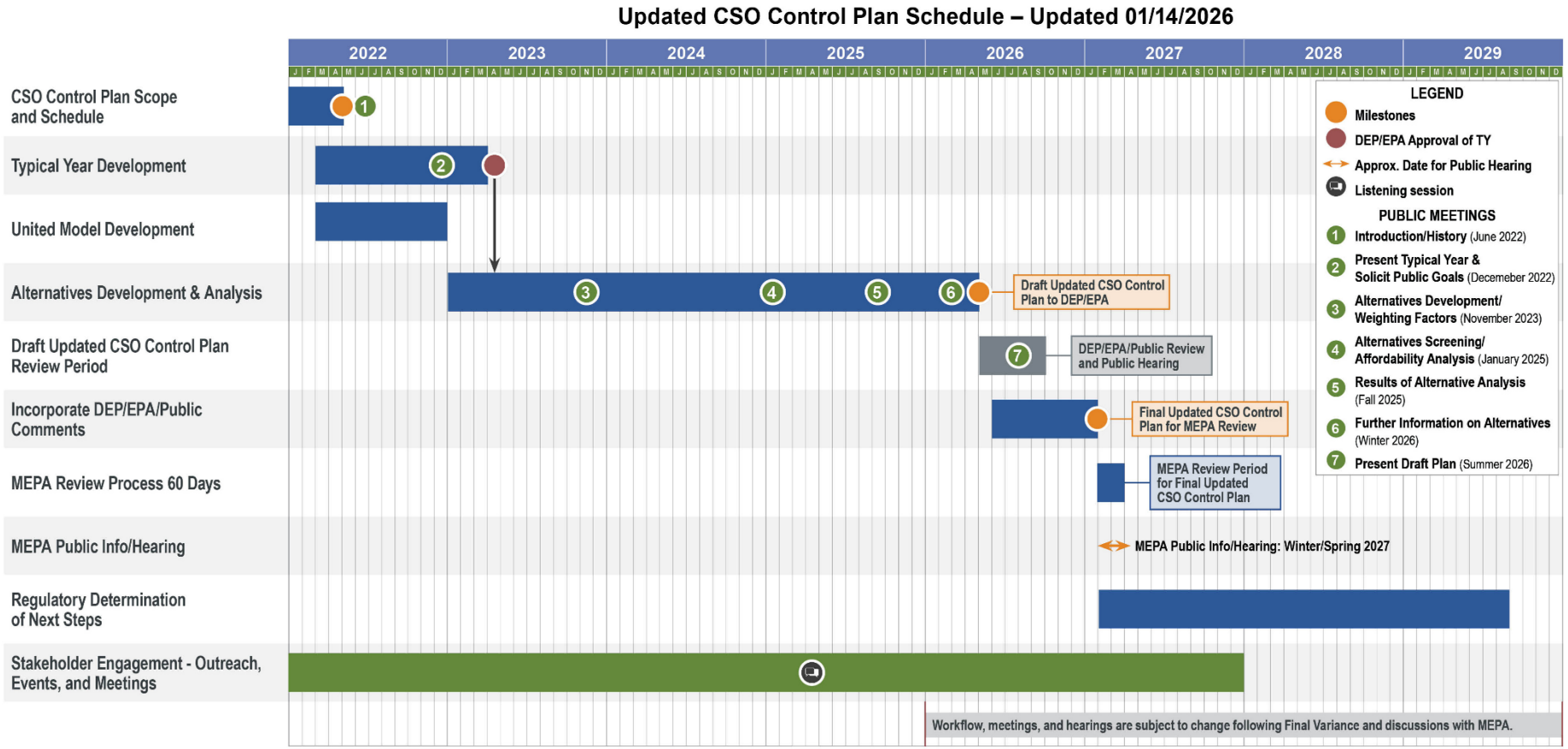



**Figure 5-3. Initial Public Meeting Timeline included in Public Participation Plan**

More detailed descriptions of all the meetings held by the Partners—those to engage the public, the watershed advocacy groups, as well as meetings with agencies and municipal and other boards—are presented in the subsections below.

#### 5.3.2.1 Public Meetings

Public meetings were held virtually as Zoom webinars to facilitate access across the region. Communities and stakeholders listed in **Table 5-1**, as well as individuals who signed up be notified about project activities through the project website, were notified of these public meetings by email. These meetings had consistently high attendance, due to both interest in the Updated CSO Control Plan and successful outreach by the Partners and watershed advocacy groups. Public meetings were interpreted into multiple languages as requested (summarized in **Section 5.2**).

Meetings lasted approximately two hours and included presentations and opportunities for the public to both provide input (via survey or poll questions, see **Section 5.3.3**) and ask questions. **Table 5-4** summarizes each public meeting, including the date, format, number of participants, and topics. Meeting slides and recordings can be found on the joint project website[3].

**Table 5-4. Public Meetings Held as part of the Updated CSO Control Plan Engagement Process**

| Meeting | Date | Participant Count(1) | Topics |
|---|---|---|---|
| Public Meeting #1 | 06/29/2022 | 226 | • Introduction to the planning process and schedule |
| Public Meeting #2 | 12/15/2022 | 177 | • Project goals and approach<br>• Developing the 2050 Typical Year<br>• Solicit public goals |
| Public Meeting #3 | 11/15/2023 | 243 | • CSO control technologies toolbox<br>• Solicit input on values to inform evaluation criteria development |
| Public Meeting #4 | 01/22/2025 | 355 | • Process of developing alternatives and presentation of some alternatives being considered<br>• Process for affordability analysis calculations |
| Listening Session | 04/03/2025 | 173 | • Solicit input, concerns, and advice from participants<br>• Individuals each given 2 minutes to speak<br>• Watershed advocacy groups and MWRA Advisory Board each given extended time (5 minutes each) |
| Public Meeting #5 | 09/25/2025 | 198 | • Preview alternatives under consideration |
| Public Meeting #6 | 01/15/2026 | 359 | • Information about requested extension to submit Draft Plan<br>• Details on the short list of potential recommended alternatives<br>• Additional information on water quality, alternative construction impacts, and cost and rate impacts |
| Public Meeting #7 | TBD | TBD | • Present Draft Recommended Plan |

**Note:**

(1) Number of participants includes the Partner representatives.

[3] https://voice.somervillema.gov/joint-cso-planning

Given the technical complexity of the Plan, the Partners dedicated significant time and coordination to developing materials that would help the public clearly understand this work and facilitate meaningful contributions to the Updated CSO Control Plan. A large team of technical experts attended each public meeting and answered questions asked by participants either live in the meetings or in the meeting chat. At some meetings, the technical team answered as many as 80 written questions submitted by participants. The Partners relied on a deep bench of technical experts, CBI, and partnerships with the watershed advocacy groups to support the communication of these complex concepts in a way that was understandable and accessible.

#### 5.3.2.2 Watershed Advocacy Groups

The Partners engaged three watershed advocacy groups during the Updated CSO Control Plan development effort: 1) the Charles River Watershed Association (CRWA), 2) the Mystic River Watershed Association (MyRWA), and 3) Save the Alewife Brook (StAB). The first two of these are non-profit watershed organizations with paid staff, the third an active volunteer group. Representatives of these groups expressed a desire early in the process to be more involved, and the Partners agreed that close engagement with these organizations would support the overall intent of hearing from key stakeholders and robust outreach. Targeted meetings with the watershed advocacy groups proceeded in parallel with the public meetings described above.

The Partners met with representatives from the three watershed advocacy groups to present technical components of the Plan and to preview materials to be shared at public meetings. **Table 5-5** provides details about these meetings, including date, format, number of participants and topics.

**Table 5-5. Watershed Advocacy Group Meetings Held throughout Public Participation Process**

| Meeting | Date | Format | Participant Count(1) | Primary Topics |
|---|---|---|---|---|
| Meeting #1 | 10/24/2023 | In-person | 21 | CSO control technologies, 2050 Typical Year development, preview of Public Meeting #3 topics |
| Meeting #2 | 06/24/2024 | In-person | 32 | Process for alternatives development, discussion of tools being explored, mapping exercise |
| Meeting #3 | 12/17/2024 | Virtual | 35 | Alternatives development progress, cost assumptions, preview of Public Meeting #4 topics |
| Meeting #4 | 9/04/2025 | In-person | 29 | Alternatives development process, summary of alternatives analyzed, criteria and preliminary scoring, water quality modeling |

**Note:**
(1) Number of participants includes watershed advocacy group and Partner representatives.

In addition to the meetings listed above, the Partners solicited input from the watershed advocacy groups on two of the Variance feasibility studies in 2024: real-time notifications of CSO activations and odor control. See Section 4.7 for details on these feasibility studies. Based on this solicited input, the Partners conducted two focused meetings about the real-time notifications studies, as shown in **Table 5-6**. Engagement for the odor control studies was conducted over email.

**Table 5-6. Watershed Advocacy Group Meetings on Variance Studies**

| Meeting | Date | Format | Participant Count[(1)] | Primary Topics |
|---|---|---|---|---|
| Real-time notification Meeting #1 | 11/20/2024 | Virtual | 25 | • Identify modifications to improve public notification in flood-prone areas<br>• Provide input on scope for feasibility study |
| Real-time notification Meeting #2 | 5/5/2025 | Virtual | 20 | • Review notification requirements, interim measures, project timeline<br>• Review findings from research done on existing real-time on-site notification systems<br>• Discuss preferred notification option<br>• Get feedback on public education campaign |

**Note:**
(1) Number of participants includes watershed group and Partner representatives.

Watershed advocacy groups, Partners, and the CBI facilitators were also informally in touch via email and phone during the multi-year planning process to request or share information. The three watershed advocacy groups also provided valuable service to the engagement effort by conducting significant outreach to their constituents about the public meetings. This outreach significantly bolstered awareness, interest, and attendance at the project's public meetings.

#### 5.3.2.3 Federal and State Agencies

The Partners held various meetings with the federal and state agency partners laid out in **Table 5-1.** The team held monthly coordination meetings with MassDEP and EPA (the Regulators) throughout the planning process. The Partners and the Regulators used these meetings to review technical progress, discuss regulatory considerations, and ensure alignment with current water quality standards and permitting requirements. The discussions focused on the scope and objectives of the Updated CSO Control Plan, the evaluation of control alternatives, and the consistency of proposed measures with the CWA and the Massachusetts SWQS. The Partners shared interim findings, modeling results, and implementation considerations with MassDEP and EPA to solicit input and guidance at key milestones. This collaborative approach helped the Partners identify data needs, clarify regulatory expectations, and ensure that the updated plan remains responsive to both local water quality objectives and federal oversight requirements.

Continued coordination with these agencies will remain a priority through finalization of the Plan and subsequent implementation phases to maintain transparency, regulatory consistency, and shared commitment to improving water quality in the affected receiving waters.

The Partners also held targeted meetings with DCR and the MBTA, as many of the potential project sites identified during alternative development (Section 9) identified DCR- or MBTA-owned properties. The Partners have kept DCR informed throughout the process and worked to understand the feasibility of using DCR-owned land for project sites. The Partners have also worked with the MBTA through the Alewife MBTA station redevelopment to understand opportunities to implement CSO control projects during their ongoing work.

MEPA and EEA were engaged to provide guidance on the public outreach approach summarized in this section. Engagement with these agencies will ramp up after the Draft Plan is submitted as shown in **Figure 5-3.**

#### 5.3.2.4 Municipalities and Representative Boards

The Partners met with boards, councils, and committees within each of their jurisdictions, as well as representatives from other adjacent communities. These entities represent their constituents, and the Partners conducted this outreach to seek input, advice, and guidance from local representatives, ensuring that their local perspectives and expertise informed the evolving work. In particular, the MWRA Advisory Board, which elects three members of the Board of Directors, is an advocate for MWRA communities and ratepayers. It was created over 30 years ago and is made up of a representative from each customer

community. By statute, the Advisory Board reviews and comments on all MWRA's operating and capital budgets The meeting frequency varied depending upon the entity and jurisdiction. The Partners met with the following groups during the Updated CSO Control Plan development:

- MWRA Board of Directors;
- MWRA Advisory Board;
- MWRA Water Supply Citizens Advisory Council;
- MWRA Wastewater Advisory Committee;
- Somerville City Council;
- Cambridge City Council;
- Cambridge Health and Environment Committee; and
- Cambridge Conservation Commission.

### 5.3.3 Written Input

The Partners elicited public input via writing in multiple ways: through live survey questions in public meetings, verbally, and through written correspondence outside of meetings (surveys and email input). The Partners distributed input opportunities alongside meeting invitations when possible; additionally, meeting participants were invited to share these input opportunities with their networks to provide people unable to attend the meetings with an opportunity to submit questions and comments. The project website also provided direct contact information for the Partners, and many stakeholders communicated directly with Partners via email or phone.

**Table 5-7** highlights the formal written input opportunities during and around the public meetings. Some surveys were conducted as live questions during the public meetings, and some were more open ended and shared beyond meeting participants (denoted as "open questionnaire" in **Table 5-7**).

These surveys asked a mix of demographic and open-ended questions to elicit participants' perspectives. Demographic questions such as "Where do you live?" and "Where do you work?" helped the Partners to identify where participants came from and who was in the meeting. Other questions invited topical feedback such as:

- What hopes and/or concerns do you have about this project and CSOs in general?
- What is your top feedback for the project partners as they develop the draft Updated CSO Control Plan?
- Do you have any specific hopes for the future of the Alewife Brook, Charles River, and/or Mystic River related to water quality or activities like swimming, fishing, or boating?
- Do you have any thoughts about how our plans to reduce CSOs in the future should incorporate climate change projections and consider the expected impacts of climate change on local rivers and communities?
- Please rank these 10 criteria in order of how important they are to the evaluation and comparison of alternatives to control CSOs. Please share any comments you have about particular criteria. Please share other criteria you would like to see considered.

**Table 5-7. Written Surveys Available to the Public / Stakeholders through Meetings / Listening Sessions**

| Survey | Dates Open | Format(1) | Respondent Count |
|---|---|---|---|
| Public Meeting #2 Open Questionnaire | 11/15/2022 – 1/15/2023 | Mentimeter | 86 |
| Public Meeting #3 Live Survey (English + Translation(2)) | 11/15/2023 | Mentimeter | 81 |
| Public Meeting #3 Open Questionnaire | 12/12/2023 – 1/15/2024 | Mentimeter | 1,312 |
| Public Meeting #4 Live Survey | 1/22/2025 | Mentimeter | 167 |
| Listening Session Live Survey | 4/3/2025 | Mentimeter | 88 |
| Public Meeting #5 Live Survey | 9/25/2025 | Mentimeter | 70 |
| Public Meeting #6 Live Survey | 1/15/2026 | Mentimeter | 140 |

**Notes:**
(1) Mentimeter is an interactive online audience engagement platform (https://www.mentimeter.com/).
(2) Translation was requested during this meeting and survey questions were also translated.

The Partners reviewed all the responses received through the surveys shown here, and they also responded to hundreds of questions asked both verbally and in writing during and outside of the public meetings. The feedback solicited through these channels informed various decisions in Plan development, as is described in more detail in **Section 5.4**.

### 5.3.4 Targeted Outreach at Community Events

The Partners attended community events to share project information with people attending those existing events. The format and structure of each of these engagements was tailored to the likely audience and structure of the event. The topics shared by the Partners ranged from general education about combined and separated sewer systems to more specifics about how to get involved with the CSO planning process. As CSO control is just one part of how each individual Partner manages and communicates about their collection system, these events covered many topics connected to Partners' ongoing CSO planning work. These events are summarized in **Table 5-8.**

**Table 5-8. Summary of Tabling Events held throughout Updated CSO Control Plan Development**

| Event | Partner Lead | Date | Topics Shared |
|---|---|---|---|
| Somerville Civic Day | Somerville | April 2023<br>April 2024 | Combined sewer systems and separated systems in Somerville; citywide flooding |
| High School Presentations | Somerville | Sept 2021<br>Sept 2022 | Combined sewer systems and separated systems in Somerville; citywide flooding |
| Cambridge Science Festival | Cambridge | Oct 1, 2023 | Combined sewer systems and separated systems in Cambridge |
| The Port Open House | Cambridge | Nov 9, 2023 | Combined sewer systems and separated systems in Cambridge, info on Updated CSO Plan |
| Cambridge Arts River Festival | Cambridge | June 15, 2024 | Combined sewer systems and separated systems in Cambridge |
| Fresh Pond Day | Cambridge | June 22, 2024 | Combined sewer systems and separated systems in Cambridge, info on Updated CSO Plan |
| Danehy Park Day | Cambridge | Sept 21, 2024 | Combined sewer systems and separated systems in Cambridge |
| The Port Arts Festival | Cambridge | May 17, 2025 | Combined sewer systems and separated systems in Cambridge, info on Updated CSO Plan |

### Table 5-8. Summary of Tabling Events held throughout Updated CSO Control Plan Development

| Event | Partner Lead | Date | Topics Shared |
|---|---|---|---|
| ArtBeat (Somerville) | MWRA | July 13, 2024 | Updated CSO Control Plan flyers[4] available for distribution |
| Boston July 4th Pops (at the Esplanade on the Charles) | MWRA | July 4, 2023<br>July 4, 2025 | Updated CSO Control Plan flyers[4] available for distribution |
| Bow Tie Ride (Cambridge) | MWRA | Oct 1, 2023 | Updated CSO Control Plan flyers[4] available for distribution |
| Cambridge 5K (Cambridge) | MWRA | Nov 5, 2023 | Updated CSO Control Plan flyers[4] available for distribution |
| Children's Hospital 5K (at the Esplanade on the Charles) | MWRA | Sept 24,2023 | Updated CSO Control Plan flyers[4] available for distribution |
| Community Spring Bike Ride (Cambridge) | MWRA | May 18, 2024 | Updated CSO Control Plan flyers[4] available for distribution |
| CX Summer Nights (Cambridge) | MWRA | June 26, 2025 - Aug 21, 2025,<br>June 22, 2023,<br>July 20, 2023<br>Aug 17, 2023 | Updated CSO Control Plan flyers[4] available for distribution |
| Dragon Boat Festival (on the Charles) | MWRA | May 31,2025 | Updated CSO Control Plan flyers[4] available for distribution |
| Esplanade Association 5K (at the Esplanade on the Charles) | MWRA | May 20, 2023 | Updated CSO Control Plan flyers[4] available for distribution |
| GS23 - Gilman Sq Arts & Music Festival (Somerville) | MWRA | Sept 13, 2026 | Updated CSO Control Plan flyers[4] available for distribution |
| Head of the Charles (on the Charles) | MWRA | Oct 18, 2024 – Oct 20, 2024 | Updated CSO Control Plan flyers[4] available for distribution |
| Herring Run and Paddle (with MyRWA) | MWRA | May 21, 2023<br>May 19, 2024 | Updated CSO Control Plan flyers[4] available for distribution |
| Juneteenth (Cambridge) | MWRA | Jun 19, 2025 | Updated CSO Control Plan flyers[4] available for distribution |
| Landmark Orchestra at the Hatchshell (every Wednesday night on the Charles) | MWRA | July 16, 2025 – Aug 27, 2025 | Updated CSO Control Plan flyers[4] available for distribution |
| Making Strides For Breast Cancer (on the Charles) | MWRA | Oct 1, 2023<br>Oct 4, 2025 | Updated CSO Control Plan flyers[4] available for distribution |
| March of Dimes (at the Esplanade on the Charles) | MWRA | May 13, 2026 | Updated CSO Control Plan flyers[4] available for distribution |
| MIT Block Party (Cambridge) | MWRA | Oct 14, 2023 | Updated CSO Control Plan flyers[4] available for distribution |
| Mobile Canoe (with MyRWA) | MWRA | Sept 18, 2024 – Sept 21, 2024,<br>Sept 23, 2025 – Sept 27, 2025 | Updated CSO Control Plan flyers[4] available for distribution |
| Pride Flotilla (with MyRWA) | MWRA | June 29, 2024<br>June 28, 2025 | Updated CSO Control Plan flyers[4] available for distribution |
| Run of the Charles (with CRWA) | MWRA | April 27, 2024<br>April 27, 2025 | Updated CSO Control Plan flyers[4] available for distribution |
| SomerStreets: Carnaval (Somerville) | MWRA | June 2, 2024<br>Oct 19, 2025 | Updated CSO Control Plan flyers[4] available for distribution |

[4] Updated CSO Control Plan flyers contain a brief description of the process and a QR code directing people to the project website where they could sign up to be on the project contact list.

## 5.4 Key Project-Related Input and How it was Used

The Partners received substantial and diverse feedback during the four years of engagement that informed various stages of this Plan. The consistent feedback for developing a plan grounded in future climate conditions influenced the development of climate-informed rainfall scenarios that form the basis of this entire Plan (see Section 6); many of the requests for solutions that prioritize co-benefits, near-term action, and water quality improvements informed the alternatives evaluation criteria to ensure community priorities informed the alternatives evaluation (Section 10). Questions requesting more transparency in the evaluation process led the Partners to hold additional public meetings. (**Section 5.3.2**).

The Partners reviewed and considered all the comments received—through conversations, focused meetings, public meetings, and written input—and determined whether and how to incorporate the thousands of recommendations and ideas into the planning process. **Table 5-9** summarizes the stakeholder input the Partners heard most frequently, organized by theme, and summarizes how this input informed the Plan.

**Table 5-9. Summary of Key Project Input Provided by Stakeholders and How It Was Incorporated into the Updated CSO Control Plan**

| Input Theme | Input Summary | Summary of Incorporation into Plan |
|---|---|---|
| *Future Conditions* | • Technical analysis, including the Typical Year, should account for projected future climate conditions.<br>• Consider anticipated changes in precipitation patterns, increased likelihood of drought, and other expected climate shifts.<br>• Project alternatives should be developed to function effectively under future climate scenarios.<br>• Future conditions should also incorporate non-climate future conditions, such as population growth. | • Developed a 2050 Typical Year that included anticipated future climate conditions (see Section 6).<br>• Included evaluation criterion “provide resiliency and adaptability” in alternatives evaluation. |
| *Affordability* | • Prioritize affordability for ratepayers, including low-income ratepayers, when selecting among alternatives, given many competing community priorities beyond CSOs.<br>• Consider approaches to reduce financial burdens through potential funding sources, including federal funding, tiered rate systems, tax incentives, public subsidies, or state funding.<br>• Select higher-cost options only when they provide significant additional benefits, such as water quality improvements.<br>• Make larger investments now to prevent more costly interventions needed later. | • Conducted Financial Capability Assessments (FCA) and studied impacts on rate payers to inform the recommendations in the Draft Plan.<br>• Optimized project elements during the alternatives development process to identify cost-efficient ways to achieve each level of benefit (see Section 9).<br>• Included cost impacts in relation to community priorities and ratepayer impacts as part of the preferred alternative selection process.<br>• Alternatives that were evaluated spanned a range of costs. |
| *Highest Levels of Control* | • Select alternatives that achieve the highest level of CSO control.<br>• Evaluate associated benefits such as public health protection, water quality improvements, habitat enhancements, recreation opportunities, and aesthetic conditions. | • Considered a wide range of levels of control (see Section 7), including developing future design storms of greater intensity than previously considered. |
| *Swift Action* | • Prioritize near-term action.<br>• Include consideration of schedules that enable expedited design and implementation.<br>• Evaluate alternatives based on how long they would take to construct. | • Included evaluation criterion “schedule: minimize duration to CSO reduction benefit” in alternatives evaluation. |
| *Green Stormwater Infrastructure (GSI)* | • Incorporate green infrastructure and nature-based solutions where feasible.<br>• Include strategies that provide co-benefits such as urban cooling, reduced impervious area, and improved air quality. | • Evaluated the level of CSO control that could be achieved through GSI.<br>• Many alternatives include implementation of GSI where feasible.<br>• Included evaluation criterion “community co-benefits and long-term site impacts” in alternatives evaluation. |
| *Notification System* | • Improve public notification system for CSO activations.<br>• Provide community members with different options, (i.e., email, text, social media) to receive timely information when CSO activations occur. | • Centralized sign-up links to the shared project website.<br>• Conducted real-time notification feasibility studies which included meetings with watershed advocacy groups.<br>• MWRA is pilot-testing an indicator beacon at SOM007A/MWR205A. |

**Table 5-9. Summary of Key Project Input Provided by Stakeholders and How It Was Incorporated into the Updated CSO Control Plan**

| Input Theme | Input Summary | Summary of Incorporation into Plan |
|---|---|---|
| *Additional Co-Benefits* | • Identify alternatives that provide benefits beyond CSO reduction.<br>• Consider co-benefits such as reducing urban heat island effects, improving habitat and streamflow conditions, and reducing flooding.<br>• Include opportunities to upgrade existing inground sewer infrastructure.<br>• Evaluate options that enhance recreation near outfalls, including walking, boating, and swimming. | • Included the following evaluation criteria: “community co-benefits and long-term site impacts,” “flooding: reduce sewer/storm flood risk,” and “renewal of existing infrastructure.” |
| *Alewife Brook* | • Prioritize improvements in the Alewife Brook.<br>• Implement near-term mitigation measures for odor and floatables to control odors and floating waste. | • Prioritized alternatives that included components that can mitigate CSOs sooner.<br>• Developed odor control and floatables control feasibility studies. |
| *Water Quality* | • Identify alternatives that provide measurable improvements to water quality.<br>• Consider water quality performance as a factor in evaluating alternatives. | • Included evaluation criterion “change in nutrient loading” as a proxy for water quality in alternatives evaluation. |
| *Impacts to the Public* | • Consider land availability constraints when evaluating implementation feasibility.<br>• Prioritize alternatives that can be constructed on sites where the Partners are likely to have access.<br>• Account for potential neighborhood impacts during construction, including traffic and noise.<br>• Weigh long-term benefits as more important than short term construction impacts to neighbors. | • Included evaluation criteria “minimize construction impacts” and “minimize construction complexity/risk” in alternatives evaluation.<br>• Considered multiple evaluation scenarios that weight construction impacts higher and lower to balance the varied feedback received on this item from the stakeholders. |
| *Raw Sewage Discharge* | • Reduce or eliminate SSOs – raw sewage entering waterways. | • Considered the impacts of alternatives developed on both CSOs and SSOs, aiming to not recommend alternatives that would increase SSOs. |
| *Trade-offs / alternative scoring* | • Provide transparency around evaluation criteria, how criteria were scored and weighted and how the Partners arrived at the preferred alternative. | • Partners hosted two public meetings specifically to address these questions (Sept 2025 and Jan 2026), the latter of which was added in response to feedback. |

## 5.5 Engagement Activities Planned in Next Steps of Updated CSO Control Plan Development

The engagement process will continue beyond the release of this Draft Updated CSO Control Plan, including a 5-month public comment period. Final details of this review and comment period are still under development; however, a general timeline of future activities and opportunities for future engagement are presented in **Table 5-10**.

## Table 5-10. Upcoming Milestones and Engagement Opportunities

| Milestone | Date | Partner Activities | Engagement Opportunities | Regulators |
|---|---|---|---|---|
| Draft Updated CSO Control Plan Released | April 30, 2026 | • Share the Draft Updated CSO Control Plan, supporting materials, and instructions on how to comment on the project website. | • Review the Draft Updated CSO Control Plan and materials posted online | • MassDEP Review of Draft Updated CSO Control Plan |
| Public Comment Period | May 2026 – September 2026 | • Conduct outreach to residents of impacted communities and/or vulnerable communities about the Draft Plan and how to comment.<br>• Hold a public meeting to present the draft preferred alternatives (expected May 2026).<br>• Hold a public hearing to gather verbal comments (TBD). | • Attend a public meeting to learn about the Draft Recommended Plan.<br>• Provide written comments during the comment period.<br>• Provide verbal comments at the public hearing. | N/A |
| MassDEP Review Period | October 2026 | N/A | N/A | • Review of Public Comments<br>• Prepare MassDEP Comments |
| Draft CSO Control Plan Revision Period | October 2026 – January 2027 | • Review and consider all public and Regulator comments.<br>• Revise the draft and prepare the Final Plan.<br>• Formally respond to Regulator comments | N/A | N/A |
| Final CSO Control Plan Submitted | January 31, 2027 | • Publish and share the Final Updated CSO Control Plan and supporting materials on the project website. | • Review final plan | N/A |

# 6. Planning Components for the Updated CSO Control Plan

This section describes the key analytical tools developed that support the Updated CSO Control Plan. **Sections 6.1** and **6.2** reinforce the Partners' commitment to considering future climate and document the robust, first-of-their-kind, technical analyses undertaken to embed climate resilience into the fabric of this Plan. These climate tools are integrated into the two major model types used for CSO control: the hydrologic/hydraulic model (**Section 6.3**), and the water quality models (**Section 6.4**).

The Unified Hydrologic and Hydraulic Model (Unified Model) is a complex collection system model that aligns the individual models developed by each of the Partners into one tool that can be used regionally. This is the primary tool used to estimate CSO activation frequencies and volumes under various conditions. The Water Quality Model is used in partnership with the Unified Model to assess CSO impacts on water quality by comparing bacteria concentrations from projected CSO flows to MassDEP Class B standards. As Section 2 described, having a robust understanding of the receiving water impacts is critical to understanding the results of various levels of CSO control, as well as determining ultimate compliance with the SWQS. The Partners rely on these two models in tandem to assess alternatives for hydraulic capacity, CSO reduction, and their ability to improve water quality outcomes in the region.

## 6.1 Climate Equity and Resilience Considerations for Model Use

The Greater Boston area, like many urban areas across the globe, are increasingly experiencing the effects of climate change, most notably through more frequent and intense precipitation events. These shifting precipitation patterns have been documented in the 2023 Massachusetts State Hazard Mitigation and Climate Adaptation Plan (ResilientMass Plan),[1] the Massachusetts Climate Change Assessment,[2] and in its supporting datasets such as the Cornell Scaled Intensity-Duration-Frequency (IDF) curves.[3] These more intense and frequent rainfall events exacerbate urban flood risks, overwhelm aging infrastructure, and lead to greater volumes of stormwater entering the combined sewer systems in short time periods, potentially contributing to more CSOs.

As the climate continues to change, infrastructure challenges such as flooding, CSOs, SSOs and basement backups increasingly threaten critical community infrastructure and public services. In older cities in the Greater Boston area, the convergence of aging infrastructure, extreme precipitation, and legacy combined sewer systems amplify these risks. While many neighborhoods may experience flooding, the consequences can be more severe for EJ populations (Figure 5-2 in Section 5) who often have limited resources to prepare for, respond to, or recover from these events. Communities like Boston, Cambridge and Somerville may also experience compounding stressors, such as reduced access to green space, lower-quality housing, or proximity to legacy infrastructure. Though some areas with severe flooding, such as Morrison Avenue in Somerville, may not fall within designated EJ boundaries, the broader pattern of disproportionate burden remains relevant, particularly where CSO and flooding issues overlap with socioeconomic vulnerabilities.

The Climate Resilience Playbook,[4] developed with input from the City of Cambridge, underscores the importance of infrastructure upgrades as a key resilience strategy. Through this Plan's engagement process (Section 5), the Partners heard consistent community feedback on the importance of incorporating climate change into CSO control planning. Consequently, the Partners have integrated best

[1] ResilientMass Plan: 2023 Massachusetts State Hazard Mitigation and Climate Adaptation Plan. 2023. Commonwealth of Massachusetts. https://www.mass.gov/doc/resilientmass-plan-2023/download
[2] Massachusetts Climate Change Assessment: Volume II – Statewide report. 2022. Commonwealth of Massachusetts. https://www.mass.gov/doc/2022-massachusetts-climate-change-assessment-december-2022-volume-ii-statewide-report/download
[3] Steinschneider, S., & Najibi, N. (2022). Observed and Projected Scaling of Daily Extreme Precipitation with Dew Point Temperature at Annual and Seasonal Scales across the Northeastern United States, Journal of Hydrometeorology, 23(3), 403-419. https://journals.ametsoc.org/view/journals/hydr/23/3/JHM-D-21-0183.1.xml
[4] Climate Resilience Playbook: Implementation guidance and resources for Massachusetts municipalities. 2025. Metropolitan Area Planning Council. https://resilienceplaybook.mapc.org/report

available climate data and projections that have been adopted by the Commonwealth of Massachusetts in developing this Updated CSO Control Plan.

## 6.2 Future Climate Conditions for CSO Planning

### 6.2.1 Typical Year: Definition, Purpose, and Use

EPA's CSO Control Policy requires the development and use of a "Typical Year" (TY) to plan and assess the performance of CSO control. A Typical Year is a full year of rainfall data that best represents rainfall conditions over 365 days, and this must be established as part of the Updated CSO Control Plan to assess how planned improvements would perform under a series of rainfall conditions representative of conditions during a 365-day period. The Partners were required to develop a Typical Year to comply with EPA's CSO Control Policy.

The Typical Year is used throughout the CSO control planning process at three distinct phases:

- Plan Initiation: At the onset of Plan development, the Typical Year is used to understand current system performance to establish baseline conditions.
- Plan Development: During the technical analysis, the Typical Year is used to develop and evaluate alternatives.
- Plan Implementation: As the recommended Plan is implemented, the Typical Year is used to measure and assess progress of the Plan.

A Typical Year is generally backward-looking and constructed from observed rainfall data that closely reflects long-term regional precipitation averages. As discussed in Section 3, the 1992 TY served as the benchmark for the 2006 LTCP. It was specifically developed as part of MWRA's approved 2006 LTCP and is based on rainfall records from Logan Airport (1949–1987 plus 1992). The selected 1992 dataset was chosen because it closely aligned with the 40-year average in terms of annual precipitation and storm distribution. Following the CSO Control Policy guidance, adjustments were made by adding or removing specific storm events to better match historical trends in frequency and intensity. The process was detailed in MWRA's *CSO Conceptual Plan and System Master Plan* (June 1994).

Before developing a new, climate-informed, Typical Year for this Updated CSO Control Plan, the Partners first followed the guidance in the CSO Control Policy to determine the appropriate traditional Typical Year per EPA's methodologies[5]. Interestingly, the 1992 TY still contains a range of storm events that adequately represent the frequency and magnitude of historic precipitation to this day, including sequences of wet and dry weather that are critical for modeling CSO behavior.[6] Therefore, the 1992 TY remains a valid representation of historic rainfall and reflects the traditional approach used in CSO control planning.

This Updated CSO Control Plan moves beyond nationally accepted convention by developing and adopting a 2050 Typical Year (2050 TY) to evaluate system performance under projected climate conditions. However, the 1992 TY remains a valuable benchmarking tool to compare CSO mitigation projects that have been designed and constructed to date, and as a benchmark with established precedent and broad institutional acceptance. It allows for direct comparison between past planning efforts, past compliance milestones, and current or future projections, thereby creating a consistent basis for assessing system improvements over time.

[5] The dataset for evaluation of the traditional Typical Year was based on 15-min rainfall data for the years 1996 - 2021 using the MWRA Columbus Park gage BO-DI-2. This is further explained in Appendix B.
[6] U.S. Environmental Protection Agency. (n.d.). Combined sewer overflow guidance for long-term control plan development (EPA Publication OWM-0272). https://www.epa.gov/sites/default/files/2015-10/documents/owm0272_0.pdf

#### 6.2.1.1 Defining the 2050 Typical Year

Long-term precipitation variability shows substantial seasonal and decadal fluctuations with an overall increasing trend for annual total precipitation. In order to understand future precipitation patterns, it is important to evaluate long-term trends in future precipitation variability. The Partners developed a 2050 TY using the best available climate projections and design guidance as adopted by the Commonwealth of Massachusetts. This future-focused rainfall series provides the basis to assess system performance under anticipated future conditions, thus supplementing the historical benchmark with a forward-looking climate risk lens.

This consideration of future climate change projections represents a unique approach to CSO control. According to information available currently, there is no EPA or MassDEP guidance on how to incorporate future precipitation projections into developing a Typical Year for CSO Control Plans. The method provided in this report is a first of its kind approach, vetted and peer-reviewed by climate scientists.

The 2050 TY was developed by considering both historic observed and modeled future precipitation parameters to understand how the system improvements will perform under the impacts of climate change, and to develop alternatives that are sized for this predicted increase in precipitation. The 2050 TY identified an observed year that is most representative of future projected precipitation patterns for the 2050 planning horizon. This synthetic 2050 TY will then be used to run combined sewer models (**Section 6.3**) to assess system improvements and anticipated level of control.

Instead of using a single future year (e.g., “2050”), the analysis to create the 2050 TY relied on a 30-year climate period around 2050 with bounding years of 2040–2069 for the analysis. This is the same averaging window the Commonwealth uses when referring to mid-century conditions, and it aligns with the climate resilience strategies employed in both Cambridge and Somerville (see Sections 4.4.2 and 4.5.2). A 30-year window offers a more stable, representative projection of climate change trends rather than the variability that occurs year-to-year. It also aligns with the spirit of the methodologies for developing a historic Typical Year outlined in the CSO Control Policy.

An overview of the methodology for determining the 2050 TY is contained in the following sections. Appendix B contains a more detailed technical summary of the methodology.

### 6.2.2 Modeled Future Precipitation Projections

As a first step toward developing a future TY, the Partners analyzed long-term historical precipitation records. These records included 15-minute interval data from nine gauges, and hourly data from one. Three gauges—Ward Street, Columbus Park, and Chelsea Creek—all located in Metro-Boston, were ultimately selected because of their resolution, continuity of record, reliability, and direct relevance to the combined sewer system. These gauges provided between 23 and 29 years of data, capturing rainfall variability in the study area and serving as the best available record for subsequent analysis.

The Partners further narrowed down the data to focus on the Columbus Park gauge for developing the 2050 TY. This was selected because it recorded the highest average observed precipitation across the three gauges. Although there is spatial variability in annual rainfall totals and in the intensity and duration of specific storm events across the CSO project area (i.e., not all locations receive the same amount of rainfall at the same time), this assumption provides a conservative basis for modeling.

**Table 6-1** describes key decisions made by the Partners regarding the future precipitation projections. The multi-step process to develop the 2050 TY is illustrated in **Figure 6-1**.

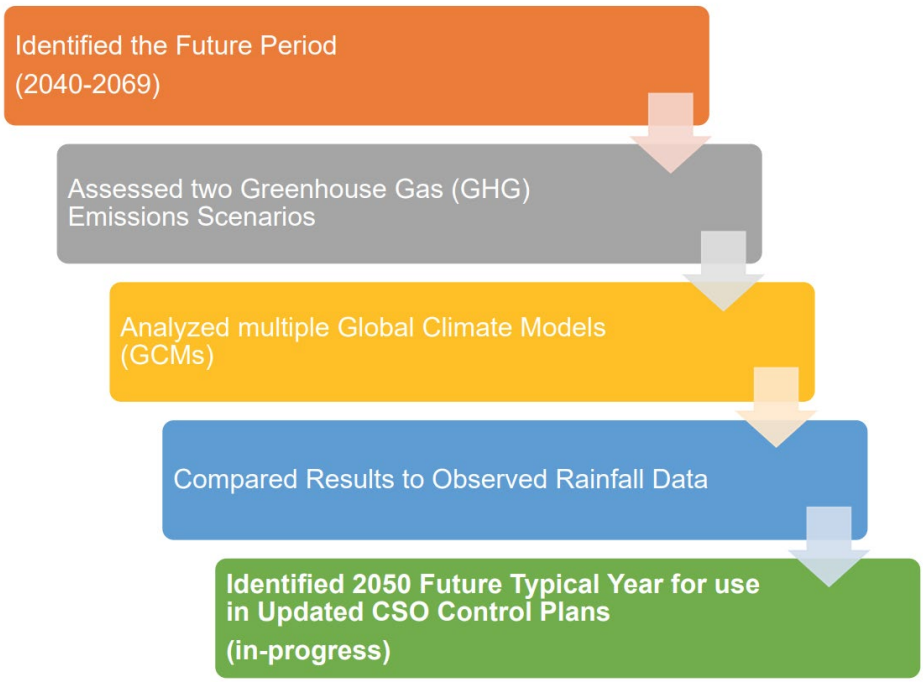



**Figure 6-1. Steps used to develop the 2050 Typical Year**

**Table 6-1. Description of Key Decisions Made for the Future Typical Year Analysis**

| Key Component | Description |
|---|---|
| **Planning Horizons** | The Partners identified two planning horizons for this analysis: a historical planning horizon for the period of 1996-2021, and a 2050 (future) planning horizon, which represents a 30-year averaging period of 2040-2069. This 30-year average window is the same as used by the Commonwealth when referring to mid-century conditions and offers a more stable, representative projection of climate change trends rather than the variability that occurs year-to-year. |
| **Greenhouse Gas (GHG) Emissions Scenarios** | The Partners assessed two GHG emissions scenarios, low (RCP 4.5) and high (RCP 8.5). Ultimately, the 2050 TY development relies on using the high (RCP 8.5) emissions scenario, which is the upper-end GHG emissions pathway adopted by Massachusetts for resilience planning and climate design applications. This pathway reflects more rapid warming and more intense precipitation compared to lower-emissions scenarios. By using the higher-emissions scenario, the analysis leans toward capturing conditions where storms are larger, more frequent, and more intense, which aligns with how the State considers mid-century climate risk for infrastructure. |
| **Global Climate Model (GCM)** | The Partners analyzed eleven (11) CMIP5[7] global climate models (GCMs) in developing the 2050 TY. GCMs are complex mathematical representations of the major climate system components (atmosphere, land surface, ocean, and sea ice) and their interactions. These GCMs are the same as adopted by EEA for the Statewide Climate Resilience Design Standards and Guidance, the Statewide Climate Assessment and ResilientMass planning guidance, and they reflect a broad ensemble of climate models rather than one single projection. Using multiple climate models helps to bound the uncertainty associated with future climate projections, captures a range of plausible futures and avoids bias towards any one model's behavior. This approach also mirrors the State's recommended climate science foundation for decision-making. |
| **Multivariate Adaptive Constructed Analogs (MACA)** | The Partners obtained future daily GCM projections from the MACA statistically downscale product. This product converts large scale GCMs into fine spatial scales so that the data is in close agreement with local data and can be used for station level analysis. |
| **MACA Grids** | MACA projections used in the analysis are based on approximately 4-km resolution grids, with modeled future daily rainfall projections available for each grid. The Partners selected three grids around each precipitation gauge location to normalize any error related to geographical spread around the location. Using multiple spatial grids helps account for the fact that rainfall intensity can vary across short distances in the region. Hence, by combining the 11 GCMs across the 30-year period for each of the 3 grids around a rainfall gauge, effectively 990 model-years were used in developing the 2050 TY. |

[7] https://journals.ametsoc.org/view/journals/bams/93/4/bams-d-11-00094.1.xml

The precipitation projections used in developing the 2050 TY are based on the best available rainfall projections for the study area and are consistent with those adopted by the EEA as part of the Statewide Climate Resilience Design Standards Tool and Guidance.[8] These projections are a conservative approach and are representative of potential worst-case scenarios considering mid-century climate change conditions.

**Precipitation Parameter Analysis**

The Partners assessed future precipitation patterns using the following three parameters (further described in Appendix B):

- Number of average annual consecutive dry days;
- Total annual precipitation depth; and
- Count of 1-day wet days using NOAA Atlas-14 depths binned from <3-month to >2-yr.[9]

Several of the precipitation parameters used in analyzing historic observed precipitation data were not suitable for assessing future precipitation patterns because they require 15-min interval precipitation data, whereas future precipitation projections are only available at a daily interval.

**Bias Correction**

Bias correction is the process of adjusting the future model data, such that it aligns with observed data. The purpose of the bias correction process is to correct uncertainties in the modeled future data set based on observed data. Guidance developed for the National Cooperative Highway Research Program recommends the use of downscaled and bias-corrected GCM projections when incorporating climate change information into infrastructure design and system performance assessments. The Partners conducted the following two bias correction steps:

1. Compared the observed precipitation data with the historical model data for each GCM for each grid under each RCP scenario to **calculate the bias correction factor**.
2. **Applied the corresponding bias correction factor** to the respective GCM's modeled projection data such that it best represents future conditions.

**Compiling Model Data**

After conducting bias correction, the Partners calculated a 330-model year average (30 years across 11 models, see **Table 6-1**) for each precipitation parameter at each grid for each gauge under each RCP scenario to derive the model future average values for each of the three future precipitation parameters (number of average annual consecutive dry days, annual precipitation depth, and wet days binned by storm depth and duration). The team calculated the median of the three grids for each of the model precipitation parameters for each gauge under each RCP scenario for continuation of the analysis. Across the three grids for each rainfall gauge, effectively 990 model-years were used in developing the 2050 TY.

**Deviation Analysis**

The Partners selected the RCP 8.5 scenario for the deviation analysis following the Statewide Climate Resilience Design Standards and Guidance by the Massachusetts EEA. The RCP 8.5 scenario is the upper-end greenhouse gas emissions pathway adopted by Massachusetts and reflects more rapid warming and more intense precipitation compared to lower-emissions scenarios. By using the higher-

[8] Climate Resilient Design Standards Tool. Resilient MA Action Team. 2022. https://resilientma.mass.gov/rmat_home/designstandards/

[9] 24-hour depths from NOAA Atlas 14 are divided by a derived factor of 1.13 to convert 24-hour amounts to 1-day depth accumulations, based on NOAA Atlas 14 adopted conversion factors

emissions scenario, the analysis favors conditions where storms are larger, more frequent, and more intense, which aligns with how the State considers mid-century climate risk for infrastructure.

The Partners performed deviation analysis using the same stepwise process as for the historic observed precipitation data, with some adjustments for the 2050 TY analysis. Notably, the Partners compared the observed years' precipitation data with the average of the model future precipitation parameters at each respective gauge and used weights from the Daily Data Scenario.[10]

**Further Typicalization of the Representative Year**

Typicalization of a rainfall year by selectively adjusting storm frequency and intensity is a standard step in developing a representative TY rainfall record under EPA's CSO Control Policy. To typicalize the observed year based on the data from the rainfall projections, the Partners compared the precipitation events in the observed year with the future IDF curves representing the 2050 climate projections. Based on this comparison, the team substituted small events from the representative observed year with identified alternate events from other observed years to add events with higher intensities over short durations and reduce the largest event, thus aligning more closely with future precipitation projections.

This substitution was conducted to better represent changes expected in storm characteristics, such as an increase in short-duration, high-intensity events. Smaller storm events were selectively replaced with similar duration events from other observed years that had higher intensities to be consistent with modeled future trends. At the same time, the single largest extreme event in the observed year was adjusted to reflect the projected shift from fewer extreme outliers to more frequent, moderate-intensity events. For example, the largest storm event was greater than a 3-year return period event, which is significantly large event in terms of CSO planning[11]. So, it was replaced with a slightly lower intensity event corresponding to a 1–2-year return period event in 2050. This way, the future year is more "typical" of representative storm events in a given year. This approach allowed the Partners to adjust the distribution of events in a way that aligns with future climate projections, without introducing extreme events or distorting the total annual precipitation.

### 6.2.3 Comparison to the 1992 Typical Year

The Partners used the current 1992 TY as a benchmark to assess the differences between historically observed precipitation patterns and projected future precipitations. The 2050 TY contains notable increases in both storm intensity and total annual precipitation, reflecting the influence of a changing climate (**Table 6-2**). While the 1992 TY consists of 94 storms with a total precipitation of 46.8 inches, the 2050 TY consists of 98 storms with a total precipitation of 49.8 inches.

**Figure 6-2** shows that storms that are currently considered low-frequency, high-intensity events are expected to become more common in the future. The projected rainfall depths associated with these design storms are based on the IDF projections developed by EEA's Hydro Risk Project and adopted by the State as part of the Climate Resilience Design Standards and Guidance. For example, the 2-year 24-hour storm as depicted in NOAA Atlas 14 Volume 10 (published in 2015)[12] is likely to be the 1-year 24-hour storm by the 2050 planning horizon, and the 1-year 24-hour storm is likely to be the 6-month 24-hour storm by the 2050 planning horizon. Therefore, while the 1992 TY continues to serve as a historical reference point, the 2050 TY is essential for evaluating how CSO infrastructure will perform under future climate stressors.

[10] The Daily Data Scenario is a simplified framework developed to reflect the availability of only daily precipitation outputs from global climate models; as such, it evaluates precipitation characteristics using daily (1-day) depth bins and wet-day counts rather than sub-daily rainfall intensities.
[11] According to EPA guidance documents, design and performance targets focus on storms at or below about the 1-year to 2-year return period. Including larger storms would disproportionately influence annual overflow frequency and volume estimates under typical year conditions.
[12] Perica, Sanja et al. (2015). Precipitation-Frequency Atlas of the United States. Volume 10, Version 3.0: Northeastern States. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service. DOI, https://doi.org/10.25923/99jt-a543.

## Table 6-2. Comparison of 1992 Typical Year to Future 2050 Typical Year

| | | | Count of storms – 15-minute Bins based on 2050 Projections | | | | | Count of storms - 1 hour Bins based on 2050 Projections | | | | | Count of storms - 6 hour Bins based on 2050 Projections | | | | | Count of storms – 24-hour Bins based on 2050 Projections | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR | # STORMS | TOTAL DEPTH (IN) | <3M* | 3M to 6M* | 6M* to 1Y | 1Y to 2Y | >2Y | <3M* | 3M to 6M* | 6M* to 1Y | 1Y to 2Y | >2Y | <3M* | 3M to 6M* | 6M* to 1Y | 1Y to 2Y | >2Y | <3M* | 3M to 6M* | 6M* to 1Y | 1Y to 2Y | >2Y |
| Future 2050 (2040-2069) bins | | | < 0.46 | 0.46 - 0.50 | 0.50 - 0.61 | 0.61- 0.76 | > 0.76 | < 0.78 | 0.78 - 0.87 | 0.87 – 1.06 | 1.06- 1.31 | > 1.31 | <1.54 | 1.54- 1.71 | 1.71- 2.08 | 2.08- 2.57 | >2.57 | < 2.37 | 2.37 – 2.63 | 2.63 – 3.22 | 3.22- 4.0 | > 4.0 |
| **2050 Typical Year** | **98** | **49.8** | **94** | **1** | **2** | **1** | **0** | **94** | **2** | **1** | **1** | **0** | **95** | **0** | **1** | **2** | **0** | **95** | **0** | **2** | **1** | **0** |
| **1992 TY** | **94** | **46.8** | **94** | **0** | **0** | **0** | **0** | **93** | **0** | **0** | **1** | **0** | **92** | **1** | **1** | **0** | **0** | **92** | **0** | **2** | **0** | **0** |

Note: *Rainfall depth projections for the 3- and 6-month return periods by 2050 were extrapolated from the projected 1-, 2-, and 5-year storm event depths by 2050.

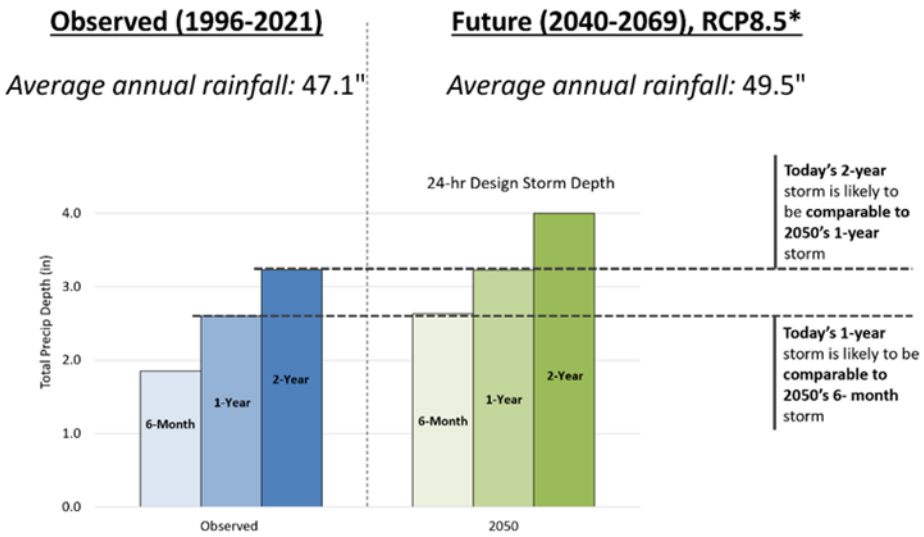



**Figure 6-2. Future (2050) Design Storm Projection Depths Plotted Against Present Day NOAA Atlas14 Values to Describe the Change in Storm Depth by 2050 Planning Horizon**

Note: *Using RCP 8.5 scenario, which has been selected by Massachusetts EEA for the Statewide Climate Resilience Design Standards and Guidance[13].

### 6.2.4 2050 Large Design Storms

In addition to developing the 2050 TY, the Partners also evaluated a range of large 2050 design storms to consider higher levels of CSO control, as required by the 2024 Variances. These design storms serve as the basis for evaluating alternatives that could service "up to and including elimination" of CSOs (2024 Variances). Assessing performance under larger design storms is essential to understand system robustness and guide the sizing of infrastructure.

A comparison of the precipitation depths for the different design storms of 24-hour duration under the present-day benchmark (NOAA Atlas-14) and the 2050 planning horizon are presented in **Table 6-3** for the Columbus Park gage location in Boston, MA. These 24-hour design storm projections are part of the IDF projections developed by EEA's Hydro Risk Project and these have been adopted by the Massachusetts EEA in the Climate Resilience Design Standards. According to these projections, there is an increase in frequency and intensity of these larger design storms. For example, the 5-year 24-hour storm by 2050 (5.3 inches) is similar to the current 10-year storm, the 10-year 24-hour storm by 2050 (6.4 inches) is similar to the current 25-year storm, and the 25-year 24-hour storm by 2050 (7.8 inches) is larger than the current 50-year storm.

[13] Massachusetts Executive Office of Energy and Environmental Affairs. (2022). Climate resilience design standards tool. Resilient Massachusetts Action Team. https://resilient.mass.gov/rmat_home/designstandards/

**Table 6-3. 24-hr Design Storm Depths for Present Day and 2050 at Columbus Park, Boston**

| Return Period | Present-Day Benchmark Precipitation Depth (NOAA Atlas-14), Inches | 2050 (2040-2069) Projected Precipitation Depth (Cornell[14]) Inches |
|---|---|---|
| **1-year** | 2.6 | 3.2 |
| **2-year** | 3.3 | 4.0 |
| **5-year** | 4.3 | 5.3 |
| **10-year** | 5.2 | 6.4 |
| **25-year** | 6.3 | 7.8 |
| **50-year** | 7.2 | 8.8 |
| **100-year** | 8.2 | 10.0 |

In addition to projected precipitation total depths, selecting an appropriate design storm distribution is important to estimate precipitation intensities during the storm event, as peak rainfall intensity is an important consideration for assessing CSO controls. In the past, the SCS Type III distribution was commonly used for design storms. However, the Partners used a more stringent distribution—the Alternating Block distribution—which results in a higher peak intensity compared to the SCS Type III distribution. Precipitation distribution curves for the 2050 5-year storm under the SCS Type III distribution and the Alternating Block distribution are shown in **Figure 6-3.** While the Alternating Block is similar to the SCS Type III distribution, it has the added advantage that it maintains the same return period for every time step in a design storm. The Partners selected the Alternating Block distribution because it represents a more consistent reference.

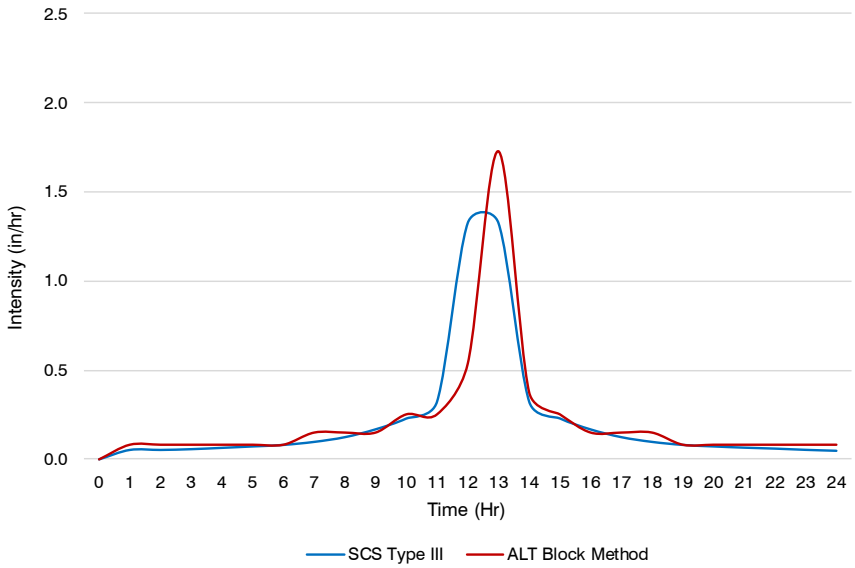



**Figure 6-3. Precipitation Distribution Curves for the 2050 5-year 24-hour Design Storm.**

[14] Steinschneider, S., & Najibi, N. (2022). Observed and Projected Scaling of Daily Extreme Precipitation with Dew Point Temperature at Annual and Seasonal Scales across the Northeastern United States, Journal of Hydrometeorology, 23(3), 403-419.

### 6.2.5 Tides and Temperature

In addition to developing the 2050 TY and 2050 design storms, two other climate-influenced model inputs include boundary tidal elevations and annual average temperature data. The Partners incorporated 2050 tidal boundary conditions into both the 2050 TY and the 2050 design storms. These conditions factor sea level rise and temperature projections in the Boston Harbor area by 2050.

The 2050 tidal boundary conditions were estimated using the Massachusetts Coast Flood Risk Model, which has been adopted by the State as the best available model for considering sea level rise and storm surge projections. The Partners developed a full year of projected 2050 tidal and storm surge boundary conditions by adjusting observed historical water surface elevations to match 2050 projections for sea level rise (1.28 feet, RCP 8.5, 50$^{th}$ percentile) from the Greater Boston Research Advisory Group report.

The only CSO outfall that is tidally influenced is SOM007A/MWR205A; all other CSO outfalls are upstream of the Amelia Earhart Dam or the New Charles River Dam and are not expected to be impacted from sea level rise and storm surge as long as the dams are not flanked and overtopped. The 2050 sea level rise and storm surge boundary conditions were used as the boundary condition for SOM007A/MWR205A downstream of the Amelia Earhart Dam.

To estimate changes in evapotranspiration parameters in the Unified Model, the Partners used annual average temperature projections for 2050 under the RCP 8.5 scenario. These projections align with the State's Climate Resilience Design Standards Tool and incorporate the latest updates from Cornell University as part of EEA's Climate and Hydrologic Risk project. The projected increase is from 1950 – 2013 is 5.4°F by 2050. This value was added to observed historical temperatures to model evapotranspiration for the 2050 TY model simulations.

### 6.2.6 Summary of Conservatism in Development of Future Storm Conditions

The Partners developed the 2050 TY and design storms based on conservative approaches using best available climate change projections, datasets, and design standards. This approach aimed to represent potential worst-case-scenarios considering mid-century climate change conditions, and to align with local climate strategies and State standards. Typical Year development typically relies on historical data, and so this analysis was performed without explicit guidance from EPA or MassDEP on how to incorporate future climate. The following items summarize the conservative assumptions used:

1. **State-adopted high-emissions scenario (RCP 8.5):** The 2050 TY relies on the RCP 8.5 emissions scenario, which is the upper-end greenhouse gas emissions pathway adopted by Massachusetts for resilience planning and climate design. This pathway reflects more rapid warming and more intense precipitation compared to lower-emissions scenarios. By using the higher-emissions scenario, the analysis favors conditions where storms are larger, more frequent, and more intense, which aligns with how the State considers mid-century climate risk for infrastructure.

2. **Best-available CMIP5 climate models and State-adopted MACA downscaling (multi-model ensemble):** The 2050 TY analysis used eleven (11) CMIP5 GCMs and MACA 4-km downscaled datasets, which were the same set of GCMs as adopted by the Massachusetts EEA for the Statewide Climate Resilience Design Standards and Guidance, the Statewide Climate Assessment, and ResilientMass Plan. These GCMs reflect a broad ensemble of climate models rather than one single projection and is one of the approaches used to bound the uncertainty associated with future climate projections. Using multiple climate models captures a range of plausible futures and avoids leaning heavily on any one model's behavior, and it mirrors the State's recommended climate science foundation for decision-making.

3. **Bounding years of 2040–2069 to represent 2050:** Instead of using a single future year (e.g., "2050"), the analysis relied on using a 30-year climate period around 2050, using the years 2040–2069 for the analysis. This is the same averaging window the Commonwealth uses when

referring to mid-century 2050 conditions. Using a 30-year period (2040–2069) to represent 2050 provides more stable, representative projections of climate change trends, while also incorporating a conservative planning approach. By extending the analysis approximately 20 years beyond the target year of 2050 under the high-emissions scenario (RCP 8.5), the methodology captures progressively increasing precipitation and temperature conditions, such that the infrastructure is evaluated against more severe future scenarios rather than being limited to the earlier part of the mid-century planning horizon.

4. **Multiple spatial MACA grids to represent uncertainty:** The rainfall projections at each rain gauge were analyzed across three different MACA spatial grids, including the MWRA Columbus Park rain gauge (BO-DI-2), which historically showed some of the highest projected precipitation totals. Using multiple spatial grids helps account for the fact that rainfall intensity can vary across short distances in the region. Using the rainfall from BO-DI-2 implies that the 2050 TY was based on wetter future conditions, rather than potentially underestimating rainfall. Combining the 11 GCMs across the 30-year period for each of the 3 grids around BO-DI-2 means that effectively 990 model-years were used in developing the 2050 TY.

5. **Projected increases in design storm intensities by 2050 included in rainfall adjustments:** In addition to the storms in the 2050 TY, the Partners also evaluated large 2050 design storms. The projected rainfall depths associated with these design storms are based on the IDF projections developed by EEA's Hydro Risk Project and adopted by Massachusetts as part of the Climate Resilience Design Standards and Guidance.

6. **Alternating Block rainfall distribution used to simulate higher rainfall peak intensities in future design storms**: The Alternating Block rainfall distribution method was used for the 2050 design storms, which assumes the same rainfall return period as the overall storm return period for every hourly time step over the 24-hour duration. This implies that the peak rainfall intensity used for the design storms is higher than the peak rainfall intensities from the traditional rainfall distribution methods.

7. **Same rainfall data was applied to the whole project area:** The same rainfall projections were applied uniformly across the entire project area. Although there is spatial variability in annual rainfall totals and in the intensity and duration of specific storm events across the CSO project area (i.e., not all locations receive the same amount of rainfall at the same time), this assumption provides a conservative basis for modeling.

8. **Higher projected maximum temperatures included to reflect groundwater and evapotranspiration behavior:** The unified hydraulic model uses higher mid-century air temperatures under RCP 8.5, which influence evapotranspiration rates, soil moisture, and groundwater levels. Warmer temperatures shift seasonal runoff timing and can increase the likelihood of elevated antecedent wetness, meaning the ground is more saturated before storms occur, which can lead to higher runoff and inflow to the system.

## 6.3 Unified Model

The Unified Model is the collection system model used to assess the hydrologic and hydraulic system performance through this Updated CSO Control Plan. This model is the primary tool used to generate estimates of the CSO flows and volumes discharged to the local receiving waters under various conditions (i.e., the 1992 TY, the 2050 TY). The Partners developed this model by combining the collection system models previously developed by MWRA and the cities of Cambridge and Somerville together using Infoworks ICM version 2021.9. Environmental variables such as rainfall, tide, and evaporation serve as inputs to the model. These inputs are used to estimate the flow entering the sewer system, as well as the hydraulic performance of the system at CSO regulators. The model is continuously updated to incorporate new information about the collection systems that can affect CSOs.

MWRA originally developed a hydrologic/hydraulic model of the wastewater collection system in support of its 1997 *CSO Facilities Plan and Environmental Impact Report* (see Section 3.1.1). The hydrologic component of the model routes the stormwater runoff into the collection system, and the hydraulic component represents the pipe network that conveys the flow to the remote headworks facilities upstream of the DITP. MWRA's model included the regional interceptor system and some of the local sewers within the combined sewer communities of Cambridge, Somerville, Boston and Chelsea. Over time, Cambridge, Somerville, and the BWSC independently developed models of their own collection systems to support their own planning needs. The individual cities' models included a higher level of detail within each of the community's systems than MWRA's model.

Over the years, MWRA, the cities of Cambridge and Somerville, and the BWSC have been continually updating their respective models to reflect changes to their systems. MWRA, Cambridge, Somerville and the BWSC each use their individual models for annual CSO reporting. Updates to Chelsea were included in MWRA's model updates. Not surprisingly, some variations in model predictions typically existed among the four models, and the regulatory agencies had encouraged these four entities to consolidate their models so the results would be more consistent. In addition, the CSO outfalls along the Alewife Brook and Charles River are located relatively close together and many are hydraulically connected, meaning that CSO impacts along the interceptor systems could affect the performance at other CSO outfalls along the same system. A combined model provides an opportunity to optimize CSO control strategies in this Plan.

The Partners decided that the best path forward was to combine the individual models into one Unified Model that would be used for the Updated CSO Control Plan. MWRA had already incorporated components of the BWSC model tributary to the Charles River into the MWRA's model prior to this process. With this unified approach, the Partners used one model to develop baseline conditions (Section 7.3), develop alternatives (Section 9), and evaluate performance (Section 10) across all CSO outfalls. This approach provides consistency and identifies interconnected upstream and downstream hydraulic impacts.

The following sections summarize the development and assessment of the Unified Model. Additional detail on the Unified Model is available in Appendix C.

### 6.3.1 Unified Model Development

To begin the model unification process, the MWRA, Cambridge, and Somerville modeling teams conducted a series of working meetings to develop consensus on a range of key modeling parameters such as the software version, model datum, model run parameters, approach to addressing groundwater, naming conventions, and post processing procedures.

A key step in preparing to unify the models was identifying locations where the models would be connected. These connection points were primarily located where the Cambridge and Somerville's systems connect to the MWRA interceptors, although some upstream interconnections also existed. The MWRA model was used as the base model for creating the Unified Model. The preexisting representations of the Cambridge and Somerville systems within the MWRA model were removed, then the more detailed Cambridge and Somerville models were incorporated at the agreed-upon connection points. After incorporating the models, the Partners resolved resulting runtime errors and removed unused land use types and runoff surfaces.

**Figure 6-4** presents a comparison of the model networks for the original MWRA model and the Unified Model. The figure shows the substantially increased level of detail in Cambridge and Somerville in the Unified Model. **Table 6-4** presents a comparison of the model network elements in MWRA's first quarter of 2023 conditions (Q1-2023) to the Unified Model's 2023 conditions. As shown in the table, the number of model nodes and conduits increased by 65% and 68%, respectively, and the number of subcatchments increased by 73%. The changes to the model required that new post processing tools be developed,

increasing model run time by at least 50% depending on the processing power of the computer that was used. This run time increase reflects the increased detail and complexity of the Unified Model.

**Table 6-4. Comparison of Model Nodes, Conduits and Subcatchments in the Original MWRA Model and the Unified Model**

| | MWRA (Q1-2023) | Unified Model (2023bEC) | Difference | % Increase |
|---|---|---|---|---|
| Nodes | 10,088 | 16,628 | +6,540 | 65% |
| Conduits | 9,885 | 16,566 | +6,681 | 68% |
| Subcatchments | 3,135 | 5,419 | +2,284 | 73% |

### 6.3.2 Unified Model Calibration Assessment

Prior to combining the models, each of the individual models were calibrated to meter data. These models are used to report annual activation frequency and volume, as a result, calibration is focused on storm events that occur during metering periods that are aligned with typical year sized storm events. When simulating a storm event outside of a typical year storm, such as 5-year and 25-year storm events, the collection system may behave differently. For example, there could be changes to pump operation, inflow quantity, overland flow, or catch basin behavior. These conditions may not be accounted for, making the model results differ from actual performance during large storms.

Once the models were combined, each of the Partners individually compared results between their original models, the Unified Model, and meter data. In cases where differences were noted between the individual entity models and the Unified Model, the differences were investigated and in some cases adjustments to the Unified Model were needed. Most of the differences were minor; however, some more notable differences in activation frequency and volume were observed. Often, the differences were attributable to the additional details included in the Unified Model that were not in the original MWRA model. These changes ultimately improved model accuracy when compared to meter data.

Following the Unified Model calibration assessment, the Partners could run the Unified Model independently and produce similar results. Each entity then developed a list of projects planned for implementation independent of the Updated CSO Control Plan that could affect the combined sewer system. These projects were integrated into the Unified model to develop the Baseline Conditions. These projects as well as the Baseline Conditions model results are presented in Section 7.3.

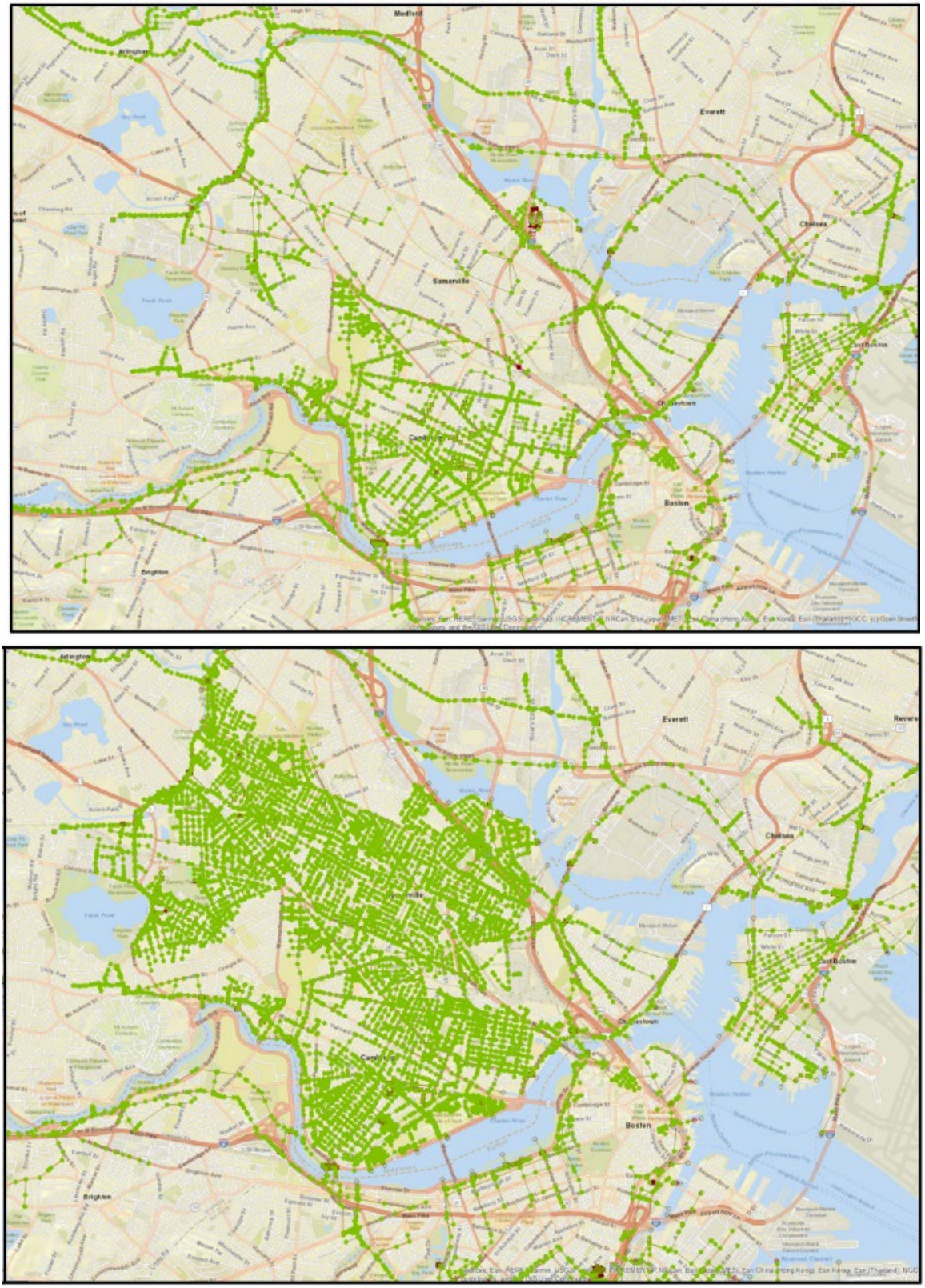



**Figure 6-4. Comparison of Model Network of Original MWRA Model (top) and the Unified Model (bottom)**

## 6.4 Receiving Water Quality Model Development and Updates

While the Unified Model is used to estimate CSO volumes and activations, a separate water quality model is needed to understand the impacts of CSO sources on water quality. This section describes the tools used to assess CSO impacts on bacteria concentrations in the receiving waters, and how those tools have been updated for this Plan.

In December 2021, the MWRA submitted its Final Assessment Report[15] to MassDEP and EPA (detailed in Section 3.2.1). This report presented the results of field investigations and modeling to assess the performance achieved by the MWRA's LTCP program including, among other things, an assessment of the water quality impacts of remaining CSOs and compliance with Massachusetts SWQS. The performance assessment was based on the 1992 TY rainfall and 2019 system conditions.

To support the assessment of water quality impacts in the Final Assessment Report, MWRA developed two hydrodynamic and water quality models for the regions with Variances: one for the Alewife Brook and Upper Mystic River systems, and one for the Lower Charles River/Charles Basin. These models computed time- and spatially-varying concentrations of *E. coli* and *Enterococcus* in the rivers, considering the impacts of river flow, geometry, dilution, dispersion, and die-off. These computations allowed for comparison of bacterial concentrations in the rivers to the numeric water quality criteria established for these waterbodies. Comparing these bacteria concentrations to water quality criteria provides an estimate of illness risk from recreation in these waterbodies. Details of original development and calibration of these water quality models were provided in the Final Assessment Report, and they form the basis of the water quality modeling performed in this Plan. Updates made to these models to incorporate the Unified Model outputs and 2050 TY are presented below.

### 6.4.1 Overview of Water Quality Models and Updates

The Alewife Brook/Upper Mystic River model is a one-dimensional model based on the InfoWorks ICM software that incorporates the dynamics of both receiving waters. The model includes a hydrodynamic part, which calculates water levels and cross-section-averaged velocities, and a water quality part, which calculates cross-section-averaged *E. coli* and *Enterococcus* counts. The model extends from the Amelia Earhart Dam to the Lower Mystic Lake and covers Alewife Brook in its entirety (**Figure 6-5**).

The Charles River model is a horizontally two-dimensional model based on the Delft3D software. The model includes a hydrodynamic part, which calculates water levels and depth-averaged velocities, and a water quality part, which calculates depth-averaged *E. coli* and *Enterococcus* counts. The model extends from the New Charles River Dam and locks to the Watertown Dam (**Figure 6-5**).

[15] https://www.mwra.com/cso/pcmpa-reports/Final12302021.pdf

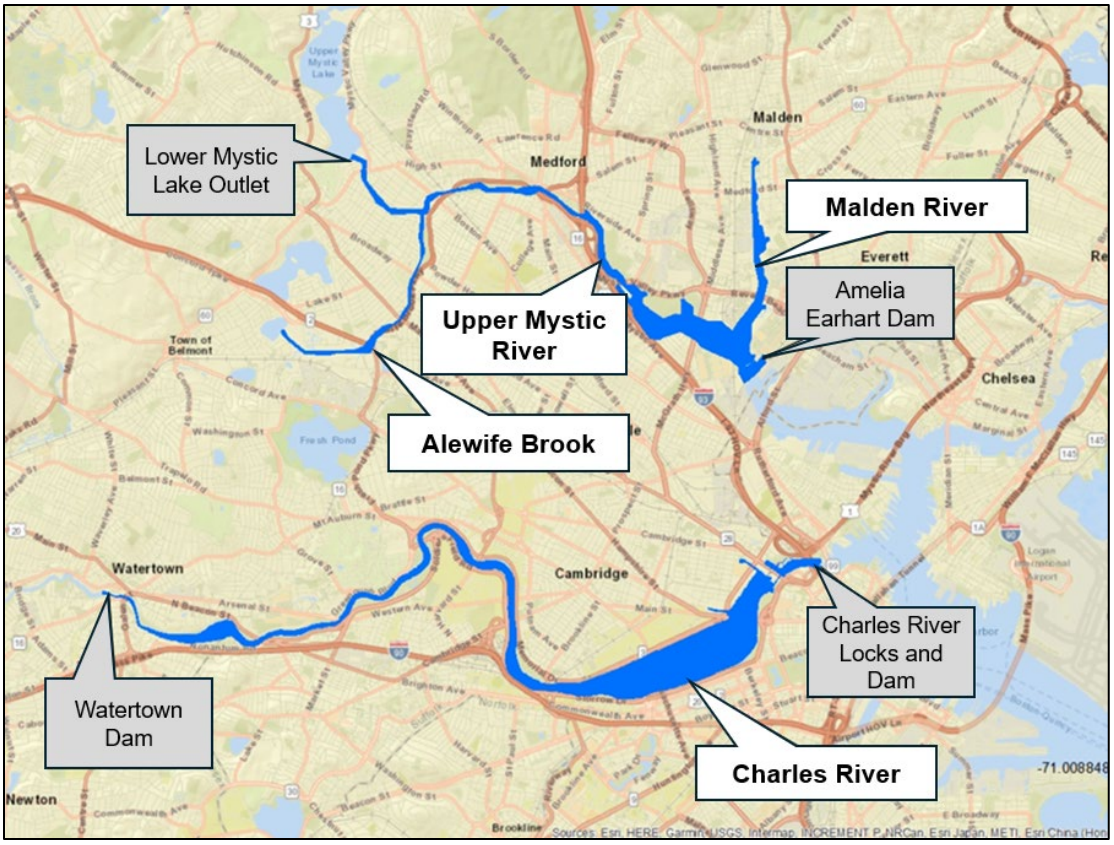



**Figure 6-5. Extent of the Alewife Brook/Upper Mystic River and Charles River Models**

The models use flow and pollutant load inputs to perform its hydrodynamic and water quality calculations. Bacteria sources represented in the models include the following:

- Stormwater;
- Untreated and treated CSO;
- Dry weather base flow (infiltration flow from storm drains or groundwater flow directly to a waterbody; could also include flow from illicit sanitary connections to storm drains); and
- Boundary conditions (flow into the study area from upstream).

As described in the Final Assessment Report, the models were calibrated by comparing model-predicted *E. coli* and *Enterococcus* counts at specific locations in the receiving waters with concentrations measured at those locations during specific storm events and dry weather periods. From 2018-2019, MWRA sampled intensively after storms of varied sizes, both with and without CSO discharges, to provide extensive in-stream water quality monitoring data to be used as the basis for comparing to model results during the calibration process. These data included the results of water quality sampling and analysis at 17 stations in the Charles River and 17 stations in the Alewife Brook/Upper Mystic River (**Figure 6-6**). Additional samples were collected from stormwater and untreated CSO outfalls in 2019. The *E. coli* and *Enterococcus* die-off rates and stormwater and CSO bacterial counts were adjusted within reasonable ranges to improve the match between the modeled concentrations and the measured concentrations from river samples.

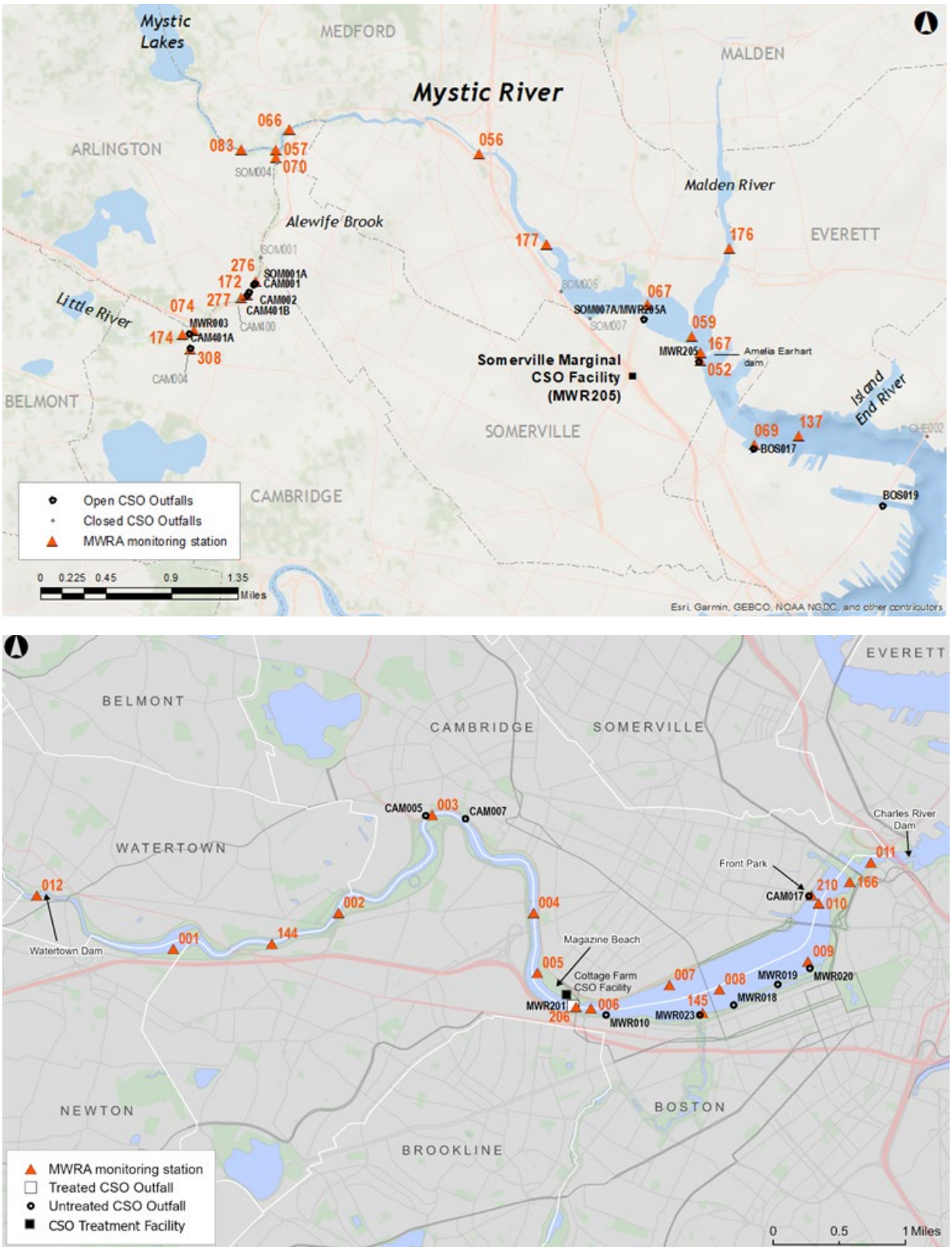



**Figure 6-6. MWRA Monitoring Stations Used for Model Development and Calibration for the Alewife Brook/Mystic River (above) and Charles River (below)**

### 6.4.2 Updates to the Alewife Brook/Mystic River

For the Final Assessment Report, the flow and bacteria load inputs into the Alewife Brook/Upper Mystic River Water Quality Model included CSO and stormwater generated under the 1992 TY by the MWRA's 2019 system conditions collection system model, boundary flow into the Upper Mystic River from the Mystic Lakes, and dry weather base flows. The flows and loads from the collection system model were updated to reflect the collection system conditions represented in the Unified Model, and the boundary and dry weather flows and loads were updated to reflect the 2050 TY conditions. The physical extent of the Alewife Brook/Upper Mystic River water quality model remained the same as presented in the Final Assessment Report (Alewife Brook from Little Pond outlet to the Upper Mystic River, and Upper Mystic River from Mystic Lake outlet to Amelia Earhart Dam). While the other sections of this Plan refer to the Alewife Brook and Mystic River performance separately, the water quality model is one singular, interdependent model for these two systems and is presented here as such.

#### 6.4.2.1 Updates Related to the Unified Model

Time series of flow inputs were incorporated into the Alewife Brook/Upper Mystic River Water Quality Model at the same locations as for the Final Assessment Report, but the flows were updated using the Unified Model under Baseline Conditions (briefly summarized in **Section 6.3.2**) for the 2050 TY. The stormwater and baseflow bacteria concentrations were the same as applied in the Final Assessment Report, as were the sanitary and non-sanitary components of CSO used to compute the time-varying CSO concentrations (**Table 6-5**). The model computed time-varying bacteria concentrations in the CSO based on the computed proportion of sanitary and non-sanitary flow in each model timestep when a CSO discharged. The concentration of the sanitary component of CSO shown in **Table 6-5** was derived through calibration, and it was within the range of influent sampling data influent sampling data at the MWRA's DITP. The non-sanitary component was based on the stormwater concentration and adjusted to better match the calibration.

**Table 6-5. Water Quality Model Parameters – Alewife Brook/Upper Mystic River**

| Bacteria | Stormwater Counts (#/100 mL) | Dry Weather Baseflow Counts (#/100 mL) | CSO Sanitary Fraction Counts (#/100 mL) | CSO non-Sanitary Fraction Counts (#/100 mL) | Upstream Boundary Counts (#/100mL) |
|---|---|---|---|---|---|
| *E. coli* | 25,000 (50,000 upstream of station 083) | 134 (20,000 upstream of station 083) | 2,500,000 | 14,000 | 10 |
| *Enterococcus* | 6,700 (20,000 upstream of station 083) | 45 (3,000 upstream of station 083) | 1,000,000 | 6,700 | 45 |

The proportions of sanitary and non-sanitary components in the CSO changed when using the 2050 TY rainfall pattern. **Table 6-6** presents the flow-weighted sanitary fraction and the flow-weighted average counts of *E. coli* and *Enterococcus* in each of the CSO discharges to Alewife Brook and the Upper Mystic River for the 2050 TY. The flow-weighted average counts at some outfalls increased compared to the previous assessment and decreased at others. The concentration of the treated discharge from the Somerville Marginal CSO Facility did not change, as it was based on a constant value computed from historical effluent sampling data from that facility. The stormwater and baseflow bacteria concentrations were the same as applied in the Final Assessment Report, but the time-varying CSO concentrations generated by the stormwater/sanitary mass balance calculations changed based on the 2050 TY flows.

**Table 6-6. Alewife Brook/Upper Mystic River Predicted Sanitary Fractions and Flow-weighted Counts for the 2050 Typical Year**

| Location | Flow-weighted Sanitary Fraction (%)[1] | Flow-weighted Counts (#/100 mL) | |
|---|---|---|---|
| | | *E. coli* | *Enterococcus* |
| MWR003 | 4.3 | 130,493 | 49,038 |
| CAM401A | 0.1 | 27,225 | 7,593 |
| CAM401B | 10.5 | 284,032 | 110,658 |
| CAM002 | N/A[2] | N/A | N/A |
| CAM001 | 36.5 | 927,207 | 368,786 |
| SOM001A | 1.5 | 62,470 | 21,738 |
| SOM007A/MWR205A (Somerville Marginal CSO Facility Treated Discharge)[3] | <0.01 | 18 | 17 |

**Notes:**

(1) For each untreated CSO outfall, the sanitary fraction shown is the flow weighted average in the discharge pipe over the periods when the outfalls were discharging flow.

(2) N/A = Not Applicable; outfall did not discharge CSO during the 2050 Typical Year.

(3) For SOM007A/MWR205A the sanitary fraction method was not applied to the treated discharge. The flow-weighted counts reflect the average treated discharge counts sampled from the Somerville Marginal CSO Facility effluent in 2018.

#### 6.4.2.2 Updates to Upstream Boundary Flows

The Mystic Lake upstream flow boundary condition for the hydrodynamic model was updated using flow data from the USGS Aberjona River Station to account for changes in watershed response under 2050 TY conditions. The upstream boundary bacteria concentration at the outlet from Mystic Lake was not changed, so the change in bacteria loading from the Mystic Lake upstream boundary was solely a function of the change in upstream boundary flow from the lake. The upstream bacteria concentration was updated based on the Storm Water Management Model (SWMM) runoff formulation using the flow data from the USGS Aberjona River station. The upstream boundaries for Alewife Brook and the Malden River were represented as runoff areas in the Unified Model. The Unified Model Baseline Conditions 2050 TY model run generated the flows at those locations, and the average stormwater concentrations shown in **Table 6-3** were applied to generate the bacterial loads.

#### 6.4.2.3 Updates to Dry Weather Flows

The timing and duration of dry weather flows was revised to reflect the dry weather periods included in the 2050 TY. The bacterial concentrations associated with the dry weather flows did not change.

### 6.4.3 Updates to the Charles River Model

For the Final Assessment Report, the flow and bacteria load inputs into the Charles River Water Quality Model included CSO and stormwater generated under the 1992 TY by the MWRA's 2019 system conditions collection system model, boundary flow into the Lower Charles River Basin from the Watertown Dam, inputs from USGS and BWSC stormwater models, and dry weather base flows. Boundary flow and bacteria loads into the Lower Charles from the Watertown were generated by a separate build up/wash off model. The USGS and BWSC stormwater models covered separate stormwater areas tributary to the Charles River that are not included in the Unified Model. These models also included dry weather base flows from tributary brooks and certain stormwater outfalls. The outputs from the USGS and BWSC stormwater models were used to develop bacterial mass loadings from those separate stormwater areas as inputs to the water quality model.

The CSO flows and loads were updated to reflect the collection system conditions represented in the Unified Model, and the boundary, stormwater, and dry weather flows and loads were updated to reflect the 2050 TY conditions. For example, the USGS, BWSC, and upstream build up/wash off models were run for the 2050 TY rainfall. The physical extent of the Charles River water quality model remained the same as presented in the Final Assessment Report (Watertown Dam to New Charles River Dam).

#### 6.4.3.1 Updates Related to the Unified Model

Using the Unified Model under Baseline Conditions for the 2050 TY, additional stormwater discharge locations were identified and added to the Charles River hydrodynamic and water quality models. Time series of flow inputs were incorporated into the Charles River Water Quality Model at the same locations as for the Final Assessment Report, plus the additional stormwater locations noted. The stormwater and baseflow bacteria concentrations were the same as applied in the Final Assessment Report, as were the sanitary and non-sanitary components of CSO used to compute the time-varying CSO concentrations (**Table 6-7**). The model computed time-varying bacteria concentrations in the CSO based on the computed proportion of sanitary and non-sanitary flow in each model timestep when a CSO discharged. The concentration of the sanitary component of CSO shown in **Table 6-7** was derived through calibration, and it was within the range of influent sampling data at the MWRA's DITP. The non-sanitary component was set equal to the stormwater concentration. The use of time-varying CSO bacteria concentrations was previously demonstrated to provide a better match to measured CSO concentrations over the course of a CSO event compared to assigning a static concentration.

**Table 6-7. Water Quality Model Parameters - Charles River**

| | Stormwater Counts (#/100 mL) | Dry Weather Baseflow Counts (#/100 mL) | CSO Sanitary Fraction Counts (#/100 mL) | CSO non-Sanitary Fraction Counts (#/100 mL) |
|---|---|---|---|---|
| *E. coli* | 14,000 | 134 | 7,000,000 | 14,000 |
| *Enterococcus* | 10,000 | 45 | 1,000,000 | 10,000 |

The proportions of sanitary and non-sanitary contributions in a CSO changed when using the 2050 TY rainfall pattern. **Table 6-8** presents the flow-weighted sanitary fraction and the flow-weighted average counts of *E. coli* and *Enterococcus* in each of the CSO discharges to the Charles River for the 2050 TY. The flow-weighted average counts at some outfalls increased compared to the previous assessment, and they decreased at others. The concentration of the treated discharge from the Cottage Farm CSO Facility did not change, as it was based on a constant value computed from historical effluent sampling data from that facility.

**Table 6-8. Charles River Predicted Sanitary Fractions and Flow-weighted Counts for the 2050 Typical Year**

| Location | Flow-weighted Sanitary Fraction (%)[1] | Flow-weighted Counts (#/100 mL) | |
|---|---|---|---|
| | | *E. coli* | *Enterococcus* |
| CAM005 | <0.01 | 22,655 | 11,227 |
| CAM007 | N/A[2] | N/A | N/A |
| MWR010 | N/A | N/A | N/A |
| MWR023 | <0.01 | 20,056 | 10,858 |
| MWR201 (Cottage Farm CSO Facility Treated Discharge)[3] | <0.01 | 394 | 212 |
| MWR018 | 0.7 | 42,378 | 14,022 |
| MWR019 | 1.1 | 95,674 | 21,577 |
| MWR020 | 0.2 | 26,854 | 11,822 |
| CAM017 | 4.4 | 306,118 | 51,397 |

**Notes:**

(1) For each untreated CSO outfall, the sanitary fraction shown is the flow weighted average in the discharge pipe over the periods when the outfalls were discharging flow.

(2) N/A = Not Applicable; outfall did not discharge CSO during the 2050 Typical Year.

(3) For MWR201 the sanitary fraction method was not applied to the treated discharge. The flow-weighted counts reflect the average treated discharge counts sampled from the Cottage Farm CSO Facility effluent between July 2018 and April 2019.

#### 6.4.3.2 Updates to BWSC and USGS Stormwater Models

The USGS and BWSC stormwater models were run for the 2050 TY rainfall with updated climatological (temperature) data. The stormwater bacteria concentrations were the same as applied in the Final Assessment Report (see **Table 6-7**). These stormwater concentrations were applied to the stormwater flows from these models to generate bacteria mass loading time series inputs to the water quality model. The timing and duration of dry weather flows were revised to reflect the dry weather periods included in the 2050 TY rainfall pattern. The bacterial concentrations associated with the dry weather flows were the same as applied in the Final Assessment Report (see **Table 6-7**). The updated temperature data affected the modeled evapotranspiration rates.

#### 6.4.3.3 Updates to Upstream Boundary Flows

New upstream boundary conditions were developed at the USGS Watertown Dam Station for both flow and bacteria concentrations. The flows and bacteria loads were based on updated build up/wash off modeling for the upstream tributary area and accounted for changes in watershed response expected under 2050 TY conditions.

# 7. Levels of CSO Control and System Baseline Condition

This section establishes the analytical framework for the Updated CSO Control Plan with two critical components:

1. **Levels of CSO Control:** A definition of the performance benchmarks considered for reducing or eliminating CSOs tied to specific design rainfall events (e.g. 2050 TY or 5-year storm).
2. **System Baseline Conditions:** The anticipated collection system configuration against which all proposed alternatives will be measured. This includes an assessment of the system performance under the various levels of control considered and the water quality conditions and pollutant sources.

## 7.1 Background on Levels of Control

A Level of Control (LOC) is defined as the extent to which CSOs are reduced or eliminated by a specific system configuration or intervention under specific rainfall events. These events can include long-term rainfall patterns, such as a Typical Year, or single, intense design storms (e.g., a storm of 24-hour duration having a 5-year recurrence interval, referred to as a 5-year, 24-hour storm). Historically, LTCPs have been developed throughout the country to control CSOs using the Typical Year framework as described in Section 6.2.1. This is consistent with the approach described in the CSO Control Policy, where alternatives are developed and analyzed to achieve a range of levels of control in that given Typical Year. The CSO Control Policy states that “EPA expects the long-term CSO control plan to consider a reasonable range of alternatives. The plan should, for example, evaluate controls that would be necessary to achieve zero overflow events per year, an average of one to three, four to seven, and eight to twelve overflow events per year” (Policy at II.C.4).

The Variances driving this Updated CSO Control Plan explicitly require “an evaluation of the costs and water quality benefits of further CSO control alternatives, up to and including elimination of CSO discharges" for Alewife Brook, Upper Mystic River and the Charles River. Section 6 describes the robust technical process the Partners underwent to develop a first-of-its-kind, climate forward TY and to develop large future design storms for use in meeting this Variance requirement. Using these technical bases, the following presents a comprehensive assessment the LOCs evaluated in this Plan.

### 7.1.1 The Challenge of "CSO Elimination"

While the notion of "CSO elimination" seems straightforward on the surface—implying that a fully separated system with no CSO regulators would eliminate all CSO discharges—achieving absolute elimination in a combined sewer system is technically complex due existing infrastructure constraints as well as extreme climate events. For example, the MWRA LTCP included sewer separation in the combined sewer areas tributary to outfall MWR023 in the Charles River. Modeling of the proposed sewer separation project at the time, however, indicated that several of the CSO regulators tributary to outfall MWR023 would need to remain open after completion of the sewer separation work due to the impact of residual inflow sources that could not be feasibly removed from the system. The sewer separation proceeded as modeled, and while the areas upstream of MWR023 are now fully separate, the CSO regulators remain open to protect the contributing area (see Section 9.8.6 for more details). This example demonstrates that “full sewer separation” does not necessarily mean CSO regulators can be closed or that discharges to the rivers are eliminated.

The Partners investigated how fully separating the combined sewer systems upstream of all outfalls discharging to Alewife Brook, Upper Mystic River and the Charles River would perform under the 2050 TY and the selected 2050 design storms to understand if elimination of the CSOs to those waterbodies, in the traditional sense of the term, would be feasible. Two key issues arose:

- **Upstream Flow Inputs:** Based on the analysis presented in Section 9.2.4, even with full-scale sewer separation, the combination of residual inflow that cannot feasibly be removed from the separated system and I/I entering the interceptor system from outside the Partners' direct area of

influence will create conditions where in some locations overflow relief points would still be needed to avoid upstream flooding and SSOs.

- **Downstream Infrastructure Constraints:** The systems downstream of existing CSO outfalls do not have the capacity to carry more flows. This includes long length of MWRA interceptors, Wastewater Pump Stations and Headworks Facilities, Tunnels to DITP, as well as DITP pumping, treatment, and the ocean outfall capacity. Further discussion of these constraints and the significant cost to reduce or eliminate CSOs through capacity increases in discussed in Section 9.2.5. DITP was designed around these upstream limitations. During wet weather events, one of the bedrock tools that MWRA utilizes to reduce CSO discharges is to maximize the amount of sewage flow to the DITP for treatment. Maximizing flow in this fashion is one of the Nine Minimum Controls set forth in EPA's 1994 CSO Control Policy and the terms of the existing DITP NPDES Permit. As a result of these constraints, strict sewer separation is unable to achieve traditional CSO elimination in this region. The performance of system-wide sewer separation described in Section 9.2.4, and regional sewer separation for Alewife Brook, Upper Mystic River, and Charles River described in Sections 9.5.12, 9.7.14, and 9.9.13 respectively, details the anticipated remaining wet weather discharges under various modeled conditions.

### 7.1.2 Defining "Effective" CSO Elimination

Given these practical limitations, the Partners aimed to establish a reasonable definition of **"effective" CSO elimination**. This concept ties elimination of CSOs to a very large and infrequent storm event. The establishment of what large storm event constitutes effective elimination is not a one-size-fits-all approach, but rather, requires consideration of the system configuration and performance. This assessment is further complicated by uncertainties associated with modeling system performance in storms that are substantially larger than the storms which were used as a basis for calibrating the collection system model (see Section 6.3.2). In very large storms, system inlet capacity, i.e., the ability of surface runoff to enter the collection system through catch basins, can become a limiting factor. Resulting overland surface flooding routes and street gutter flow that are not present during smaller storms can convey flow to different points in the system or can result in surface flows discharging directly to waterways. These conditions are not directly calibrated in the model, and therefore they lead to a higher level of uncertainty in the quantification of CSO volumes in the more extreme rain events.

The Partners sought guidance on what could be considered as elimination from a variety of sources. Through conversations with the regulators and stakeholders, the following feedback was received:

- **Analyze and Quantify Sewer Separation:** While the regulating authorities understand the practical limitations of using sewer separation to achieve full elimination in this system, the Partners were advised to present the full sewer separation evaluation and clearly define the highest LOC that could be achieved under that scenario (even if CSO regulators must remain open). This is presented in Section 9.2.4.
- **Benchmark Against Peer Projects:** The Partners were also advised to consider other projects that defined effective elimination, such as the MWRA's North Dorchester Bay Storage Tunnel. This project, designed between 2003-2006, defined "effective" elimination as CSO control up to the present-day (at the time) 25-year, 24-hour storm event (5.4 inches of rain in 24 hours). That storm was selected for the North Dorchester Bay project because a detailed analysis of that sub-system, including inlet capacity and potential overland flow routes, showed that 5.4 inches of rain in 24 hours represented the limit of the sewer system's capacity to convey flow. For larger storm events, the system would be overwhelmed, leading to SSOs, flooding, and other system challenges that would **create** the same types of public health and water quality issues that CSO elimination aims to mitigate. Therefore, effective elimination was defined for this project as that inflection point where the sewer system is overwhelmed and unable to protect water quality and public health. It is important to note that the storm defining the LOC was selected not because it had a 25-year recurrence interval, but instead because the rainfall associated with that storm (5.4 inches in 24-hours) was found to create the flows that met the system conveyance capacity. This assessment of system capacity is presented in **Section 7.5**.

## 7.2 Levels of CSO Control Evaluated

Based on the guiding principles presented above, the Partners selected four comprehensive LOCs for evaluation to meet the full spectrum as described by the Variances. While traditionally, the LOC established in an LTCP uses present- or backwards-looking rainfall, based on input from the regulators and stakeholders, the Partners agreed at an early stage in this process that it was important to be forward-looking in the development of this Plan. The selected LOCs were therefore assessed against the 2050 rainfall projections (detailed in Section 6) so that alternatives would remain effective under projected climate change impacts.

**Note on Typical Year:** As described in Section 6, the 2050 TY is significantly more severe than the 1992 TY that was the basis of performance for the 2006 LTCP. Because alternatives were developed using the more severe and conservative 2050 conditions, they will inherently achieve a higher level of control when evaluated against the 1992 TY and current rainfall conditions. The assessment in Section 6.2 demonstrated that the 1992 TY is a representative benchmark based on EPA guidance in the CSO Control Policy.

The four levels of CSO control evaluated are described in **Table 7-1**. The “Context” column is provided to assist in deriving a more direct comparison between these future events and the existing regulatory framework. Section 6.2.4 described the multiple design storms that were developed and considered. Two of these design storms are included in the LOCs presented in **Table 7-1**. The 2050 1- and 2-year storms were excluded because the 2050 TY already includes events of these magnitudes. The present-day 10-year storm is a common design storm used to evaluate flooding and system performance; however, since the present-day 10-year storm is more comparable to the 2050 5-year storm, the 2050 5-year storm was selected for inclusion. For comparison, the present day 10-year storm amounts to 5.2 inches in 24 hours while the 2050 5-year storm amounts to 5.3 inches in 24 hours. When considering the larger storms presented in Table 6-3 (10-year, 25-year, 50-year, 100-year), the Partners chose to include the 25-year storm as its extreme rainfall event. While the recurrence interval of this storm (25-years) coincidentally matches that of the storm used to size the North Dorchester Bay Storage Tunnel, it is significantly larger in magnitude (7.8 inches compared to 5.4 inches) and therefore likely represents an upper bound of system capacity.

**Table 7-1. Levels of Control Evaluated in Plan**

| Level of Control | Definition | Context |
|---|---|---|
| **Limited CSOs in the 2050 TY** | Proposed alternatives that significantly reduce, but do not fully eliminate all CSO activations during the 2050 Typical Year. | For some outfalls, allowing limited CSOs to remain in the 2050 TY could greatly benefit the implementation burden, costs, and timeline for alternatives, where a more substantial increase in project size would be required to achieve zero CSOs in the 2050 Typical Year. This approach is consistent with the National CSO Policy language at paragraph II.C.4 cited above regarding the range of levels of control that should be evaluated. |
| **Zero CSOs in the 2050 TY** | Alternatives that eliminate CSO activations during the 2050 Typical Year. | This also results in zero activations under the 1992 TY. |
| **Zero CSOs during the 2050 5-year Storm** | Alternatives that eliminate CSO activations during the 5-year, 24-hour 2050 design storm and for the 2050 TY. | The 2050 5-year storm is comparable in magnitude to the present-day 10-year storm, potentially representing "effective" CSO elimination. |
| **Zero CSOs during the 2050 25-year Storm** | Alternatives that eliminate CSO activations during the 25-year, 24-hour 2050 design storm and for the 2050 TY. | The 2050 25-year storm is comparable in magnitude to a storm exceeding the present-day 50-year storm, potentially representing "effective" CSO elimination. |

## 7.3 Baseline Condition

After developing the Unified Model (described in Section 6.3), the Partners incorporated projects that have been planned or will be implemented independent of the Updated CSO Control Plan that may impact CSO activations or volumes. This scenario—called the Baseline Condition—represents the expected configuration of the combined sewer system at the start of the Plan's implementation phase.

The Baseline Conditions model differs from the 2022 System Conditions model (the system configuration at the start of this Plan's development) because it incorporates several recently completed or ongoing projects. These projects, anticipated to be finalized between 2022 and 2027, go beyond the requirements of the 2006 LTCP and have direct or indirect impacts on overall CSO system performance. Therefore, they are included as the foundational system configuration. The Baseline Conditions model serves as the benchmark (or starting point) against which quantitative metrics—such as CSO reduction, water quality improvements, and flood impact—are measured for the proposed alternatives evaluated in this Plan. The specific projects included in the Baseline Conditions are itemized in **Table 7-2**.

**Table 7-2. List of Ongoing or Planned Projects Included in the Baseline Conditions Model**

| Project Owner | Project Name | Potentially Impacted Outfall(s)/Regulator(s) - Listed Outfall to See Greatest Benefit | Status |
|---|---|---|---|
| MWRA | CHE008 DWF Connection Modification | CHE008 | Completed June 2023 |
| MWRA | BOS017 - Siphon Reconfiguration | BOS017 | Completed October 2024 |
| MWRA | RE062-4 Regulator Modification | BOS062 | Completed July 2024 |
| MWRA | RE064-5 Regulator Modification | BOS064 | Completed July 2024 |
| MWRA | RE065-2 Regulator Modification | BOS065 | Completed July 2024 |
| MWRA | BMI Relief Pipe (RE070/7-2) | BOS070 | Completed December 2024 |
| MWRA | South Boston sewer separation Contracts 1 and 2 | BOS070 | Contract 1 was completed in August 2023 and Contract 2 is anticipated to be completed in April 2026 |
| MWRA | RE013-1 Removal of restrictive nozzle. | BOS013 | Completed in 2024 |
| MWRA | South Boston Sewer Separation Contract 3 | BOS070 | Construction in progress |
| MWRA | East Boston Sewer Separation Phase 3 | BOS003/BOS009 | Completed December 2023 |
| MWRA | East Boston Sewer Separation Phase 4 | BOS003 | Construction in progress |
| MWRA | Roxbury Sewer Separation Contracts 2 and 3 | BOS070 | Completed December 2024 |
| MWRA(1) | Somerville Marginal CSO Facility - New DWF Connection and gate structure including RTC (Task 8.4) | MWR205/SOM007A | Design in progress/Tentatively scheduled completion: December 2026 |
| MWRA(1) | MWR205 - Repair Leaky Tidegate | MWR205/SOM007A | Completed May 2023 |
| Somerville | Somerville Ave Utility and Streetscape Improvements Project (SAUSI) | Prison Point (MWR203) | Completed in 2023 |
| Somerville | Spring Hill Sewer Separation Phase 1 | Prison Point (MWR203) | Completed in 2025 |
| Somerville | Poplar St Pump Station | Prison Point (MWR203) | Construction in progress/Tentatively scheduled completion: 2027 |
| Cambridge(1) | Tobin School 1MG Stormwater Storage Tank | Formerly CAM004 | Completed in 2025 |
| Cambridge | Gore Street Utility Upgrades (does not include separation) | Prison Point (MWR203) | Completed in 2022 |
| Cambridge(1) | Inman Square Sewer Separation | CAM017 | Completed in 2023 |
| Cambridge(1) | Willard Street Sewer Separation and Outfall | CAM005 | Completed in 2024 |
| Cambridge(1) | River Street Sewer Separation | MWRA Cottage Farm | Construction in progress/Tentatively scheduled completion: 2026 |
| Cambridge | Monsignor O'Brien Highway Sewer Separation | Prison Point (MWR203) | Completed in 2020 |
| Cambridge(1) | Sherman Street I/I Mitigation – Redirection of I/I flows | CAM401A | Completed in 2023 |
| Cambridge(1) | Land Boulevard Sewer Separation | CAM017 | Completed in 2024 |
| Cambridge(1) | Broadway Drain Upsize (Galileo to Ames and 3rd to Broad) | CAM017 | Completed in 2024 |

**Note:**
(1) Projects impacting outfalls outside the Variances

## 7.4 Level of CSO Control Under Baseline Condition

Before developing alternatives to achieve the four LOCs described in **Section 7.2**, it is critical to understand the performance of the current system for these four LOC scenarios. **Table 7-3** and **Table 7-4** illustrate the system performance for the 2022 System Conditions model and the Baseline Conditions model for the 1992 TY, the 2050 TY, and the 2050 5-year and 25-year storms.

The Baseline Conditions model provides varying levels of improvement within each of the three waterbodies with respect to the 2022 System Conditions model, demonstrating that projects executed in recent years are effective at reducing CSOs even if their primary goal was not solely CSO abatement. **Table 7-3** quantifies those CSO reductions.

This comparison also underscores the impact of using future climate projections: the 2050 TY is significantly more severe than the 1992 TY. This greater severity in precipitation volume and/or intensity generates more CSO activations with larger volumes under the same system conditions. For instance, CSO volumes approximately double in the Alewife Brook (from 9.89 MG to 20.86 MG) and increase around twenty times in the Upper Mystic River (from 1.30 MG to 29.31 MG) when comparing the performance in the 1992 and 2050 TYs for the Baseline Condition.

The proposed CSO control alternatives evaluated in this Plan were developed assuming these more severe 2050 conditions, and the resulting 2050 Baseline Level of Control serves as the primary benchmark to determine reduction effectiveness. With this approach, any chosen alternative provides an even higher level of control when evaluated using the 1992 TY.

**Table 7-3. 2022 System Conditions Model Level of CSO Control Results with the 1992 TY, 2050 TY, and 2050 Large Design Storms**

| Outfall | 1992 Typical Year[1] | | 2050 Typical Year[1] | | 2050 5-Year, 24-Hour Design Storm[1][2] | 2050 25-Year, 24-Hour Design Storm[1][2] |
|---|---|---|---|---|---|---|
| | Activation Frequency | Volume (MG) | Activation Frequency | Volume (MG) | Volume (MG) | Volume (MG) |
| **Alewife Brook** | | | | | | |
| CAM001 | 0 | 0.00 | 1 | 0.02 | 0.21 | 0.54 |
| CAM002 | 0 | 0.00 | 0 | 0.00 | 0.20 | 0.70 |
| CAM401A | 8 | 5.68 | 14 | 11.73 | 8.79 | 17.16 |
| CAM401B | 1 | 0.03 | 3 | 0.30 | 1.30 | 2.83 |
| MWR003 | 2 | 0.13 | 3 | 1.09 | 5.65 | 10.74 |
| SOM001A | 8 | 4.46 | 13 | 8.54 | 5.11 | 8.57 |
| **Alewife Brook (Max/Total)** | **8** | **10.30** | **14** | **21.68** | **21.26** | **40.54** |
| **Upper Mystic River** | | | | | | |
| SOM007A/MWR205A | 2 | 2.22 | 14 | 38.32 | 18.76 | 27.58 |
| **Upper Mystic River Total** | **2** | **2.22** | **14** | **38.32** | **18.76** | **27.58** |
| **Charles River** | | | | | | |
| CAM005 | 3 | 0.22 | 6 | 0.80 | 1.71 | 4.28 |
| CAM007 | 0 | 0.00 | 0 | 0.00 | 6.22 | 16.15 |
| CAM017 | 0 | 0.00 | 3 | 1.02 | 13.25 | 26.97 |
| MWR010 | 0 | 0.00 | 0 | 0.00 | 1.36 | 3.71 |
| MWR018 | 3 | 0.63 | 4 | 2.06 | 2.16 | 3.29 |
| MWR019 | 2 | 0.36 | 3 | 1.39 | 1.65 | 2.52 |
| MWR020 | 2 | 0.41 | 3 | 3.46 | 6.34 | 10.0 |
| MWR201 - Cottage Farm | 2 | 7.72 | 4 | 34.98 | 34.80 | 57.69 |
| MWR023 [3] | 3 | 0.05 | 6 | 0.13 | 0.27 | 0.56 |
| **Charles River (Max/Total)** | **3** | **9.39** | **6** | **43.84** | **67.76** | **125.17** |

**Notes:**

(1) Results reflect CSO activations and volumes in 2022 system conditions without any of the CSO control improvements evaluated in this Plan.

(2) Discharge volumes during storms larger than the 2050 Typical Year are estimates that may not account for overland flows that could potentially affect the CSO discharge volumes, and the model used was calibrated to smaller storm events.

(3) Values represent the portion of CSO discharge to the Charles River from the 046 regulators that activate and discharge at outfall MWR023 when Boston Gatehouse No. 1 is open. Approximately 25% of the volume from the 046 regulators discharges at outfall MWR023 when Boston Gatehouse No. 1 is open.

## Table 7-4. Baseline Condition Level of CSO Control Results with the 1992 TY, 2050 TY and 2050 Large Design Storm

| Outfall | 1992 Typical Year | | 2050 Typical Year | | 2050 5-Year, 24-Hour Design Storm[1] | 2050 25-Year, 24-Hour Design Storm[1] |
|---|---|---|---|---|---|---|
| | Activation Frequency | Volume (MG) | Activation Frequency | Volume (MG) | Volume (MG) | Volume (MG) |
| **Alewife Brook** | | | | | | |
| CAM001 | 0 | 0.00 | 1 | 0.02 | 0.21 | 0.54 |
| CAM002 | 0 | 0.00 | 0 | 0.00 | 0.20 | 0.70 |
| CAM401A | 8 | 5.29 | 12 | 10.95 | 8.43 | 16.75 |
| CAM401B | 1 | 0.02 | 3 | 0.30 | 1.29 | 2.82 |
| MWR003 | 2 | 0.13 | 3 | 1.08 | 5.63 | 10.70 |
| SOM001A | 8 | 4.45 | 13 | 8.51 | 5.10 | 8.56 |
| **Alewife Brook (Max/Total)** | **8** | **9.89** | **13** | **20.86** | **20.86** | **40.07** |
| **Upper Mystic River** | | | | | | |
| SOM007A/MWR205A | 2 | 1.30 | 8 | 29.31 | 17.42 | 27.17 |
| **Upper Mystic River Total** | **2** | **1.30** | **8** | **29.31** | **17.42** | **27.17** |
| **Charles River** | | | | | | |
| CAM005 | 1 | 0.19 | 6 | 0.73 | 1.61 | 4.13 |
| CAM007 | 0 | 0.00 | 0 | 0.00 | 5.92 | 15.72 |
| CAM017 | 0 | 0.00 | 3 | 1.04 | 12.54 | 24.96 |
| MWR010 | 0 | 0.00 | 0 | 0.00 | 1.32 | 3.62 |
| MWR018 | 3 | 0.50 | 4 | 1.86 | 2.14 | 3.24 |
| MWR019 | 2 | 0.26 | 3 | 1.33 | 1.63 | 2.48 |
| MWR020 | 2 | 0.28 | 3 | 3.14 | 6.21 | 9.86 |
| MWR201 - Cottage Farm | 2 | 6.59 | 4 | 29.81 | 33.84 | 55.92 |
| MWR023[2] | 3 | 0.05 | 6 | 0.13 | 0.26 | 0.57 |
| **Charles River (Max/Total)** | **3** | **7.87** | **6** | **38.04** | **65.47** | **120.5** |

**Notes:**

(1) Discharge volumes during storms larger than the Typical Year are estimates that may not account for overland flows that could potentially affect the CSO discharge volumes, and the model used was calibrated for smaller storm events.

(2) Values represent the portion of CSO discharge to the Charles River from the 046 regulators that activate and discharge at outfall MWR023 when Boston Gatehouse No. 1 is open. Approximately 25% of the volume from the 046 regulators discharges at outfall MWR023 when Boston Gatehouse No. 1 is open.

## Table 7-5. CSO Reductions due to Implementation of Baseline Projects and List of Projects with the Most Direct Reduction Impacts

| Outfall | 1992 Typical Year | | 2050 Typical Year | | 2050 5-Year, 24-Hour Design Storm | 2050 25-Year, 24-Hour Design Storm |
|---|---|---|---|---|---|---|
| | Change in Activation Frequency | Change in Volume (MG) | Change in Activation Frequency | Change in Volume (MG) | Change in Volume (MG) | Change in Volume (MG) |
| **Alewife Brook** | | | | | | |
| CAM001 | 0 | 0.00 | 0 | 0.00 | 0.0 | 0.00 |
| CAM002 | 0 | 0.00 | 0 | 0.00 | 0.0 | 0.00 |
| CAM401A | 0 | -0.39 | -2 | -0.78 | -0.4 | -0.41 |
| CAM401B | 0 | -0.01 | 0 | 0.00 | 0.0 | -0.01 |
| MWR003 | 0 | 0.00 | 0 | -0.01 | 0.0 | -0.04 |
| SOM001A | 0 | -0.01 | 0 | -0.03 | 0.0 | -0.01 |
| **Alewife Brook (Max/Total)** | **0** | **-0.41** | **-1(1)** | **-0.82** | **-0.4** | **-0.47** |
| **Upper Mystic River** | | | | | | |
| SOM007A/MWR205A | 0 | -0.92 | -6 | -9.01 | -1.34 | -0.41 |
| **Upper Mystic River Total** | **0** | **-0.92** | **-6** | **-9.01** | **-1.34** | **-0.41** |
| **Charles River** | | | | | | |
| CAM005 | -2 | -0.03 | 0 | -0.07 | -0.10 | -0.15 |
| CAM007 | 0 | 0.00 | 0 | 0.00 | -0.30 | -0.43 |
| CAM017 | 0 | 0.00 | 0 | 0.02 | -0.71 | -2.01 |
| MWR010 | 0 | 0.00 | 0 | 0.00 | -0.04 | -0.09 |
| MWR018 | 0 | -0.13 | 0 | -0.20 | -0.02 | -0.05 |
| MWR019 | 0 | -0.10 | 0 | -0.06 | -0.02 | -0.04 |
| MWR020 | 0 | -0.13 | 0 | -0.32 | -0.13 | -0.14 |
| MWR201 - Cottage Farm | 0 | -1.13 | 0 | -5.17 | -0.96 | -1.77 |
| MWR023 | 0 | 0.00 | 0 | 0.00 | -0.01 | 0.01 |
| **Charles River (Max/Total)** | **0(1)** | **-1.52** | **0** | **-5.80** | **-2.29** | **-4.67** |

**Notes:**

(1) Since the activation frequencies are the totals, the overall change in activation frequency may not match the changes at individual outfalls. For example, while CAM401A frequency decreased by 2 activations in the 2050 TY, the overall change in activation frequency in the Alewife Brook decreased by just 1 since the maximum activation at SOM001A remained at 13 total activations.

## 7.5 Collection System Capacity and Flooding Under Large Future Storms

In addition to understanding CSO activations and volumes during large storm events, it is also imperative to understand how the collection system performs in these large design storms. **Section 7.1.2** described the guidance the Partners received in selecting LOCs that evaluate the full spectrum of CSO elimination, and one of these components was to evaluate the system performance in large storm events to identify where the collection system reaches its conveyance capacity. For the North Dorchester Bay Storage Tunnel, that capacity was realized at a storm size of 5.4 inches in 24-hours. The Partners selected two LOCs around and far surpassing this storm size: the 2050 5-year storm (5.3 inches in 24-hours) and the 2050 25-year storm (7.8 inches in 24-hours).

**Figure 7-1** through **Figure 7-6** show the collection system performance across each LOC. **Figure 7-1**, **Figure 7-3** and **Figure 7-5** show the manhole locations where the system is full in the largest storm in the 2050 TY, the 2050 5-year, and 2050 25-year storms, respectively. A flooded manhole indicates that water cannot get into the sewer and stormwater pipes, thus indicating system capacity. **Figure 7-2**, **Figure 7-4**, and **Figure 7-6** each show the corresponding picture of how that trapped stormwater, and potential SSOs, would pool aboveground, according to topography, causing flooding in low lying areas for each respective storm. Riverine flooding from the Alewife Brook is not part of this model because the unified model is a one-dimensional network model that is not able to represent or quantify overland flooding from the brook. To account for this, another model that includes a representation of the ground surface was used to generate a representative area of aboveground flooding around Alewife Brook. **Figure 7-2**, representing flooding in the 2050 TY, shows no flooding outside of the Alewife Brook extents; however, some storms in the 2050 TY may flood the adjacent low-lying recreational pathways beyond the river extents shown because the parts of the path lie within the lowest reaches of the floodplain. **Figure 7-4** and **Figure 7-6**, illustrating flooding in the 2050 5-year and 25-year storms, show a common, representative area of inundation outside of the parkway toward streets and homes that are subject to flooding in these large design storms.

The sewer and stormwater systems both perform relatively effectively in the largest storm in the 2050 TY (**Figure 7-2**), but at more intense future storm conditions (both the 2050 5- and 25-year storms), the infrastructure is already full (**Figure 7-4, Figure 7-6**), and significant surcharging and flooding occurs as the system is overwhelmed. These conditions in both the 5- and 25-year storm events are predicted by the hydraulic model to lead to SSOs, flooding, and other system failures that result in the same types of public health and water quality issues as CSOs. The local system failures that gave rise to the 25-year LOC as the definition of “effective elimination” for Dorchester Bay are present in this area at or below the 2050 5-year storm. The Partners developed and evaluated alternatives to achieve these two LOCs, but these performance limitations will factor into the ultimate evaluations in selecting a LOC and a recommend alternative for each waterbody.

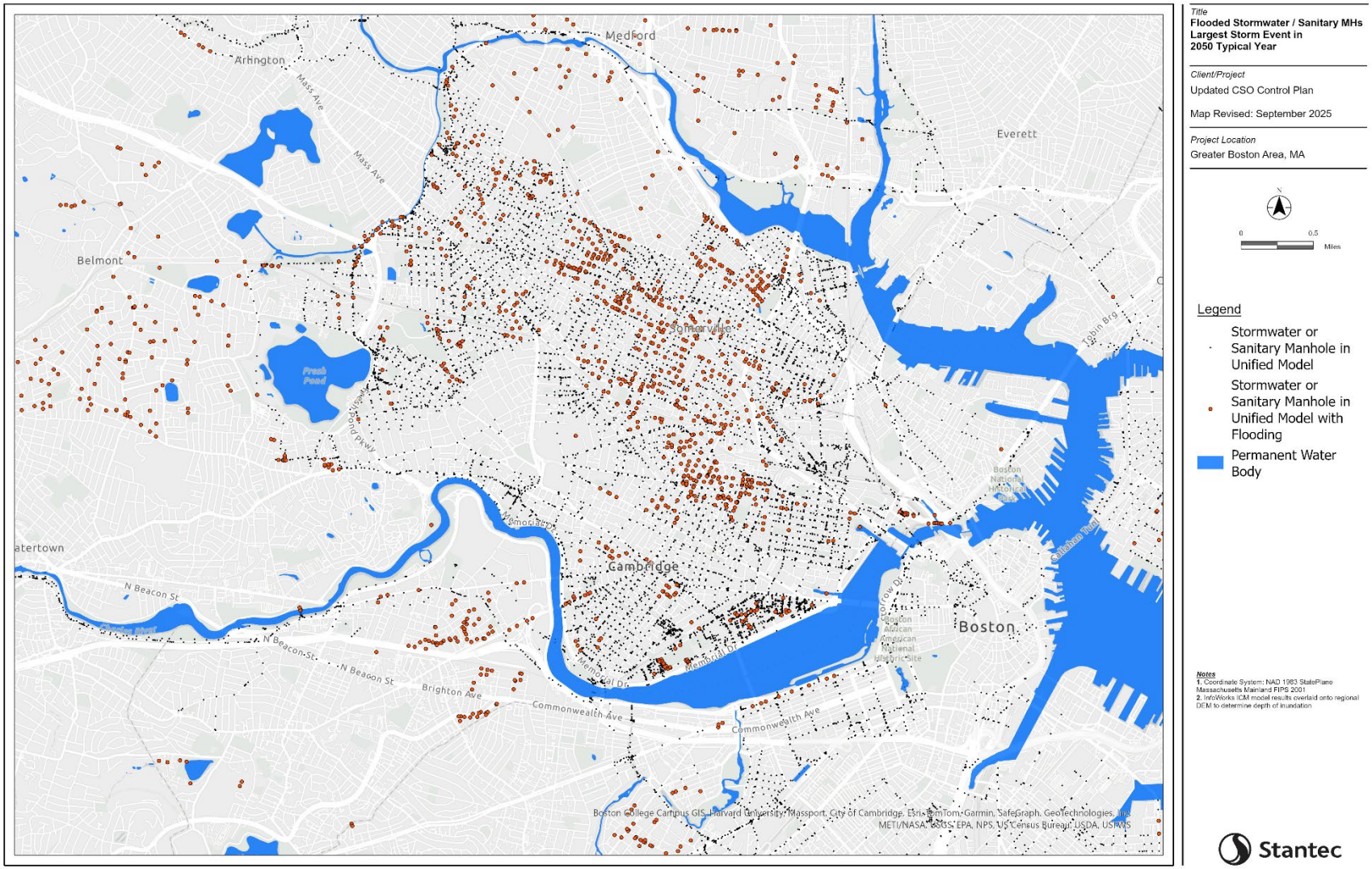



**Figure 7-1. System Performance in Largest Storm in 2050 Typical Year: Manhole Flooding**

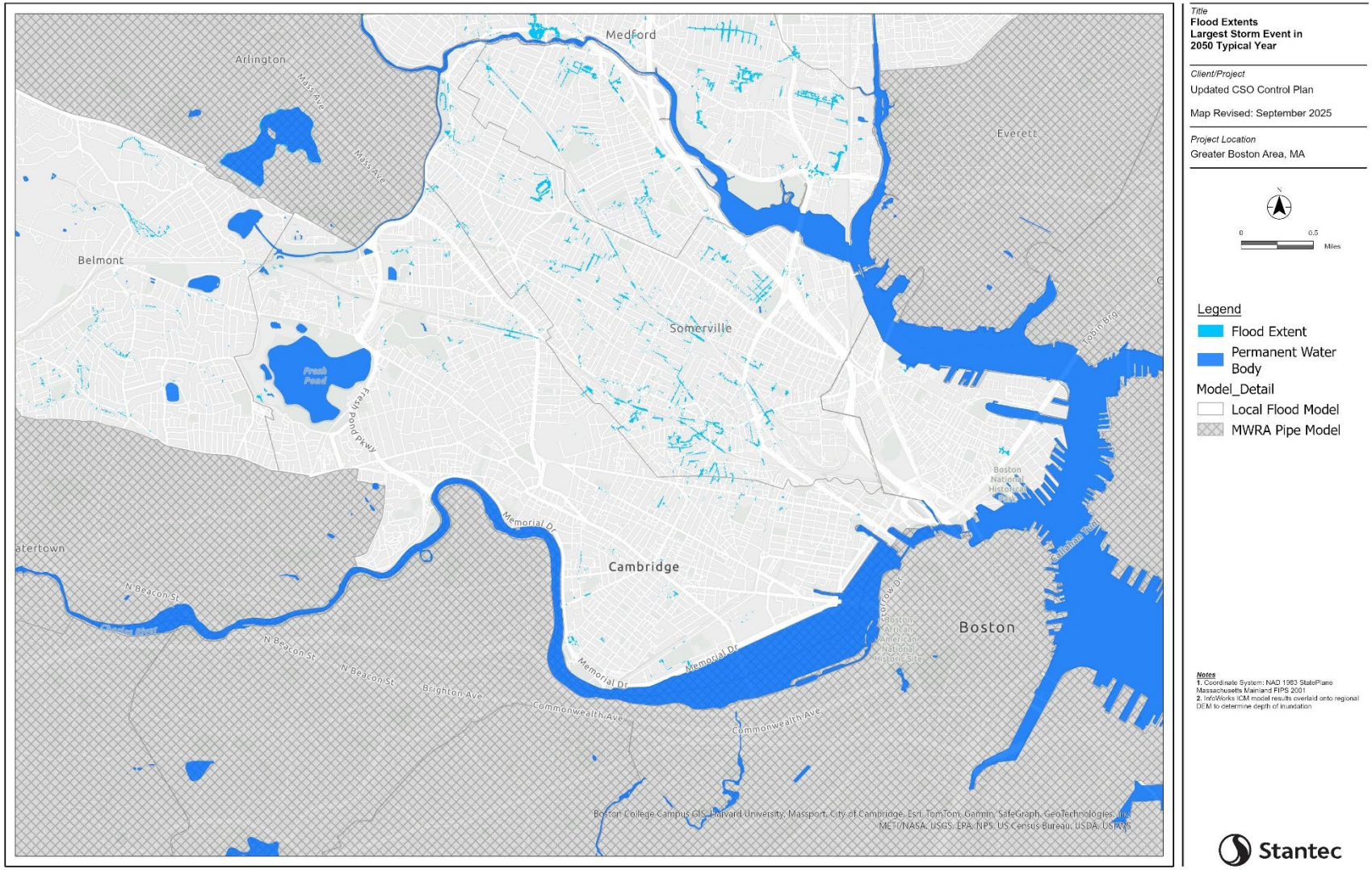



**Figure 7-2. System Performance in Largest Storm in 2050 Typical Year: Flooding Extents**

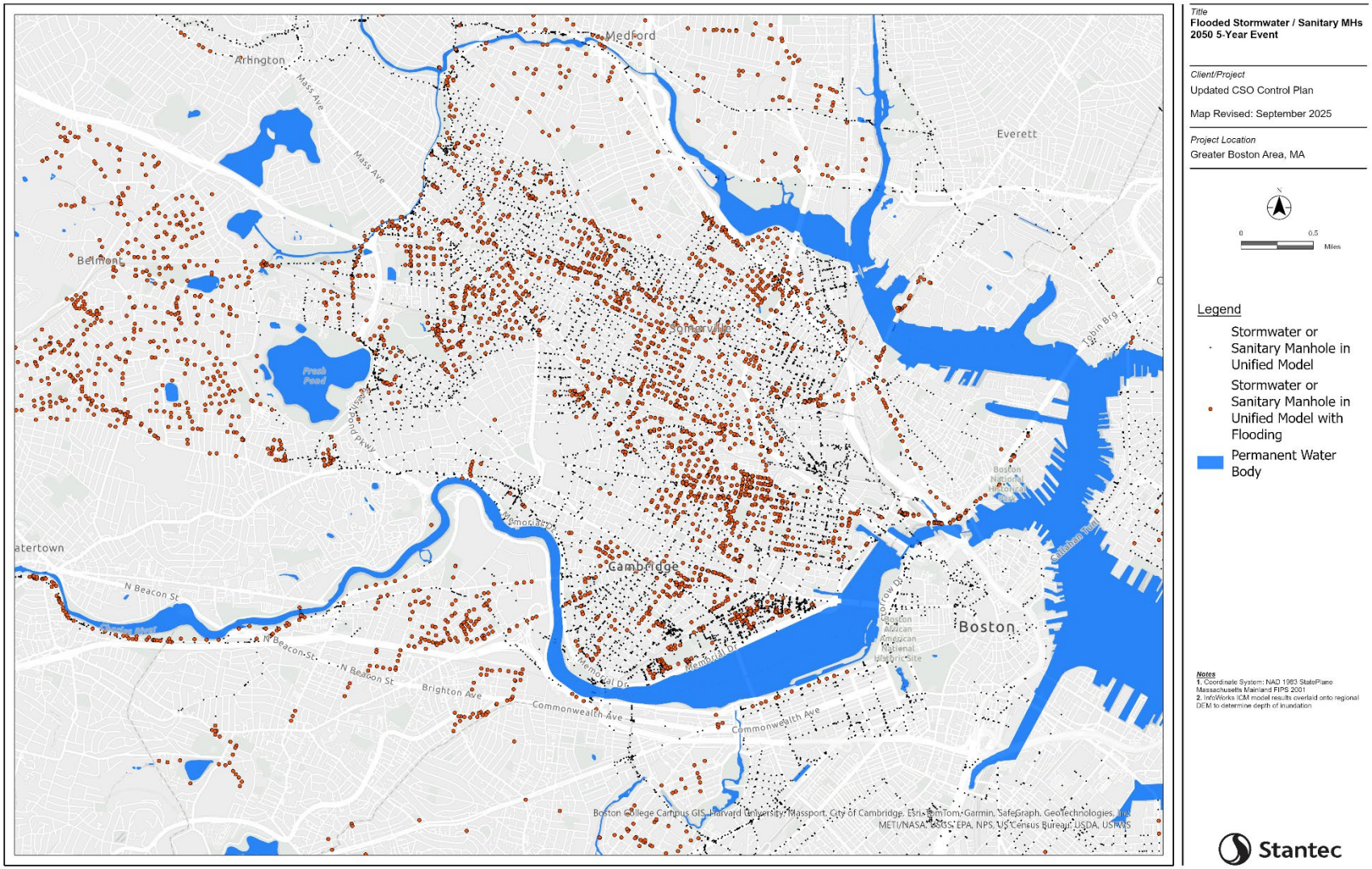



**Figure 7-3. System Performance in 2050 5-Year Storm: Manhole Flooding**

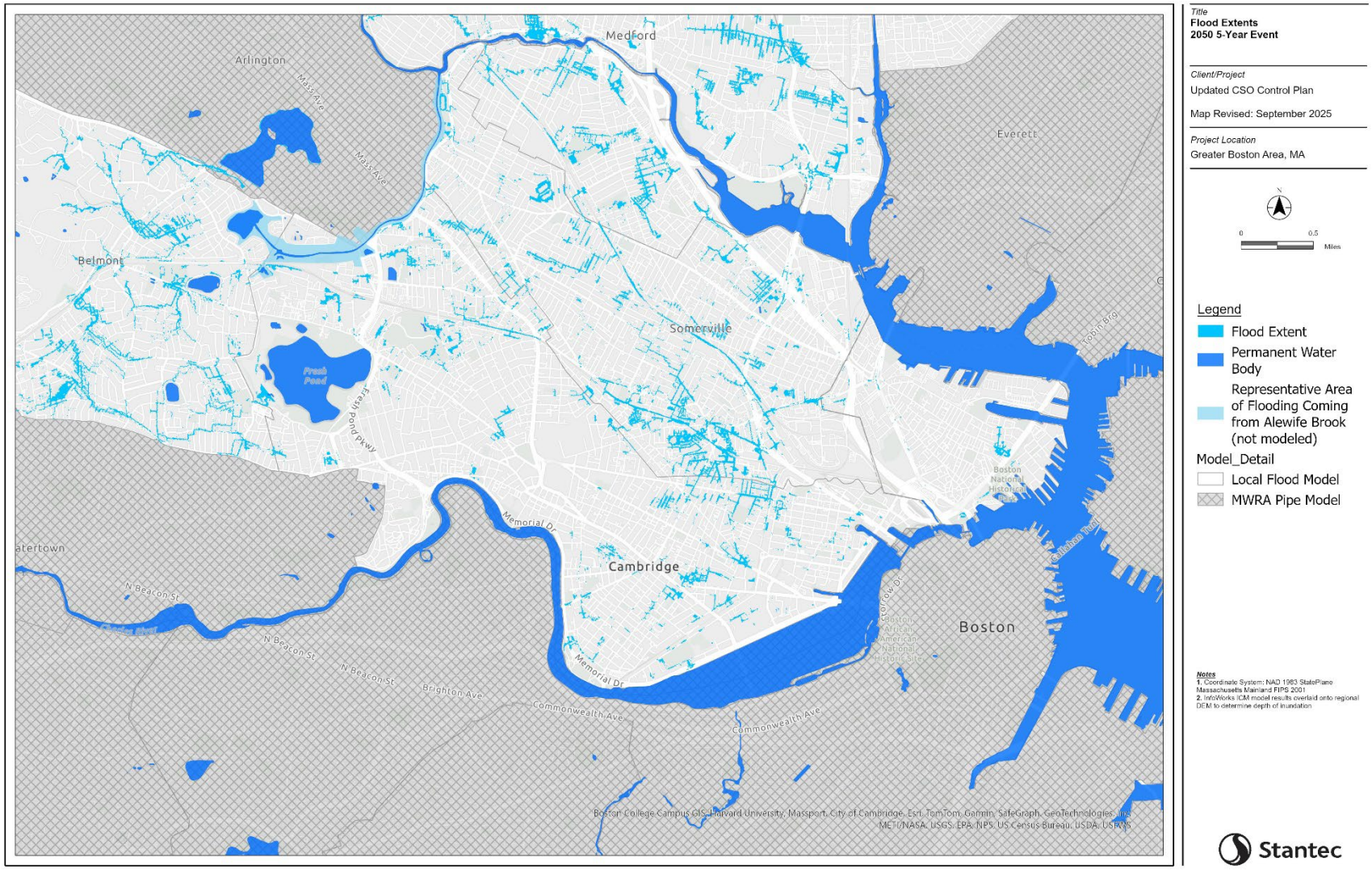



**Figure 7-4. System Performance in 2050 5-Year Storm: Flooding Extents**

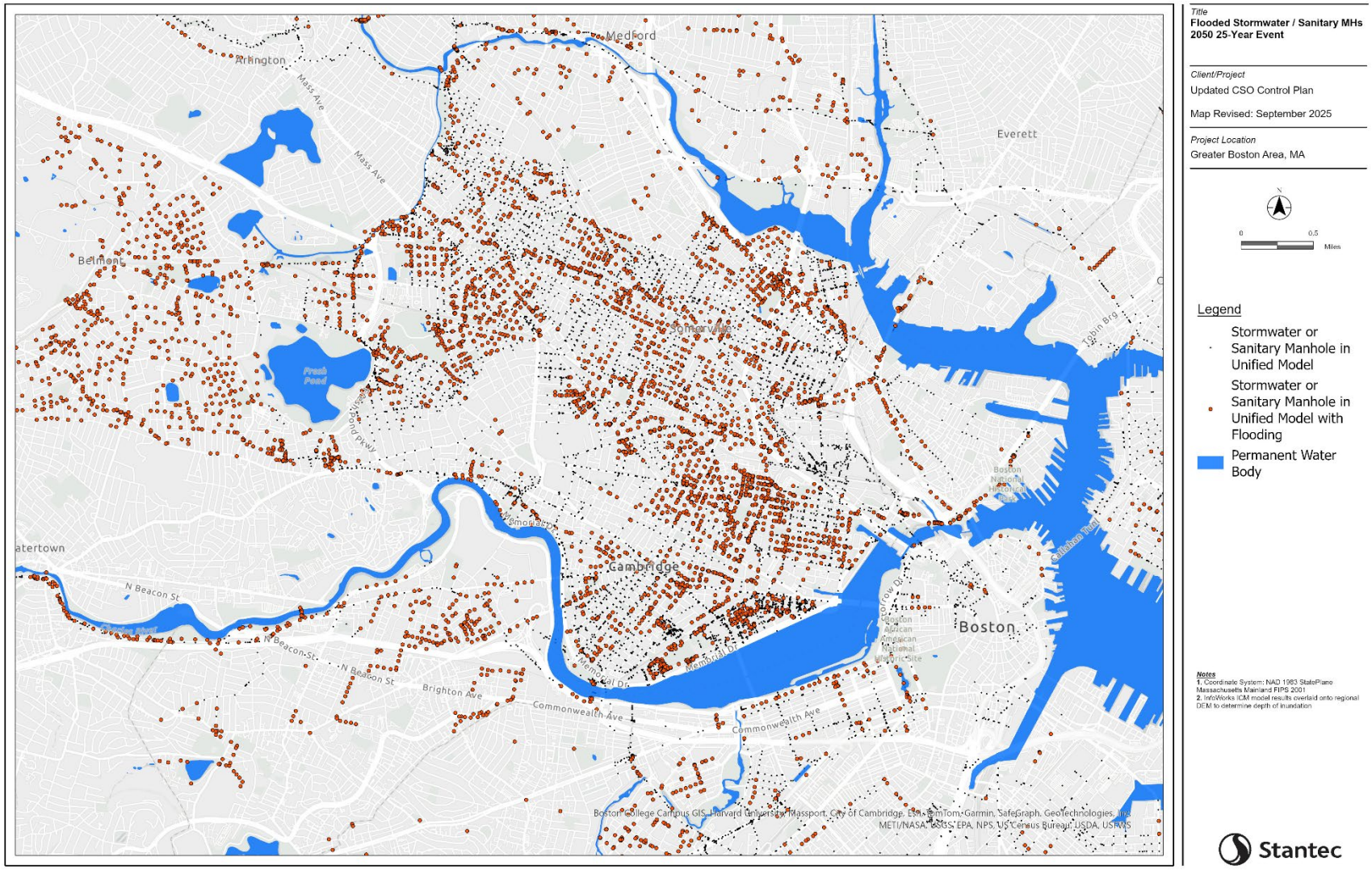



**Figure 7-5. System Performance in 2050 25-Year Storm: Manhole Flooding**

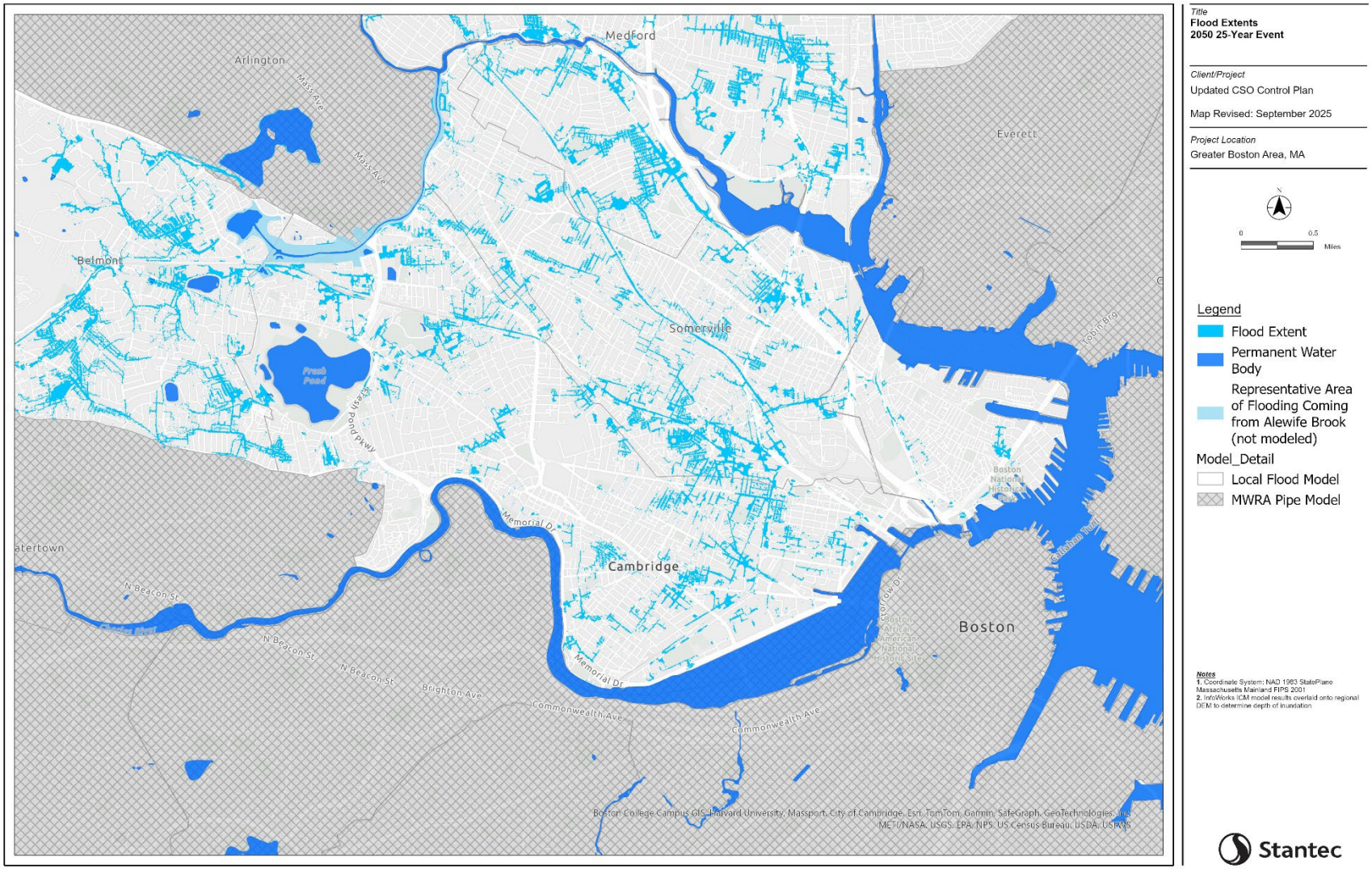



**Figure 7-6. System Performance in 2050 25-Year Storm: Flooding Extents**

## 7.6 Baseline Assessment of Attainment of Current Water Quality Criteria

This section presents a baseline assessment of water quality in the Alewife Brook, Upper Mystic River, and the Charles River. While **Section 7.4** described the CSO activations and volumes predicted to be discharged under Baseline Conditions, this section evaluates the bacteria loads from those CSOs and their overall impact on water quality in these receiving waters.

**Section 6.4** detailed the process for developing and updating the receiving water quality models that are maintained by MWRA (one combined model Alewife Brook/Mystic River, and one model for the Charles River). The baseline water quality assessments were based on a continuous simulation of the 2050 TY, with the system conditions as represented by Baseline Conditions. As described in Section 6, bacteria concentrations used for point sources in the model are based on sampling conducted on dry weather wastewater flow, stormwater outfall discharges, and CSO outfall discharges. The water quality models were calibrated to reflect actual bacteria concentrations observed in these receiving waters during intensive sampling conducted in 2018 and 2019. Output from the baseline assessments include tabulations of the volumes and bacterial loadings from the various bacteria sources for the 2050 TY and graphical representations of the model outputs.

The analyses presented below focus on results for *E. coli.* Similar analyses for *Enterococcus* are presented in Appendix D.

### 7.6.1 Baseline Water Quality Assessment - Alewife Brook/Upper Mystic River

The Alewife Brook/Upper Mystic River 1-dimensional water quality model was run for the 2050 TY with a 90-day period added prior to the start of the TY to establish appropriate antecedent conditions for the start of the year. The rainfall for the 90-day start-up period was copied from the final 90 days in the 2050 TY rainfall. As this is a 1-dimensional model for these waterbodies, the output was generated in the form of *E. coli* and *Enterococcus* counts at 15-minute intervals at each defined segment along the linear model.

The format of the model output from the Alewife Brook/Upper Mystic River water quality model differs from the output presented for the Charles River. As noted in Section 6, Alewife Brook/Upper Mystic River model output is presented as linear river segments where modeled concentrations are computed for the entire segment, with no differentiation across the width of the segment. The one-dimensional model was considered to be appropriate for Alewife Brook/Upper Mystic River given the relatively narrow widths of Alewife Brook and most of the Upper Mystic River.

Simulations were conducted for the following conditions for both *E. coli* and *Enterococcus*:

- All-Sources;
- Non-CSO Sources Only;
- Stormwater Only; and
- CSO Only.

Because the bacteria fate and transport model is linear, in-stream bacteria counts due to the different sources are additive. In the model runs for the individual sources, the bacterial counts in the other sources were set to zero, but the flows from the other sources were retained.

The following sections present the bacterial mass loadings from the various sources to Alewife Brook and the Upper Mystic River for the 2050 TY Baseline Conditions, and an assessment of the impacts of those loadings to the Alewife Brook/Upper Mystic River in terms of:

- Single sample maximum criteria;
- 30-day geometric mean criteria;
- 30-day STV criteria;

- Maximum bacteria concentrations; and
- Change in bacteria concentration over time.

The single sample maximum was assessed at MassDEP's recommendation, and the 30-day geometric mean and 30-day STV criteria are part of the SWQS in 314 CMR 4.05 (presented in Section 2.1.2). The maximum concentrations and changes over time aim to capture acute and time-sensitive impacts of CSOs.

#### 7.6.1.1 Volume and *E. coli* Loadings

**Table 7-6** presents a summary of the 2050 TY Baseline Condition volumes and *E. coli* loads to Alewife Brook, and **Table 7-7** provides a similar summary for the Upper Mystic River. As indicated in **Table 7-6**, the single largest source of volume to Alewife Brook is the continuous dry weather flow, with stormwater the next largest source. CSOs contribute less than 1% of the total annual volume. In terms of *E. coli* loading, stormwater is the predominant source at just under 80%. The sanitary component of CSO contributes 10% of the total annual load, and the stormwater component of CSO contributes another 8%.

**Table 7-6. Alewife Brook 2050 Typical Year Baseline Conditions Volumes and *E. coli* Loads**

| Source | Alewife Brook 2050 Typical Year Baseline Conditions | | | |
|---|---|---|---|---|
| | Volume | | *E. coli* | |
| | Volume (MG) | Percent of Total | Loading (counts x $10^{12}$) | Percent of Total |
| Untreated CSO(1) | 21 | 0.9% | Sanitary Component: 25<br>Stormwater Component: 20 | 10%<br>8% |
| Treated CSO(2) | 0 | 0 | 0 | 0% |
| Stormwater | 216 | 9% | 204 | 78% |
| Dry Weather(3) | 2,269 | 91% | 12 | 4% |
| Boundary(4) | 0 | 0 | 0 | 0% |
| **Total** | **2,506** | **100%** | **260** | **100%** |

**Notes:**
(1) Untreated CSO includes a sanitary sewage component and a stormwater component.
(2) No treated CSOs discharge to Alewife Brook.
(3) Dry weather sources include continuous dry weather flows from tributary brooks and storm drains
(4) Upstream flows into Alewife Brook were categorized as stormwater in the model, and a unique "boundary" flow was not defined.

As indicated in **Table 7-7**, the single largest source of volume to the Upper Mystic River is the flow coming into the river from the Mystic Lakes, followed by stormwater and dry weather sources. Treated CSOs contribute less than 1% of the total annual volume. Stormwater is the predominant source of *E. coli* loading at just over 70%. The treated CSO contributes less than 0.01% of the total annual load. No untreated CSOs discharge directly to the Upper Mystic River, but as described in more detail below, the influence of the Alewife Brook CSOs can be seen in the *E. coli* concentrations in the Upper Mystic River. Since Alewife Brook and the Upper Mystic River are together part of a single continuous model, the loadings from the untreated CSOs in Alewife Brook that flow into the Upper Mystic River are accounted for within the model and were not quantified as an "external" boundary source.

**Table 7-7. Upper Mystic River 2050 Typical Year Baseline Conditions Volumes and *E. coli* Loads**

| Source | Upper Mystic River 2050 Typical Year Baseline Conditions | | | |
|---|---|---|---|---|
| | Volume | | *E. coli* | |
| | Volume (MG) | Percent of Total | Loading (counts x $10^{12}$) | Percent of Total |
| Untreated CSO(1) | 0 | 0 | 0 | 0% |
| Treated CSO(2) | 27 | 0.1% | 0.018 | <0.01% |
| Stormwater | 1,366 | 6% | 1,293 | 74% |
| Dry Weather(3) | 5,233 | 21% | 147 | 8% |
| Boundary(4) | 17,915 | 73% | 312 | 18% |
| **Total** | **24,541** | **100%** | **1,753** | **100%** |

**Notes:**
(1) No untreated CSOs discharge directly to the Upper Mystic River.
(2) Treated CSO from the MWRA Somerville Marginal CSO Facility receives screening, disinfection and dechlorination.
(3) Dry weather sources are continuous dry weather flows from tributary brooks and storm drains.
(4) Boundary sources are from dry and wet weather flows into the Upper Mystic River from the Mystic Lakes.

The impacts of these loadings on modeled *E. coli* concentrations in Alewife Brook and the Upper Mystic River are presented in the sections below.

#### 7.6.1.2 Attainment of Single Sample Maximum Criteria

Section 2 described the Massachusetts SWQS for Class B waterways (314 CMR 4.05), which currently includes geometric mean and 90th percentile STV criteria for *E. coli* and *Enterococcus*. Prior to 2021, the Class B Standards were based on geometric mean and single-sample maximum criteria. In the MWRA's Final Assessment Report, compliance was assessed in terms of the more stringent single-sample maximum criteria (235 #100mL for *E. coli*, 61 #/100mL for *Enterococcus*). While the new criteria expressed in 314 CMR 4.05 no longer include a single sample maximum, MassDEP recommended that the Updated CSO Control Plan include an assessment of attainment with a single sample maximum value based on the 90th percentile STV for *E. coli* and *Enterococcus*.

The single sample maximum criteria were assessed using two approaches. The first approach computed percent attainment based on the proportion of modeled time in which bacterial concentrations at every defined segment along the linear model remained below the single sample maximum criterion. This approach presents a conservative assessment of the condition of the river, as the model segments where exceedances occur shift in time, and the extent of exceedance in any one model timestep may be only a fraction of the total river length.

To address the spatial variability of bacteria concentrations, a second approach included creating longitudinal plots of hours of criteria exceedance along Alewife Brook and the Upper Mystic River for the individual model segments. With these plots, the percent of river length achieving varying levels of annual attainment of the single sample maximum criteria could be assessed.

**Table 7-8** summarizes the percent attainment of the single sample maximum criteria for both *E. coli* and *Enterococcus* for the 2050 TY, using the first approach described above. As indicated in **Table 7-8**, for both *E. coli* and *Enterococcus*, no differences were predicted in the percent attainment for All Sources compared to Non-CSO Sources for either Alewife Brook or the Upper Mystic River. Thus, elimination of CSO would not change this assessment of attainment. Attainment with Stormwater Only was only a few percentage points higher than for All Sources. With CSOs Only, annual attainment was 99% for Alewife Brook and 96% for Upper Mystic River. Since the only CSO discharge directly into the Upper Mystic River

is the treated CSO discharge at outfall SOM007A/MWR205A, the non-attainment in the Upper Mystic River is driven by the CSO loads coming into the Upper Mystic River from Alewife Brook.

**Table 7-8. Alewife Brook and Upper Mystic River Percent Annual Attainment of the Single Sample Maximum Criteria for the 2050 Typical Year**

| Percentage Time Entire Modeled River Meets the Single Sample Maximum Criteria(1) – 2050 Typical Year Baseline Conditions | | | | | | | |
|---|---|---|---|---|---|---|---|
| *E. coli* (410 #/100mL) | | | | *Enterococcus* (130 #/100mL) | | | |
| All Sources | Non-CSO Sources | CSO Only | Stormwater Only | All Sources | Non-CSO Sources | CSO Only | Stormwater Only |
| **Alewife Brook** | | | | | | | |
| 41% | 41% | 99% | 43% | 42% | 42% | 99% | 45% |
| **Mystic River** | | | | | | | |
| 52% | 53% | 96% | 54% | 53% | 54% | 97% | 57% |

**Notes:**
(1) Based on guidance from MassDEP, model results were analyzed for a single sample maximum equivalent to the value of the Class B Statistical Threshold Value Criterion for bacteria.

**Figure 7-7** shows the Alewife Brook and Upper Mystic River with stationing values at major landmarks. This is presented to orient the reader to the locations and distances indicated in the subsequent plots.

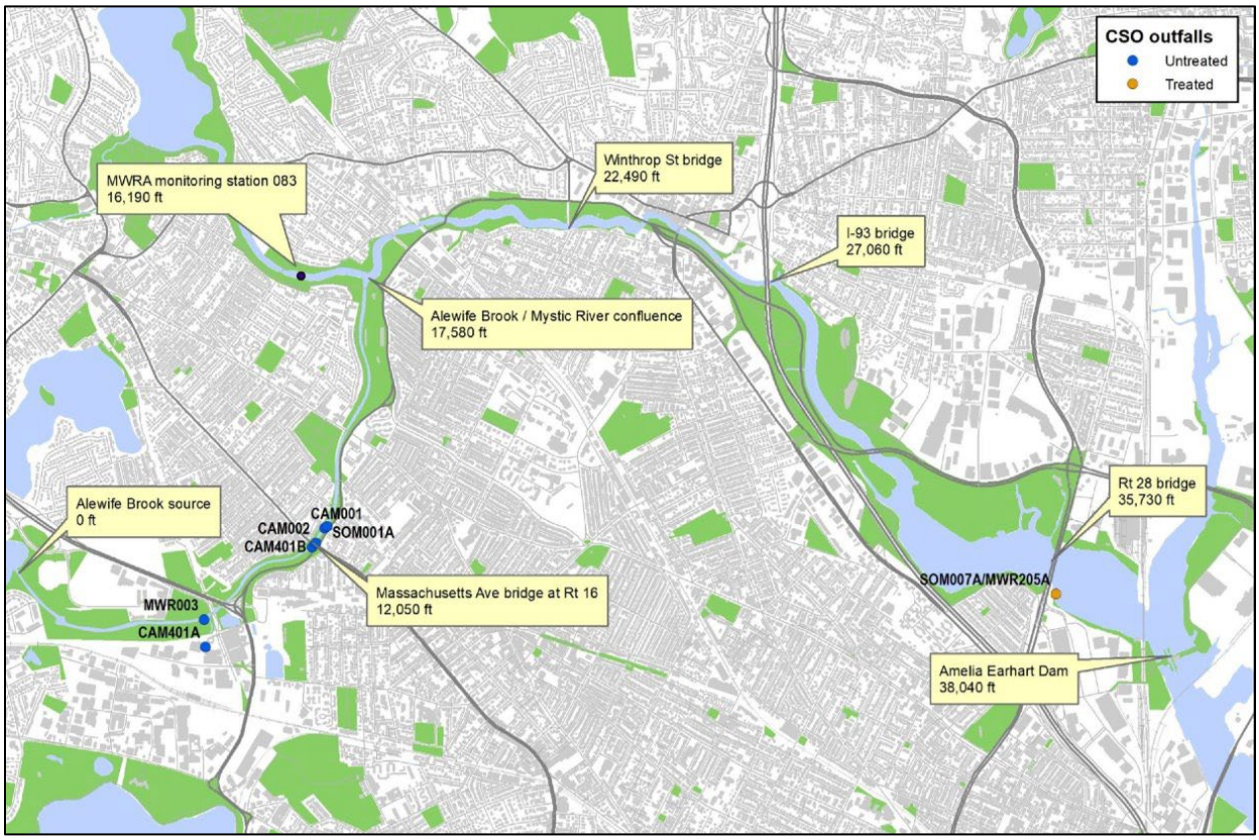



**Figure 7-7. Alewife Brook and Mystic River Landmarks and Distances**

**Figure 7-8** presents a longitudinal plot of the number of hours in the 2050 TY that the maximum *E. coli* concentration is above the single sample maximum criterion (410#/100mL) under the All-Sources scenario. The Y-axis also shows the values as a percentage of the total hours in the 2050 TY (8,784 total hours—366 days x 24 hours/day; the 2050 TY is a leap year). This figure provides a more nuanced assessment of the spatial distribution of attainment of the single sample maximum criterion.

As indicated in **Figure 7-8**, the single sample maximum criterion for *E. coli* is exceeded in Alewife Brook for approximately half of the total hours in the 2050 TY. The hours of exceedance in the Upper Mystic River are about between 25 to 30% from the confluence with Alewife Brook to a point approximately 15,000 feet downstream, meaning that attainment with the single sample maximum criterion would be in the 70 to 75% range. The attainment improves to about 90% at the downstream end by the Malden River and the Amelia Earhart Dam.

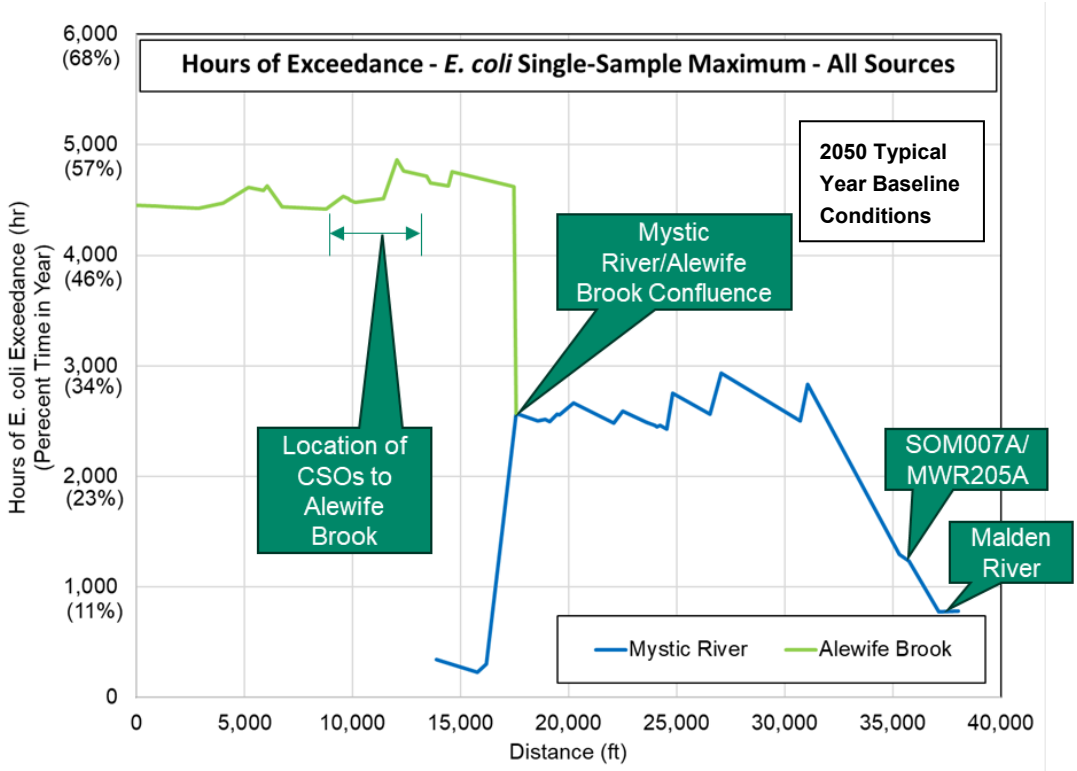



**Figure 7-8. Alewife Brook/Upper Mystic River Hours of Exceedance of *E. coli* Single Sample Maximum Criterion, 2050 Typical Year Baseline Conditions All Sources**

**Figure 7-9** is a similar plot for the Non-CSO Sources condition. In comparing **Figure 7-8** and **Figure 7-9**, it is apparent that eliminating the CSO loads would not affect the spatial distribution of the duration of exceedance of the *E. coli* single sample maximum criterion.

**Figure 7-10** presents the duration of exceedance of the *E. coli* single sample maximum criterion for the condition of CSO Only. Note the scale of the Y-axis for **Figure 7-10** from the scale of **Figure 7-8** and **Figure 7-9**. As indicated in **Figure 7-10**, the maximum duration of exceedance of the criterion in Alewife Brook is approximately 50 hours. In the Upper Mystic River, the duration of exceedance ranges from about 40 to 45 hours from the confluence with Alewife Brook to a point approximately 15,000 feet downstream, at which point the hours of exceedance drop off to below 20 hours at the downstream end.

Based on **Figure 7-8** to **Figure 7-10**, controlling the non-CSO sources of *E. coli* to Alewife Brook and the Upper Mystic River would be necessary to substantially reduce the hours of exceedance of the single sample maximum criterion in those waterbodies.

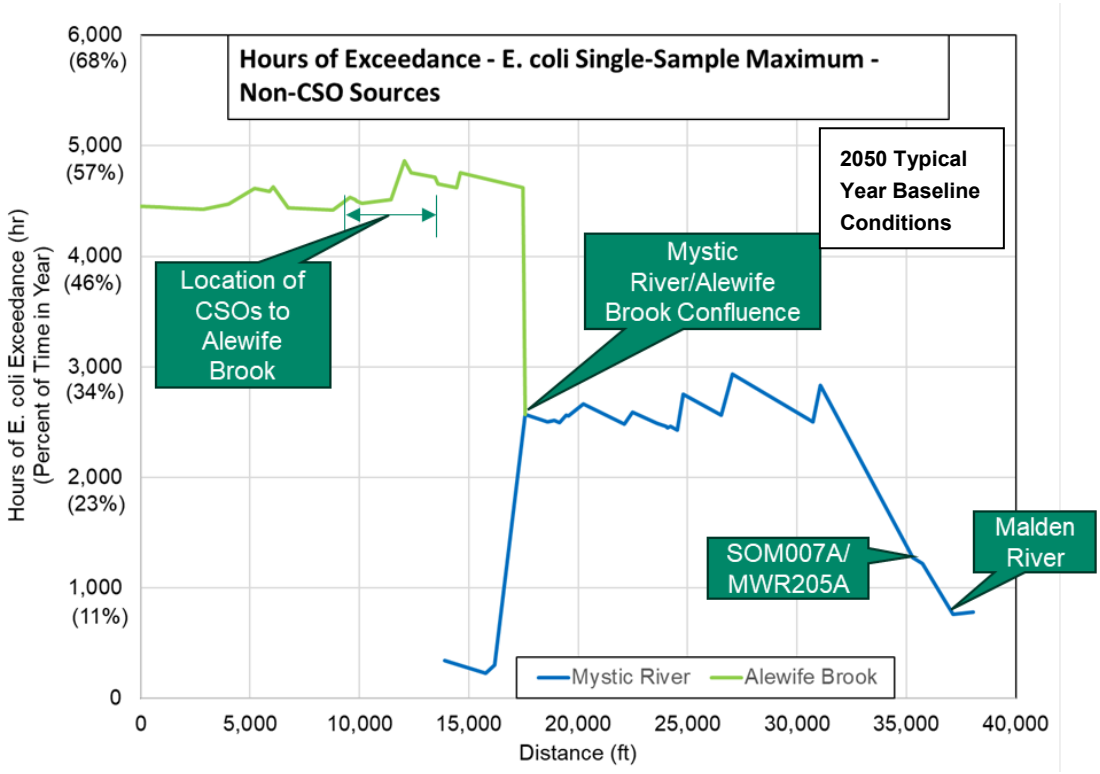



**Figure 7-9. Alewife Brook/Upper Mystic River Hours of Exceedance of *E. coli* Single Sample Maximum Criterion, 2050 Typical Year Baseline Conditions Non-CSO Sources**

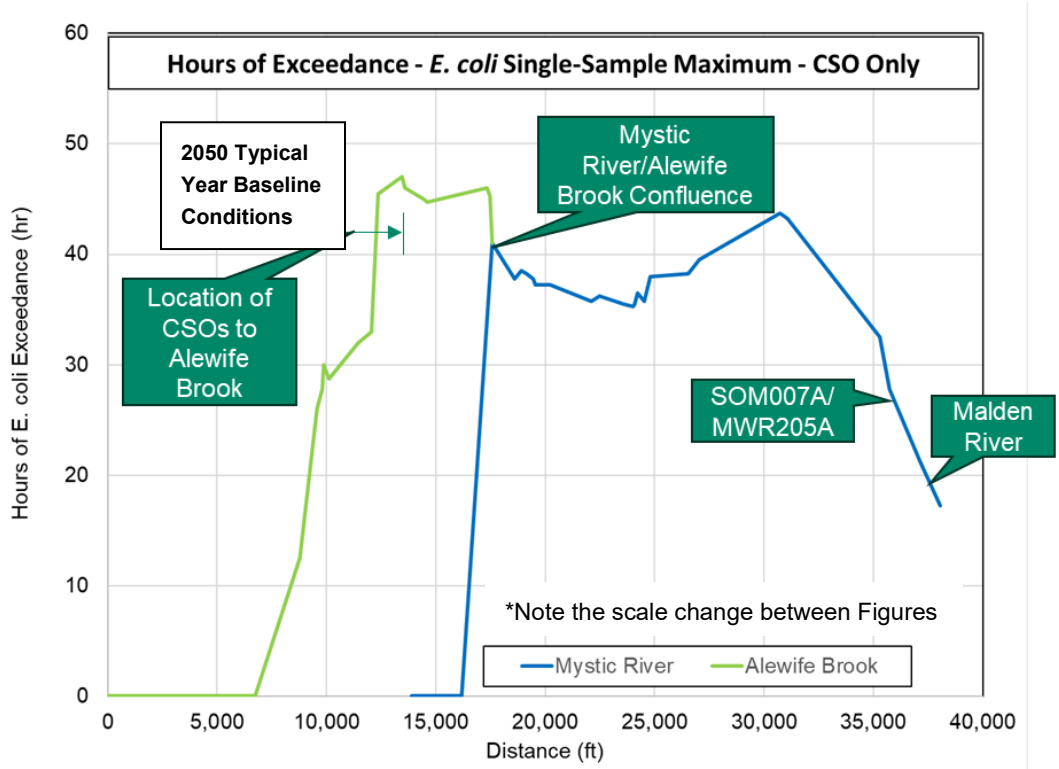



**Figure 7-10. Alewife Brook/Upper Mystic River Hours of Exceedance of *E. coli* Single Sample Maximum Criterion, 2050 Typical Year Baseline Conditions CSO Only**

#### 7.6.1.3 Attainment of 30-Day Geometric Mean Criteria

**Figure 7-11** to **Figure 7-14** present a series of plots of the percent of the time over the 2050 TY that each modeled segment was in attainment with the 30-day *E. coli* geometric mean criterion for the four simulation scenarios.

As indicated in **Figure 7-11** and **Figure 7-12,** in Alewife Brook, the 30-day geometric mean criterion for *E. coli* is exceeded for the entire 8,784-hour duration of the 2050 TY for All Sources and Non-CSO Sources. In the Upper Mystic River below the confluence with Alewife Brook, the duration of exceedance fluctuates between about 30 and 60% of the year, then drops to near zero percent at the downstream end. In comparing the All Sources and Non-CSO Sources plots in **Figure 7-11** and **Figure 7-12**, the plots are essentially identical, indicating that CSOs have no impact on attainment of the 30-day geometric mean criterion for *E. coli*. This finding is supported by **Figure 7-13**, which shows no exceedance of the 30-day geometric mean criterion for *E. coli* for CSO Only. While CSOs affect the peak bacteria concentrations in Alewife Brook, as demonstrated further below, the duration of impact is short enough as to not exceed the 30-day geometric mean criterion. **Figure 7-14** demonstrates the impact of Stormwater Only. The differences in attainment between **Figure 7-11** and **Figure 7-14** would be attributable to upstream and dry weather flow sources.

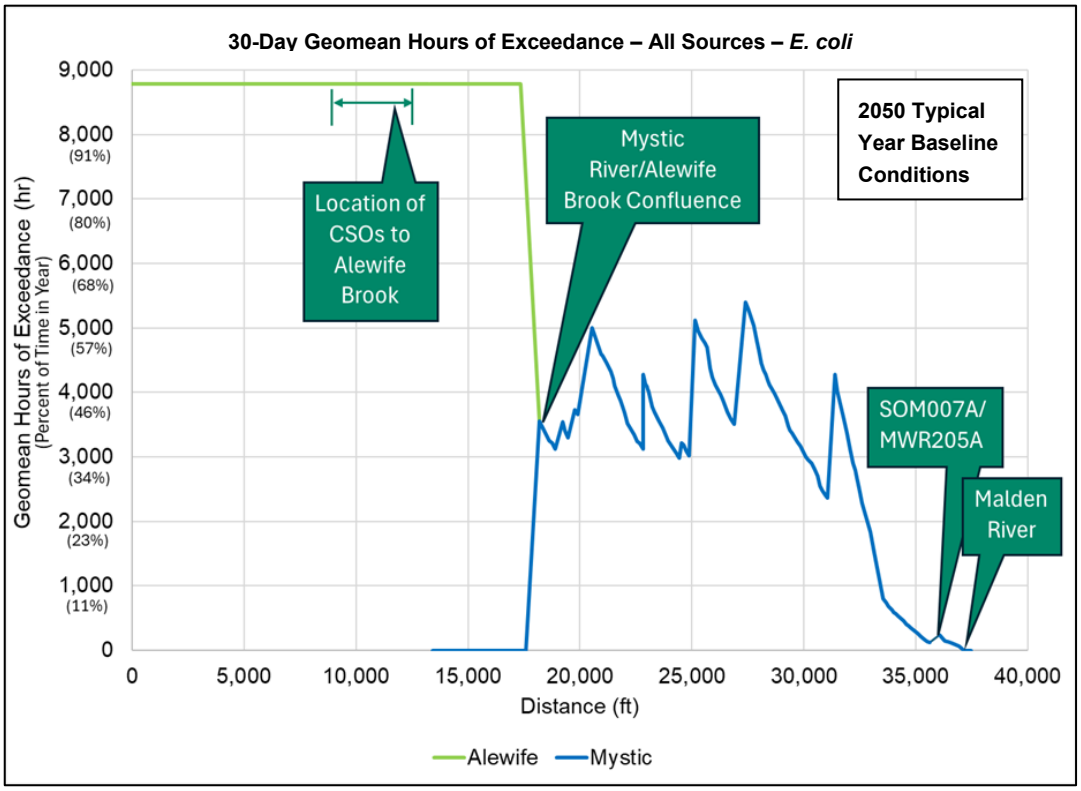



**Figure 7-11. Hours of Exceedance of *E. coli* 30-Day Geometric Mean Criterion, 2050 Typical Year Baseline Conditions, All Sources**

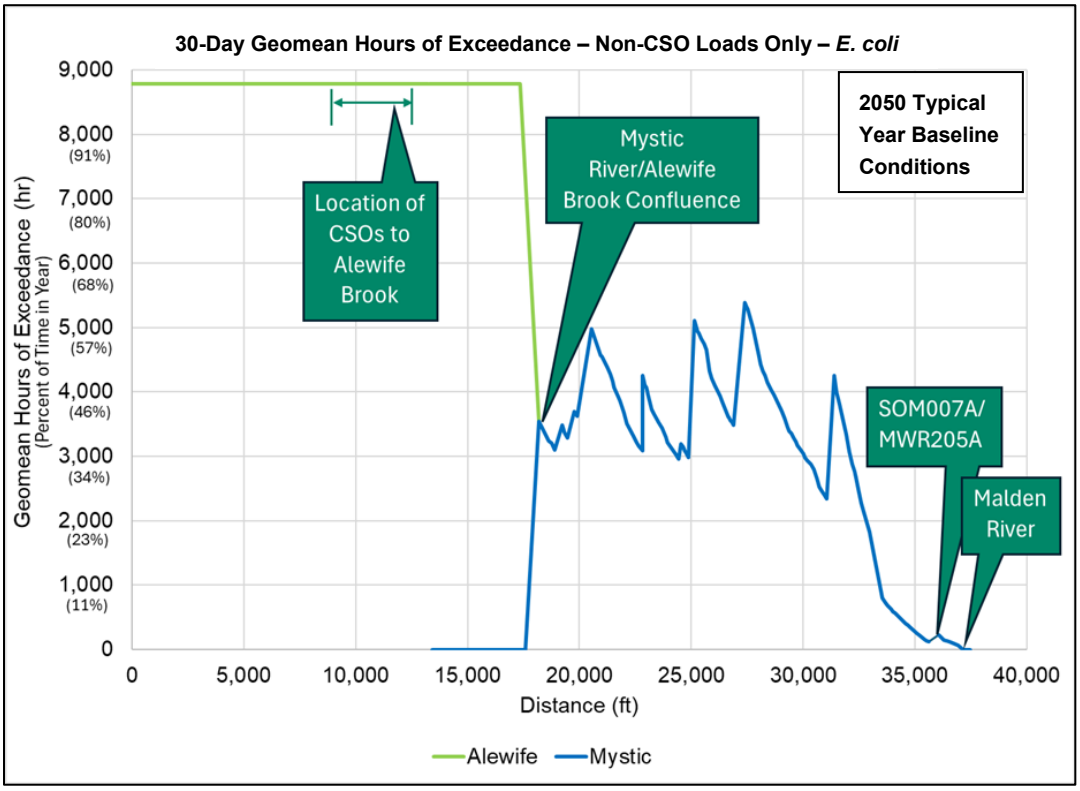



**Figure 7-12. Hours of Exceedance of *E. coli* 30-Day Geometric Mean Criterion, 2050 Typical Year Baseline Conditions, Non-CSO Sources**

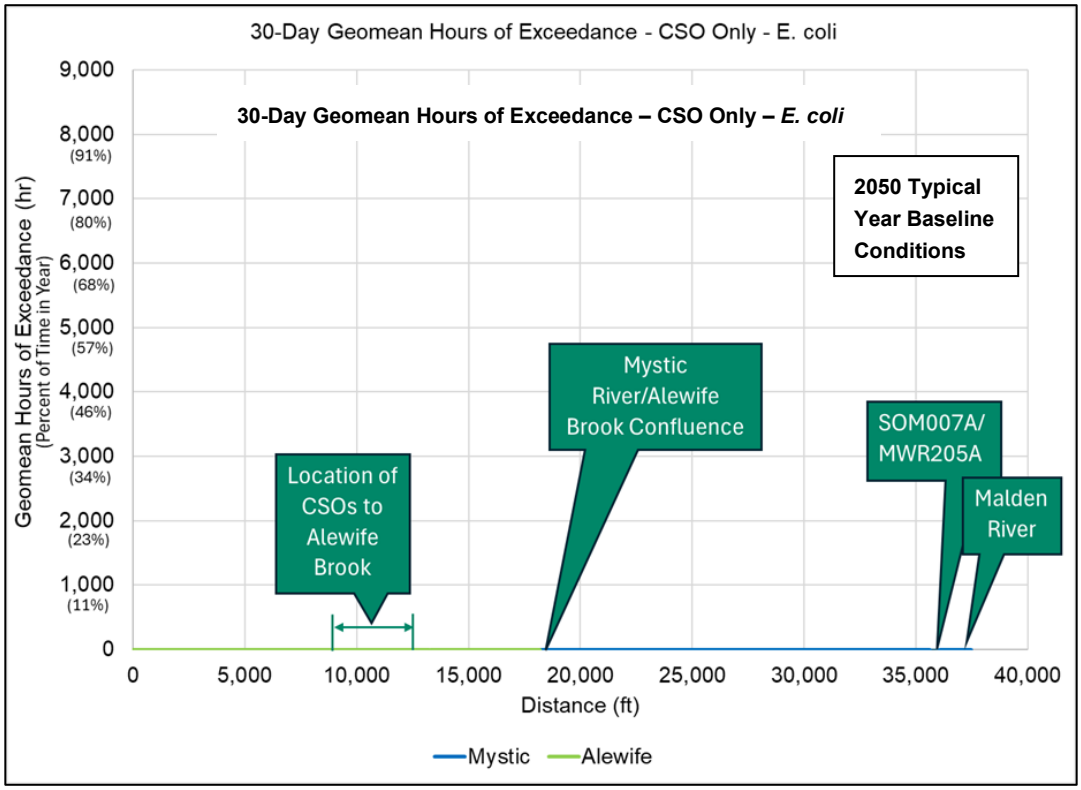



**Figure 7-13. Hours of Exceedance of *E. coli* 30-Day Geometric Mean Criterion, 2050 Typical Year Baseline Conditions, CSO Only**

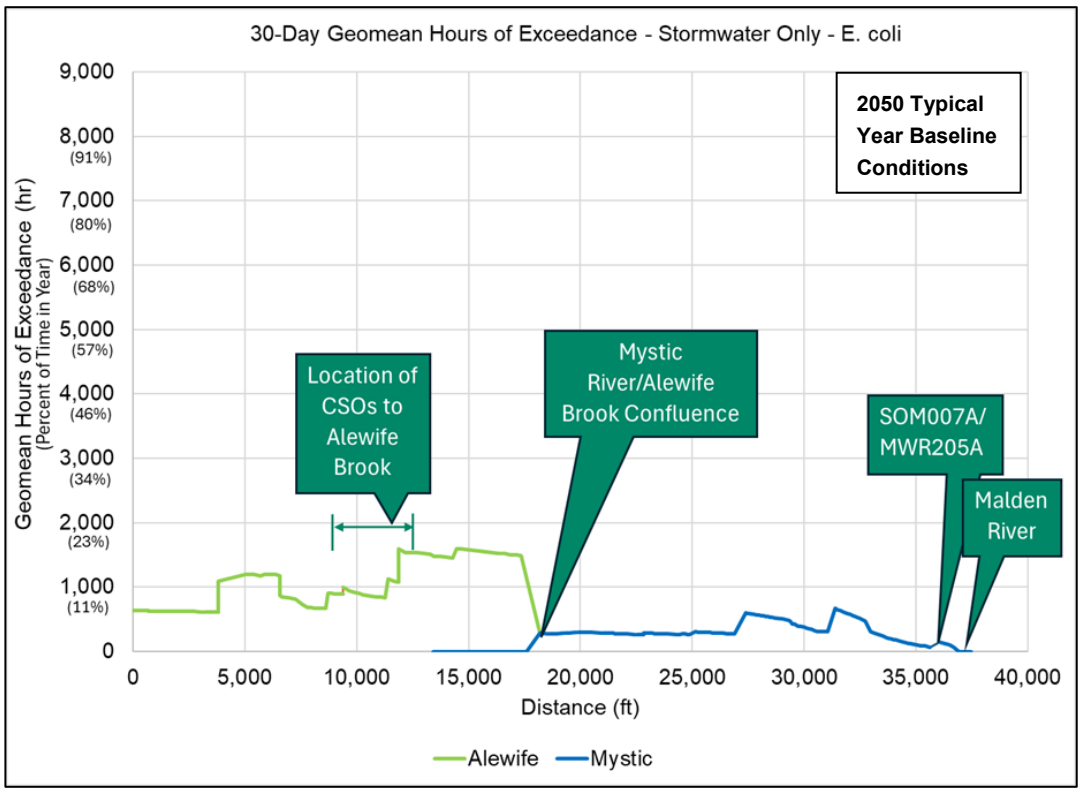



**Figure 7-14. Hours of Exceedance of *E. coli* 30-Day Geometric Mean Criterion, 2050 Typical Year Baseline Conditions, Stormwater Only**

#### 7.6.1.4 Attainment of 30-Day STV Criteria

**Figure 7-15** to **Figure 7-18** present a series of plots of the percent of the time over the 2050 TY that each modeled segment was in compliance with the 30-day *E. coli* STV criterion, for four simulation scenarios.

As indicated in **Figure 7-15** and **Figure 7-16,** in Alewife Brook, the 30-day STV criterion for *E. coli* is exceeded for the entire 8,784-hour duration of the 2050 TY for All Sources and Non-CSO Sources. In the Upper Mystic River below the confluence with Alewife Brook, the criterion is also exceeded for the entire year until a point approximately 15,000 feet downstream of Alewife Brook. This is direct reflection of persistent bacterial pollution from non-CSO sources. In comparing the All Sources and Non-CSO Sources plots in **Figure 7-15** and **Figure 7-16**, the plots are essentially identical, indicating that CSOs have no impact on attainment of the 30-day STV criterion for *E. coli*. This finding is supported by **Figure 7-17**, which shows no exceedance of the 30-day STV criterion for *E. coli* with CSO Only. As noted above, while CSOs affect the peak bacteria concentrations in Alewife Brook, the duration of impact is short enough as to not exceed the 30-day STV criterion. **Figure 7-18** demonstrates the impact of Stormwater Only. The exceedances of the 30-day STV criterion are primarily driven by the stormwater loadings, as this plot is also essentially identical to the All Sources plot in **Figure 7-15**.

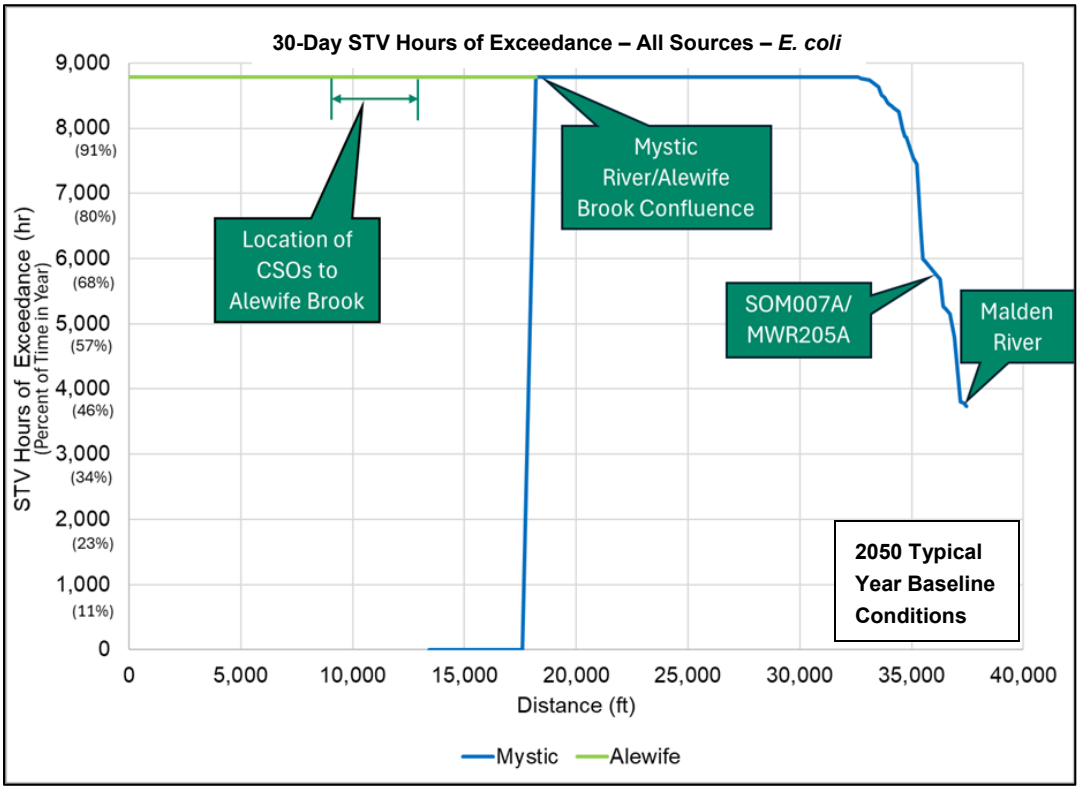



**Figure 7-15. Hours of Exceedance of *E. coli* 30-Day STV Criterion, 2050 Typical Year Baseline Conditions, All Sources**

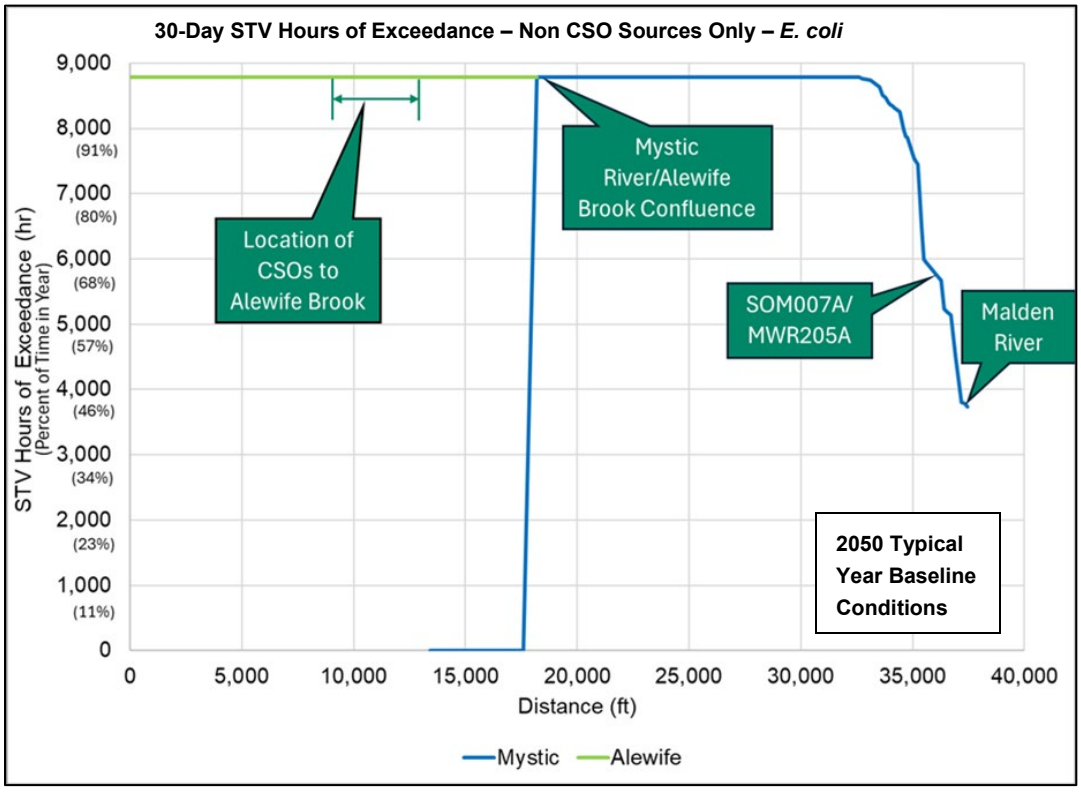



**Figure 7-16. Hours of Exceedance of *E. coli* 30-Day STV Criterion, 2050 Typical Year Baseline Conditions, Non-CSO Sources**

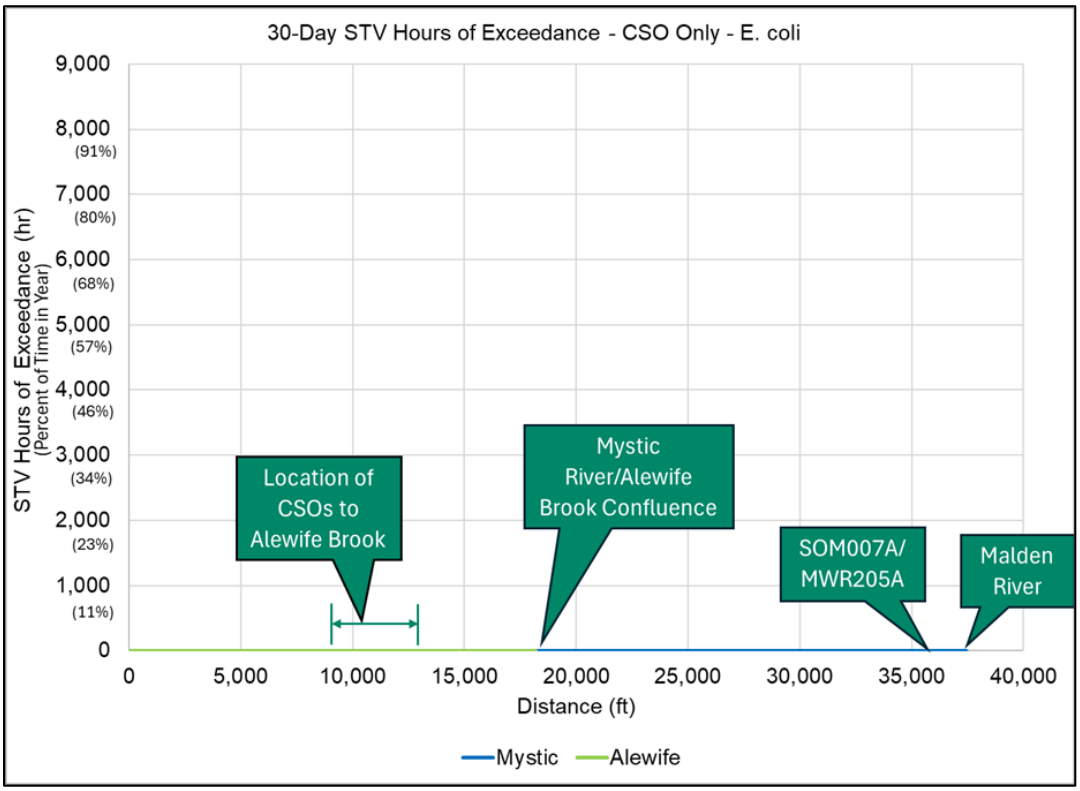



**Figure 7-17. Hours of Exceedance of *E. coli* 30-Day STV Criterion, 2050 Typical Year Baseline Conditions, CSO Only**

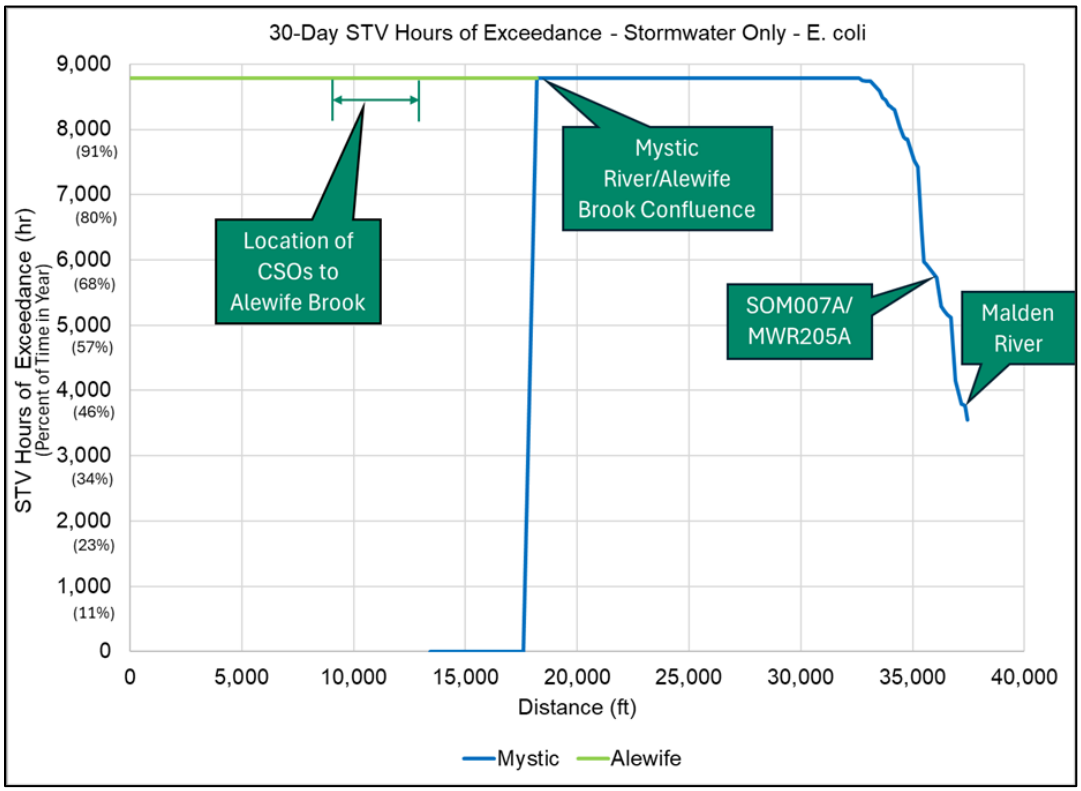



**Figure 7-18. Hours of Exceedance of E. coli 30-Day STV Criterion, 2050 Typical Year Baseline Conditions, Stormwater Only**

### 7.6.1.5 Maximum *E. coli* Concentrations

While the preceding sections demonstrated the relatively limited impact of CSOs on attainment of water quality criteria over the 2050 TY, those assessments do not necessarily reflect the short-term impacts of CSOs on water quality during the periods of time when the CSOs are discharging. One approach to assessing those short-term impacts is by plotting the maximum concentrations at each model segment in Alewife Brook and the Upper Mystic River under conditions of All Sources versus Non-CSO Sources (**Figure 7-19**). As indicated in **Figure 7-19**, elimination of CSO loads in the 2050 TY would result in substantial reductions in the peak *E. coli* concentrations in Alewife Brook and in the reach of the Upper Mystic River downstream of Alewife Brook. The peak *E. coli* concentrations for the Non-CSO Sources condition would, however, still be substantially higher than the MassDEP-recommended single sample maximum criterion of 410 #/100mL, due mostly to the remaining stormwater loadings. A further observation from **Figure 7-19** is that the CSO-driven peak concentrations are predicted to start upstream of the CSOs along the brook, as the CSO discharges are predicted to cause flow to move upstream during the larger CSO events.

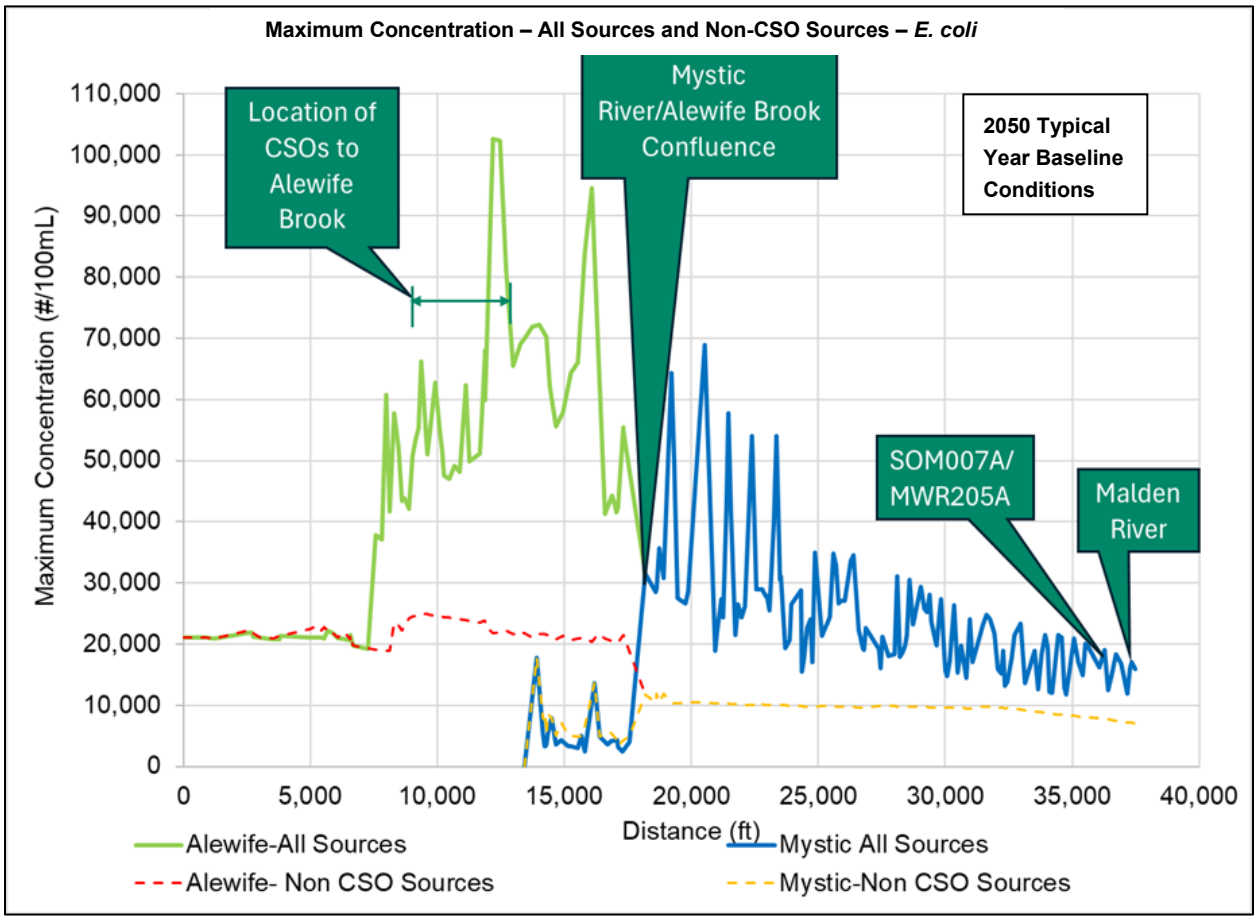



**Figure 7-19. Maximum *E. coli* Concentrations, 2050 Typical Year Baseline Conditions, All Sources vs. Non-CSO Sources**

### 7.6.1.6 *E. coli* Concentrations Over Time Following Storm Event

The Partners also developed a series of plots to present *E. coli* concentrations during and after the storm in the 2050 TY that generated the largest CSO volume to Alewife Brook and the Upper Mystic River (the December 17 storm) to visualize how pollutants from CSO move through the waterbodies over time. **Figure 7-20** presents longitudinal plots of *E. coli* concentrations at the peak of the December 17 storm from the 2050 TY, and at intervals of 6, 12, 24, and 48 hours following the peak, for All Sources. **Figure 7-21** presents similar plots for the CSO Sources Only condition.

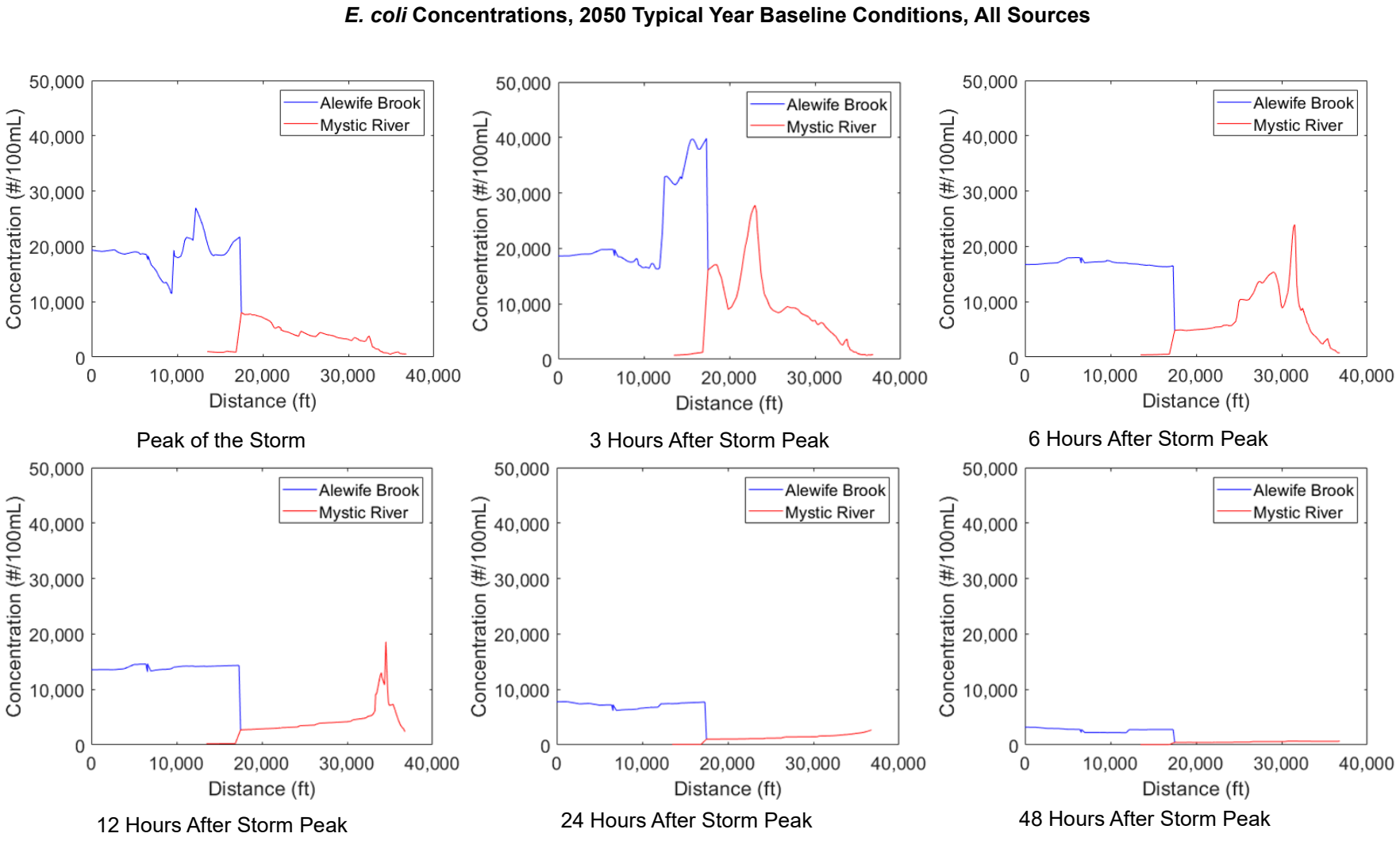



**Figure 7-20. Alewife Brook/Upper Mystic River *E. coli* Concentrations Over Time During and After the December 17 Storm from the 2050 Typical Year, Baseline Conditions, All Sources**

**_E. coli_ Concentrations, 2050 Typical Year Baseline Conditions, CSO Sources Only**

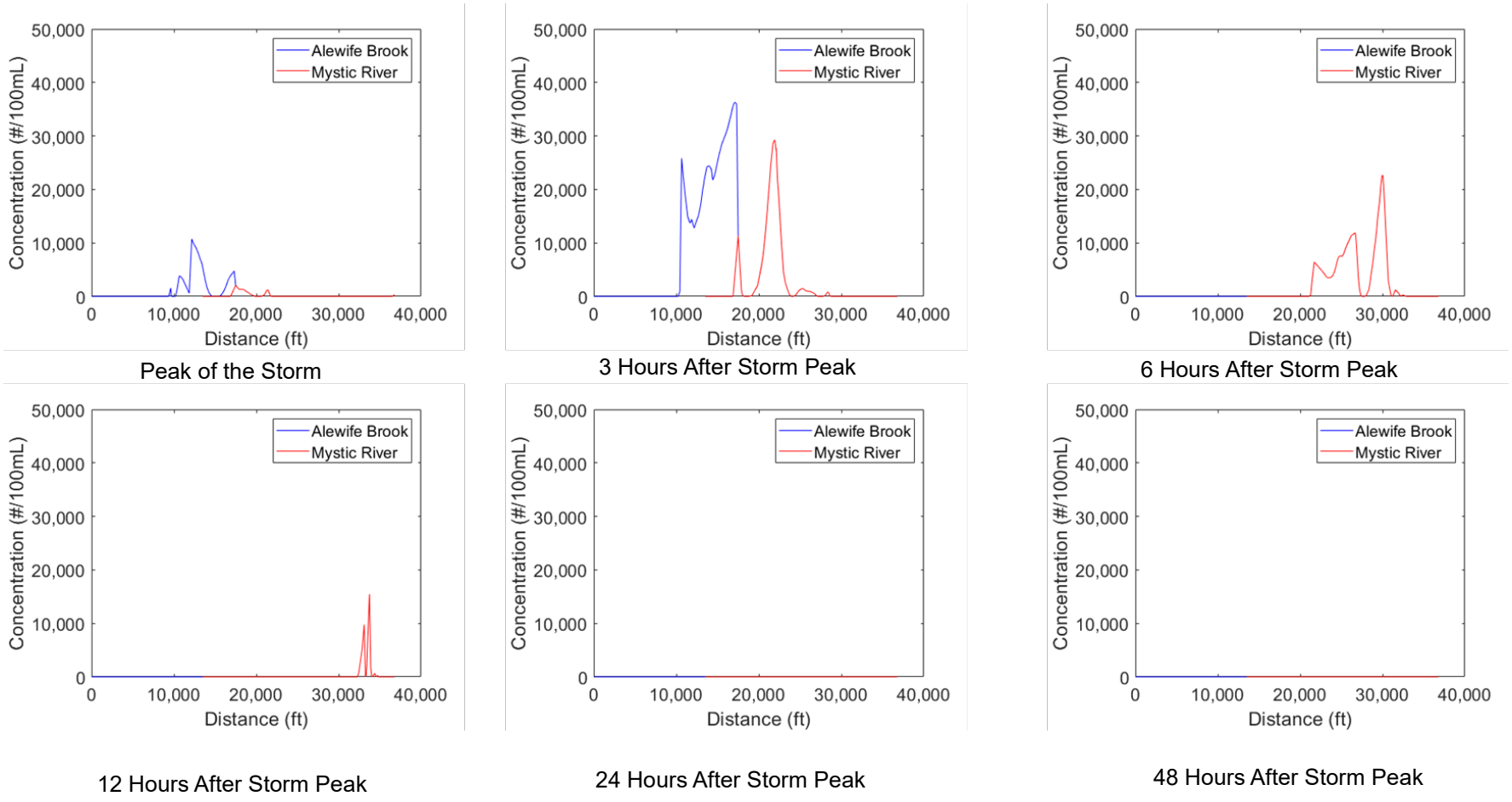



**Figure 7-21. Alewife Brook/Upper Mystic River _E. coli_ Concentrations Over Time During and After the December 17 Storm from the 2050 Typical Year, Baseline Conditions, CSO Sources Only**

As indicated in **Figure 7-20**, for the time intervals assessed, the highest *E. coli* concentrations in Alewife Brook occur three hours after the peak of the storm. This result is likely a function of the timing of the peak CSO discharges relative to the peak rainfall. The overall maximum concentrations indicated above in **Figure 7-19** likely occurred between the peak rainfall and the 3-hour point. The spike in concentration in the Upper Mystic River just downstream of Alewife Brook at the 3-hour timestep is also likely due to a spike in CSO in Alewife Brook that occurred just after the peak of the storm. Six hours after the peak of the storm, the high concentrations from the CSOs in Alewife Brook have moved downstream and started to attenuate. The CSO-related spike moves further downstream by hour 12 and essentially disappears by hour 24. During that time, the concentrations in Alewife Brook gradually drop from around 17,000 #/100mL to approximately 8,000 #/100mL. The concentrations continue to drop to around 2,000 #/100mL by hour 48 which is still considerably higher than the MassDEP recommended single sample maximum criterion.

As indicated in **Figure 7-21**, for CSO Sources Only, the peak *E. coli* concentrations have passed through Alewife Brook by 6 hours after the peak of the storm. The localized spike in concentration gradually moves downstream in the Upper Mystic River, diminishing in magnitude as it moves further downstream. By 24 hours after the peak of the storm, the impact of the CSO load is no longer apparent. **Figure 7-20** and **Figure 7-21** together highlight an important consideration for CSO control alternatives analysis. These acute CSO impacts occur concurrently with significant impacts from non-CSO sources.

#### 7.6.1.7 Summary of the Baseline Water Quality Assessment for Alewife Brook and the Upper Mystic River

Key points from the 2050 TY Baseline Condition water quality assessment for Alewife Brook are summarized as follows:

- In Alewife Brook, stormwater is the predominant source of *E. coli* loads at just under 80% of the total annual load. The sanitary component of CSO contributes 10% of the total annual load.
- No difference was predicted in the attainment of the MassDEP-recommended single sample maximum criterion for *E. coli* for the All Sources condition compared to the Non-CSO Sources condition. Thus, elimination of CSO in the 2050 TY would not change the extent of attainment.
- For the All Sources and Non-CSO Sources conditions, the single sample maximum criterion for *E. coli* is exceeded for approximately half of the total hours in the 2050 TY along all of Alewife Brook. For the CSO-only condition, the maximum duration of exceedance of the criterion is approximately 50 hours, limited to the reach of the brook downstream of the active CSOs.
- For the All Sources and Non-CSO Sources conditions, the 30-day *E. coli* geometric mean and STV criteria are predicted to be exceeded for the full 2050 TY along the Alewife Brook. For the CSO Only, no exceedances of the 30-day *E. coli* geometric mean and STV criteria are predicted. For the Stormwater Only condition, the 30-day *E. coli* geometric mean criterion is predicted to be exceeded between approximately 10 and 20% of the time, while the STV criterion is predicted to be exceeded 100% of the time along Alewife Brook.
- Dry weather and boundary sources drive the non-attainment of the 30-day *E. coli* geometric mean criterion, while stormwater appears to be the key driver for non-attainment of the 30-day *E. coli* STV criterion. Elimination of CSO would not change the extent of attainment of either criterion.
- Plots of maximum *E. coli* concentrations for conditions of All Sources versus Non-CSO Sources Only showed that CSOs contributed to substantially higher maximum concentrations along the Brook starting at a point approximately 2,000 feet upstream of the most upstream CSO (due to CSO discharges causing flow to move upstream during the larger CSO events). Thus, elimination of CSO loads in the 2050 TY would result in substantial reductions in the peak *E. coli* concentrations in Alewife Brook. The peak *E. coli* concentrations for the Non-CSO Sources condition would, however, still be in the range of 20,000 #/100mL, substantially higher than the MassDEP-recommended single sample maximum criterion of 410 #/100mL, due mostly to the remaining stormwater loads.
- Plots of *E. coli* concentration at different time intervals during and after the storm that generated the largest CSO volume in the 2050 TY demonstrated the movement and attenuation of peak concentrations over time. For the All Sources condition, by six hours after the peak of the storm, the

high concentrations from the CSOs in Alewife Brook have moved downstream into the Lower Mystic River and have started to attenuate. Between hour 6 and hour 48, the concentrations in Alewife Brook gradually drop from around 17,000 #/100mL to approximately 2,000 #/100mL. For the CSO Sources Only condition, the *E. coli* concentrations from CSO are no longer apparent in Alewife Brook at 6 hours after the peak of the storm. These acute CSO impacts occur concurrently with significant impacts from non-CSO sources.

Key points from the 2050 TY Baseline Conditions water quality assessment for the Upper Mystic River are summarized as follows:

- In the Upper Mystic River, stormwater is the predominant source of *E. coli* loads at just over 90% of the total annual load. Treated CSO contributes less than 0.01% of the total annual load. No untreated CSOs discharge directly to the Upper Mystic River, but *E. coli* concentrations in the Upper Mystic River are influenced by *E. coli* loadings coming into the Upper Mystic River from untreated CSOs in Alewife Brook.
- No difference was predicted in the attainment of the MassDEP-recommended single sample maximum criterion for *E. coli* for the All Sources condition compared to the Non-CSO Sources condition. Thus, elimination of CSO in the 2050 TY would not change the extent of attainment.
- For the All Sources and Non-CSO Sources conditions, the single sample maximum criterion for *E. coli* is exceeded for approximately 25 to 30% of the total hours in the 2050 TY from the confluence with Alewife Brook to a point approximately 15,000 feet downstream. The exceedance drops to about 10% at the downstream end by the Malden River and the Amelia Earhart Dam. For the CSO Only condition, the duration of exceedance ranges from about 40 to 45 hours from the confluence with Alewife Brook to a point approximately 15,000 feet downstream, at which point the hours of exceedance drop off to below 20 hours at the downstream end.
- For the All Sources and Non-CSO Sources conditions, the 30-day *E. coli* geometric mean criterion is predicted to be exceeded between about 30 and 60% of the year between the confluence with Alewife Brook and a point approximately 15,0000 feet downstream of Alewife Brook, dropping to near zero percent at the far downstream end. For the CSO Only condition, no exceedances of the 30-day *E. coli* geometric mean criterion are predicted.
- For the All Sources and Non-CSO Sources conditions, the 30-day *E. coli* STV criterion is predicted to be exceeded 100% of the year between the confluence with Alewife Brook and a point approximately 15,0000 feet downstream of Alewife Brook, dropping to about 40% of the year at the far downstream end. For the CSO Only condition, no exceedances of the 30-day *E. coli* STV criterion are predicted.
- Dry weather and boundary sources drive the non-attainment of the 30-day *E. coli* geometric mean criterion, while stormwater appears to be the key driver for non-attainment of the 30-day *E. coli* STV criterion. Elimination of CSO would not change the extent of attainment of either criterion.
- Plots of maximum *E. coli* concentrations for conditions of All Sources versus Non-CSO Sources Only showed that CSOs contributed to substantially higher maximum concentrations along the Upper Mystic River at the confluence with Alewife Brook. Elimination of CSO loads in the 2050 TY would result in substantial reductions in the peak *E. coli* concentrations in the reach of the Upper Mystic River just below the confluence. The peak *E. coli* concentrations for the Non-CSO Sources condition would, however, still be in the range of 10,000 to 20,000 #/100mL, substantially higher than the MassDEP-recommended single sample maximum criterion of 410 #/100mL, due mostly to the remaining stormwater loadings.
- Plots of *E. coli* concentration at different time intervals during and after the storm that generated the largest CSO volume in the 2050 TY demonstrated influence of the Alewife Brook CSOs on peak concentrations along the Upper Mystic River. For the All Sources condition, by hour 24, the “wave” of peak concentration had moved through the downstream end of the Upper Mystic River, and the concentrations in the Upper Mystic River drop to approximately 1,000 to 3,000 #/100mL. For the CSO Sources Only condition, the *E. coli* concentrations from CSO are no longer apparent in the Upper Mystic River by 24 hours after the peak of the storm.

CSO represents a very small fraction of the total annual bacteria load to Alewife Brook and the Upper Mystic River, and it is not the main driver of water quality degradation in these waters. Elimination of CSO would reduce peak short-term concentrations, and would positively impact public health outcomes, but it would not substantially change the duration or extent of exceedance of SWQS criteria.

### 7.6.2 Baseline Water Quality Assessment - Charles River

The Charles River 2-dimensional water quality model was run for the 2050 TY with a 90-day period added prior to the start of the TY to establish appropriate antecedent conditions for the start of the year. The rainfall for the 90-day start-up period was copied from the final 90 days in the 2050 TY rainfall. Model output was generated in the form of *E. coli* and *Enterococcus* counts at 1-hour intervals at each of the 4,400 grid cells in the model. Simulations were conducted for the following conditions for both *E. coli* and *Enterococcus*:

- All Sources;
- Non-CSO Sources Only;
- CSO Only; and
- Stormwater Only.

Because the bacteria fate and transport model is linear, in-stream bacteria counts due to the different sources are additive. In the model runs for the individual sources, the bacterial counts in the other sources were set to zero, but the flows from the other sources were retained.

The following sections present the bacterial mass loadings from the various sources to the Charles River for the 2050 TY Baseline Conditions, and an assessment of the impacts of those loadings to the Charles River in terms of:

- Single sample maximum criteria;
- 30-day geometric mean criteria;
- 30-day STV criteria;
- Maximum bacteria concentrations; and
- Change in bacteria concentration over time.

The single sample maximum was assessed at MassDEP's recommendation, and the 30-day geometric mean and 30-day STV criteria are part of the SWQS in 314 CMR 4.05 (presented in Section 2.1.2). The maximum concentrations and changes over time aim to capture acute and time-sensitive impacts of CSOs.

#### 7.6.2.1 Volume and *E. coli* Loadings

**Table 7-9** presents a summary of the 2050 TY Baseline Condition volumes and *E. coli* loads to the Charles River. As indicated in **Table 7-9**, the single largest source of volume to the Charles River is the continuous flow over the Watertown Dam from the upstream reaches of the river. Stormwater and dry weather base flows are the next largest source, while treated and untreated CSO represent less than 0.1% of the annual volume. Stormwater is the predominant source of *E. coli* loading, followed by the upstream boundary loads. The sanitary component of untreated CSO represents a very small fraction (0.4%) of the total bacteria load to the Charles River. The impacts of these loadings on modeled *E. coli* concentrations in the Charles River are presented in the sections below.

**Table 7-9. Charles River 2050 Typical Year Baseline Conditions Volumes and *E. coli* Loads**

| | Charles River 2050 Typical Year Baseline Conditions | | | |
|---|---|---|---|---|
| | *Volume* | | *E. coli* | |
| *Source* | Volume (MG) | Percent of Total | Loading (counts x $10^{12}$) | Percent of Total |
| Untreated CSO(1) | 7.7 | 0.01% | Sanitary Component: 26<br>Stormwater Component: 4 | 0.4%<br>0.1% |
| Treated CSO(2) | 30 | 0.03% | 0.45 | 0.01% |
| Stormwater | 7,137 | 7% | 3,782 | 64% |
| Dry Weather(3) | 9,663 | 10% | 49 | 1% |
| Boundary(4) | 80,415 | 83% | 2,054 | 35% |
| **Total** | **97,252** | **100%** | **5,916** | **100%** |

**Notes:**

(1) Untreated CSO includes a sanitary sewage component and a stormwater component.

(2) Treated CSO from the MWRA Cottage Farm CSO Facility receives screening, sedimentation, disinfection and dechlorination.

(3) Treated CSO from the MWRA Cottage Farm CSO Facility receives screening, sedimentation, disinfection and dechlorination.

(4) Boundary sources include dry and wet weather flows over the Watertown Dam.

#### 7.6.2.2 Attainment of Single Sample Maximum Criteria

As described above for the Alewife Brook and Upper Mystic River, based on direction from MassDEP, the Charles River water quality model was used to assess attainment with single sample maximum criteria equal to the existing 30-day STV criteria of 410 #/100mL for *E. coli* and 130 #/100mL for *Enterococcus.*

The single sample maximum criterion was assessed using two approaches. The first approach computed percent attainment based on the proportion of modeled time in which bacterial concentrations at all grid cells remained below the single sample maximum criterion. For example, the 2050 TY includes a total of 8,784 1-hour model timesteps (366 days x 24 hours/day; the 2050 TY is a leap year). If the model predicted that the maximum *E. coli* concentrations at all grid cells was less than 410 #/100mL for 4,000 hours, the percent attainment would be 4,000/8,784 = 46%. This approach presents a conservative assessment of the condition of the river, as the model cells where exceedances occur shift in time, and the area of exceedance may be only a fraction of the total river area.

To address the spatial variability of bacteria concentrations, a second approach included plotting isopleths of percent attainment within individual model cells. With these plots, the percent of river area achieving varying levels of annual attainment with the single sample maximum criteria could be assessed.

**Table 7-10** summarizes the percent attainment with the single sample maximum criteria for both *E. coli* and *Enterococcus* for the 2050 TY, using the first approach described above. As indicated in, for both *E. coli* and *Enterococcus*, no differences were predicted in the percent attainment for All Sources compared to Non-CSO Sources. Thus, elimination of CSO would not change this assessment of attainment. Attainment with Stormwater Only was between 11 to 13% higher than All Sources, with the improvement driven primarily by the removal of the Boundary Flow sources (flow over the Watertown Dam). With CSOs Only, annual attainment was above 99%.

**Table 7-10. Charles River Percent Annual Attainment of the Single Sample Maximum Criteria for the 2050 Typical Year**

| Percentage of Time Entire Modeled Charles River is in Attainment with Single Sample Maximum Criteria – 2050 Typical Year (1) | | | | | | | |
|---|---|---|---|---|---|---|---|
| *E. coli* (410 #/100mL) | | | | *Enterococcus* (130 #/100mL) | | | |
| All Sources | Non-CSO Sources | CSO Only | Stormwater Only | All Sources | Non-CSO Sources | CSO Only | Stormwater Only |
| 51% | 51% | 99.7% | 63% | 34% | 34% | 99.7% | 45% |

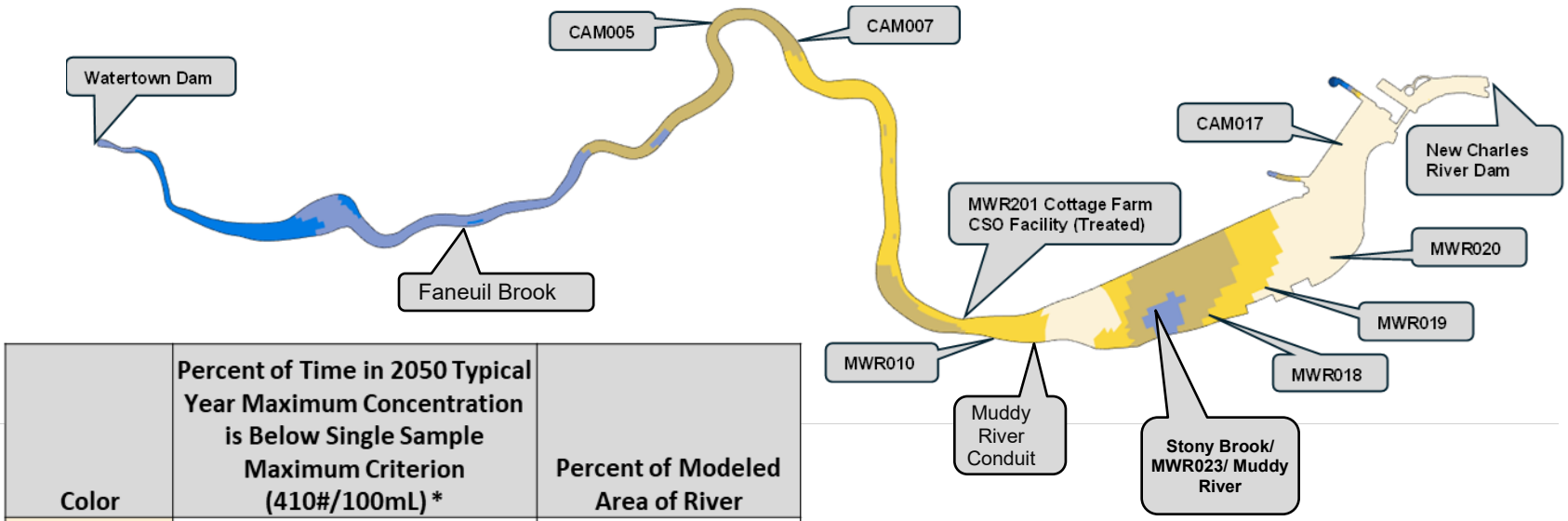
**Note:**

(1) Based on guidance from MassDEP, model results were analyzed for a single sample maximum equivalent to the value of the Class B Statistical Threshold Value Criterion for bacteria.

**Figure 7-22** presents a contour map of the percent of time in the 2050 TY that the maximum *E. coli* concentration is below the single sample maximum criterion (410#/100mL) under the All Sources scenario. Since the Charles River water quality model is a 2-dimensional model, the contour map presents the spatial extents along the river. This figure provides a more nuanced assessment of the spatial distribution of attainment of the single sample maximum criterion. As indicated in **Figure 7-22**, nearly 60% of the river area is predicted to meet the single sample maximum criterion for *E. coli* at least 90% of the time in the 2050 TY, and over 80% of the river area is predicted to meet the single sample maximum criterion for *E. coli* at least 80% of the time. Thus, even without future improvements in CSO control and stormwater management, substantial portions of the Lower Charles River would meet this recreational standard most of the time. Areas of consistently lower attainment are just downstream of the Watertown Dam, and the area adjacent to the Muddy River confluence and Stony Brook/MWR023 outfall. The lower attainment downstream of the Watertown Dam is driven by the bacteria loads coming over the dam from upstream, while the lower attainment adjacent to the Stony Brook/MWR023 outfall/Muddy River is driven primarily by the brook/river base flow and stormwater loadings from those sources.

**Figure 7-23** is a similar plot for the Non-CSO Sources condition. In comparing **Figure 7-22** and **Figure 7-23**, it is apparent that eliminating the CSO loads would not affect the spatial distribution of the duration of exceedance of the *E. coli* single sample maximum criterion.

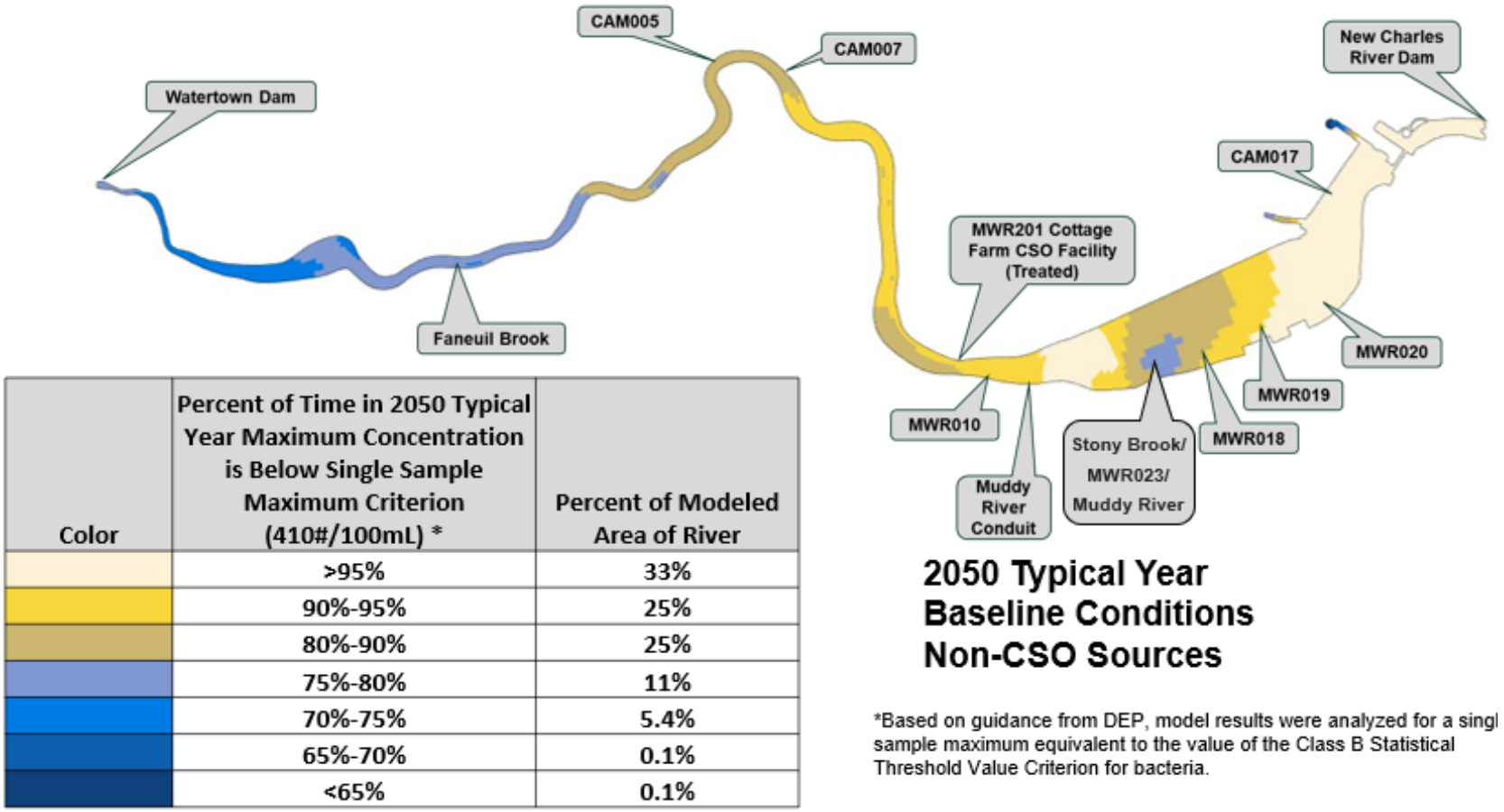
**Figure 7-24** presents the duration of exceedance of the *E. coli* single-sample maximum criterion for the condition of CSO loads, only. As indicated in **Figure 7-24,** with only CSO loadings, the entire modeled river would be below the single sample maximum criterion at least 95 percent of the time in the 2050 TY.




| Color | Percent of Time in 2050 Typical Year Maximum Concentration is Below Single Sample Maximum Criterion (410#/100mL) * | Percent of Modeled Area of River |
|---|---|---|
| | >95% | 33% |
| | 90%-95% | 25% |
| | 80%-90% | 25% |
| | 75%-80% | 11% |
| | 70%-75% | 5.4% |
| | 65%-70% | 0.1% |
| | <65% | 0.1% |

*Based on guidance from DEP, model results were analyzed for a single sample maximum equivalent to the value of the Class B Statistical Threshold Value Criterion for bacteria.

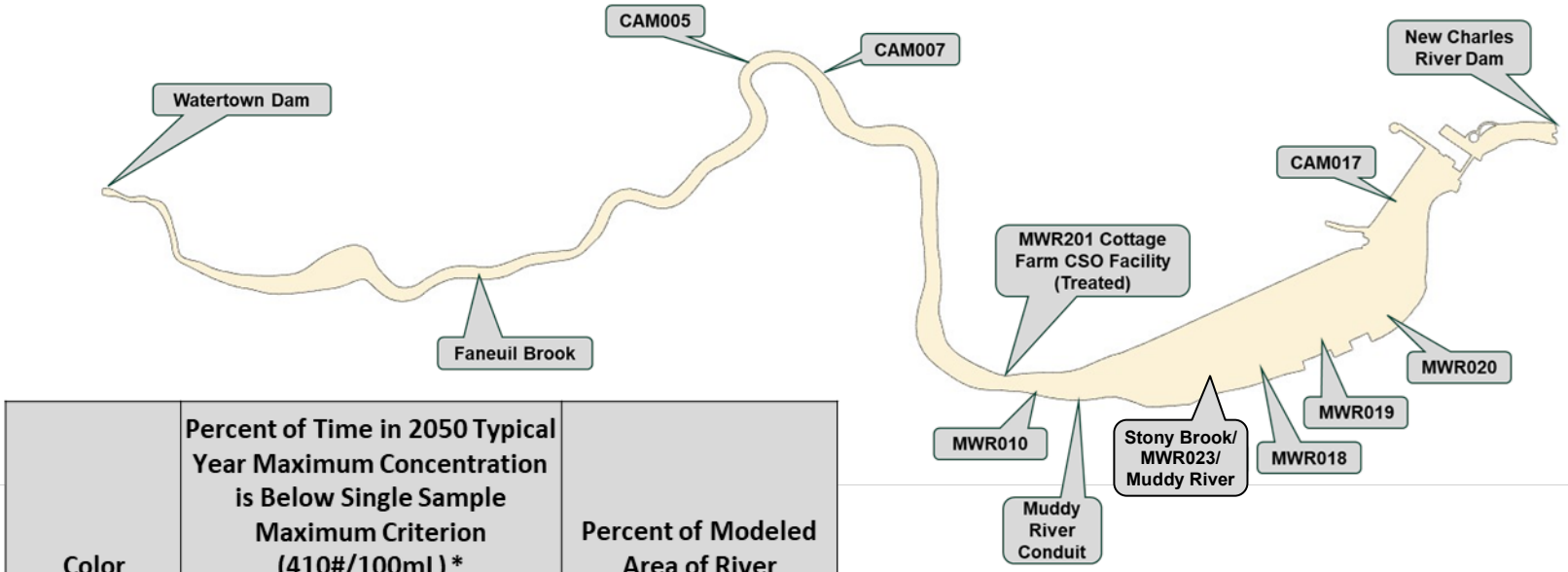
**Figure 7-22. Charles River Percent Annual Attainment of Single Sample Maximum Criterion for *E. coli*, 2050 Typical Year Baseline Conditions All Sources**




| Color | Percent of Time in 2050 Typical Year Maximum Concentration is Below Single Sample Maximum Criterion (410#/100mL) * | Percent of Modeled Area of River |
|---|---|---|
| | >95% | 33% |
| | 90%-95% | 25% |
| | 80%-90% | 25% |
| | 75%-80% | 11% |
| | 70%-75% | 5.4% |
| | 65%-70% | 0.1% |
| | <65% | 0.1% |

*Based on guidance from DEP, model results were analyzed for a singl sample maximum equivalent to the value of the Class B Statistical Threshold Value Criterion for bacteria.

**Figure 7-23. Charles River Percent Annual Attainment of Single Sample Maximum Criterion for *E. coli*, 2050 Typical Year Baseline Conditions Non-CSO Sources**




| Color | Percent of Time in 2050 Typical Year Maximum Concentration is Below Single Sample Maximum Criterion (410#/100mL) * | Percent of Modeled Area of River |
|---|---|---|
| | >95% | 100% |
| | 90%-95% | 0% |
| | 80%-90% | 0% |
| | 75%-80% | 0% |
| | 70%-75% | 0% |
| | 65%-70% | 0% |
| | <65% | 0% |

*Based on guidance from DEP, model results were analyzed for a single sample maximum equivalent to the value of the Class B Statistical Threshold Value Criterion for bacteria.

**Figure 7-24. Charles River Percent Annual Attainment of Single Sample Maximum Criterion for *E. coli*, 2050 Typical Year Baseline Conditions CSO Sources Only**

#### 7.6.2.3 Attainment of 30-Day Geometric Mean Criteria

314 CMR 4.05(5)(f)3.a.ii specifies that for waters impacted by CSO, “the geometric mean and statistical threshold value used for calculating the minimum criteria for bacteria […] shall be calculated and assessed, respectively, over a 30-day or smaller interval”. **Figure 7-25** presents a series of plots of the percent of the time over the 2050 TY that each modeled cell was in attainment with the 30-day *E. coli* geometric mean criterion, for four simulation scenarios: All Sources, Non-CSO Sources, CSO Only, and Stormwater Only. **Table 7-11** presents the percent of the modeled area which falls within the various categories of percent of time in attainment with 30-day *E. coli* geometric mean criterion for the four scenarios.

The All Sources and Non-CSO Sources plots in **Figure 7-25** are essentially identical, indicating minimal influence of CSOs in attainment of the 30-day geometric mean criterion. The CSO Only plot shows greater than 95% attainment for the entire modeled river, and Stormwater Only plots show nearly similar attainment, indicating that upstream sources and base flows are the key drivers of non-attainment of the 30-day *E. coli* geometric mean criterion.

As indicated in **Table 7-11**, with All Sources about half of the river is in attainment with the 30-day *E. coli* geometric mean criterion at least 95% of the time in the 2050 TY. About 20% of the river is in attainment with the 30-day *E. coli* geometric mean criterion less than 65% of the time in the 2050 TY. Most of that non-attainment occurs in the relatively narrow reach of the river downstream of the Watertown Dam and upstream of the most upstream CSO outfall.

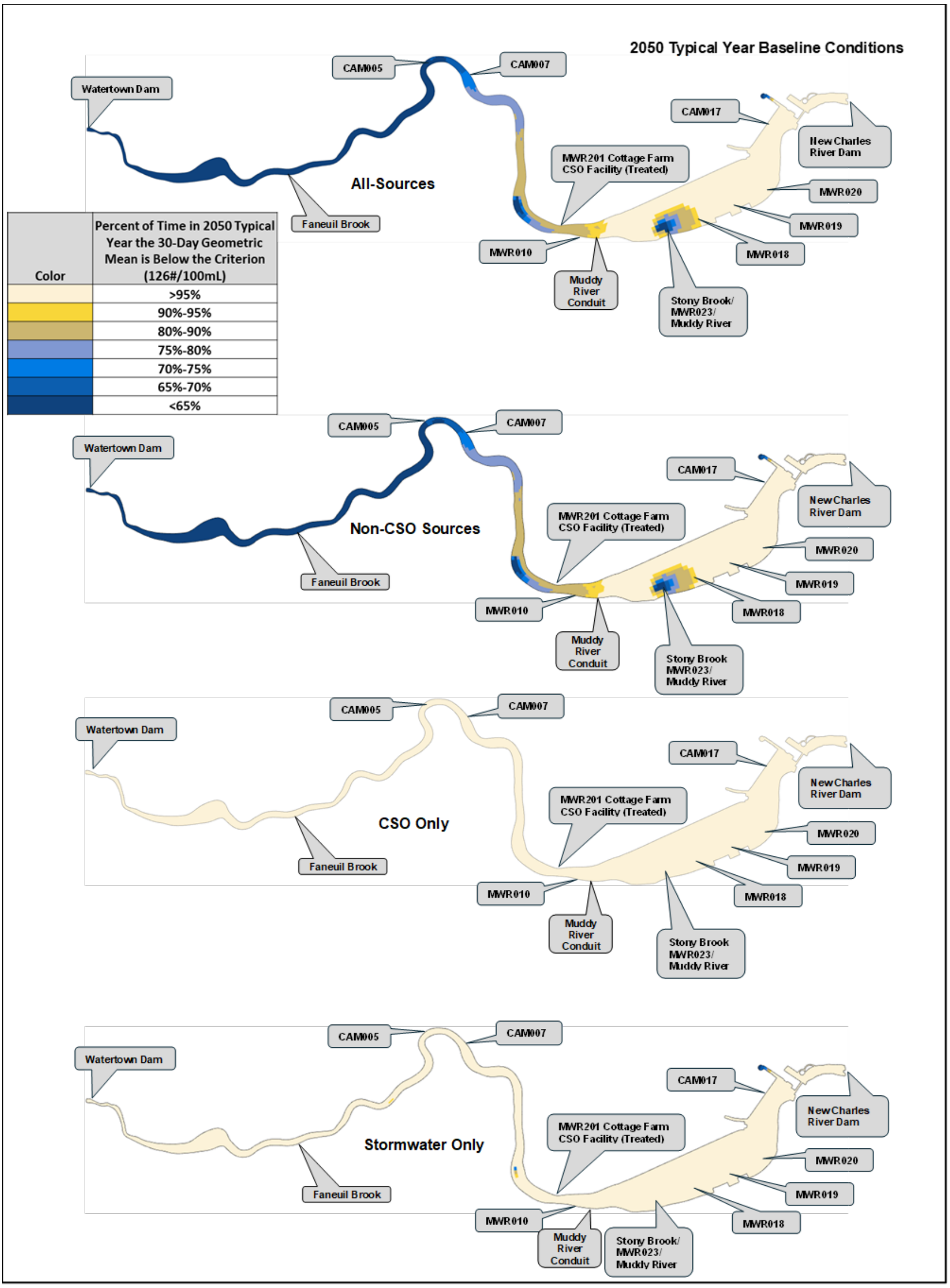



**Figure 7-25. Charles River Percent Annual Compliance with *E. coli* 30-Day Geometric Mean Criterion for 2050 Typical Year Baseline Conditions**

**Table 7-11. Charles River Percent of River Area and Range of Percent Attainment of *E. coli* 30-Day Geometric Mean Criterion Baseline Conditions**

| Color | Percent of Time in 2050 Typical Year the 30-Day Geometric Mean is Below the Criterion (*E. coli* 126 #/100mL) | Percent of Modeled Area | | | |
|---|---|---|---|---|---|
| | | All Sources | Non-CSO Sources | CSO Only | Stormwater Only |
| | >95% | 53% | 54% | 100% | 99.4% |
| | 90%-95% | 4% | 4% | 0% | 0.2% |
| | 80%-90% | 11% | 11% | 0% | 0.1% |
| | 75%-80% | 7% | 6% | 0% | 0.0% |
| | 70%-75% | 2% | 2% | 0% | 0.1% |
| | 65%-70% | 2% | 2% | 0% | 0.1% |
| | <65% | 21% | 21% | 0% | 0.1% |

#### 7.6.2.4 Attainment of 30-Day STV Criteria

**Figure 7-26** presents a series of plots of the percent of the time over the 2050 TY that each modeled cell was in attainment with the 30-day *E. coli* STV criterion, for four simulation scenarios: All Sources, Non-CSO Sources, CSO Only, and Stormwater Only. **Table 7-12** presents the percent of the modeled area which falls within the various categories of percent of time in attainment with the 30-day *E. coli* STV criterion for the four scenarios.

The All Sources and Non-CSO Sources plots in **Figure 7-26** are nearly identical, indicating minimal influence of CSOs in attainment of the 30-day STV criterion. The Stormwater Only plot indicates that stormwater has a greater impact on attainment of the STV criterion than attainment of the geometric mean criterion, while upstream sources and base flows are also key drivers of non-attainment with the 30-day *E. coli* STV criterion. As indicated in **Table 7-12**, just over 10% of the river is in attainment with the 30-day *E. coli* STV criterion at least 95% of the time in the 2050 TY. Between the geometric mean and STV criteria, it is the STV that creates the greater extent of non-attainment, while the non-CSO sources are the greatest contributors to that non-attainment.

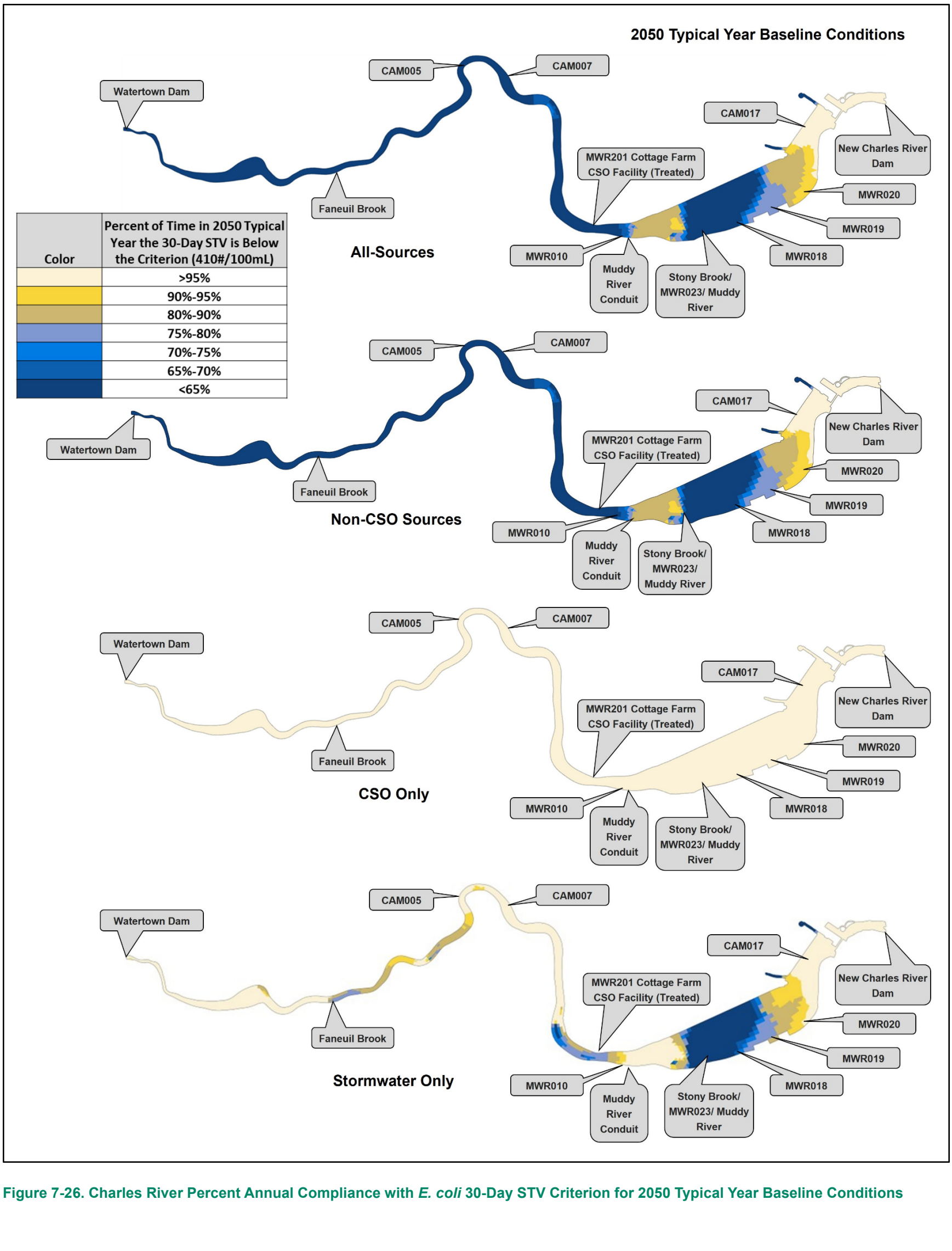



**Figure 7-26. Charles River Percent Annual Compliance with *E. coli* 30-Day STV Criterion for 2050 Typical Year Baseline Conditions**

**Table 7-12. Charles River Percent of River Area and Range of Percent Attainment of *E. coli* 30-Day STV Criterion Baseline Conditions**

| Color | Percent of Time in 2050 Typical Year the 30-Day STV is Below the Criterion (*E. coli* 410 #/100mL) | Percent of Modeled Area | | | |
|---|---|---|---|---|---|
| | | All Sources | Non-CSO Sources | CSO Only | Stormwater Only |
| | >95% | 11% | 12% | 100% | 45% |
| | 90%-95% | 6% | 7% | 0% | 10% |
| | 80%-90% | 15% | 14% | 0% | 13% |
| | 75%-80% | 6% | 6% | 0% | 7% |
| | 70%-75% | 3% | 2% | 0% | 3% |
| | 65%-70% | 4% | 4% | 0% | 2% |
| | <65% | 55% | 55% | 0% | 20% |

#### 7.6.2.5 Maximum *E. coli* Concentrations

While the preceding sections demonstrated the relatively limited impact of CSOs on attainment of water quality criteria over the 2050 TY, those assessments do not necessarily reflect the short-term impacts of CSOs on water quality during the periods of time when the CSOs are discharging. One approach to assessing those short-term impacts is by plotting the maximum concentrations at each model cell in the river under conditions of All Sources, Non-CSO Sources Only, and CSO Only. **Figure 7-27** presents the plots for All Sources and Non-CSO Sources, while **Figure 7-28** presents the plot for CSO Only. Note that the color-coded scales of maximum concentration are different between **Figure 7-27** and **Figure 7-28**.

In comparing the two plots in **Figure 7-27**, the impact of CSOs on maximum concentrations can be seen by the small differences in shading color adjacent to outfalls MWR018, MWR019 and CAM017. The extents of the blue shading opposite the MWR023 outfall are also slightly greater for All Sources compared to Non-CSO Sources Only. For most of the river area, however, the CSOs do not appear to affect the extent of the different ranges in maximum concentration.

**Figure 7-28** isolates the maximum concentrations for CSO Only. The relatively limited areas with peak concentrations above 410 #/100mL are clustered around the active untreated CSO outfalls (CAM005, MWR023, MWR018, MWR019, MWR020 and CAM017). The areas above 1,000 #/100mL are even more tightly centered on the model cells representing the ends of the outfalls, and the immediately adjacent model cells. Note that treated CSO discharges at Cottage Farm (MWR201) do not noticeably contribute to higher bacteria counts in the same way that untreated CSO discharges do. Areas in beige/yellow meet the MassDEP recommended single sample maximum criterion for *E. coli* under this CSO-only scenario for the entire 2050 TY

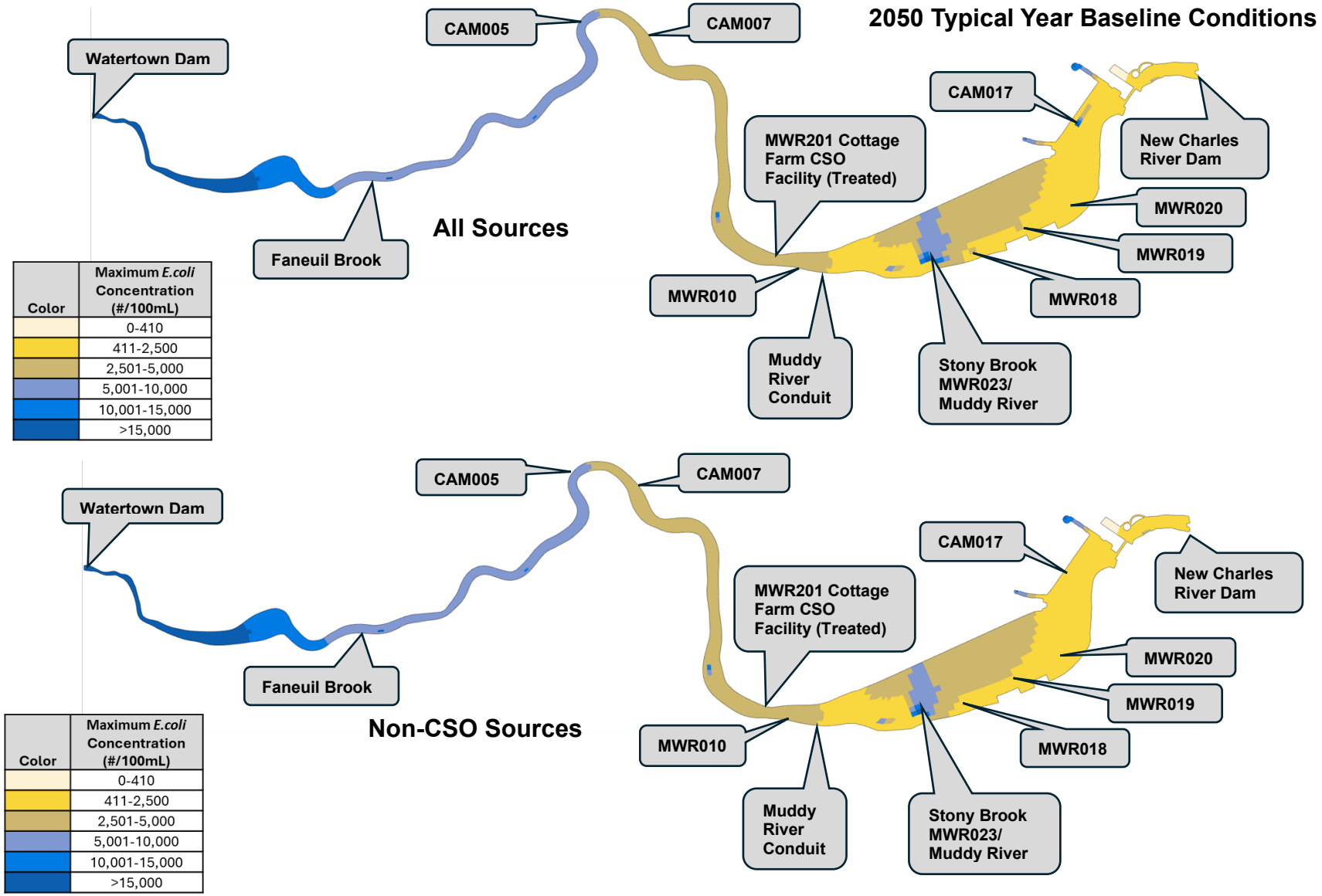



**Figure 7-27. Charles River Maximum *E. coli* Concentrations in 2050 Typical Year Baseline Conditions, All Sources and Non-CSO Sources**

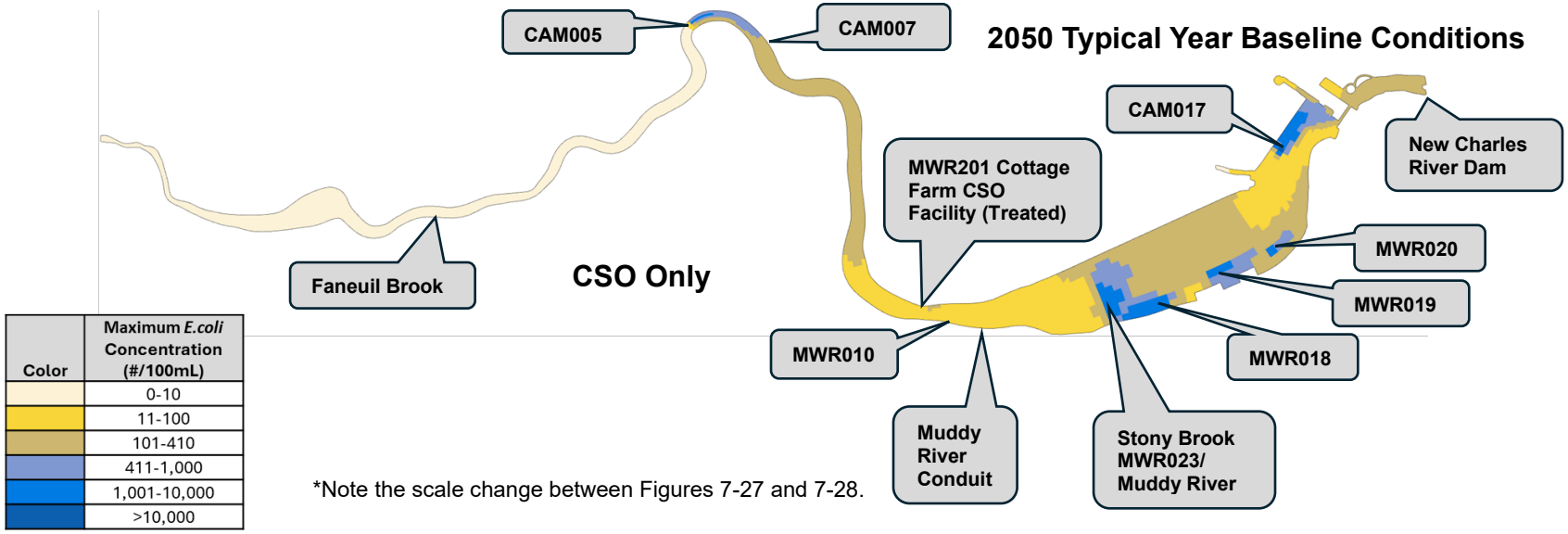



**Figure 7-28. Charles River Maximum *E. coli* Concentrations in 2050 Typical Year Baseline Conditions, CSO Only**

#### 7.6.2.6 *E. coli* Concentrations Over Time Following Storm Event

The Partners also developed a series of plots that present *E. coli* concentrations during and after the storm in the 2050 TY that generated the largest CSO volume to the Charles River (the December 17 storm) to visualize how pollutants from CSO move through the river over time. **Figure 7-29** presents contour plots color coded by the *E. coli* concentrations at the peak of the December 17 storm from the 2050 TY, and at intervals of 6, 12, 24, 48, and 72 hours following the peak, for the All Sources condition.

As indicated in **Figure 7-29**, at the peak of the storm, the highest *E. coli* concentrations are in the reach of the river downstream of the Watertown Dam, at specific points associated with the MWR023, MWR018, MWR019, MWR020 and CAM017 CSO outfalls, and in the Lechmere Canal. Six hours after the peak of the storm, the high concentrations from the Watertown Dam have moved downstream, and the peak concentrations associated with outfalls MWR019, MWR020 and CAM017 have dissipated. A very small area of concentration above 5,000 #/100mL persists through hour 12 following the peak. That concentration is likely driven mostly by stormwater from the Stony Brook Conduit and Muddy River, as the CSO volume at outfall MWR023 during that storm is relatively small (0.02MG). By 48 hours after the peak of the storm, the upstream reach of the Charles River is under 410 #/100ml, while most of the lower basin is in the 410-1,260 #/100mL range. By 72 hours after the peak, the entire modeled river is under 410 #/100mL except for an area adjacent to the MWR023 outfall. The elevated concentrations near outfall MWR023 are due to a second rainfall event that occurred in the 2050 TY between the 48 and 72-hour marks. The elevated concentrations are a result of stormwater loadings from this subsequent storm rather than a prolonged effect from the original December 17 event (no CSO discharged during the second event).

**Figure 7-30** presents a similar set of contour plots for those same time intervals for the CSO Sources Only condition. Note that the color-coding scale in **Figure 7-30** is different from the scale presented in **Figure 7-29**. As indicated in **Figure 7-30**, by 6 hours after the peak of the storm, the *E. coli* concentrations from CSOs have dropped below the 410 #/100mL single sample maximum criterion level.

To provide additional detail on the impact of CSOs on peak *E. coli* concentrations, the Partners developed plots of *E. coli* concentration over time at two specific model grid cells in the Charles River for the December 17 event. One grid cell was located in the region of elevated concentration adjacent to the MWR023 outfall/Muddy River discharge (**Figure 7-31**) and one was located at the discharge point for outfall MWR020 (**Figure 7-32**).

In **Figure 7-31**, the slightly higher peaks near outfall MWR023 on December 17 for the All Sources condition coincide with CSO discharges. CSOs were not discharging during the peaks on December 14 and December 20.

In **Figure 7-32**, the initial peak coincides with the CSO discharge at outfall MWR020. The second peak on December 19 reflects CSO and other loading sources moving into the area near outfall MWR020 from upstream. Note that the Y-axis scales on **Figure 7-31** and **Figure 7-32** are different.

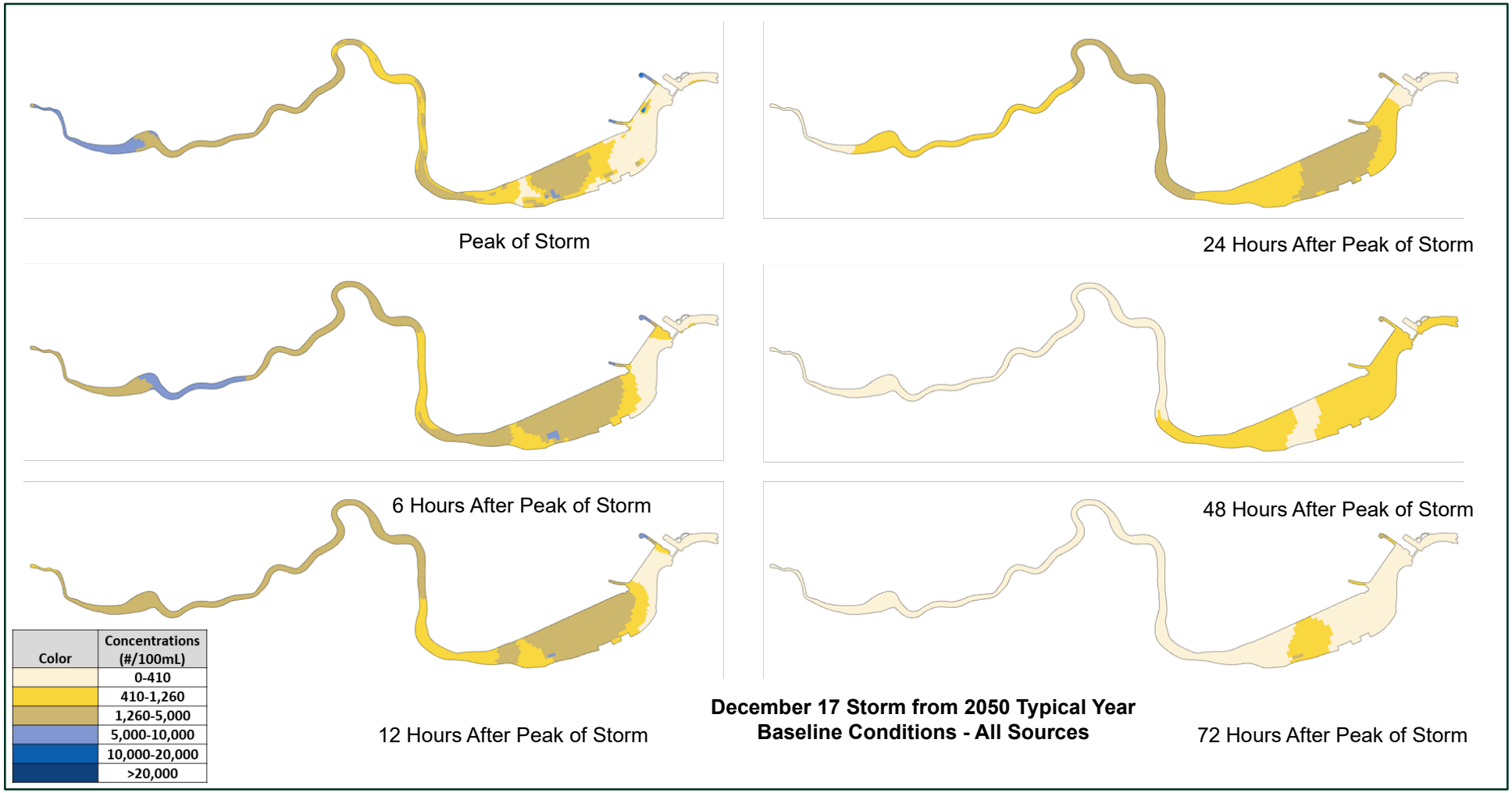



**Figure 7-29. Charles River *E. coli* Concentrations Over Time During and After the December 17 Storm from the 2050 Typical Year, Baseline Conditions, All Sources**

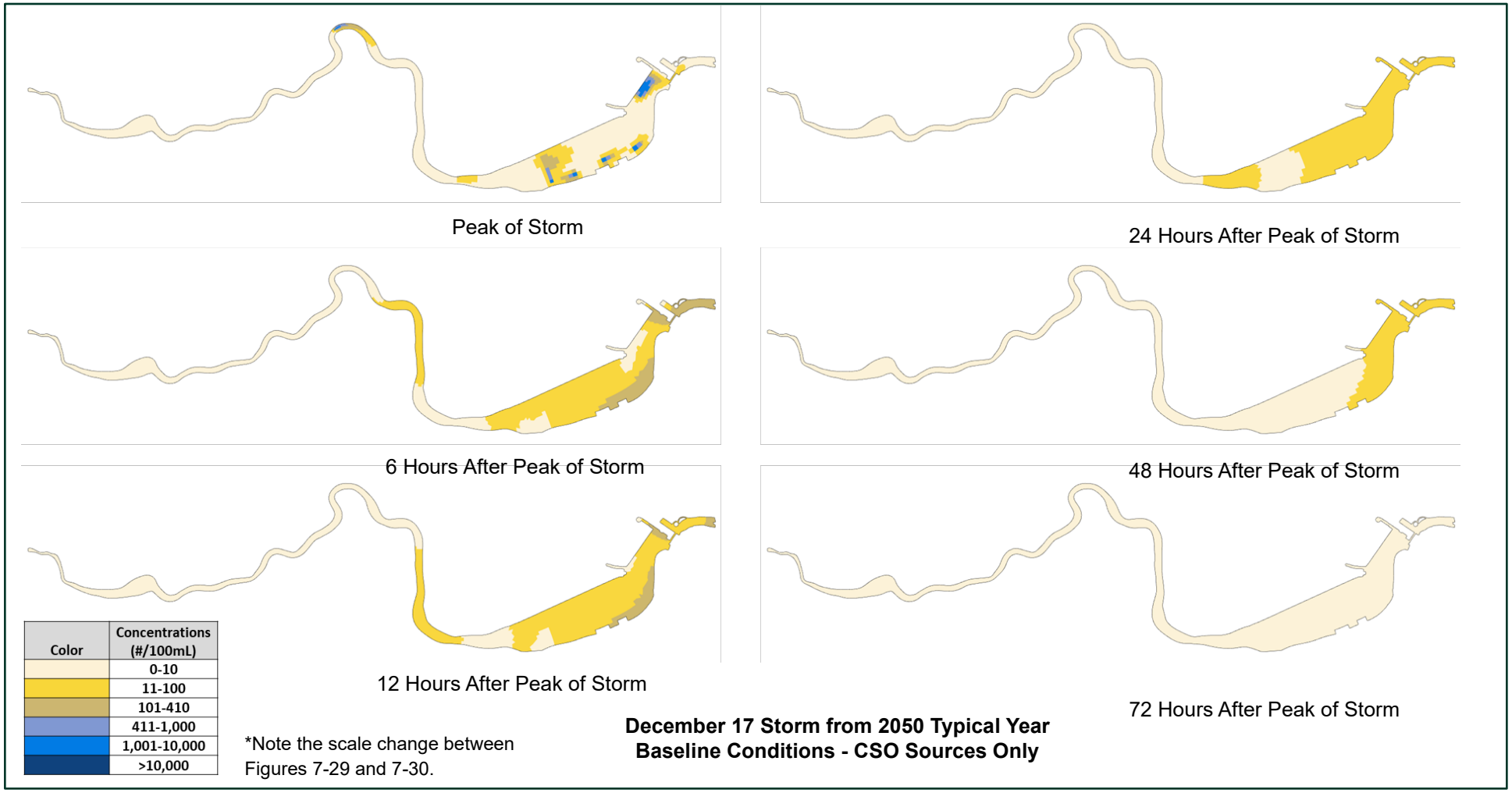



**Figure 7-30. Charles River *E. coli* Concentrations Over Time During and After the December 17 Storm from the 2050 Typical Year, Baseline Conditions, CSO Sources Only**

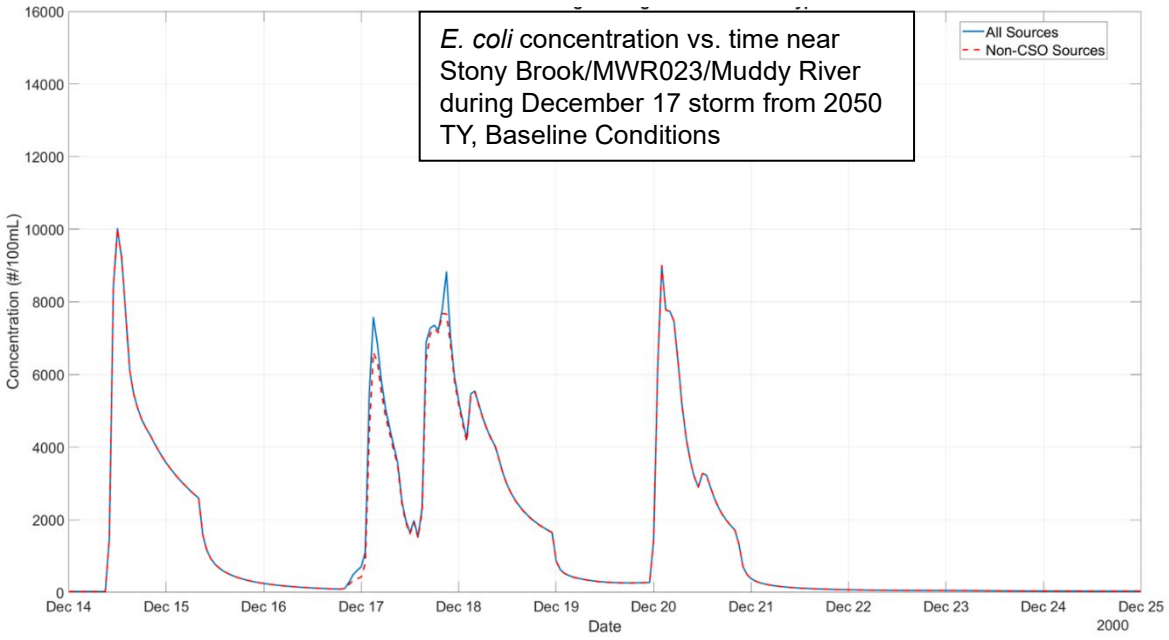



**Figure 7-31. *E. coli* Concentration vs. Time Near Stony Brook/MWR023/Muddy River, All Sources vs. Non-CSO Sources**

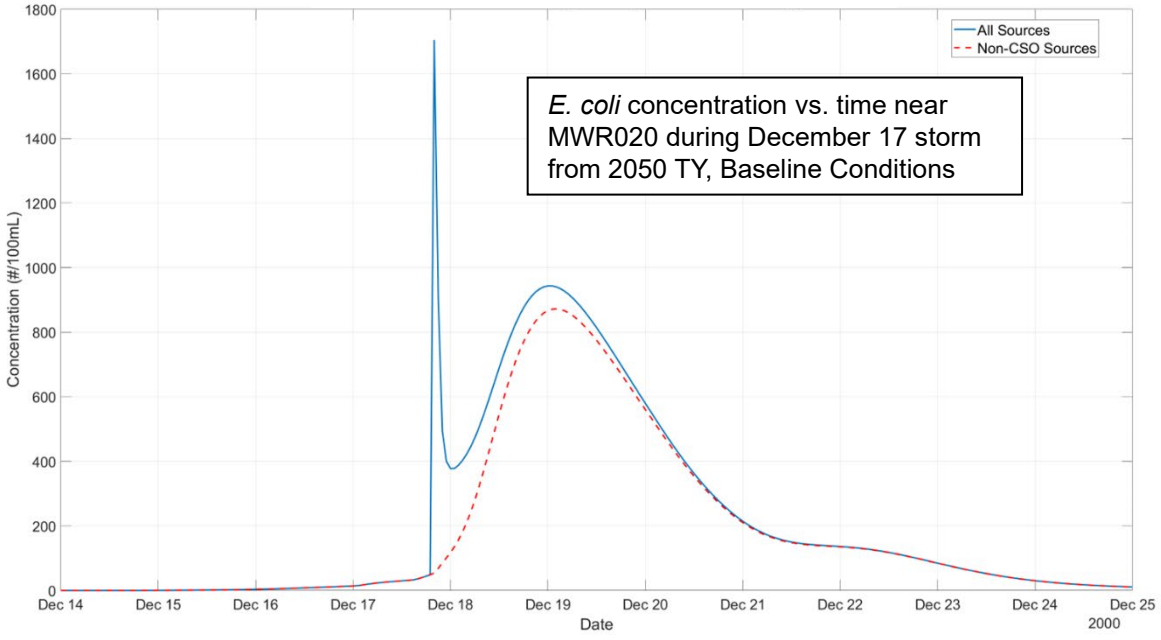



**Figure 7-32. *E. coli* Concentration vs. Time Near MWR020, All Sources vs. Non-CSO Sources**

#### 7.6.2.7 Summary of the Baseline Water Quality Assessment for the Charles River

Key points from the 2050 TY Baseline Condition water quality assessment for the Charles River are summarized as follows:

- Stormwater is the predominant source of *E. coli* loading to the Charles River, followed by the boundary loads from upstream. The sanitary component of untreated CSO represents a very small fraction (0.4%) of the total annual bacteria load to the Charles River.
- For the MassDEP-recommended single sample maximum *E. coli* criteria, no differences were predicted in the percentage of time the concentration in the entire modeled river was less than the specified maximum for All Sources compared to Non-CSO Sources. Thus, elimination of CSO would not change this assessment of attainment.
- For the All Sources condition, nearly 60% of the river area was predicted to meet the single sample maximum criterion for *E. coli* at least 90% of the time, and over 80% of the river area is predicted to meet the single sample maximum criterion for *E. coli* at least 80% of the time.
- Assessments isolating the various sources of bacterial loading indicated that upstream sources and base flows are the key drivers of non-attainment with the 30-day *E. coli* geometric mean criterion. CSO and stormwater loads have limited impact on attainment of the 30-day *E. coli* geometric mean criterion.
- For the All Sources condition, about half of the river is in attainment with the 30-day *E. coli* geometric mean criterion at least 95% of the time, and about 20% of the river is in attainment with the 30-day *E. coli* geometric mean criterion less than 65% of the time. Most of the non-attainment occurs in the relatively narrow reach of the river downstream of the Watertown Dam, and upstream of the most upstream CSO.
- CSOs and stormwater appear to have more of an influence on the level of attainment with the STV criterion than the geometric mean criterion. Upstream sources and base flows are also key drivers of non-attainment with the 30-day *E. coli* STV criterion.
- For the All Sources condition, just over 10% of the river is in attainment with the 30-day *E. coli* STV criterion at least 95% of the time, and more than 50% of the river is in attainment with the 30-day *E. coli* STV criterion less than 65% of the time. Between the geometric mean and STV criteria, the STV creates the greater extent of non-attainment, and the non-CSO sources are the greatest contributors to that non-attainment.
- Plots of maximum *E. coli* concentrations in the Charles River showed that CSOs contributed to higher maximum concentrations in the river, but those areas of higher concentration were generally limited to the immediate vicinity of the CSO outfalls. For most of the river area, the CSOs did not appear to affect the extent of the different ranges in maximum concentration.
- Plots of *E. coli* concentration at different time intervals during and after the storm that generated the largest CSO volume in the 2050 TY demonstrated the movement and attenuation of peak concentrations over time. By six hours after the peak of the storm, the high concentrations from the Watertown Dam have moved downstream, and the peak concentrations associated with outfalls MWR019, MWR020 and CAM017 have dissipated. By 48 hours after the peak of the storm, the upstream reach of the Charles River is under 410 #/100mL, while most of the lower basin is in the 410-1,260 #/100mL range. By 72 hours after the peak, the entire modeled river is under 410 #/100mL except for an area adjacent to the MWR023 outfall that was influenced by a second rain event (with no CSO). For the CSO Sources Only condition, the *E. coli* concentrations in the Charles River were predicted to drop below the 410 #/100mL level by 6 hours after the peak of the storm.

CSO represents a very small fraction of the total annual bacteria load to the Charles River, and it is not the main driver of water quality degradation. Elimination of CSO would reduce peak short-term concentrations, but it would not substantially change the duration or extent of the river being deemed unsafe for recreation.

# 8. CSO Control Technologies

This section outlines the types of CSO control technologies that the Partners considered to achieve the four LOCs presented in Section 7. EPA broadly categorizes CSO control technologies into four (4) main areas, each encompassing a variety of associated technologies, as described in *USEPA CSO Guidance for Long-Term Control Plan, September 1995*. These categories are:

- **Source Control:** reduce the generation of stormwater runoff volumes, peak flows, and pollutant loads *before* they enter the combined sewer systems.
- **Collection System Control:** manage combined flows once they have entered the combined sewer system. These controls reduce CSO volume and frequency by redirecting stormwater flows to a separate system, diverting them to higher capacity sections, maximizing in-line storage within the collection system, or optimizing flow conveyance to POTW via passive or Real-Time Controls.
- **Storage Technologies:** capture excess flows from the combined system, store the additional volume, and then release it back into the system for treatment once the conveyance capacity is restored.
- **Treatment Technologies:** mitigate the pollutant load discharged into a receiving water body with end-of-line treatment. These controls do not reduce the number of CSO activations or the volume of CSOs but instead treat the discharges.

Under this Updated CSO Control Plan, technologies considered for CSO control are categorized under two main areas: 1) reducing CSO volumes and 2) treating CSOs. Within these two areas, six different technologies were evaluated and described in **Table 8-1.**

**Table 8-1. CSO Control Strategies Evaluated in this Updated CSO Control Plan**

| Strategy Goal | Description |
|---|---|
| **Reduction of CSO Volumes** | |
| *Sewer Separation*(1) | This involves the separation of combined sewers into dedicated sanitary and stormwater sewers. |
| *Green Stormwater Infrastructure* | This uses nature-based solutions that can assist in mitigating the impacts of stormwater and improving water quality by infiltrating or detaining flows before releasing them back into the drainage system. |
| *Inflow/Infiltration Reduction* | This reduces the volume of groundwater or stormwater entering a sanitary or combined sewer system from cracked sewer mains, offset joints, or erroneously connected stormwater conduits that should otherwise go to the stormwater system. |
| *Storage* | This consists of deflecting or detaining stormwater or combined sewage into a storage unit and holding it until the system has available hydraulic capacity to handle the flows when they are released back into the system. Storage facilities can also be designed to provide some sedimentation treatment capacity for flows exceeding the storage volume of the unit. |
| *Conveyance* | This involves upsizing pipes, upsizing pumps, and improving pump station operations to increase the volume and flow that the sewer system can handle, and therefore reducing the need for CSOs as a point of relief. |
| **CSO Treatment** | This consists of end-of-line treatment of the CSOs before they are released into the receiving waterways to reduce their pollutant loads. |

**Note**:

(1) The EPA CSO abatement policies require that combined sewer system separation be evaluated as a step in CSO facilities planning. Although separation typically eliminates CSOs, it may not, in all cases, be the most appropriate technology in terms of addressing site-specific water quality objectives.

Descriptions of these different technologies are provided below.

## 8.1 CSO Volume Reduction Technologies

### 8.1.1 Sewer Separation

Sewer separation involves constructing new, dedicated sanitary sewers and/or storm drains, typically within roadways, to separate sanitary wastewater from stormwater. In these systems, dedicated storm drains collect and convey stormwater directly to a receiving waterbody via an outfall. This significantly reduces the volume of water entering the sanitary or combined system, thereby reducing or eliminating the risk of CSOs at downstream regulators and lowering treatment demands at the respective end-of-line treatment facility.

Due to its extensive nature, sewer separation tends to be invasive, requiring new infrastructure in public right-of-way, leading to potential utility conflicts, road closures, and disruptions to traffic and community activities during construction, which can span decades depending on project scope and complexity.

Sewer separation contributes to significant reductions in CSOs and a decrease in flows reaching the end-of-line treatment facility; however, the creation of dedicated separate stormwater systems triggers additional requirements that must be met. For an accurate representation of sewer separation, these additional requirements must be considered.

**NPDES MS4 Permit Requirements**: New separated stormwater discharges are regulated by the NPDES MS4 Permit (as previously detailed in Section 2.4.2). The watersheds tributary to the Alewife Brook, Upper Mystic River, and the Charles River are subject to enhanced MS4 requirements based on phosphorus and bacteria impairments. These impairments were summarized in detail in Section 2.1.3. Meeting the MS4 Permit requirements typically involves installing treatment systems and/or green infrastructure.

**Flood Protection Requirements**: Under 310 CMR 10.57(4), projects within *Bordering Land Subject to Flooding* must provide compensatory storage for any lost floodplain volume. Construction within any floodplain for outfalls or other structures must ensure that any flood storage volume lost (e.g., from filling or structures) must be replaced, ensuring the replacement area has an unrestricted hydraulic connection to the same water body. A large portion of the land area along and beyond the Alewife Brook lies within a floodplain, making it more difficult to create new hydraulically connected compensatory storage for lost floodplain due to construction modifications. In contrast, the Charles River and Upper Mystic River have less compensatory storage challenges since the floodplain has limited impact beyond their banks.

**Local Conservation Commissions Permitting**: The local conservations commissions enforce the MassDEP Stormwater Standards, which are incorporated into the Wetlands Protection Act (310 CMR 10.00) and the Massachusetts Water Quality Standards (314 CMR 4.00) through a public permitting process. Compliance with these requirements—which also contains many of the MS4 and flood protection requirements discussed above—are reviewed and permitted by the local conservation commissions. The ability to meet permitting standards will vary based on the varying hydrologic conditions across the watersheds and leads to different project requirements. The stormwater management standard that requires that *systems shall be designed so that post-development peak discharge rates do not exceed pre-development peak discharge* rates is more challenging to achieve in the Alewife Brook than in the Charles and Mystic Rivers due to the hydraulic conditions in the Alewife Brook. Attenuating/detaining the post sewer separation peak discharge rate is essential to avoid worsening flood risk during the peak discharge. Flow attenuation/detention requires constructing stormwater storage or stormwater detention facilities that hold runoff during the peak of the storm and releases it more slowly after the peak.

Sewer separation is a complex technology with many additional confounding factors. These considerations are included in alternative development in Section 9.

### 8.1.2 Green Stormwater Infrastructure (GSI)

GSI encompasses a diverse range of site-specific installations designed to capture and/or infiltrate stormwater runoff from their respective tributary areas, thereby preventing it from entering the drainage

system or reducing flows. Typical GSI examples include grassy swales, infiltration basins, subsurface leaching facilities, rain gardens, or infiltration sumps. Infiltration practices reduce flows to the collection system altogether, and detention practices can dampen incoming peak flows and consequently reducing the risk of some CSOs. Flow detention involves collecting stormwater runoff from a localized area and slowly releasing it back into the drainage system.

Beyond peak flow reduction, GSI also offers water quality benefits by reducing stormwater runoff pollutant loads from their tributary areas. Contaminants like phosphorus and suspended solids can be treated by properly sized GSI. Effective GSI relies on adequate space to treat the desired runoff capture area as well as suitable hydrologic soil types for infiltration. In dense urban environments like those in Cambridge, Somerville, and Boston, finding the necessary space and adequate soil conditions can be challenging. In order to achieve a noticeable impact on CSO volume and pollutant load reduction, hundreds or thousands of installations are often required.

### 8.1.3 Infiltration/Inflow (I/I) Reduction

Infiltration refers to water that leaks into a sewer system from groundwater, while inflow refers to water other than sewage that is discharged into a sewer system. Inflow can be from constant sources, such as cooling water discharges or foundation drains, or from intermittent sources typically related to stormwater runoff, such as roof leaders or catch basins. Together, infiltration and inflow (I/I) can take up hydraulic capacity in downstream areas, potentially increasing the risk of CSOs or SSOs. I/I controls are typically targeted in separate sanitary sewer systems, as combined sewer systems are designed to accept inflow. Long-term I/I programs are usually most effective in their initial stages where the most obvious and easily-resolved I/I contributors can be addressed, with diminishing returns as the remaining I/I sources become more challenging to identify and resolve.

**Control of Inflow:** Inflow in the form of runoff from impervious areas can enter a sewer system through direct connections from catch basins, area drains, and roof drains. Sump pump connections from private properties are another common inflow source. These types of sources can be readily identified by traditional investigation methods such as smoke testing. The effort to resolve these inflow sources can range from relatively easy (redirecting a roof leader or downspout), to moderate (redirecting a catch basin to a nearby storm drain), to difficult (disconnecting internal roof drains tied into interior building plumbing). In each case, a location to safely discharge the inflow sources needs to be identified nearby. Inflow can also enter pipes indirectly through manhole covers or pipe defects such as offset joints or cracks after rainfall events or prolonged rainy seasons that raise the groundwater table. These sources of flow straddle the boundary between infiltration and inflow and are generally referred to as Rainfall Derived Infiltration/Inflow. Sources of Rainfall Derived Infiltration/Inflow can be more difficult to detect than the point sources described above and often require pipe or manhole rehabilitation to resolve.

**Control of Infiltration:** Infiltration occurs when groundwater enters the collection system through defective pipe joints, cracked or broken pipes, manholes, and similar sources. Infiltration tends to be a more constant but lower-magnitude flow compared to inflow and fluctuates with groundwater levels. Infiltration sources related to pipe condition can be resolved by rehabilitating the pipes (e.g. fixing identified cracks, or relining the pipe). In many communities, infiltration through private service connections (i.e. house connections) has been identified as a significant source of flow into the collection system. Private service connections are more difficult to remediate because they are located on private property and each neighborhood block can have multiple private connections to the sewer. Another challenge with infiltration remediation is that infiltration into pipes can affect the local groundwater elevation (watertable). If the infiltration sources are fixed, the watertable elevation may rise, creating new locations of infiltration to be addressed.

**I/I Reduction and CSO Control:** Sewer system maintenance, which would include pipe condition assessment and control of I/I, is typically an on-going activity for communities with sewer systems. I/I tends to increase as pipes age, so some level of I/I control is generally needed just to prevent an increase in I/I over time. As described further in Section 9, for the purposes of this Updated CSO Control Plan, I/I reduction has been evaluated for the separately-sewered areas that are tributary to downstream combined sewer areas or interceptor systems along Alewife Brook, the Mystic River, and the Charles River. I/I from these upstream areas can affect the downstream CSOs by taking up conveyance capacity in the interceptor system, or by contributing to wet weather flows upstream of CSO regulators. However,

because the separated systems are further away from the CSO regulators than the immediately tributary combined sewer areas, the timing of peak I/I flows may not coincide with the timing of peak combined sewer flows. The magnitude of the I/I flows from separated areas is also typically much lower than the peak wet weather flows from combined sewer areas. For these reasons, I/I controls in upstream areas tend to have a more muted effect on downstream CSOs compared to the amount of I/I removed.

### 8.1.4 Storage Controls

Storage controls are those that temporarily store or remove wet weather flows from the system while it is at peak capacity and then returns it to the system once there is available capacity. There are two main types of storage controls: in-line and off-line/end-of-line systems.

**In-line Storage Controls:** This involves maximizing the use of available storage capacity within the combined sewer pipe network. The primary goal of in-line storage is to detain flows within the pipe system, ensuring they reach the CSO regulator more gradually and thereby reducing the risk of CSO overflows. In-line storage typically involves installing large-diameter, longitudinal culverts or conduits in series with existing sewers. Dry weather flow would pass through these structures, while peak wet weather flows would be limited and held via a flow throttle or a flow restriction. This technique is highly site-specific and may increase the risk of localized flooding by raising the hydraulic grade line in surrounding areas. Maximizing available storage capacity often requires an optimization process to ensure that the risk of flooding is not exacerbated by artificially using pipe capacity for storage, which inherently limits conveyance. In-line storage controls are typically implemented by installing flow control structures, such as orifices or flow throttling devices, at specific locations to limit downstream flows and store excess volume upstream, thereby raising the hydraulic grade line.

**Off-Line or End-of-Line Storage Controls:** This involves building underground storage tanks or tunnels fed by combined flows overtopping a weir connecting the pipe system to the storage facility. End-of-line storage differs from off-line storage only in its location; end-of-line facilities specifically capture and store flows that pass over the CSO weir, typically situated at the most downstream end of the combined sewer system. Off-line storage can be strategically located at any point across the conveyance system's tributary area. However, the further off-line storage is from the CSO regulator, the less effective the storage becomes, requiring larger tanks for the same CSO reduction. The fundamental concept and operating procedure are consistent for both.

Because storage facilities retain flow until the conveyance system's capacity is restored, they are usually equipped with pumping facilities for post-storm emptying unless gravity dewatering is possible. Given that these systems are designed to store combined sewage, they commonly include flushing systems to prevent sediment accumulation and odor control facilities to minimize impact on neighboring communities.

### 8.1.5 Conveyance Controls

These controls are designed to improve flow throughput in the drainage system by increasing the hydraulic capacity of the existing combined sewer network. One example is the expansion of the regional interceptor system's conveyance capacity and its associated pumping facilities, which allows more flows from tributary areas to enter the system, reducing the risk of CSO activations that would otherwise be needed to provide hydraulic relief.

## 8.2 Treatment Control Technologies

Treatment technologies do not reduce the number of CSO activations or the volume of CSOs; rather, they reduce the pollutant load contained in the CSO. Typically, these technologies target settleable solids, floatables, and/or bacteria. Various treatment technologies impact different aspects of wastewater and can operate at various points within the system. Most traditionally, they are installed at the end-of-line, where upstream flows have been consolidated into one or multiple conveyance conduits or regional trunk sewer pipes. End-of-line controls tend to be the most efficient from an O&M perspective, as operations concentrate on one single point where all flows converge. Some technologies physically remove pollutants, while others neutralize them. Common examples include:

- **Swirl/Vortex Technologies:** These can be deployed anywhere within the collection system. While often used as flow regulators, they also offer the added benefit of acting as solids separators.
- **Coarse Screening:** These are typically located at the end-of-pipe treatment, upstream of other treatment technologies, to remove coarse solids and floatables.
- **Disinfection:** This commonly utilizes forms of chlorine to destroy or deactivate microorganisms in wastewater. This may necessitate a subsequent de-chlorination process to remove residual chlorine from the waste stream before it enters receiving waterbodies, thereby preventing harm to aquatic organisms and wildlife.

Treatment technologies were not divided into distinct sectors but considered as one control for planning purposes.

## 8.3 Summary of CSO Control Technologies

The Partners developed alternatives that leverage different combinations of the six technologies described above to meet the established LOCs for the Updated CSO Control Plan. **Table 8-2** maps these six technologies into the four EPA categories.

**Table 8-2. Representation of the Six Evaluated CSO Control Technologies and How they Relate to the EPA Categories**

<table>
<tr><th colspan="5">EPA Categories</th></tr>
<tr><th></th><th>1) Source Control</th><th>2) Collection System Control</th><th>3) Storage Technologies</th><th>4) Treatment Technologies</th></tr>
<tr><td rowspan="4">Reduction of CSO Volumes</td><td rowspan="4">Green Stormwater Infrastructure (GSI)</td><td>Sewer Separation</td><td rowspan="4">Off-line Storage</td><td rowspan="4"></td></tr>
<tr><td>Infiltration/Inflow (I/I) Controls</td></tr>
<tr><td>In-line Storage</td></tr>
<tr><td>Conveyance Controls</td></tr>
<tr><td>Treatment of CSO Volumes</td><td></td><td></td><td></td><td>Treatment Controls</td></tr>
</table>

# 9. Development of CSO Control Alternatives

## 9.1 Process for Development of CSO Control Alternatives

Both the Alewife Brook/Mystic River and Charles River Variances require "[a]n evaluation of the costs and water quality benefits of further CSO control alternatives, up to and including elimination of CSO discharges." To address this requirement, the Partners developed many alternatives to achieve each level of control described in Section 7. Alternative development was an iterative process that involved the following steps shown in **Figure 9-1** and described below.

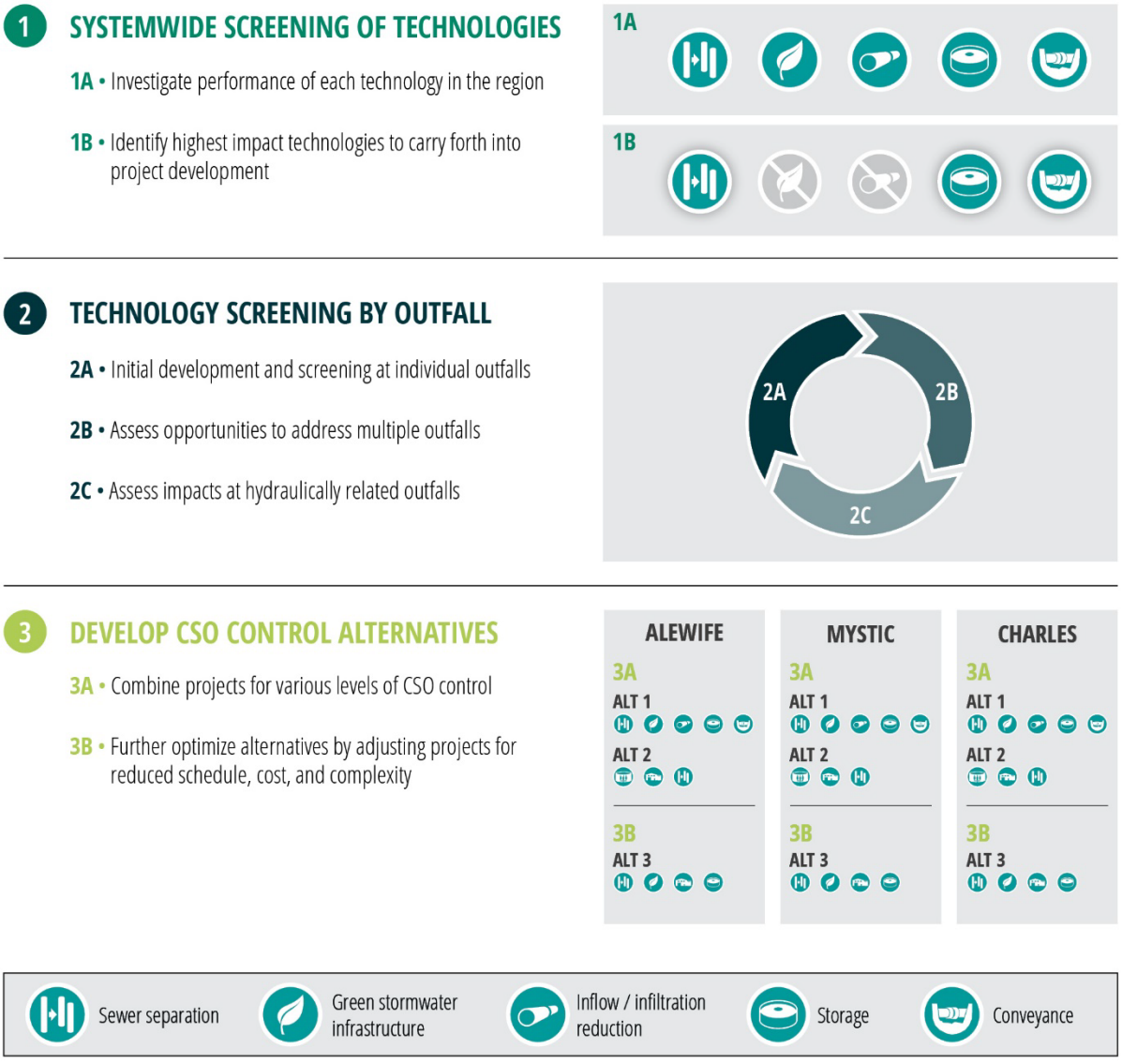



**Figure 9-1. Process for Development of CSO Control Alternatives**

**Step 1: Systemwide Screening of Technologies**

First, the Partners assessed each of the CSO control technologies described in Section 8 for applicability and feasibility across the region. This first step identified the upper limit of CSO control if each technology was applied on a systemwide basis. In some cases, these evaluations identified limitations in performance or implementation feasibility that indicated the technology would not be worth evaluating further on a systemwide basis. The assessment, however, did not necessarily preclude any technology from being evaluated for individual outfalls. This screening is presented in Section 9.2.

**Step 2: Local and Regional Technology Assessment**

Next, each Partner independently evaluated the feasibility of each technology for each individual outfall under its jurisdiction. The Unified Model was used to develop initial technology sizing and assess CSO reduction performance. For the Alewife Brook and Charles River, multiple CSO outfalls are located near each other, creating opportunities to consolidate technologies across multiple outfalls. For these waterbodies, this step included an assessment of consolidation opportunities. This encompassed strategies like regional treatment or storage facilities to capture flow from multiple close-proximity outfalls as well as regional sewer separation for all outfalls discharging to one waterbody.

The Partners followed a similar process to develop alternatives to control CSOs in the 2050 5-year and 25-year design storms. Individual outfall assessments illustrated that fewer technologies could achieve these levels of control. Therefore, alternatives for these levels of control focused on regional strategies.

This was a comprehensive effort on the part of each Partner, with a variety of scenarios modeled, as presented in **Sections 9.4**, **9.6**, and **9.8**.

**Step 3: Develop CSO Control Alternatives**

The final step culminated in the combination of technologies to create alternatives for each level of control in each waterbody. Starting with 0 CSOs in the 2050 TY, the Partners combined the individual technologies at each outfall into one single alternative, referred to as the “Integrated Alternative” for each waterbody. Then, based on the cumulative impacts of the interconnected outfalls, individual technologies were re-sized and optimized for the intended level of control. This optimization included substituting technologies where modeling or other feasibility considerations suggested a different arrangement could potentially be beneficial. These alternatives were referred to as "Hybrid” alternatives.

Working from the group of integrated and hybrid alternatives, the Partners also investigated optimal alternative sizing to reduce but not eliminate CSO discharges in the 2050 Typical Year (Limited CSOs in 2050 TY LOC). This approach investigated the predicted CSO volumes at each outfall for each storm and identified a cost-effective “breakpoint” where a substantial increase in size, cost, or implementation complexity of the alternative would be required.

Development of alternatives for the 2050 5-year and 25-year design storms generally built upon the regional approaches created in each waterbody in the regional assessment. Regional approaches are more appropriate for the larger design storms because of the large volumes that must be mitigated. Regional solutions are the most efficient way to handle such great volumes in a centralized manner. The Partners also sought to optimize alternatives for the large design storms, often by integrating GSI with other technologies.

This effort culminated in a total of 39 alternatives across the four LOCs and three waterbodies. **Sections 9.5, 9.7**, and **9.9** present this effort in the Alewife Brook, Mystic River, and Charles River, respectively.

## 9.2 Systemwide Screening of Technologies

The first step in the initial development of alternatives involved a systemwide technology screening to identify an outer limit of implementation and the associated effectiveness of CSO control for a single technology. This is the first step as illustrated previously in **Figure 9-1**, shown again in **Figure 9-2**. The

Partners used these results to guide how (and whether) individual CSO control technologies could be incorporated into alternatives moving forward.




**Figure 9-2. Alternatives Development Step 1**

### 9.2.1 GSI

GSI was initially evaluated systemwide to determine the overall impact GSI implementation would have on CSO reduction. This GSI performance assessment is grounded in the assumption that GSI would be installed within the public right-of-way and capture the first inch of runoff from 10 percent of the impervious right-of-way in the combined sewer areas tributary to the Alewife Brook, Mystic River, and Charles River. This was configured in the modeling analysis so GSI installations would drain down in less than 72 hours, which is a requirement of the Massachusetts Stormwater Standards.

The Partners adopted a 10 percent impervious area capture assumption based on the runoff capture goals established in other CSO programs in the US. Examples include New York City, Philadelphia, and Kansas City; each of these programs implement GSI to varying degrees (10% for NYC[1], 20% for Philadelphia and 1% for Kansas City, see **Table 9-1**).

Comparing these three cities to Somerville, Cambridge, and Boston shows that New York City's urban landscape most closely reflects the conditions found in these New England communities. Somerville, Cambridge, and Boston rank as the 1st, 3rd, and 4th most densely populated cities in New England, underscoring the significant public space constraints inherent in such dense urban environments. Based on this information, New York City's goal of capturing and treating 10 percent of impervious area with GSI was adopted for the systemwide GSI analysis. **Table 9-1** provides a comparison of densities and GSI treatment goals between the different cities' CSO programs.

[1] The original goal (2012 consent Order) was to reduce CSOs by 1.67 billion gallons per year by 2030 and manage stormwater equivalent to one inch of rainfall on 10% of impervious services by 2030. The consent order milestones was recently revised to remove the requirement to manage stormwater equivalent to one inch of rainfall on 10% of impervious surfaces by 2030. The new milestone is based on amount spent and CSO reduction.

**Table 9-1. Comparison of GSI Runoff Capture Goals and Population Density in Cities with Active CSO Programs**

| | Population Density (Pop/sq. mi.) | % Area Serviced by Combined Sewers | % Imp. Area Treated by GSI |
|---|---|---|---|
| New York City[1] | 29,300 | 60% | 10% Goal |
| Philadelphia[2] | 11,936 | 47% | 20% Goal |
| Kansas City[3] | 1,410 | 18% | 1% Goal |
| Somerville | 19,652 | 81% | 10% Modeled[4] |
| Cambridge | 18,512 | 63% | 10% Modeled[4] |
| Boston | 13,977 | 20% | 10% Modeled[4] |

**Notes:**
(1) NYC: https://extapps.dec.ny.gov/docs/water_pdf/2023nycgiordermod.pdf. See also footnote 1 on Page 9-3.
(2) Philadelphia: https://water.phila.gov/wp-content/uploads/files/gsi-strategic-framework.pdf
(3) KC: https://www.kcsmartsewer.us/approach/third-amended-consent-decree
(4) 10% of the impervious right-of-way area in the combined sewershed was modeled as an overly optimistic representation of system wide GSI

Based on recent project experience, a 10 percent impervious area capture is an optimistic assumption for such dense urban environments. While 10 percent was adopted for the systemwide assessment based on New York City's goals, the reality is that achieving it would be extremely challenging.

Recent project experience within Somerville, Cambridge, and Boston indicates this degree of GSI treatment cannot be achieved in many locations due to site limitations such as subsurface utility congestion, existing buildings/foundations from which GSI must be offset, high groundwater, steep slopes, or poor subsoils. Furthermore, aboveground GSI features can occupy valuable space in highly congested, urban areas that may impact other municipal priorities such as bike lanes, public transit, sidewalk width, existing street trees, and parking spaces.

Due to these significant challenges and local project experience, the 10 percent capture assumption is an overly optimistic target for a region-wide screening-level assessment.

**Table 9-2** presents a comparison of the CSO activation frequencies and volumes for the Alewife Brook, Mystic River, and Charles River CSOs for Baseline Conditions versus the systemwide GSI implementation alternative. As indicated in **Table 9-2**, implementing an aggressive GSI program capturing 10% of the impervious area reduced CSO volume in the 2050 TY by 16%, 19%, and 7% in the Alewife Brook, Mystic River, and Charles River, respectively, and it did not generally change the number of activations.

## Table 9-2. Alewife Brook, Upper Mystic River, and Charles River 2050 Typical Year Baseline Conditions vs. Systemwide GSI Implementation

| Outfall | Baseline Conditions 2050 Typical Year | | Systemwide GSI Implementation 2050 Typical Year | | Difference | |
|---|---|---|---|---|---|---|
| | Activation Frequency | Volume (MG) | Activation Frequency | Volume (MG) | Activation Frequency | Volume (MG) |
| **Alewife Brook** | | | | | | |
| CAM001 | 1 | 0.02 | 1 | 0.01 | 0 | -0.01 |
| CAM002 | 0 | 0 | 0 | 0.00 | 0 | 0.00 |
| CAM401A | 12 | 10.95 | 12 | 10.06 | 0 | -0.89 |
| CAM401B | 3 | 0.30 | 3 | 0.26 | 0 | -0.04 |
| MWR003 | 3 | 1.08 | 3 | 1.05 | 0 | -0.03 |
| SOM001A | 13 | 8.51 | 12 | 6.18 | -1 | -2.33 |
| **Alewife Brook Max/Total** | **13** | **20.86** | **12** | **17.56** | **-1/-1** | **-**3.30 |
| **Upper Mystic River** | | | | | | |
| SOM007A/MWR205A | **8** | **29.31** | **8** | **23.76** | **0** | **-**5.55 |
| **Charles River** | | | | | | |
| CAM005 | 6 | 0.73 | 6 | 0.63 | 0 | -0.10 |
| CAM007 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| CAM017 | 3 | 1.04 | 2 | 0.46 | -1 | -0.58 |
| MWR010 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| MWR018 | 4 | 1.86 | 4 | 1.71 | 0 | -0.15 |
| MWR019 | 3 | 1.33 | 3 | 1.20 | 0 | -0.13 |
| MWR020 | 3 | 3.14 | 3 | 2.60 | 0 | -0.54 |
| MWR201 (Cottage Farm) | 4 | 29.81 | 4 | 28.57 | 0 | -1.24 |
| MWR023(1) | 6 | 0.13 | 6 | 0.13 | 0 | 0.00 |
| **Charles River Max/Total** | **6** | **38.04** | **6** | **35.3** | **0/-1** | **-2.74** |

**Note:**
(1) Values represent the portion of CSO discharge to the Charles River from the 046 regulators that activate and discharge at outfall MWR023 when Boston Gatehouse No. 1 is open. Approximately 25% of the volume from the 046 regulators discharges at outfall MWR023 when Boston Gatehouse No. 1 is open.

**Table 9-2** shows that even with an aggressive and aspirational goal of capturing 10 percent of impervious areas with GSI, the resulting CSO reduction benefits remain limited. This is due to a variety of factors:

- GSI is assumed to capture up to one inch of runoff from the tributary impervious area, which reflects the highest requirement in the Massachusetts Stormwater Standards. Many storm events, particularly those at the 2050 5-year and 25-year levels of control, exceed this volume by a substantial margin (5.3 and 7.8 inches, respectively). Therefore, because GSI manages the first inch of rain that falls, it does not necessarily shave the peak from wet weather flows or contribute to a reduction or elimination of CSO volumes.
- GSI is primarily designed to improve stormwater quality by capturing the first flush, which typically contains the highest concentrations of pollutants. Because GSI systems must store and treat this initial runoff, much of their available storage is used early in a storm. As a result, little to no capacity remains during later, more intense portions of the storm—when CSOs are most likely to occur.
- GSI installations are small and dispersed in nature. Numerous installations, into the hundreds or thousands, are often required to achieve meaningful impacts. Siting this quantity of GSI in urban environments is incredibly difficult to achieve, thus further constraining the treated areas able to be captured.

In highly urbanized settings such as Somerville, Cambridge, and Boston, these limitations make GSI ineffective as a primary CSO control strategy. However, GSI can still serve as a valuable complementary measure when used alongside other technologies that are more capable of delivering substantial CSO reductions. Therefore, the Partners evaluated GSI as a tool to augment other technologies. The cities of Cambridge, Somerville, and Boston remain committed to incorporating local GSI wherever practical as part of their infrastructure projects, using it to complement other interventions that are proven to be more effective for CSO reduction in dense urban environments.

### 9.2.2 I/I Reduction

The Partners evaluated the potential for regional I/I reduction to reduce CSOs to Alewife Brook, Upper Mystic River, and Charles River. The approach was to configure the Unified Model to remove a portion of the I/I from the upstream separately-sewered systems. The challenge was in identifying an appropriate level of I/I reduction to represent in the model.

I/I reduction is difficult to quantify for several reasons, including:

- Local I/I reduction and sewer rehabilitation projects provide gradual improvements to the regional collection system by reducing I/I and stormwater sources. However, each year the regional collection system gets older and continues to deteriorate, which can lead to increased I/I.
- Sewer capacity gained by elimination of I/I in one subsystem may allow additional I/I to enter the collection system at a different location (known as infiltration migration), resulting in less net flow reduction at the end of the collection system.
- Wastewater flows within the collection system vary dramatically due to changes in precipitation. For example, annual average daily flow for MWRA's system varies up to 100 MGD from year to year (from a low of less than 300 MGD to a high of more than 400 MGD). Small flow reductions for individual projects are dwarfed by regional flow fluctuations

MWRA has invested in I/I reduction heavily through its I/I assistance program. From 1993 through 2025, MWRA has provided $596 million of the total I/I assistance program budget of $1.086 billion to fund 705 projects across the regional system. Over $498 million remains available for distribution, with future phases expected to be approved. The estimated average daily flow reduction associated with completed projects funded through this program was reported to be about 103 MGD. However, the five-year running average daily flow to the DITP declined from approximately 391 MGD (in the five-year period beginning in 1989) to approximately 324 MGD (in the most recent 5-year period), a reduction of 67 MGD. Of that

reduction, approximately 20 MGD is attributable to a decline in the per capita indoor water use within the MWRA service area (MWRA, 2025).

The net reduction that could potentially be attributable to I/I reduction would therefore be 47 MGD, or 12 percent of the 1989 5-year average. Thus, while implemented projects were successful in removing about 103 MGD of I/I, ongoing aging of the system, infiltration migration, and other issues would appear to have contributed 56 MGD of increased I/I in other parts of the system over the same time period, leaving the net reduction of 47 MGD (approximately 12 percent).

For the sensitivity analysis, the Partners chose a level of 30 percent I/I reduction. This reduction, which should be considered a net reduction that also takes into account increased I/I in other parts of the system as a result of aging and infiltration migration, was considered to be a very high level of net I/I removal to be achieved on a widespread, regional basis based on the analysis of MWRA data presented above.

**Table 9-3** presents a comparison of the CSO activation frequencies and volumes for the Alewife Brook, Mystic River, and Charles River CSOs for Baseline Conditions versus with regionwide 30 percent I/I reduction. As indicated in **Table 9-3**, applying regionwide 30 percent I/I reduction had marginal impacts in each waterbody. The total activations remained the same with and without I/I reduction, and the following changes in volumes were predicted:

- 1.0 MG volume reduction in the Alewife Brook;
- Virtually no volume change in the Mystic River; and
- 5.08 MG volume reduction in the Charles River, most of which was treated discharge from MWR201 (Cottage Farm CSO Facility) because that outfall has the largest tributary area.

**Table 9-3. Alewife Brook, Upper Mystic River, and Charles River 2050 Typical Year Baseline Conditions vs. Systemwide I/I Reduction**

| Outfall | Baseline Conditions 2050 Typical Year | | Systemwide I/I Reduction 2050 Typical Year | |
|---|---|---|---|---|
| | Activation Frequency | Volume (MG) | Activation Frequency | Volume (MG) |
| **Alewife Brook** | | | | |
| CAM001 | 1 | 0.02 | 0 | 0.00 |
| CAM002 | 0 | 0 | 0 | 0.00 |
| CAM401A | 12 | 10.95 | 12 | 10.84 |
| CAM401B | 3 | 0.30 | 3 | 0.21 |
| MWR003 | 3 | 1.08 | 3 | 0.67 |
| SOM001A | 13 | 8.51 | 13 | 8.14 |
| **Max/Total** | **13** | **20.86** | **13** | **19.86** |
| **Upper Mystic River** | | | | |
| SOM007A/MWR205A | 8 | 29.31 | 8 | 28.99 |
| **Charles River** | | | | |
| CAM005 | 6 | 0.73 | 6 | 0.68 |
| CAM007 | 0 | 0.00 | 0 | 0.00 |
| CAM017 | 3 | 1.04 | 3 | 0.82 |
| MWR010 | 0 | 0.00 | 0 | 0.00 |
| MWR018 | 4 | 1.86 | 4 | 1.85 |
| MWR019 | 3 | 1.33 | 3 | 1.33 |
| MWR020 | 3 | 3.14 | 3 | 3.09 |

| Outfall | Baseline Conditions 2050 Typical Year | | Systemwide I/I Reduction 2050 Typical Year | |
|---|---|---|---|---|
| | Activation Frequency | Volume (MG) | Activation Frequency | Volume (MG) |
| MWR201 (Cottage Farm) | 4 | 29.81 | 4 | 24.66 |
| MWR023(1) | 6 | 0.13 | 6 | 0.12 |
| **Charles River Max/Total** | **6** | **38.04** | **6** | **32.55** |

**Note:**

(1) Values represent the portion of CSO discharge to the Charles River from the 046 regulators that activate and discharge at outfall MWR023 when Boston Gatehouse No. 1 is open. Approximately 25% of the volume from the 046 regulators discharges at outfall MWR023 when Boston Gatehouse No. 1 is open.

Based on the limited CSO reduction, this technology was not considered further as a stand-alone solution. However, MWRA and its member communities will continue to address I/I through the local I/I community financial assistance program. Cambridge and Somerville also implement I/I reduction projects outside the MWRA financial assistance program, as previously described in Section 4.

### 9.2.3 Treatment

CSO treatment was considered at individual CSO outfalls in the Alewife Brook and Charles River systems and as part of regional solutions. Outfalls SOM007A/MWR205A (Mystic River) and MWR201 (Charles River) were excluded from consideration since discharges from those outfalls are already treated. The treatment systems evaluated were assumed to be similar in configuration to the MWRA's existing Cottage Farm and Prison Point CSO Treatment Facilities which include influent screens, detention tanks to provide settling and contact time for disinfection, and sodium hypochlorite disinfection systems with dechlorination. This approach to treatment would reduce bacteria concentrations in the discharge to below the single sample maximum criteria suggested by MassDEP and reduce solids and floatables; however, it would not be equivalent to secondary treatment (e.g., the level of treatment provided at DITP).

CSO treatment facilities would be configured so that storms with volumes less than the treatment facility storage volume would not be discharged to the receiving water but would be pumped back to the collection system when capacity is available, similar to the operation of a storage tank. In the event of a storm that results in a CSO peak flow exceeding the capacity of the facility, remaining untreated CSO would discharge to the receiving water through the existing outfall.

The preliminary sizing of CSO treatment facilities for the Limited 2050 TY and the 2050 TY levels of control showed that tank volumes required for settling during treatment would be similar to the volumes needed to achieve the same levels of control with storage. Since similarly-sized storage facilities would provide the same level of control without the need for intermittent operation of the disinfection equipment, the analytical equipment needed to control the disinfection system, and the storage and handling of the disinfection/dechlorination chemicals, treatment was not carried forward for further evaluation. For the 2050 5-year and 25-year levels of control, sizing equipment and maintaining sufficient volumes of disinfection/dechlorination chemicals for such infrequent design events would be extremely impractical, so treatment was not carried forward for the 2050 5-year and 25-year levels of control either.

### 9.2.4 Systemwide Sewer Separation

As described in Section 7, the Partners evaluated sewer separation systemwide as a means to represent CSO elimination. The total remaining combined areas tributary to the outfalls subject to the Variances is comprised of approximately 5,150 acres. **Figure 9-3** shows the areas with combined sewers that are tributary to the Alewife Brook, Mystic River, and Charles River, respectively. It also shows unique areas where combined sewer flows may be routed to different receiving waters in different flow scenarios (e.g. wet weather versus dry weather). When evaluating sewer separation for individual waterbodies, these unique areas are included in more than one water body, meaning that the sum of the three waterbodies is greater than 5,150 acres due to these overlapping areas.

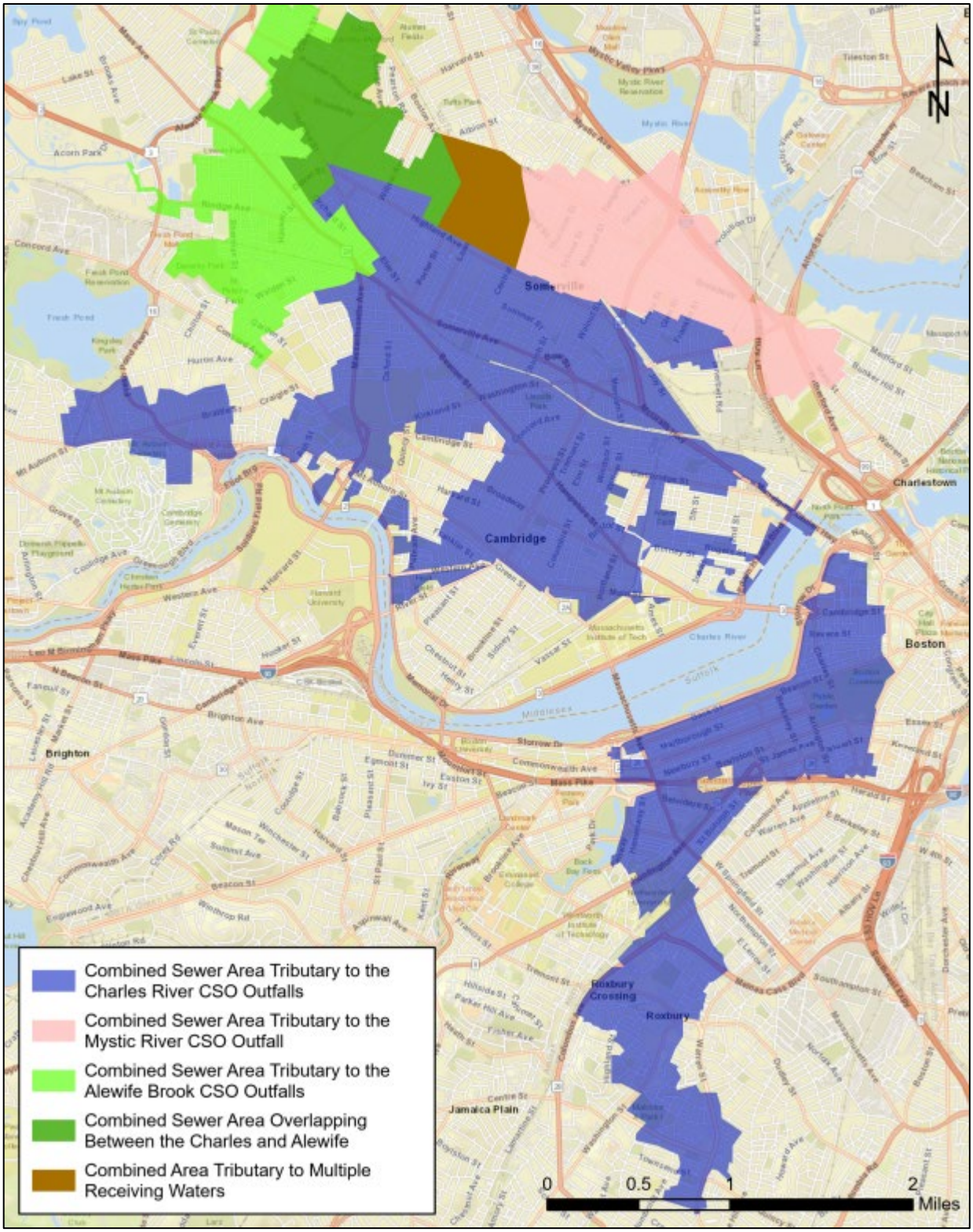



**Figure 9-3. Systemwide Sewer Separation**

For systemwide sewer separation, the Partners modeled separating this entire area of 5,150 acres. Practically speaking, sewer separation involves rerouting stormwater away from the combined system into a new storm drain network. However, it is not feasible for cities to identify and redirect every individual stormwater connection – for example, where roof drains are connected to interior building plumbing. Modeling therefore assumes that 90 percent of the inflow over a large area could be captured by the sewer separation work, and 10 percent of the inflow would remain. This assumption was based on post-construction monitoring of recent separation projects completed in the region, and it reflects what can be reasonably achieved through comprehensive inflow and infiltration reduction measures. The Partners assumed the same inflow removal rates for the 2050 5-year and 25-year storm events as the 2050 TY during the modeling. However, since the model is not calibrated to the large storm events, the percent removal is harder to predict due to potential changes in hydrologic behavior associated with large storms. During large storm events, inflow is sometimes observed to increase due to additional runoff volume as a result of soil saturation, and in other cases it may be lower due to restrictions in the catch basin inlet capacity. This variability is hard to predict if a sufficiently large storm was not captured during the flow metering that supported the model calibration.

Another consideration with sewer separation is whether the existing CSO regulators remain open or are closed. MWRA's region-wide system of interceptors was built starting in the late 1800's to manage flows from its communities at that time, and the system did not account for climate change, future CSO elimination, or population growth as we understand these elements today. The lower reaches of what is now the MWRA system were built with relief points (a weir over which wet weather flows can overflow to a river outfall, also known as a regulator). These regulators allow excess flows to escape the system when combined sewer levels rise to a certain height to minimize unintentional backups in neighborhood streets and basements. These relief points preserve wet weather capacity for combined flows and I/I in wet weather events. Full separation would reduce the stormwater contributions into the system, but it would not eliminate the risk of the system exceeding its capacity in a large rain event due to remaining I/I that was not disconnected—whether during sewer separation or from upstream MWRA communities. As such, the Partners chose to model sewer separation by leaving the CSO regulators open to assess the need for them to remain as system relief. The regulator overflow elevations have been evaluated over the years through prior CSO optimization efforts. Where appropriate the regulator weirs were raised with a goal of reducing CSO volumes without increasing the risk of upstream basement and street flooding.

**Table 9-4** presents a comparison of the activation frequencies and volumes of overflows into the Alewife Brook, Mystic River, and Charles River for the 2050 TY, 5-year, and 25-year Baseline Conditions with systemwide sewer separation. Activations and volumes reported in the table represent flows through the existing regulators that were left open in the model; these overflows are due to remaining I/I in large storm events in the many communities served by MWRA and the remaining inflow (10%) from the 5,150 acres of separated area included in the model. This result supports the decision to leave the regulators open in the analysis. If the tributary area upstream were fully separated, these flows would be considered SSOs.

## Table 9-4. Alewife Brook, Upper Mystic River, and Charles River 2050 Typical Year Baseline Conditions vs. Systemwide Sewer Separation

| | Baseline Conditions | | Systemwide Sewer Separation[1] | | Baseline Conditions | | Systemwide Sewer Separation[1] | |
|---|---|---|---|---|---|---|---|---|
| | 2050 TY | | 2050 TY | | 5-Year Storm | 25-Year Storm | 5-Year Storm | 25-Year Storm |
| Outfall | Activation Frequency | Volume (MG) | Activation Frequency | Volume (MG) | Volume (MG) | Volume (MG) | Volume (MG) | Volume (MG) |
| **Alewife Brook** | | | | | | | | |
| CAM001 | 1 | 0.02 | 0 | 0.00 | 0.21 | 0.54 | 0 | 0 |
| CAM002 | 0 | 0 | 0 | 0.00 | 0.20 | 0.70 | 0 | 0 |
| CAM401A | 12 | 10.95 | 0 | 0.00 | 8.43 | 16.75 | 0.17 | 0.46 |
| CAM401B | 3 | 0.30 | 0 | 0.00 | 1.29 | 2.82 | 0 | 0 |
| MWR003 | 3 | 1.08 | 0 | 0.00 | 5.63 | 10.70 | 0 | 0 |
| SOM001A | 13 | 8.51 | 0 | 0.00 | 5.10 | 8.56 | 0 | 0 |
| **Max/Total** | **13** | **20.86** | **0** | **0.00** | **20.86** | **40.07** | **0.17** | **0.46** |
| **Upper Mystic River** | | | | | | | | |
| SOM007A/ MWR205A | 8 | 29.31 | 0 | 0.00 | 17.42 | 27.17 | 3.29 | 8.54 |
| **Charles River** | | | | | | | | |
| CAM005 | 6 | 0.73 | 0 | 0.00 | 1.61 | 4.13 | 0 | 0.39 |
| CAM007 | 0 | 0.00 | 0 | 0.00 | 5.92 | 15.72 | 0 | 1.62 |
| CAM017 | 3 | 1.04 | 0 | 0.00 | 12.54 | 24.96 | 0 | 0 |
| MWR010 | 0 | 0.00 | 0 | 0.00 | 1.31 | 3.62 | 0.19 | 2.16 |
| MWR018 | 4 | 1.86 | 0 | 0.00 | 2.14 | 3.24 | 0 | 0.37 |
| MWR019 | 3 | 1.33 | 0 | 0.00 | 1.63 | 2.48 | 0 | 0.0 |
| MWR020 | 3 | 3.14 | 0 | 0.00 | 6.21 | 9.86 | 0 | 0.0 |
| MWR201 (Cottage Farm) | 4 | 29.81 | 1 | 0.03 | 33.84 | 55.92 | 17.66 | 32.21 |
| MWR023[2] | 6 | 0.13 | 6 | 0.12 | 0.26 | 0.57 | 0.23 | 0.52 |
| **Charles River Max/Total** | **6** | **38.04** | **6** | **0.15** | **65.46** | **120.50** | **18.08** | **37.27** |

**Notes:**

(1) This scenario included modeling sewer separation in all 3 watersheds simultaneously, and due to the interconnectivity of the sewer network, some CSO results may benefit from separation that is not immediately upstream. For example, when Mystic River sewer separation is modeled independently, CSO activations remain at SOM007A/MWR205A in the 2050 Typical Year, whereas when modeled concurrently with Charles River separation, activations go to zero at that location.

(2) Values represent the portion of CSO discharge to the Charles River from the 046 regulators that activate and discharge at outfall MWR023 when Boston Gatehouse No. 1 is open. Approximately 25% of the volume from the 046 regulators discharges at outfall MWR023 when Boston Gatehouse No. 1 is open.

As indicated in **Table 9-4** systemwide sewer separation is predicted to eliminate CSO discharges in Alewife Brook and the Upper Mystic River in the 2050 TY. In the Charles River, one discharge is predicted to remain at outfall MWR201, and six small-volume discharges tributary to outfall MWR023 are predicted to remain during the 2050 TY. The remaining discharge at outfall MWR201 is driven by inflow from the existing separately-sewered systems in the extensive upstream tributary area and the remaining inflow (10%) from the upstream Cambridge combined area now modeled as separated within the model.

The tributary areas upstream of the CSO regulators currently discharging to outfall MWR023 in the 2050 TY had already been separated, so systemwide sewer separation had no impact on those regulators. This provides a good example of the difficulty in removing all the inflow from a combined system through a recent sewer separation project.

More discharges are expected to remain in the large design storms, as highlighted below.

- Discharges predicted to remain during the 2050 5-year storm:
  - 0.17 MG of untreated discharge would remain at CAM401A;
  - 3.29 MG of treated discharge would remain at SOM007A/MWR205A;
  - 17.66 MG of treated discharge would remain at MWR201;
  - 0.19 MG of untreated discharge would remain at outfall MWR010; and
  - 0.23 MG of untreated discharge would remain at outfall MWR023.
- Discharges predicted to remain during the 2050 25-year storm:
  - 0.46 MG of untreated discharge would remain at CAM401A;
  - 8.54 MG of treated discharge would remain at SOM007A/MWR205A;
  - 32.21 MG of treated discharge would remain at MWR201; and
  - 5.06 MG of untreated discharge would remain from the Charles River outfalls CAM005, CAM007, MWR010, MWR018 and MWR023.

Systemwide sewer separation does not eliminate situations where untreated discharges would overflow into the waterbodies. As described above, this is due to many factors— inflow remaining after sewer separation, upstream I/I, downstream capacity constraints (described in **Section 9.2.5**), and the need to protect from sewer backups into homes or overwhelming treatment equipment downstream—to name a few. Existing discharges at MWR023, whose tributary area is already fully separated, illustrates the difficulty in removing all the inflow through sewer separation projects. Regardless, sewer separation provides for renewal of sewer infrastructure including the opportunity to improve level of drainage service, and separation does effectively eliminate CSOs at some outfalls in certain conditions.

It is important to note that a combined system routes stormwater flows in most rain events to DITP for treatment, but a separate system routes all stormwater from all storms directly to the storm drain system and to waterways. Therefore, sewer separation results in a direct increase in the volume of stormwater that will discharge into the waterbodies. This introduces several additional considerations that cannot be ignored, some of which were previously introduced in Section 8.1.1.

- Stormwater quality: Stormwater contains many pollutants, including nutrients, bacteria/pathogens, chloride, oil/grease, sediments, trash, as described in Section 2.1.3. It is anticipated that some form of stormwater treatment would be needed – this would require identifying the pollutants of concern, the degree of pollutant removal, acceptable and approved technologies for removing such pollutants that can operate intermittently, identifying and acquiring land for a decentralized network of stormwater treatment facilities, and operating and maintaining these facilities.

Treatment of new stormwater discharges is especially complex for waterbodies with phosphorus load limitations established under the current NPDES MS4 Permit, which are set based on approved TMDLs. For example, the Charles River has explicit limits on how much phosphorus its tributary communities may discharge. Meeting these phosphorus limits already poses substantial technical and financial challenges, particularly for projects in dense urban areas. The existing load limits were calculated using a future scenario in which certain combined sewer areas were assumed to be separated. If additional areas—beyond those originally included in the analysis—are separated as part of a systemwide sewer separation effort, the project owner would need to offset the resulting increase in phosphorus loads. Currently, no technology exists to fully offset phosphorus loads in stormwater. The Alewife Brook and Mystic River currently do not have established phosphorus load limits. However, once the new Final NPDES MS4 Permit is issued, it is expected to include quantitative phosphorus limitations based on the recommendations in the Mystic River Watershed Alternative TMDL Development for Phosphorus Management – Final Report[2].

Stormwater also contains bacteria/pathogens at levels higher than state water quality standards. While there is no current regulatory requirement to treat stormwater for bacteria/pathogens, the requirements in the NPDES MS4 Permit assume that programmatic practices like IDDE programs and public education and outreach (summarized in Section 2.4.2) help protect water quality. There are no guidelines to assist the Partners in identifying levels of bacteria/pathogen removal, distinguishing technologies that would be effective, and treating intermittent flows. Large scale sewer separation and associated new stormwater discharges could send high concentrations of *E. coli* and other pathogens directly to the waterbodies without the capability to treat it.

Stormwater treatment requirements are specific to each waterbody, and as the regulatory landscape evolves, significant uncertainties remain as to whether or how the Partners would be able to sufficiently treat new stormwater discharges.

- Stormwater quantity / peak flow mitigation: In addition to stormwater quality, there are some flood-sensitive areas where flood protection requirements add additional project considerations. Alewife Brook is especially sensitive to flooding, and any new flows during rain events would require detention of flows to prevent the addition of flood risk. That is, any flows that exceed the existing peak flowrates would need to be detained in underground storage or new wetlands; this requirement led to the City of Cambridge's construction of the Alewife Reservation Constructed Wetlands. Stormwater detention for peak flow attenuation requires identifying land in specific locations that accommodate system hydraulics and building and maintaining these facilities.
- Stormwater conveyance: Once stormwater is separated into a new storm drain-pipe network, those flows must be routed to a waterway. In some cases, the water level in the waterway may be higher than local interceptors where the stormwater used to go, or landlocked areas receiving sewer separation may have to convey stormwater a long distance. Certain areas subject to these conditions could require pump stations and force mains to convey stormwater to its destination. Even if pumping is not required, there can be crossings of major utilities, railroad tracks, or other infrastructure that brings additional complexity and cost.

Finally, sewer separation at a systemwide scale would need to be implemented in an intentional manner. On the one hand, using a single crew in the region would limit disruption to a small area at any given time, but would take centuries to complete. On the other hand, many crews working simultaneously will complete the work in fewer decades but with more intense impacts to residents, businesses, and commuters for the decades during which construction occurs. The number of crews to engage must also consider the availability of the local construction workforce. Ultimately, implementation would likely involve

[2] https://www.epa.gov/sites/default/files/2020-05/documents/mystic-phosphorus-tmdl-development.pdf

multiple crews at any given time – for example, six to twelve simultaneous crews systemwide would take an estimated 50-100 years to complete the 5,150 acres of sewer separation.

Within this timeframe, every street being separated could be impacted at least three times – first for relocation of major utilities (like gas, electric, and water mains), then for the construction of the separate drain pipe network, and finally for repaving. Residents and businesses in every neighborhood would be subject to local impacts on their streets and the traffic impacts systemwide. All of this work would be in addition to other local public and private construction projects (although efforts would be made to coordinate them to the extent possible).

Sewer separation was carried forward as an alternative for further evaluation even though it would not eliminate untreated discharges for all levels of control and would include significant additional work for stormwater management considerations. It is included in alternatives at various scales, with the recognition that large-scale sewer separation would create large-scale neighborhood disruption for decades. Sewer separation was evaluated on a regional basis, where separating the combined area tributary to each individual receiving water was assessed (see **Sections 9.4.7**, **9.6.1**, and **9.9.8**). Sewer separation was also evaluated on an outfall-by-outfall basis as described in more detail below in **Sections 9.4**, **9.6** and **9.8**.

### 9.2.5 Conveyance

Conveyance was evaluated on a systemwide basis by waterbody and by outfall. Systemwide conveyance evaluations included expanding/optimizing pump stations to increase pump capacity and increasing capacity of the interceptor system. MWRA's interceptor system centralizes and conveys flows from the individual communities to DITP for treatment. **Figure 9-4** provides a schematic of the MWRA interceptor system and facilities related to the Updated CSO Control Plan outfalls with flow arrows indicating the direction of flow. The major interceptor systems serving the Updated CSO Control Plan project area drain to Ward Street Headworks or Chelsea Creek Headworks where flow enters conveyance tunnels to the DITP. Outfall conveyance evaluations included upsizing pipelines, improving hydraulic control structures, improving hydraulics at siphons or internal regulators, and expanding/optimizing pump stations to increase pump capacity. These evaluations are summarized in **Sections 9.2.5.1** through **9.2.5.3** with varying impacts to each of the waterbodies based on the system conveyance pathways.




**Figure 9-4. MWRA Interceptor and Facility Schematic**

#### 9.2.5.1 Increased Capacity at Alewife Brook Pump Station (Alewife Brook)

The Alewife Brook Pump Station (ABPS) receives flow from the combined and sanitary sewer systems in Cambridge and Somerville, and the sanitary sewer systems in portions of Arlington, Belmont, and Medford. Flow is lifted and discharged downstream to the North Metropolitan Trunk Sewer and North Metropolitan Relief Sewer, continuing by gravity to the Chelsea Creek Headworks. The ABPS is predicted to reach its maximum capacity of 91 MGD four times in the 2050 TY. When the pump station reaches its capacity, excess flow can start to back up in the upstream Alewife Brook interceptor system, which in turn contributes to CSOs into Alewife Brook. The model was used to assess the CSO reduction benefit if the ABPS had an unlimited pumping capacity (i.e. the pump station would act as a "free discharge"). This analysis in effect would identify what pumping capacity would be needed at ABPS such that the pump station did not act as a hydraulic restriction for the upstream system.

The assessment was performed both with and without conveyance system modifications. The upstream conveyance modifications would include increasing the size of the interceptors for approximately 1.6 miles upstream of ABPS and increasing the capacity of the dry weather flow connections between the CSO regulators and the interceptors. Downstream conveyance improvements included upsizing approximately 10.5 miles of interceptors/tunnels between ABPS and the MWRA's DITP, along with increasing the capacities of MWRA's Chelsea Creek Headworks facility and the DITP to convey and treat the additional flow. These modifications are presented in **Figure 9-5**.




**Figure 9-5. Systemwide Conveyance Alternative based on Expanding Alewife Brook Pump Station Capacity**

**Table 9-5** presents the peak flow at ABPS and the total CSO volume to Alewife Brook for the 2050 TY Baseline Conditions, and for the expansion of ABPS capacity with and without upstream and downstream conveyance relief. As indicated in **Table 9-5**, without additional conveyance relief, the peak flow to ABPS in the 2050 TY would be 109 MGD, an increase of 18 MGD over the baseline conditions. This increase in ABPS capacity would have limited impact on the annual upstream CSO volume to Alewife Brook (reduction from 20.86 MG to 19.5 MG). With the extensive upstream and downstream conveyance relief projects, the peak flow at ABPS was predicted to increase to about 260 MGD, and the upstream CSO discharges would be eliminated in the 2050 TY.

**Table 9-5. Preliminary Model Assessment of Systemwide Conveyance Alternative Based on Expanding Alewife Brook Pump Station Capacity**

| ABPS System Condition | 2050 Typical Year | |
|---|---|---|
| | Peak Flow at ABPS (MGD) | CSO Volume to Alewife (MG) |
| Baseline Conditions | 91 | 20.86 |
| Free Discharge at ABPS with no conveyance system modifications | 109 | 19.5 |
| Free discharge at ABPS and modifications to upstream and downstream conveyance systems | 261 | 0 |

Since this level of performance could only be achieved with extensive upstream and downstream conveyance improvements, this approach to CSO mitigation was not considered to be practical and was not considered further. The upstream conveyance modifications would include increasing the size of the interceptors for approximately 1.6 miles upstream of ABPS and increasing the capacity of the dry weather flow connections between the CSO regulators and the interceptors. Downstream conveyance improvements to convey the additional 170 MGD would include upsizing approximately 10.5 miles of interceptors/tunnels between ABPS and increasing the capacity of MWRA's DITP, along with increasing the capacities of MWRA's Chelsea Creek Headworks facility and the DITP to convey and treat the additional flow.

#### 9.2.5.2 Increased Capacity at DeLauri Pump Station (Mystic and Charles Rivers)

The DeLauri Pump Station receives flow from the combined and sanitary sewer systems in Cambridge, Somerville, and Boston, and the sanitary sewer system in a portion of Medford. Flow is lifted and discharged to the North Metropolitan sewer system, continuing by gravity to Chelsea Creek Headworks. DeLauri Pump Station is predicted to reach its maximum capacity of 100 MGD 17 times in the 2050 TY. When the pump station reaches its capacity, excess flow can start to back up in the upstream Cambridge Branch Sewer which can contribute to CSO volumes to the Charles River at outfalls MWR018, MWR019, MWR020 and CAM017. Flow can also back up into the Somerville-Medford Branch Sewer, which can contribute to CSO volume at MWRA's Somerville Marginal Facility and outfall SOM007A/MWR205A to the Upper Mystic River. The model was used to assess the CSO reduction benefit if the DeLauri Pump Station had an unlimited pumping capacity, similar to the approach used in the ABPS evaluation described above.

The assessment was made both with and without conveyance system modifications. Upstream conveyance modifications would include increasing the size of the interceptors for approximately 4.8 miles upstream of the DeLauri Pump Station. Downstream conveyance improvements included increasing the size of approximately 7.1 miles of interceptors/tunnels between DeLauri Pump Station and the MWRA's DITP, along with increasing the capacities of MWRA's Chelsea Creek Headworks facility and the DITP to convey and treat the additional flow. These modifications are presented in **Figure 9-6.**

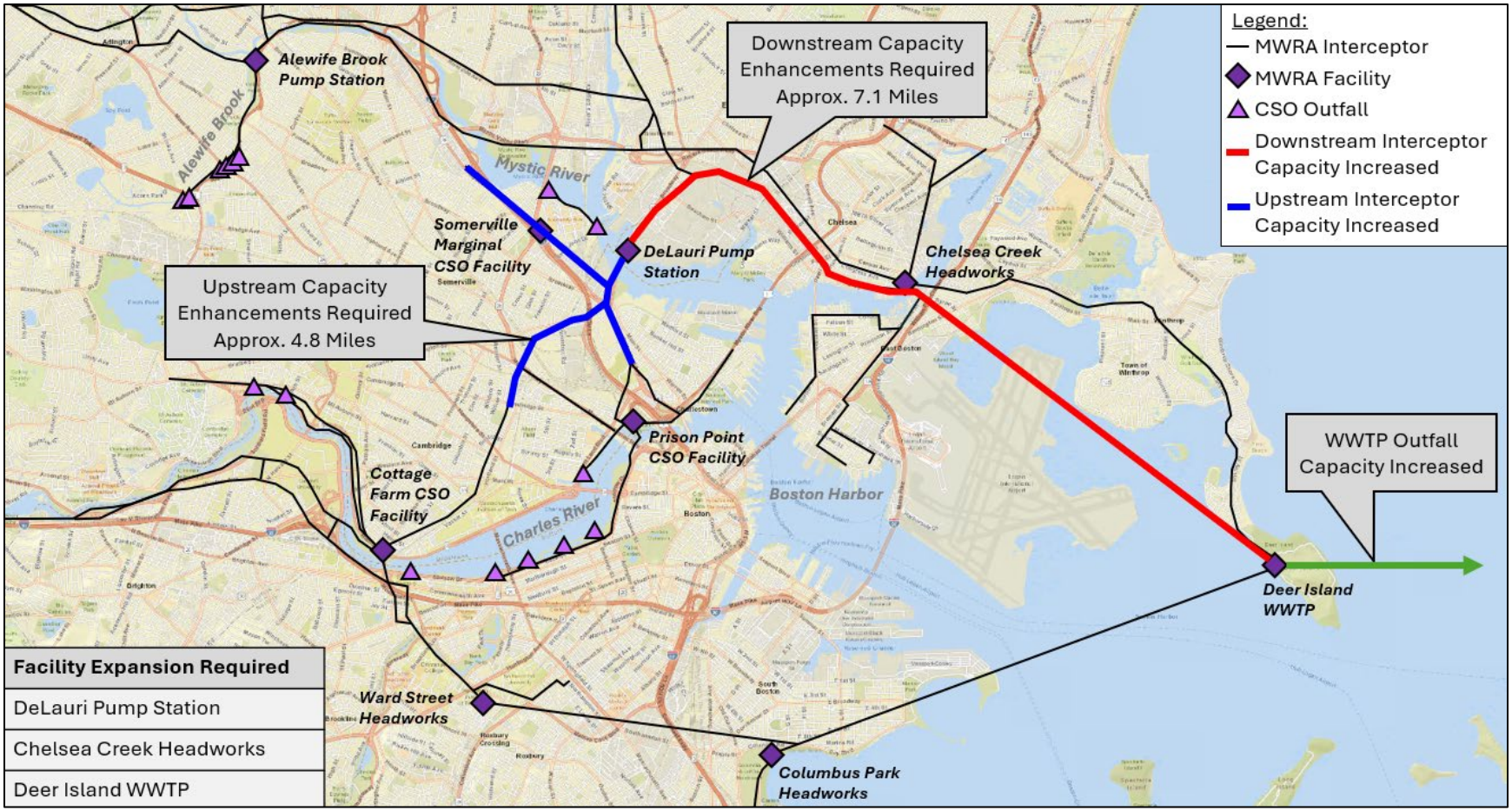



**Figure 9-6. Systemwide Conveyance Alternative based on Increasing Capacity at DeLauri Pump Station**

**Table 9-6** presents the peak flow at DeLauri Pump Station and the total CSO volume to the Upper Mystic River and Charles River from potentially affected outfalls for the 2050 TY Baseline Conditions, and for the expansion of DeLauri Pump Station capacity with and without upstream and downstream conveyance relief. As indicated in **Table 9-6**, without additional conveyance relief, the peak flow deliverable to DeLauri Pump Station in the 2050 TY would be 144 MGD, an increase of 44 MGD over the baseline conditions. This increase in DeLauri Pump Station capacity would have limited impact on the annual upstream CSO volume to the Charles River and Upper Mystic River. With the extensive upstream and downstream conveyance relief projects, the peak flow at DeLauri Pump Station was predicted to increase to 224 MGD. The additional conveyance would reduce the CSO volume discharging to the Upper Mystic River to 5.6 MG in the 2050 TY, and it would slightly reduce the CSO volume to the Charles River.

**Table 9-6. Preliminary Model Assessment of Systemwide Conveyance Alternative Based on Increasing Capacity at DeLauri Pump Station**

| DeLauri Pump Station System Condition | 2050 Typical Year | | |
|---|---|---|---|
| | Peak Flow at DeLauri Pump Station (MGD) | CSO Volume to Upper Mystic River (MG) | CSO Volume to Charles River (MG) |
| Baseline Conditions | 100 | 29.31 | 38.04 |
| Free Discharge at DeLauri Pump Station with no conveyance system modifications | 144 | 23.3 | 35.9 |
| Free discharge at DeLauri Pump Station and modifications to upstream and downstream conveyance systems | 224 | 5.6 | 33.6 |

Since this level of performance could only be achieved with extensive downstream conveyance improvements, including increasing the capacity at the DITP, this approach was not considered to be practical and was not considered further.

#### 9.2.5.3 Increased Capacity at Ward Street Headworks (Charles River)

The WSHW facility receives flow from the combined and separate sanitary sewer systems in Cambridge and Boston, and the sanitary sewer system in portions of Newton and Watertown. Flow is discharged downstream to the Boston Main Drain Tunnel where it is conveyed to the DITP. WSHW is predicted to reach its maximum capacity of 256 MGD four times in the 2050 TY. When the facility reaches its capacity, flow in excess of its capacity can start to back up in the upstream interceptor system which can contribute to CSO volumes to the Charles River, primarily at outfall MWR201. The model was used to assess the CSO reduction benefit to reducing CSOs if the WSHW facility had unlimited capacity, similar to the approach used for the ABPS and DeLauri Pump Station evaluations described above.

The assessment was made both with and without conveyance system modifications. Upstream conveyance modifications would include increasing the size of the interceptors for approximately 2.5 miles upstream of WSHW. Downstream conveyance improvements included increasing the conveyance capacity of the approximately 5-mile Boston Main Drainage Tunnel between WSHW and the DITP, along with increasing the capacity the DITP. These modifications are presented in **Figure 9-7**.

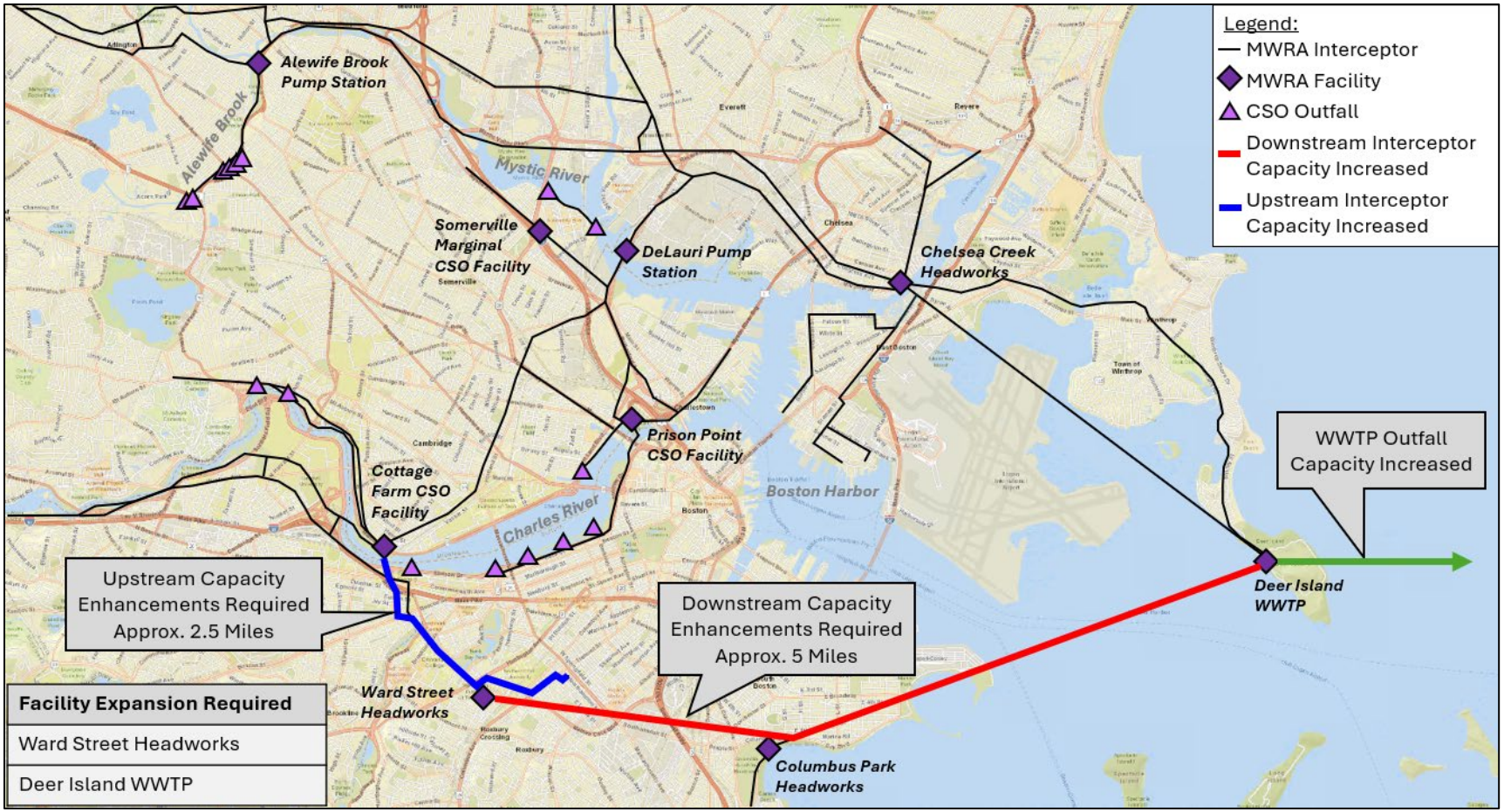



**Figure 9-7. Systemwide Conveyance Alternative Based on Increasing Capacity at Ward Street Headworks**

**Table 9-7** presents the peak flow at WSHW and the total CSO volume to the Charles River from potentially affected outfalls for the 2050 TY Baseline Conditions, and for the expansion of WSHW capacity with and without upstream and downstream conveyance relief. As indicated in **Table 9-7**, without additional conveyance relief, the peak flow deliverable to WSHW in the 2050 TY would be 428 MG, an increase of 172 MGD over the baseline conditions. This increase in WSHW capacity would reduce the annual upstream CSO volume to the Charles River to 9.4 MG. With the extensive upstream and downstream conveyance relief projects, the peak flow at WSHW was predicted to increase to 566 MGD. The additional conveyance would further reduce the CSO volume to the Charles River to 7.58 MG.

**Table 9-7. Systemwide Conveyance Alternative based on Increasing Capacity at Ward Street Headworks**

| | 2050 Typical Year | |
|---|---|---|
| WSHW System Condition | Peak Flow at WSHW (MGD) | CSO Volume to Lower Charles River (MG) |
| Baseline Conditions | 256 | 38.04 |
| Free Discharge at WSHW with no conveyance system modifications | 428 | 9.4 |
| Free discharge at WSHW and modifications to upstream and downstream conveyance systems | 566 | 7.58 |

Since this level of performance could only be achieved with extensive upstream and downstream conveyance improvements, including increasing the capacity at the DITP, this approach was not considered to be practical and was not considered further.

### 9.2.6 Storage

Storage is a common CSO technology that can be readily scaled up or down based on the need. Therefore, no systemwide screening was required, and storage technologies were evaluated at individual outfalls and a regional scale by waterbody (see **Sections 9.4** through **9.8**). In-line storage (i.e., maximizing the use of available storage capacity within the combined sewer pipe network) and off-line storage (i.e., underground storage tanks or tunnels fed by a weir connecting the pipe system to the storage facility) were both considered based on siting constraints and implementation concerns. As stated in Section 8.1.4, the most optimal storage location is closest to the CSO regulator; as the storage site moves farther away, the required volume increases, thus increasing site needs, implementation challenges, and cost. Thes considerations are considered when siting and sizing storage in the sections below.

## 9.3 Preliminary Estimate of Capital Costs

Each alternative was assigned a preliminary estimate of capital cost, and the basis for cost is described in Appendix E and summarized in the subsections below. For many CSO control technologies, general unit construction costs were derived from a group of similar projects, some based on actual construction prices of these projects where possible and sometimes based on detailed estimates developed during design of these similar projects. The resulting unit construction costs are summarized in **Table 9-8**. For tunnels and microtunnels, preliminary construction costs were based on more project-specific features and information can be found in Appendix E.

**Table 9-8. Summary of Unit Construction Cost Assumptions**

| Cost Category | Unit | Unit Construction Cost |
|---|---|---|
| Sewer Separation | Per acre separated | $450,000 |
| Stormwater Peak Flow Attenuation | Per acre separated (where applicable) | $100,000 for attenuation + $225,000 for land (0.015 ac land / ac separated x land unit cost) |
| Stormwater Pumping | Per acre separated (where applicable) | $120,000 for pumping +$60,000 for land (0.004 ac land / ac separated x land unit cost) |
| Stormwater Treatment | Per acre separated (where applicable) | $100,000 for treatment + $15,000 for land (0.001 ac land / ac separated x land unit cost) |
| Conveyance | Per linear foot | $500*ln(D)+$325<br>where D = diameter (feet) |
| Tunnels | N/A | Based on project-specific features<br>+ 10% - 30% complexity factor |
| Storage | Per million gallon (MG) of storage volume | $18,000,000*(Volume (MG))^0.6<br>+ 20% for tanks greater than 5 MG |
| Green Infrastructure | Per acre of impervious right-of-way area with first inch of rainfall managed | $540,000 |
| Land Acquisition | Per acre | $15,000,000 |
| Miscellaneous Subsurface Improvement | Per each | $500,000 |

At this conceptual planning stage, it is customary to add additional factors on top of estimated construction costs to account for other elements. The costs developed for each of the alternatives included the following multipliers, which follow industry standards:

- Contingency: 25% multiplier, which is typical for conceptual planning estimates; and
- Soft costs: 37% multiplier including design, engineering services during construction, and permitting, which is representative for the construction industry.

Capital costs are a summation of construction costs, contingency, and soft costs.

Construction Costs (Unit Construction Cost x Unit)
+ Soft Costs (37% of Construction Costs)
+ Contingency (25% of Construction Costs and Soft Costs)
**Capital Cost**

## 9.4 Alewife Brook - Local and Regional Technology Assessment

Six CSO outfalls (CAM001, CAM002, MWR003, SOM001A, CAM401A, and CAM401B) discharge to Alewife Brook. The location of each of the CSO outfalls is presented in **Figure 9-8**. In dry weather, flow from the regulators associated with these outfalls directly discharge to either the Alewife Brook Branch Sewer (ABBS) or the Alewife Brook Conduit (ABC). Dry weather flow is carried by the ABBS and ABC to the Alewife Brook Pump Station downstream. When the capacity of the dry weather flow connection from the individual CSO regulators is exceeded by inflow during a storm event or when the ABBS and ABC reach their capacity limits, excess flow will overflow to the CSO outfalls along Alewife Brook, thus causing CSOs. A schematic of the Alewife Brook System is shown in **Figure 9-9**.

Based on the systemwide screening of CSO control technologies described in **Section 9.2**, sewer separation, storage, and conveyance were evaluated for each individual Alewife Brook CSO outfall. GSI was included for consolidated regional solutions.




**Figure 9-8. Alewife Brook CSO Outfalls Location Plan**

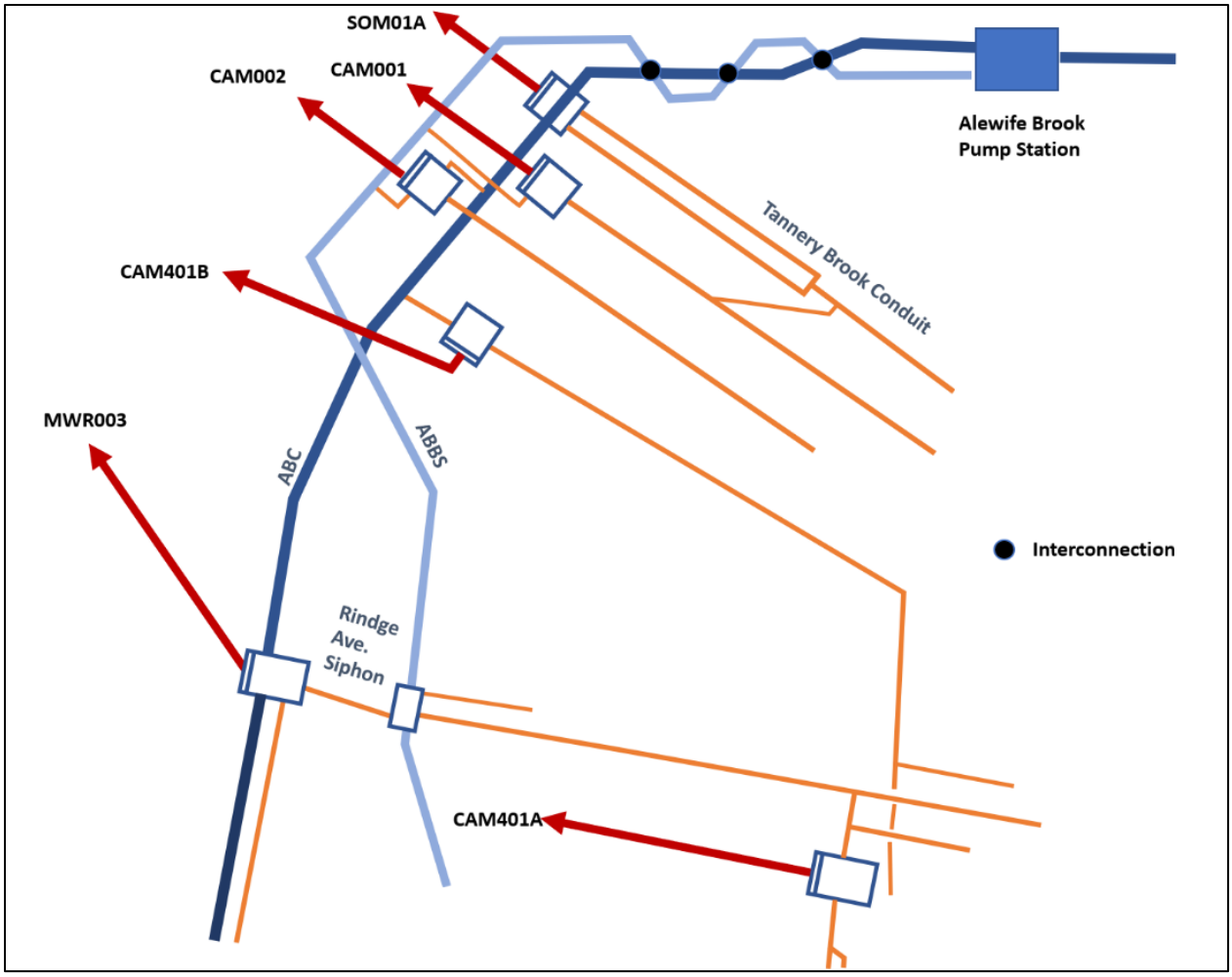



**Figure 9-9. Alewife Brook Combined Sewer System Schematic**

The following section describes the technology screening for the Alewife Brook CSO outfalls, including reasons behind the decisions to set aside certain CSO control technologies that were not selected for more detailed evaluation. This is the second step as illustrated previously in **Figure 9-1**, shown again in **Figure 9-10**.




**Figure 9-10. Alternatives Development Step 2 (Alewife Brook)**

### 9.4.1 CAM001

**Table 9-9** provides a summary of CSO discharges at CAM001.

**Table 9-9. CAM001 Summary of CSO Discharges – Baseline Conditions**

| | Baseline Conditions(1) | | |
|---|---|---|---|
| | 2050 TY CSO Start Date/Volume (MG) | 2050 5-Year Storm Volume (MG) | 2050 25-Year Storm Volume (MG) |
| **Baseline CSO volume per event** | 12/17: 0.02 | **0.21** | **0.54** |
| **Baseline CSO activations** | 1 | | |
| **Baseline CSO total volume (MG)** | **0.02** | | |

**Note:**
(1) Model results are based on the baseline conditions model. Model results may vary when evaluated in conjunction with other projects that are hydraulically connected.

#### Sewer Separation

Sewer separation was considered at CAM001. The small, eight-acre tributary area could be fully separated to eliminate the single, small-volume activation in the 2050 TY. All sanitary flow would be conveyed through the CAM001 underflow to the MWRA, with new stormwater pipes being routed to the CAM001 outfall structure, which could be converted to a stormwater outfall. The additional stormwater may require storage for attenuation of peak flows into the Alewife Brook, and treatment for removal of phosphorous and/or other pollutants of concern. The City will evaluate opportunities for GSI as part of design for sewer separation, but the small tributary area may limit the practicality of identifying space for GSI.

In order for the separation to work with the existing sanitary piping, the connection from the Tannery Brook Drain (SOM001A system) on Clarendon Avenue would need to be disconnected and redirected to the SOM001A outfall. The resulting small increase in flows being redirected to SOM001A would need to be addressed; this could be done by expanding the underflow to MWRA at the SOM001A regulator, or by sizing projects for SOM001A to manage the additional flows.

Due to the relative ease of sewer separation at this small scale, and that it would further the City of Cambridge's long term sewer separation objective, separation is preferred as a CSO control tool for CAM001 and is included in the alternatives in **Section 9.5**.

#### Storage

In-line storage was considered for CAM001, but there is limited storage space in the right-of-way. Several pipes in this neighborhood run through private property, including under buildings. Additionally, to achieve no CSOs at CAM001 in the 2050 TY, the flow through the combined sewer on Clarendon Avenue would need to be throttled to a maximum of 0.75 MGD, which would increase the flow to SOM001A as noted above. Due to the limited space available, in-line storage was not considered further.

Similarly, off-line storage was not considered due to the small volume needed to be stored (0.02 MG). At that small size, the relative high cost of small scale storage, paired with the lack of available space and the availability of other approaches, removed off-line storage from further consideration at CAM001.

#### Conveyance

Conveyance was not considered for CAM001 because the only location to convey flows would be the MWRA Alewife interceptors downstream, and the ability to accept conveyed flows is limited because those interceptors are already full in the larger rain events. Lowering the downstream hydraulic gradeline would require regional improvements through storage, further downstream conveyance, and/or

modifications to facility operation such as increasing the pump capacity of Alewife Brook Pump Station to reduce hydraulic gradelines in the interceptor.

### 9.4.2 CAM002

**Table 9-10** provides a summary of CSO discharges at CAM002.

**Table 9-10. CAM002 Summary of CSO Discharges – Baseline Conditions**

| | Baseline Conditions[1] | | |
|---|---|---|---|
| | 2050 TY CSO Start Date/Volume (MG) | 2050 5-Year Storm Volume (MG) | 2050 25-Year Storm Volume (MG) |
| **Baseline CSO volume per event** | **0** | **0.20** | **0.70** |
| **Baseline CSO activations** | **0** | | |
| **Baseline CSO total volume (MG)** | **0** | | |

**Note:**

(1) Model results are based on the baseline conditions. Model results may vary when evaluated in conjunction with other projects that are hydraulically connected.

CAM002 does not activate in the 2050 TY. Therefore, it was evaluated for CSO control only in regional alternatives for full sewer separation and in regional alternatives to address larger design storms (see **Section 9.4.7**).

### 9.4.3 CAM401B

**Table 9-11** provides a summary of CSO discharges at CAM401B.

**Table 9-11. CAM401B Summary of CSO Discharges – Baseline Conditions**

| | Baseline Conditions[1] | | |
|---|---|---|---|
| | 2050 TY CSO Start Date/Volume (MG) | 2050 5-Year Storm Volume (MG) | 2050 25-Year Storm Volume (MG) |
| **Baseline CSO volume per event[2]** | 12/17: 0.18<br>06/12: 0.08<br>06/07: 0.03 | **1.29** | **2.82** |
| **Baseline CSO activations** | **3** | | |
| **Baseline CSO total volume (MG)** | **0.30** | | |

**Notes:**

(1) Model results are based on the baseline conditions. Model results may vary when evaluated in conjunction with other projects that are hydraulically connected.

(2) Individual storms are presented in order of decreasing volumes and may not add to the total volume due to rounding and/or small inconsistencies when models are run in different environments.

#### Sewer Separation

The CAM401B tributary areas are interconnected with the CAM401A tributary areas, making sewer separation complicated and less effective. The City of Cambridge has begun sewer separation in side streets in some smaller areas in the CAM401A area, but often the cross connections between the sewer and stormwater pipes still remain (e.g., sanitary sewer lateral going into a drain pipe). Additionally, because the drain and sewer pipes are located on opposite sides of the street and placed near the same elevation, eliminating cross connections becomes very difficult without lowering one of the full pipe alignments (e.g., the sewer lateral can’t cross the drain pipe to get across the street to the sewer main).

As a result, sewer separation was not prioritized for CAM401B as a stand-alone alternative for CSO control.

**Storage**

The CAM401B regulator is located in Massachusetts Avenue near Alewife Brook Parkway. There is space for off-line storage within the roadway in Alewife Brook Parkway, but constructing it would have a significant impact on the high volume of local traffic. The nearest location that could accommodate off-line storage while minimizing construction-related traffic disruption is in the green space within the adjacent parkway under DCR control, as shown in **Figure 9-11**.

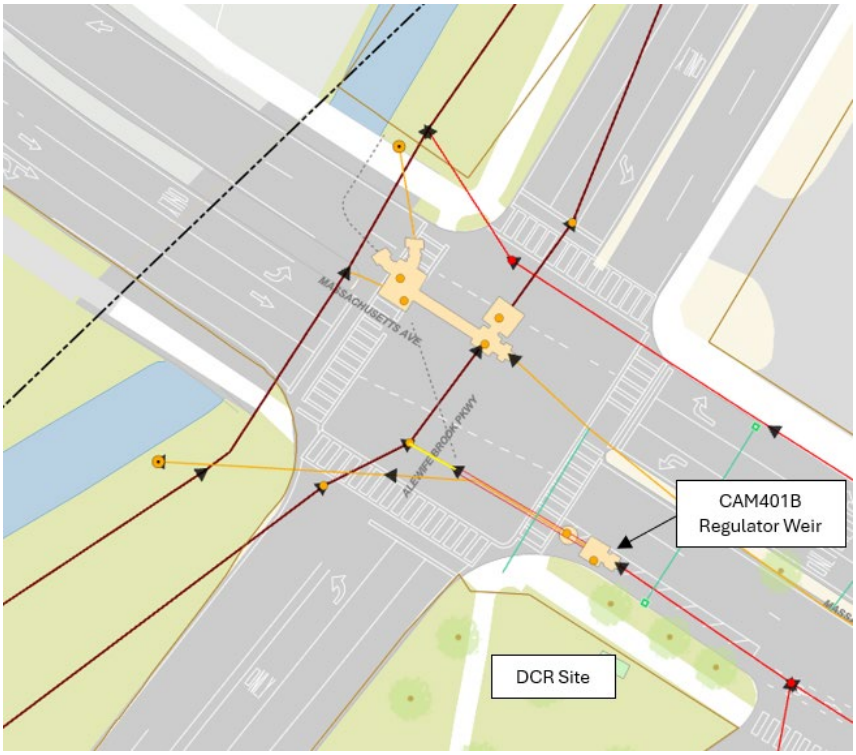



**Figure 9-11. Location of CAM401B Regulator Weir**

If CSO volume was diverted downstream from the regulator weir, the size of the storage tank would need to be 0.2 MG (the largest spill volume) to capture all CSOs in a 2050 TY (see **Table 9-11**). However, the low-lying tributary area upstream of this regulator is sensitive to flooding. Diverting flows upstream of the weir can have the additional benefit of drawing down the hydraulic gradeline and reducing flood risk upstream, but this would require 0.5 MG storage (larger than the largest spill volume). Dropping the hydraulic gradeline in the Cambridge system while leaving the MWRA water level unchanged would also require a backflow preventer in the underflow that connects the two systems. Offline storage would require a diversion structure in Massachusetts Avenue, acquisition of land or an easement for a storage tank, and a dewatering pump station to convey stored combined sewage back to the collection system after storm flows subside.

A storage tank at a farther location (Clarendon Park) was also considered; however, it would require a significantly larger tank (1.2 MG) to eliminate CSOs in the 2050 TY because the location is approximately 1,000 feet farther from the outfall and requires more flow diversion for the same CSO reduction. In-line storage was also considered. Raising the weir at CAM401B by 1.8 feet would eliminate the smallest two CSO events in the 2050 TY (thus reducing but not eliminating CSOs in the 2050 TY). However, due to the

flood risk in this area mentioned above, Cambridge evaluated the performance of this configuration in a 2050 10-year storm (event used to evaluate flooding); the results indicated that multiple locations upstream would experience higher hydraulic gradelines, and while street flooding may not occur, hydraulic gradelines come in close proximity to the ground surface, elevating the risk of localized basement backups. A smaller weir raise of 0.9 feet would eliminate only the smallest CSO without flood impacts, and therefore in-line storage was not prioritized as a stand-alone alternative.

**Conveyance**

Conveyance was not considered for CAM401B because the only location to convey flows would be the MWRA Alewife interceptors downstream, and the ability to accept conveyed flows is limited because those interceptors are already full in the larger typical year rain events (high baseline hydraulic gradeline). Lowering the downstream hydraulic gradeline would require regional improvements through storage, further downstream conveyance, and/or modification to facility operation such as increasing the pump capacity of Alewife Brook Pump Station to reduce hydraulic gradelines in the interceptor.

### 9.4.4 MWR003

**Table 9-12** provides a summary of CSO discharges at MWR003.

**Table 9-12. Summary of CSO Discharges at MWR003 – Baseline Conditions**

| | Baseline Conditions[1] | | |
|---|---|---|---|
| | 2050 TY CSO Start Date/Volume (MG) | 2050 5-Year Storm Volume (MG) | 2050 25-Year Storm Volume (MG) |
| **Baseline CSO volume per event[2]** | 12/17: 0.62<br>06/07: 0.28<br>06/12: 0.18 | **5.63** | **10.70** |
| **Baseline CSO activations** | **3** | | |
| **Baseline CSO total volume (MG)** | **1.08** | | |

**Notes:**
(1) Model results are based on the baseline conditions model. Model results may vary when evaluated in conjunction with other projects that are hydraulically connected.
(2) Individual storms are presented in order of decreasing volumes and may not add to the total volume due to rounding and/or small inconsistencies when models are run in different environments.

**Sewer Separation**

Outfall MWR003 provides direct relief off of the ABC and does not have a directly-tributary combined sewer service area. The total upstream area tributary to MWR003 is approximately 3,000 acres, located in Belmont and Cambridge. Most of the tributary area is served by separate sanitary sewers, with the exception of approximately 300 acres of combined area tributary to the Rindge Avenue sewer in Cambridge. That combined area is directly tributary to the ABBS and is only connected to MWR003 through a siphon connection between the ABBS and the ABC (shown schematically in **Figure 9-9**). This area overlaps with area tributary to CAM401A and separation of the overlapping area is further explored in **Section 9.4.5** below. Activations at outfall MWR003 are also influenced by flow from combined sewer areas tributary to the ABBS and the ABC downstream of outfall MWR003. Thus, a stand-alone sewer separation project targeting only outfall MWR003 could not be defined, and sewer separation was not considered for further evaluation specific to outfall MWR003.

**Storage**

Both in-line and off-line storage technologies were evaluated for outfall MWR003. An off-line storage tank could be constructed at a site in the vicinity of the MWR003 outfall. This site could be in property under DCR control adjacent to the outfall or in a site to be identified as part of the redevelopment of the Alewife MBTA garage. A diversion structure would be constructed along the existing MWR003 outfall to divert wet weather flow to the storage facility. After storm flows subside, the stored flow would be pumped back to the ABC. If the capacity of the storage tank is exceeded in a larger storm, excess flow would be discharged to the existing MWR003 outfall via the new diversion structure weir. While the tank structure would be underground, a permanent above-ground structure would be required for maintenance access and to house electrical and odor control equipment.

Preliminary sizing of storage at outfall MWR003 was developed for multiple levels of control. CSO volumes for the three storms that caused overflows at MWR003 in the 2050 TY are presented in **Table 9-12** above along with the 2050 5-year and 25-year CSO volumes. As indicated in **Table 9-12**, a 0.62 MG storage tank would be needed to achieve zero discharges in the 2050 TY, while 5.6 MG and 10.7 MG tanks would be needed for the 2050 5-year and 25-year storms, respectively. A 0.28 MG storage tank was selected as the initial sizing for the Limited CSOs in the 2050 TY LOC. This selection was based on the relatively large increment of additional volume to go from one to zero activations in the 2050 TY.

**Figure 9-12** presents a conceptual layout for the 0.62 MG storage tank. The figure shows the approximate location of a diversion structure that would be constructed along the outfall pipe as well as the approximate size of the storage tank

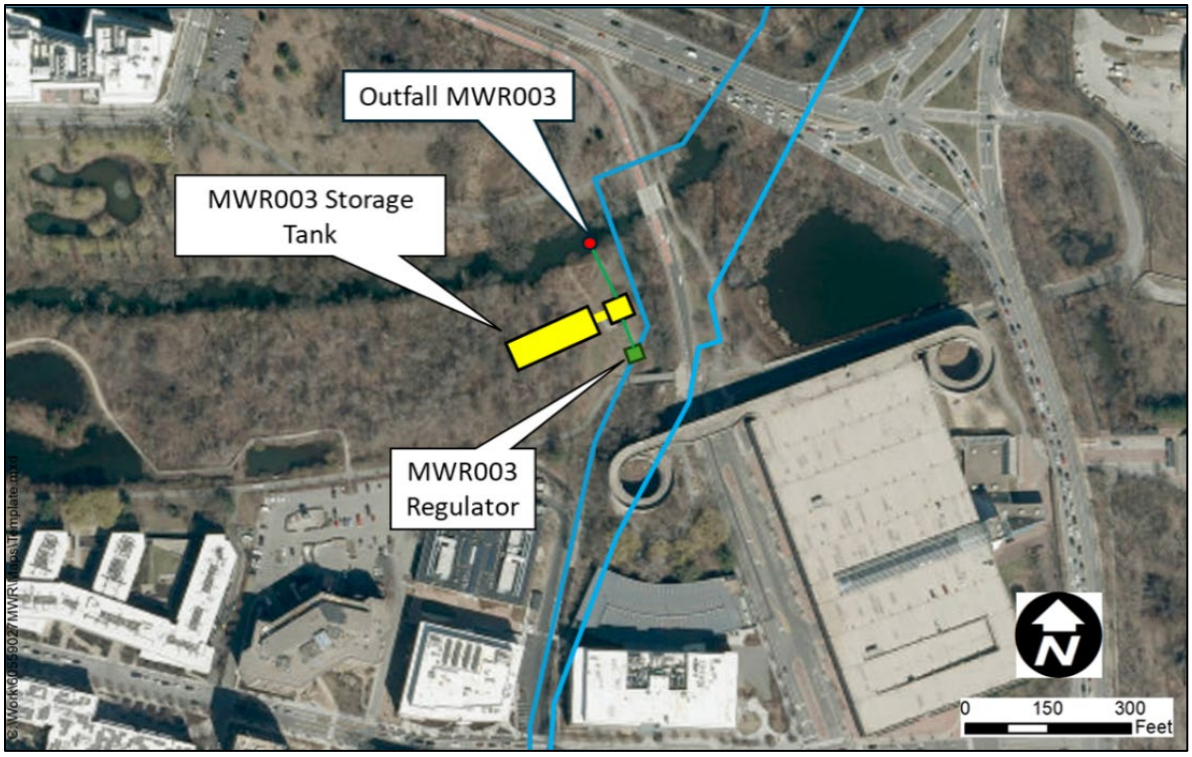



**Figure 9-12. Conceptual Layout for MWR003 Storage Tank**

In-line storage was found to be an ineffective approach for MWR003. Due to the configuration of the overflow weir for MWR003, the ABC runs completely full when outfall MWR003 activates, meaning that no in-line storage capacity is available upstream of outfall MWR003. In-line storage was therefore not evaluated further for outfall MWR003.

### Conveyance

Increasing the conveyance capacity of the ABC would affect multiple outfalls along Alewife Brook. As a result, increased conveyance was assessed at the regional level as described in **Section 9.4.7**.

## 9.4.5 CAM401A

**Table 9-13** provides a summary of CSO discharges at CAM401A.

**Table 9-13. CAM401A Summary of CSO Discharges – Baseline Conditions**

| | Baseline Conditions(1) | | |
|---|---|---|---|
| | 2050 TY CSO Start Date/Volume (MG) | 2050 5-Year Storm Volume (MG) | 2050 25-Year Storm Volume (MG) |
| **Baseline CSO volume per event(2)** | 06/7: 2.09<br>12/17: 1.84<br>06/12: 1.84<br>08/14: 1.25<br>07/16: 1.05<br>09/2: 0.71<br>06/27: 0.59<br>10/18: 0.46<br>07/18: 0.45<br>04/22: 0.40<br>10/31: 0.12<br>12/14: 0.09 | **8.43** | **16.75** |
| **Baseline CSO activations** | **12** | | |
| **Baseline CSO total volume (MG)** | **10.95** | | |

**Notes:**

(1) Model results are based on the baseline conditions model. Model results may vary when evaluated in conjunction with other projects that are hydraulically connected.

(2) Individual storms are presented in order of decreasing volumes and may not add to the total volume due to rounding and/or small inconsistencies when models are run in different environments.

### Sewer Separation

Sewer separation was initially investigated, but the CAM401A tributary areas are interconnected with the CAM401B tributary areas, making small-scale sewer separation complicated and less effective. Therefore, multiple combinations of sewer separation and off-line storage were evaluated to achieve 0 CSOs in the 2050 TY to identify the relative scale of separation and storage required. The modeled scenarios are listed in **Table 9-14**, and a map showing the general area of sewer separation is included as **Figure 9-13**.

**Table 9-14. Sewer separation scenarios modeled for CAM401A**

| **Sewer separation area** (acres) | **Complementary storage volume** (near CAM401A regulator to capture remaining CSO in 2050 TY) | **Comparative Capital Cost** (using only storage tank and separation unit costs) |
|---|---|---|
| 0 acres | 2.1 MG | $49M |
| 22 acres (Pemberton) | 2.0 MG | $84M |
| 50 acres (Pemberton – Sherman to Mead) | 1.5 MG | $140M |
| 78 acres (Pemberton and King) | 1.25 MG | $180M |
| 105 acres (Pemberton, King, and Bolton) | 1.0 MG | $230M |
| 160 acres (Pemberton to Baseball Field) | 0.75 MG | $320M |
| 180 acres (Pemberton to Cadbury) | 0.75 MG | $360M |

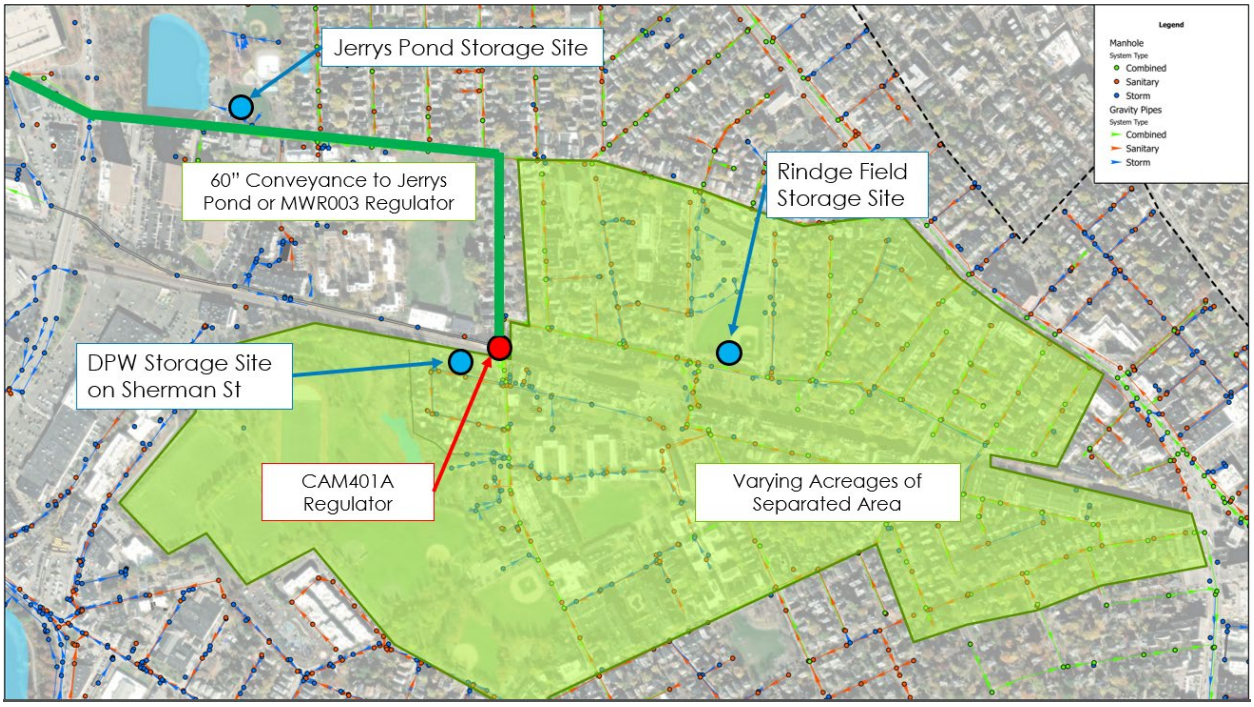



**Figure 9-13. CAM401A Components, Including Separation Areas and Potential Storage Locations**

The trade-offs between sewer separation and storage showed general trends: greater areas of sewer separation require more time to implement, have a higher cost, and greater implementation burden to neighborhoods. Additionally, due to the fact that the CAM401A tributary area is far inland, conveying stormwater to Alewife Brook adds additional expense. Therefore, sewer separation was not evaluated further as a primary or stand-alone strategy for CSO control at CAM401A at this time. However, the City of Cambridge's long-term goals to perform sewer separation throughout the City may allow for sewer separation of this area in the future outside the context of this Plan.

### Storage

Off-line storage was evaluated in a variety of configurations. Multiple sites were identified, including at Sherman Street and Rindge Field (both shown in **Figure 9-13).** The Sherman Street—a recently-acquired City of Cambridge property on Sherman Street just south of the railroad tracks—was the primary site

considered. Sizing at this site was combined with other potential sites in the vicinity to achieve 0 CSOs in the 2050 TY. The modeled scenarios are listed in **Table 9-15** below.

**Table 9-15. Storage scenarios modeled for CAM401A**

| Storage Volume / Location | Resulting CSO Volume at 401A (largest CSO event in 2050 TY) |
|---|---|
| 0 MG (no storage) | 2.1 MG |
| 2.1 MG at Sherman St site | 0.0 MG |
| 1.5 MG at Sherman St site + 0.75 MG at Rindge | 0.0 MG |
| 1.0 MG at Sherman St site + 1.25 MG at Rindge | 0.0 MG |
| 0.75 MG at Sherman St site + 1.5 MG at Rindge | 0.0 MG |

CSO storage would not be diverted downstream from the regulator weir because the outfall pipeline for the regulator receives a stormwater force main from a nearby stormwater storage tank ("Bellis Tank") and other local storm drains immediately adjacent to the regulator. Therefore, combined sewage would be diverted upstream of the weir, which requires raising the weir in the CAM401A regulator by 1.5-feet (20-foot width). This would raise the hydraulic gradeline locally to enable a diversion just south of the railroad tracks to a new combined sewer storage tank within the Sherman Street site. This is shown in **Figure 9-14.**

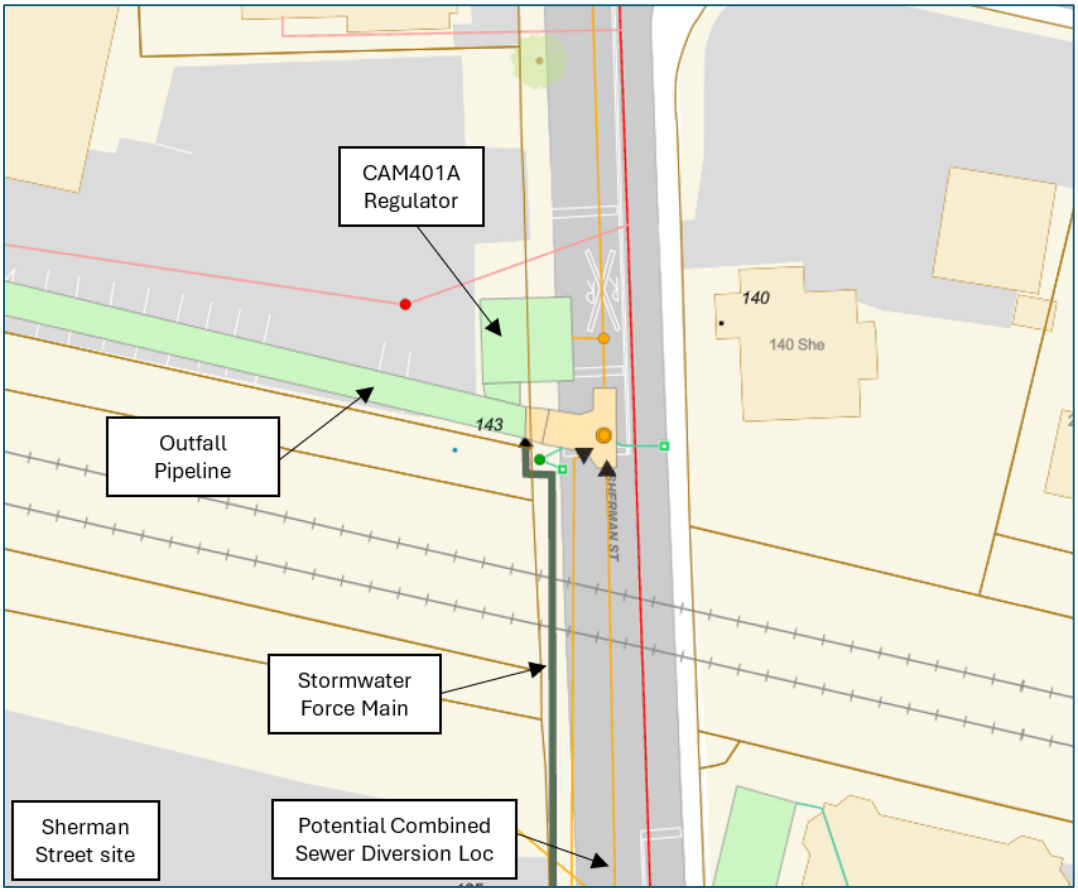



**Figure 9-14. CAM401A CSO Diversion to Stormwater Tank at Sherman Street Site**

A 2.1 MG tank at Sherman Street would be required to capture the whole 2050 TY with storage alone. Other sites may be needed should the full volume not be achievable at the Sherman Street site, although storage located farther away would require a greater storage volume. Due to the frequency with which a CSO storage tank would activate, the tank would require a washdown system that could be activated following a storage event, dewatering pumps to return stored flows to the collection system, and odor control.

**Conveyance**

Flows that do not overtop the CAM401A regulator weir are conveyed through an existing 48-inch pipe approximately 4,400 linear feet to the MWRA interceptor near MWR003. The frequency of CAM401A activations indicates that conveyance capacity may be a limitation in this area. Increasing conveyance capacity was evaluated to facilitate more flows to the MWRA interceptors instead of over the CAM401A regulator weir.

The conveyance scenario modeled in a 2050 TY is shown in **Table 9-16** below.

**Table 9-16. Conveyance Scenario Modeled for CAM401A (2050 TY)**

| Conveyance to MWRA interceptor | CSOs at CAM401A | CSOs at MWR003 | CSOs to Alewife Brook at CAM401A + MWR003 | Requisite CSO Storage Volume at Sherman Street Site |
|---|---|---|---|---|
| No conveyance | 12 activations<br>11 MG total<br>1.9 MG largest event | 3 activations<br>1.08 MG total | 12 activations<br>12.08 MG | 2.1 MG |
| Upsize existing 48-inch interceptor to 60-inch (4,400 LF) | 7 activations<br>3.4 MG total<br>1.2 MG largest event | 4 activations<br>4.26 MG total | 7 activations<br>7.66 MG | 1.5 MG |

Conveyance capacity could be increased by upsizing the existing interceptor in Pemberton Street and Rindge Avenue to the MWRA interceptor near MWR003 (4,400 linear feet) from 48-inch diameter to 60-inch or adding a parallel 30-inch auxiliary pipe.

Conveyance alone would not eliminate CSOs in the 2050 TY at CAM401A, but it would reduce them. To offset the remaining CSOs, 1.5 MG storage could be located at the Sherman Street site – a smaller storage volume than the 2.1 MG that was needed for storage alone. Conveyance away from CAM401A toward the Alewife Brook MWRA interceptor would result in increased CSO discharges at MWR003. However, the total CSO activations and volume into Alewife Brook at these two locations shows a substantial net decrease.

Although conveyance would lead to more disruption in a larger area and higher capital costs, there is a long-term benefit of having flexibility in the future to convert the conveyance to stormwater after the CAM401A tributary area is eventually separated over time. This would further Cambridge's long-term goals to separate combined sewers over time.

### 9.4.6 SOM001A

**Table 9-17** provides a summary of CSO discharges at SOM001A.

**Table 9-17. SOM001A Summary of CSO Discharges – Baseline Conditions**

| | Baseline Conditions[1] | | |
|---|---|---|---|
| | 2050 TY CSO Start Date/Volume (MG) | 2050 5-Year Storm Volume (MG) | 2050 25-Year Storm Volume (MG) |
| **Baseline CSO volume per event[2]** | 06/07: 1.92<br>12/17: 1.64<br>06/12: 1.5<br>04/22: 0.66<br>07/16: 0.64<br>08/14: 0.62<br>06/27: 0.39<br>09/02: 0.34<br>10/18: 0.32<br>12/14: 0.19<br>07/18: 0.16<br>11/26: 0.08<br>10/31: 0.03 | **5.10 MG** | **8.56 MG** |
| **Baseline CSO activations** | **13** | | |
| **Baseline CSO total volume (MG)** | **8.51** | | |

**Notes:**

(1) Model results are based on the baseline conditions model. Model results may vary when evaluated in conjunction with other projects that are hydraulically connected.

(2) Individual storms are presented in order of decreasing volumes and may not add to the total volume due to rounding and/or small inconsistencies when models are run in different environments.

### Sewer Separation

The City of Somerville previously evaluated sewer separation at SOM001A through its Citywide Flood Mitigation and Water Quality Master Plan[3] published in 2022. These analyses formed the basis of Somerville's technology assessments. Varying degrees of separation were evaluated here, ranging from separation of the entire 448 acres of combined area tributary to SOM001A to separation of smaller subareas with added interventions such as in-line storage.

Sewer separation in the areas tributary to SOM001A presents different degrees of difficulty depending on location. The combined area closest to Alewife Brook Parkway (purple polygon in **Figure 9-15**) is approximately 58 acres and presents challenges typical of sewer separation projects in urban neighborhoods. The other combined areas, which equate to approximately 390 acres (green and orange polygons in **Figure 9-15**), present very significant technical and construction phasing challenges. One of the primary challenges is related to the Tannery Brook Conduit (TBC), which does not have enough hydraulic capacity to convey all stormwater flows generated from the areas during large storms. Upsizing this TBC along the existing alignment is unfeasible because it runs through private property and underneath several homes. This limitation creates the need for a new storm drain and outfall to free capacity in the TBC so that it can act as a dedicated storm drain once separation is completed upstream.

**Figure 9-15** shows the three main combined areas for separation within Somerville that are tributary to SOM001A. The figure also depicts the existing TBC and the proposed Mass Ave Drain, which is included in several of the proposed Alewife Brook alternatives to convey separated flows to the Alewife Brook. **Table 9-18** presents a detailed area breakdown of the different combined areas.

[3] Citywide Flood Mitigation and Water Quality Master Plan - *11394d690a9269914f07d8bb49a4b868_Somerville_FloodMitigation_WQ_MasterPlan_Nov_2022_Final_wAppendices.pdf*

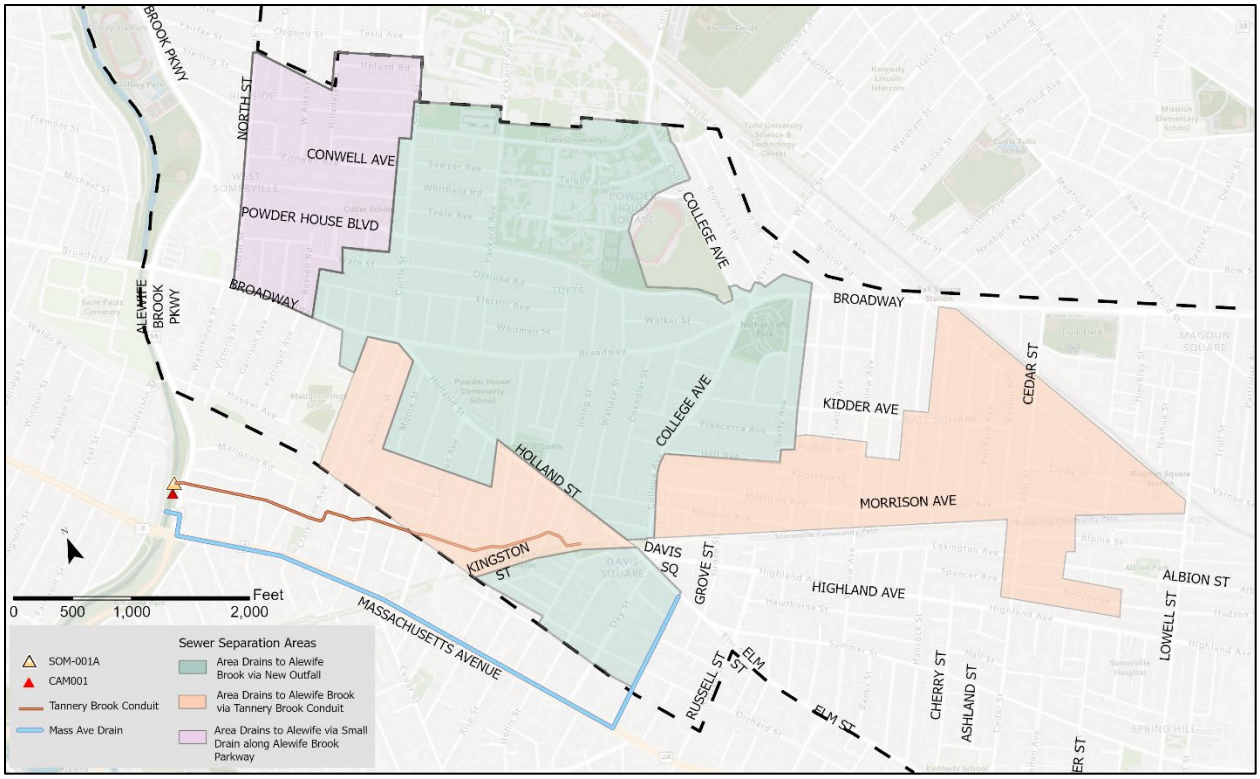



**Figure 9-15. SOM001A Tributary Area with Sewer Separation Sub-areas**

**Table 9-18. Breakdown of Somerville's Combined Sewer Areas in the Alewife Brook Watershed that were Evaluated for Separation**

| Conduits Collecting Stormwater Flows from Different Separation Areas | Area (acres) | Comments |
|---|---|---|
| Proposed Mass Ave Storm Drain | 264 | Area directly tributary to the SOM001A CSO regulator. Proposed storm drain would mostly be in Cambridge. |
| Tannery Brook Conduit (TBC) | 126 | Area directly tributary to the SOM001A CSO regulator. TBC to be repurposed as a storm drain following complete sewer separation. |
| Existing storm drains along Alewife Brook Parkway and across land under DCR control | 58 | Small combined area not directly tributary to SOM001A but affecting its performance by draining into MWRA's Alewife Brook Conduit (ABC). |

Storage for flow attenuation is required for Alewife Brook, as described in Section 8.1.1. These facilities carry significant space requirements. Full separation of SOM001A would require approximately 7 acres of storage. This storage would need to be located at or near the most downstream points within the tributary area, near Davis Square and in parkland under DCR control near Alewife Brook Parkway. Storage sites near Davis Square would require acquisition of private parcels, which would carry a significant cost premium due to its prime location and the displacement of existing private properties.

Despite these challenges, full or partial sewer separation of the combined areas tributary to SOM001A and/or the ABC was carried forward.

### Storage

Off-line storage was considered infeasible within the area tributary to SOM001A primarily due to lack of available, undeveloped land/space and difficulty of private property acquisition. Furthermore, the TBC follows an easement on which several homes have been built. Connecting to the TBC and/or constructing new facilities directly adjacent to the TBC in this residential area is considered highly unfavorable and high risk. Consequently, off-line storage was not considered further.

In-line storage was also considered for SOM001A via multiple configurations. One configuration evaluated new, large box culverts with flow regulating devices along Morrison Avenue, Grove Street, and Winslow Avenue. This was carried forward as it provides both CSO and flood reduction benefits. Maximization of in-line storage capacity in the TBC during the 2050 TY was also evaluated, as the conduit has some available capacity during this rainfall event. However, due to the conduit's location beneath existing homes, in-line storage along the TBC is not favorable and was not considered further.

### Conveyance

The main goal of conveyance projects is to increase capacity so that flow can be transported at a higher rate downstream. Increasing the rate at which flows reach SOM001A without capacity improvements in the MWRA's regional trunk sewer system (the ABC) would result in an increase in CSOs at this regulator. Therefore, conveyance improvements to SOM001A were not considered a desirable option.

## 9.4.7 Alewife Brook Regional

This section considers the efficacy of different CSO control technologies when applied to the entire Alewife Brook area as a singular regional system. **Table 9-19** provides a summary of CSO discharges to the Alewife Brook for the 2050 TY, 5-year, and 25-year storms. Technologies investigated to address CSOs to Alewife Brook at a regional level included sewer separation, storage, and conveyance.

**Table 9-19. Summary of CSO Discharges to Alewife Brook – Baseline Conditions**

| Alewife Brook Outfall | Baseline Conditions | | | |
|---|---|---|---|---|
| | 2050 TY Activation Frequency | 2050 TY Annual Volume (MG) | 5-Year Storm Volume (MG) | 25-Year Storm Volume (MG) |
| CAM001 | 1 | 0.02 | 0.21 | 0.54 |
| CAM002 | 0 | 0 | 0.20 | 0.70 |
| CAM401A | 12 | 10.95 | 8.43 | 16.75 |
| CAM401B | 3 | 0.30 | 1.29 | 2.82 |
| MWR003 | 3 | 1.08 | 5.63 | 10.70 |
| SOM001A | 13 | 8.51 | 5.10 | 8.56 |
| **Max/Total** | **13** | **20.86** | **20.86** | **40.07** |

### Sewer Separation

Sewer separation was considered regionally for the approximately 900 acres of combined sewer area tributary to the Alewife Brook CSO outfalls (**Figure 9-16**). The approximately 900 acres of combined sewer area is comprised of 438 acres in Cambridge and 448 acres in Somerville. As described in **Section 9.2.4**, sewer separation was assumed to remove 90% of the inflow from the combined sewer system.

**Table 9-20** presents a comparison of the CSO activation frequencies and volumes for the Alewife Brook for the 2050 TY Baseline Conditions versus regional sewer separation. As noted above in **Section 9.4.6**, increase conveyance capacity along the TBC would be required for regional full sewer separation which is not favorable due to the TBC location and/or proximity beneath existing homes.

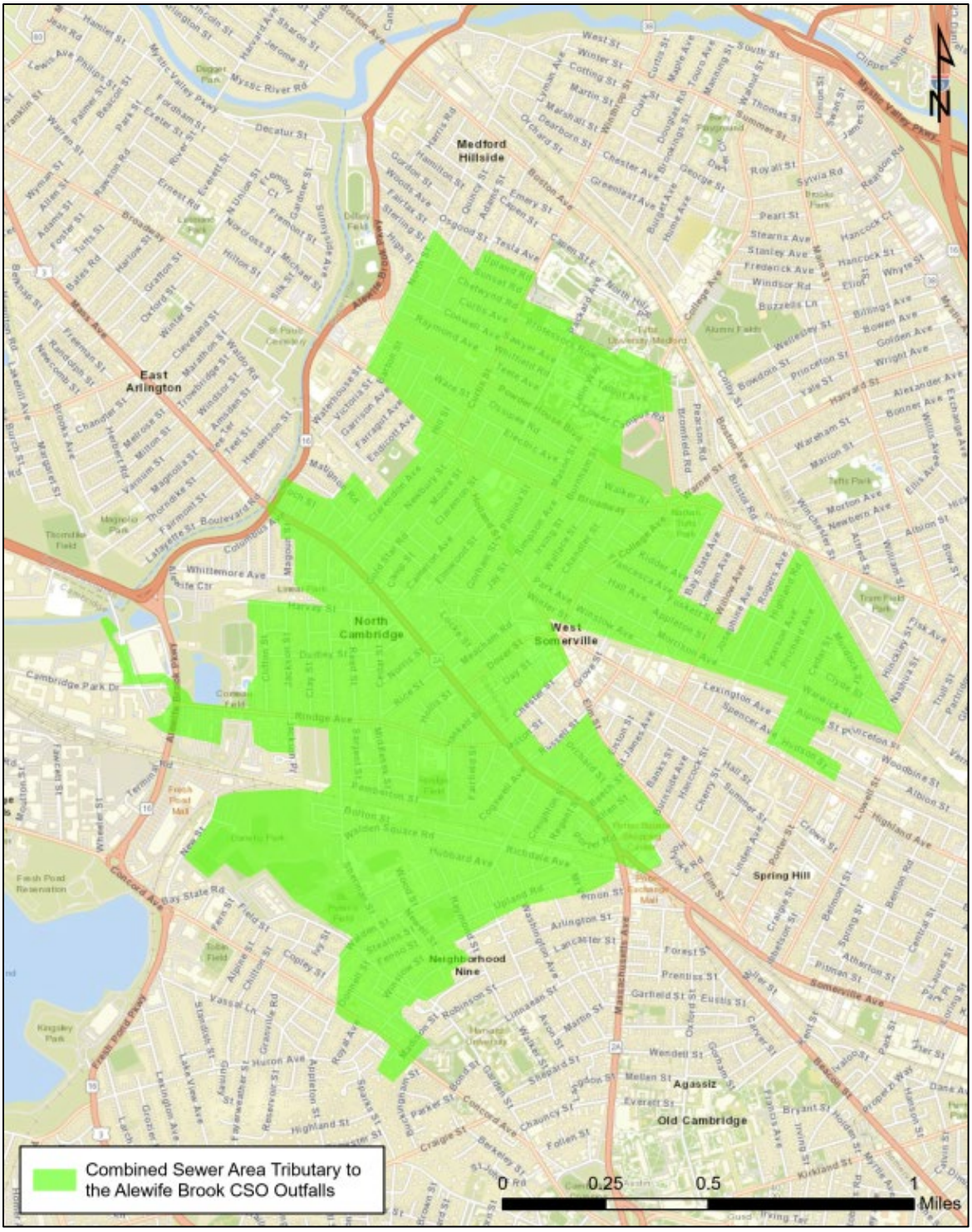



**Figure 9-16. Combined Sewer Area Tributary to the Alewife Brook CSO Outfalls**

**Table 9-20. Alewife Brook 2050 Typical Year Baseline Conditions vs. Alewife Brook Regional Sewer Separation**

| | Baseline Conditions | | Regional Sewer Separation | | Baseline Conditions | | Regional Sewer Separation | |
|---|---|---|---|---|---|---|---|---|
| | 2050 TY | | 2050 TY | | 5-Year Storm | 25-Year Storm | 5-Year Storm | 25-Year Storm |
| Outfall | Activation Frequency | Volume (MG) | Activation Frequency | Volume (MG) | Volume (MG) | Volume (MG) | Volume (MG) | Volume (MG) |
| CAM001 | 1 | 0.02 | 0 | 0.00 | 0.21 | 0.54 | 0 | 0 |
| CAM002 | 0 | 0 | 0 | 0.00 | 0.20 | 0.70 | 0 | 0 |
| CAM401A | 12 | 10.95 | 0 | 0.00 | 8.43 | 16.75 | 0.17 | 0.46 |
| CAM401B | 3 | 0.30 | 0 | 0.00 | 1.29 | 2.82 | 0 | 0 |
| MWR003 | 3 | 1.08 | 0 | 0.00 | 5.63 | 10.70 | 0 | 0 |
| SOM001A | 13 | 8.51 | 0 | 0.00 | 5.10 | 8.56 | 0 | 0 |
| **Max/Total** | **13** | **20.86** | **0** | **0.00** | **20.86** | **40.07** | **0.17** | **0.46** |

As indicated in **Table 9-20**, the model estimates that CSO activations to the Alewife Brook would be eliminated in the 2050 TY by a regional level sewer separation. In the 2050 5-year storm, outfall CAM401A was predicted to discharge 0.17 MG. In the 2050 25-year storm, outfall CAM401A was predicted to discharge 0.46 MG. As noted in **Section 9.2.4**, inflow removal in the 5-year and 25-year storm events was simulated with the same percent inflow removal as the 2050 TY; however, the percent removal may be harder to predict for these events due to additional inflow sources during these larger events. As a result, discharges could occur at other outfalls. The model is also not calibrated for these larger events as noted in Section 7.

New stormwater conveyance systems would need to be constructed to convey the separated stormwater to Alewife Brook. Without attenuation, the peak flows from these new conveyance systems would likely exceed the current peak flows discharging to Alewife Brook and increase the risk of flooding. Attenuation of the peak flows via stormwater detention was therefore assumed to be required in addition to stormwater treatment. Some concepts for sewer separation at specific outfalls, such as for SOM001A, are further along in the project development process, and thus locations are identified for stormwater detention; however, most areas of sewer separation were developed conceptually for the purpose of comparing alternatives, and specific locations of stormwater detention are not yet known.

Based on these evaluations, regional sewer separation was carried forward as a possible CSO control alternative for further assessment.

### Storage

Both in-line and off-line storage technologies were evaluated regionally. In-line storage would not be effective at the regional scale because during CSO events, both the ABC and ABBS are surcharged with no capacity available in the pipes for in-line storage. As a result, regional in-line storage along the ABC/ABBS was not considered further.

Off-line storage, in the form of a tunnel, was evaluated to capture CSOs across all the outfalls draining to the Alewife Brook. The approximate alignment of the tunnel is provided in **Figure 9-17**.

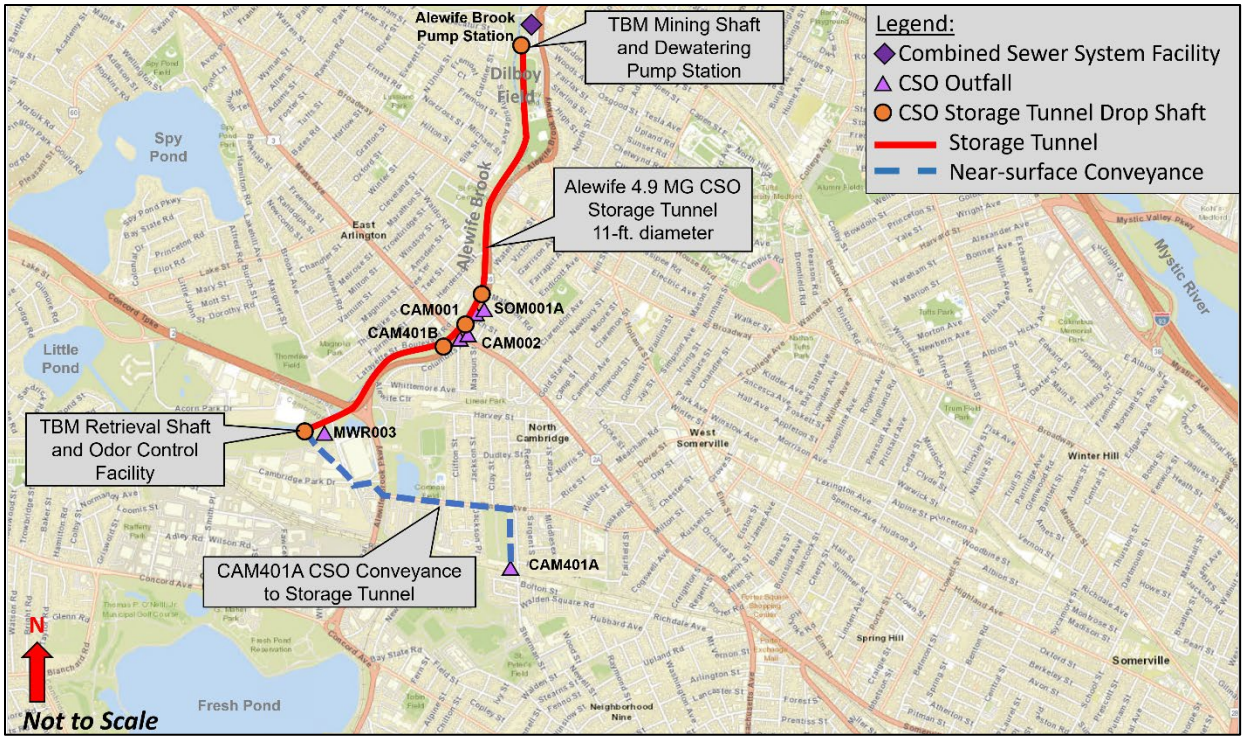



**Figure 9-17. Alewife Brook Regional Storage Tunnel (0 CSOs in the 2050 TY)**

Diversion structures would be needed to divert CSOs from each outfall to the tunnel, providing volume for storage while the system is full, and dewatering so that the combined flows are treated following the peak of the storm. Modeling indicated that adding a flow diversion point at a manhole where the ABC and ABBS interconnect was predicted to significantly reduce the peak hydraulic grade line along the interceptor system in the 2050 TY. The additional flow diversion point affected the distribution of volume to the tunnel from the various CSOs, but it had only a small impact on the total volume to be captured in the tunnel so it was included in the alternative.

**Table 9-21** presents a summary of the CSO discharges to the Alewife Brook for each storm in the 2050 TY and the 5-year and 25-year storms for Baseline Conditions, and the volume of CSO to be captured in the tunnel assuming the additional diversion location at the ABC/ABBS interconnection noted above. For the 2050 TY, the largest volume diverted to the tunnel is predicted to be 4.85 MG.

**Table 9-21. Summary of Alewife Brook CSO Activations with and without Regulator Adjustments to Divert Flow to Storage[1][3]**

| | 2050 TY[2] | | 2050 5-Year Storm | | 2050 25-Year Storm | |
|---|---|---|---|---|---|---|
| Outfall | Baseline Conditions (MG) | Volume Diverted to Storage (MG)[4] | Baseline Conditions (MG) | Volume Diverted to Storage (MG)[4] | Baseline Conditions (MG) | Volume Diverted to Storage (MG)[4] |
| CAM001 | 0.02 | 0.00 | **20.9** | **20.6** | **40.1** | **41.6** |
| CAM002 | 0.00 | 0.00 | | | | |
| MWR003 | 0.62 | 0.21 | | | | |
| CAM401A | 1.85 | 2.11 | | | | |
| CAM401B | 0.18 | 0.00 | | | | |
| SOM001A | 1.64 | 1.45 | | | | |
| Relief at ABC, ABBS connection | NA | 1.08 | | | | |
| **Storage Tunnel Volume (MG)[3]** | **4.32** | **4.85** | | | | |

**Notes:**
(1) Model results are based on the baseline conditions model. Model results may vary when evaluated in conjunction with other projects that are hydraulically connected.
(2) 2050 TY volumes represent the storm event that resulted in the largest storage tunnel volume.
(3) Volumes at individual outfalls may not add to the total volume due to rounding and/or small discrepancies when models are run in different environments.
(4) The volume diverted to storage accounts for modifications to the regulator structures and the ABC/ABBS interconnection.

The tunnel sized to provide a 2050 TY level of control would require approximately 4.9 MG of storage. The storage tunnel would be approximately 7,600 linear feet long, with a finished inside diameter of 11 feet, constructed using a tunnel boring machine (TBM). The route would run about parallel to Alewife Brook from a mining shaft in the Dilboy Field parking lot to a TBM removal shaft adjacent to outfall MWR003. Most of the construction activity would be focused at the mining shaft, where excavated material would be removed to the surface for disposal. Based on preliminary geotechnical information, the tunnel would start in rock at the downstream end near Dilboy Field, and transition into soft ground about half-way along the route. The tunnel would be lined using precast, gasketed liner segments which would be put in place inside the tunnel by the TBM. The vertical alignment of the tunnel would be established following more detailed geotechnical investigations, but the invert of the tunnel is likely to be at least 60 to 70 feet deep.

The mining shaft in the Dilboy Field parking lot would be approximately 40 feet in inside diameter while the TBM removal shaft adjacent to outfall MWR003 would be approximately 30 feet in inside diameter. Once the tunnel construction was completed, screening equipment would be installed in the mining shaft upstream of the dewatering pump station. Ventilation and odor control equipment would be provided at the upstream TBM removal shaft.

The tunnel dewatering pump station would be constructed in an approximately 50-foot diameter shaft located next to the mining shaft. The pump station would have a capacity of approximately 4.9 MGD, to allow the contents of a full tunnel to be dewatered in one day. The pump station would discharge to a force main that ties into the MWRA's interceptor system downstream of the existing Alewife Brook Pump Station. An above-ground structure would be required for maintenance access and to house electrical equipment.

Diversion structures would be provided along the outfall pipes for outfalls MWR003, CAM401B, and CAM001. For outfall CAM401A, a diversion structure would be located adjacent to the existing regulator structure off of Sherman Street because several separate storm drains tie into the existing CAM401A outfall pipe downstream of the CAM401A regulator. The new diversion structure would divert CSO into a new pipe for conveyance to a drop shaft adjacent to outfall MWR003. At outfall SOM001A, the existing regulator structure would be modified to allow diversion of CSO to the storage tunnel. As noted above, an additional flow diversion point would be located at a manhole where the ABC and ABBS interconnect just downstream of outfall SOM001A.

The diversion structures would divert CSO to the tunnel, while allowing CSO to continue to discharge in larger storm events if the tunnel was full. The diversion structures may include gates that would be triggered to close when the tunnel is full.

Flow from the diversion structures would be conveyed to drop shafts, where the flow would be conveyed down to the storage tunnel. It is anticipated that a single drop shaft would be provided at outfall MWR003 to convey flow from both outfall MWR003 and CAM401A to the tunnel. Outfalls CAM401B, SOM001A and CAM001, and the interconnection between the ABC and ABBS are all in close proximity to each other, creating another opportunity to consolidate flows to the drop shafts. However, due to utility conflicts, it is likely that at least two drop shafts will be required to cover these four diversion locations. Once the drop shafts are constructed, the sites would be restored with manhole covers/hatches at grade to allow access.

The tunnel sized to provide a Limited 2050 TY LOC would require approximately 3.9 MG of storage which results in an inside diameter of 10 feet with a length of 7,600 feet. Since this tunnel size is slightly smaller than the size required to provide a 2050 TY LOC, the tunnel alternative was not carried forward for the Limited 2050 TY LOC. For the 2050 5-year and 25-year LOCs, the project components would be similar to those for the 2050 TY except that the tunnel diameter for the 2050 5-year storm would be 22 feet, and the diameter for the 2050 25-year storm would be 32 feet. In addition, due to the increased storage volume the dewatering pump stations and odor control facilities would also increase in size. The tunnel alignment and length would be the same for each level of control.

**Conveyance**

Increasing the capacity of the Alewife interceptors in conjunction with the ABPS was discussed in **Section 9.2.5.1**. Preliminary evaluations showed that to control CSO discharges to Alewife Brook in the 2050 TY, the conveyance capacity of the existing ABC/ABBS/ABPS system would need to be increased by approximately three times its existing capacity in addition to increasing the capacity of the downstream interceptor system, headworks facility, and DITP. As a result, conveyance alternatives that included increasing the capacity of the ABPS were not considered for further evaluation.

Conveyance was then considered in conjunction with adding a storage tank or treatment facility to store or treat the additional conveyed flow in excess of the existing capacity of the ABPS. After developing preliminary sizing of conveyance pipes and storage or treatment facilities, substantial technical challenges to routing the new pipes and siting the storage or treatment facilities were identified. Since other, more feasible alternatives were identified for controlling CSOs to Alewife Brook, the conveyance-to-storage/treatment approach was not considered for more detailed evaluation.

### 9.4.8 Summary of CSO Control Technology Screening for Alewife Brook

As a result of the preliminary screening of CSO control technologies described above, **Table 9-22** presents technologies that were carried forward into alternatives development. Technologies that were carried forward for more detailed evaluation for at least one level of control are indicated with a check mark (✓) and technologies that were not considered for further evaluation are indicated with a dash (-).

**Table 9-22. CSO Control Technologies Carried Forward for Evaluation in the Alewife Brook System**

| Outfall | Sewer Separation | Green Stormwater Infrastructure (GSI) | Infiltration/Inflow (I/I) Reduction | Storage | Conveyance | Treatment |
|---|---|---|---|---|---|---|
| CAM001 | ✓ | ✓ | - | - | - | - |
| CAM002(1) | - | - | - | - | - | - |
| CAM401B | - | - | - | ✓ | - | - |
| MWR003 | - | - | - | ✓ | - | - |
| CAM401A | - | - | - | ✓ | ✓ | - |
| SOM001A | ✓ | - | - | ✓ | - | - |
| Regional Alewife | ✓ | ✓ | - | ✓ | - | - |

**Notes:**

(1) Outfall CAM002 does not activate in the 2050 TY and was therefore not evaluated individually for CSO control in the 2050 TY. It is only included in regional alternatives for CSO control in larger design storms.

"✓"- Indicates technology carried forward for more detailed evaluation.

"–" Indicates technology was not considered for further evaluation.

For the 5-year and 25-year LOCs, individual storage tanks for each of the six outfalls would be needed to store volumes ranging from 0.20 MG to 8.43 MG for the 5-year LOC and 0.70 to 16.75 MG for the 25-year LOC. Siting of the individual storage facilities for each outfall was found to be infeasible due to the size of the storage tanks required. Thus, CSO capture in a consolidated storage tunnel was carried forward for further evaluation for those levels of control. Sewer separation of the combined sewer area tributary to Alewife Brook was also carried forward as a regional alternative.

The following sections describe how these CSO control technologies were combined to create alternatives to achieve the 0 CSO in 2050 TY, Limited CSOs in the 2050 TY, and the 2050 5-year and 25-year levels of control for the Alewife Brook.

## 9.5 Alewife Brook - CSO Control Alternatives

This section describes how the CSO control technologies were combined to create alternatives for each level of control in the Alewife Brook. This is the third step as illustrated previously in **Figure 9-1**, shown again in **Figure 9-18**. The Partners developed twelve total alternatives; five were for the 2050 TY LOC, two for the Limited 2050 TY LOC, two for the 2050 5-year LOC, and two for the 2050 25-year LOC. One regional sewer separation alternative was also developed and evaluated. The 2050 TY LOC had the most alternatives because a wider range of CSO control technologies were found to be applicable. The Limited 2050 TY LOC includes two alternatives that focus on combinations of sewer separation and storage. Large storage tunnels were required to meet the 2050 5-year and 25-year LOCs, thus limiting the number of alternatives for those LOCs. Each alternative is described in detail in the following subsections.




**Figure 9-18. Alternative Development Step 3 (Alewife)**

### 9.5.1 Alternative 1.AB Integrated (0 CSOs in 2050 TY)

Alternative 1.AB Integrated represents the first attempt to combine CSO control technologies at the individual outfall level, as proposed by each Partner, and includes a combination of sewer separation, storage tanks, and in-system storage controls. Each of the individual projects (developed to have 0 CSOs in the 2050 TY) were imported into the Unified Model and run together. In some cases, these individual projects saw impacts from neighboring projects, and as a result, could be refined while still meeting the goal of 0 CSOs in the 2050 TY. The cases where projects were modified based on the impacts of neighboring projects are identified below:

- The CAM401B tank was originally proposed as 0.5 MG, but when run with its neighboring projects, the required storage volume was just under 0.4 MG;
- The CAM001 project of 8 acres sewer separation could be removed completely with no impact to the number of CSOs at CAM001;
- Increasing the throttle restriction upstream of SOM001A from 10 MGD to 10.75 MGD allowed for Somerville's sewer separation area to be reduced by 15 acres; and
- The MWR003 storage volume was decreased from 0.62 MG to 0.5 MG because of the sewer separation upstream of SOM001A.

**Table 9-23** presents, for each outfall, the Baseline Conditions 2050 TY activations and volume, the project components, the estimated capital cost, and the estimated project duration. A schematic layout of the alternative components is presented in **Figure 9-19**.

## Table 9-23. Alternative 1.AB Integrated (0 CSOs in 2050 TY) Summary

| Alewife Brook Outfall | Baseline 2050 Typical Year | | CSO Control Technology Description | Preliminary Capital Cost[2] ($million) | Project Duration[3] (Years) |
|---|---|---|---|---|---|
| | Activation Frequency | Volume (MG) | | | |
| CAM001 | 1 | 0.02 MG | No action | N/A[1] | N/A |
| CAM002 | 0 | 0 MG | No action | N/A | N/A |
| CAM401A | 12 | 10.95 MG | 2.1 MG storage tank | $64 M | 5 |
| CAM401B | 3 | 0.30 MG | 0.4 MG storage tank | $25 M | 5 |
| MWR003 | 3 | 1.08 MG | 0.5 MG storage tank | $26 M | 5 |
| SOM001A | 13 | 8.51 MG | 264 acres sewer separation + in-line storage with throttles | $480 M | 31 |
| **Max/Sum (Untreated)** | **13** | **20.86 MG** | **-** | **$600 M** | **31** |

**Notes:**
(1) N/A: not applicable.
(2) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.
(3) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

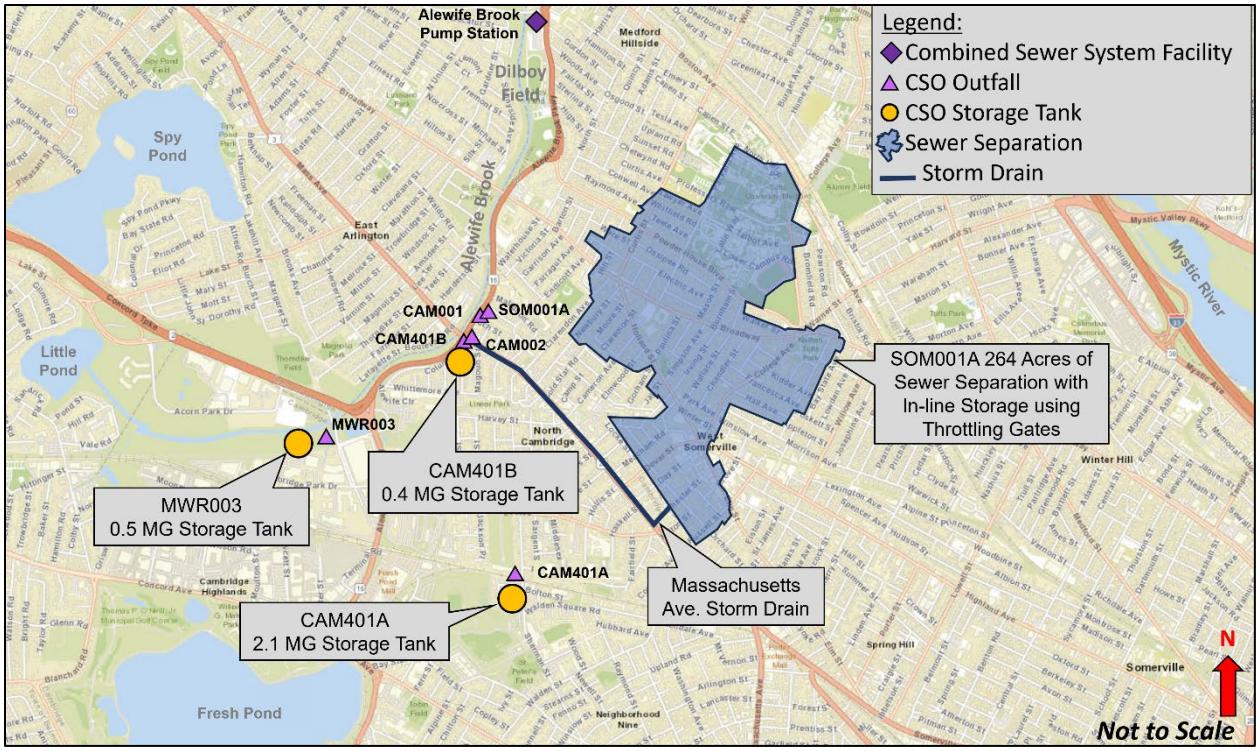



**Figure 9-19. Alternative 1.AB Integrated (0 CSOs in 2050 TY)**

### 9.5.1.1 Component Descriptions

The individual components of Alternative 1.AB Integrated are described below.

- **CAM401A:** A 2.1 MG combined sewer storage tank would be constructed underground in a City of Cambridge-owned parking lot off Sherman Street adjacent to the MBTA commuter rail tracks.
- **MWR003**: A 0.5 MG storage tank would be constructed underground at a site in the vicinity of the MWR003 outfall. The site would likely be in property under DCR control adjacent to the outfall, or potentially in a site to be identified as part of the redevelopment of the Alewife MBTA garage.
- **CAM401B**: A 0.4 MG storage tank would be constructed underground in the grassy area under DCR control (previously depicted in **Figure 9-11**).
- **SOM001A:** 264 acres of sewer separation would be implemented in the combined sewer areas tributary to outfall SOM001A. This work would include the need of 3.6 acres for stormwater compensatory storage facilities to attenuate new peak stormwater flows into the Alewife Brook generated from the separated areas. The compensatory storage would need to be located within Somerville near Davis Square, as this is the most downstream point where consolidated stormwater flows from Somerville drains could be captured and stored. A new 60-inch diameter storm drain along Massachusetts Avenue in Cambridge would be needed to convey the stormwater to a new stormwater outfall to Alewife Brook.

#### 9.5.1.2 Implementation Challenges

Challenges to implementing the components of this alternative would include:

CAM401A Storage:

- Public acceptance of CSO storage facility at that location; and
- Size limitations of proposed site may potentially preclude the ability to fit the full 2.1 MG CSO storage tank.

MWR003 Storage:

- Implementation on the site under DCR control would require Article 97 legislation to authorize a change of use of the site;
- There is also a potential opportunity to site storage tank on MBTA property instead, in conjunction with site redevelopment, but timing/location/availability of site are uncertain;
- Construction of large tank with deep excavation in an area adjacent to wetlands and Alewife Brook;
- Construction impacts to Alewife Reservation, and challenging truck access to site. If storage could be located on MBTA property these challenges may be mitigated; and
- Long-term maintenance access needed to storage facility. If storage could be located on MBTA property these challenges may be mitigated.

CAM401B Storage:

- Implementation on the site under DCR control would require Article 97 legislation to authorize a change of use of the site; and
- Site also has significant utility conflicts and mature trees.

SOM001A Sewer Separation/Storage:

- The proposed route of the 60-inch diameter Massachusetts Avenue storm drain is along a highly congested utility corridor that also crosses the MBTA Red Line. This increases construction risk, construction challenges, and construction impacts significantly;
- The proposed 60-inch drain will need to be designed with robust erosion and scouring control measures such as rip rap aprons or slope stabilization technologies;
- The proposed Massachusetts Avenue storm drain would require legal agreement between Cambridge and Somerville, specifying infrastructure ownership, construction cost sharing, and O&M responsibilities;
- Land acquisition for peak flow reduction storage facilities near Davis Square area where real estate is expensive and largely unavailable would be challenging;
- Sewer separation of this magnitude would take many years to complete, and residents in the area would be likely to experience construction fatigue; and
- Construction of large box culverts along highly congested urban areas will likely create important disruptions to residents and businesses and constructability may be challenging due to utility conflicts.

### 9.5.2 Alternative 2.AB Hybrid 1 (0 CSOs in 2050TY)

Alternative 2.AB Hybrid 1 includes a combination of sewer separation, storage tanks, a storage conduit, and conveyance to provide a 2050 TY LOC. This alternative was based on Alternative 1.AB but included the following changes:

- Reduce sewer separation extent upstream of SOM001A and address CSO control for SOM001A and CAM401B with microtunneled storage. This approach assesses the benefits of reducing the construction impacts and construction duration associated with the larger sewer separation area.
- Modify CSO controls for CAM401A to include conveyance in addition to storage. This resulted in changes to the size of storage needed for outfalls CAM401A and MWR003.
- Include 8 acres of sewer separation for CAM001.

**Table 9-24** presents, for each outfall, the Baseline Conditions 2050 TY activations and volume, the project components, the estimated capital cost, and the estimated project duration. A schematic layout of the components of this alternative is presented in **Figure 9-20**.

**Table 9-24. Alternative 2.AB Hybrid 1 (0 CSOs in 2050 TY) Summary**

| Alewife Brook Outfall | Baseline 2050 Typical Year | | CSO Control Technology Description | Preliminary Capital Cost[2] ($million) | Project Duration[3] (Years) |
|---|---|---|---|---|---|
| | Activation Frequency | Volume (MG) | | | |
| CAM001 | 1 | 0.02 MG | 8 acres sewer separation | $15 M | 5 - 10 |
| CAM002 | 0 | 0 MG | No action | N/A[1] | N/A |
| CAM401A | 12 | 10.95 MG | Conveyance + 1.5 MG storage tank | $98 M | 5 - 10 |
| CAM401B | 3 | 0.30 MG | Refer to SOM001A below | Refer to SOM001A below | Refer to SOM001A below |
| MWR003 | 3 | 1.08 MG | 1.4 MG storage tank | $50 M | 5 |
| SOM001A | 13 | 8.51 MG | 100 acres sewer separation + 1.3 MG microtunnel to store CAM401B and SOM001A | $270 M | 20 |
| **Max/Sum (Untreated)** | **13** | **20.86 MG** | - | **$440 M** | **20** |

**Notes:**
(1) N/A: not applicable.
(2) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.
(3) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

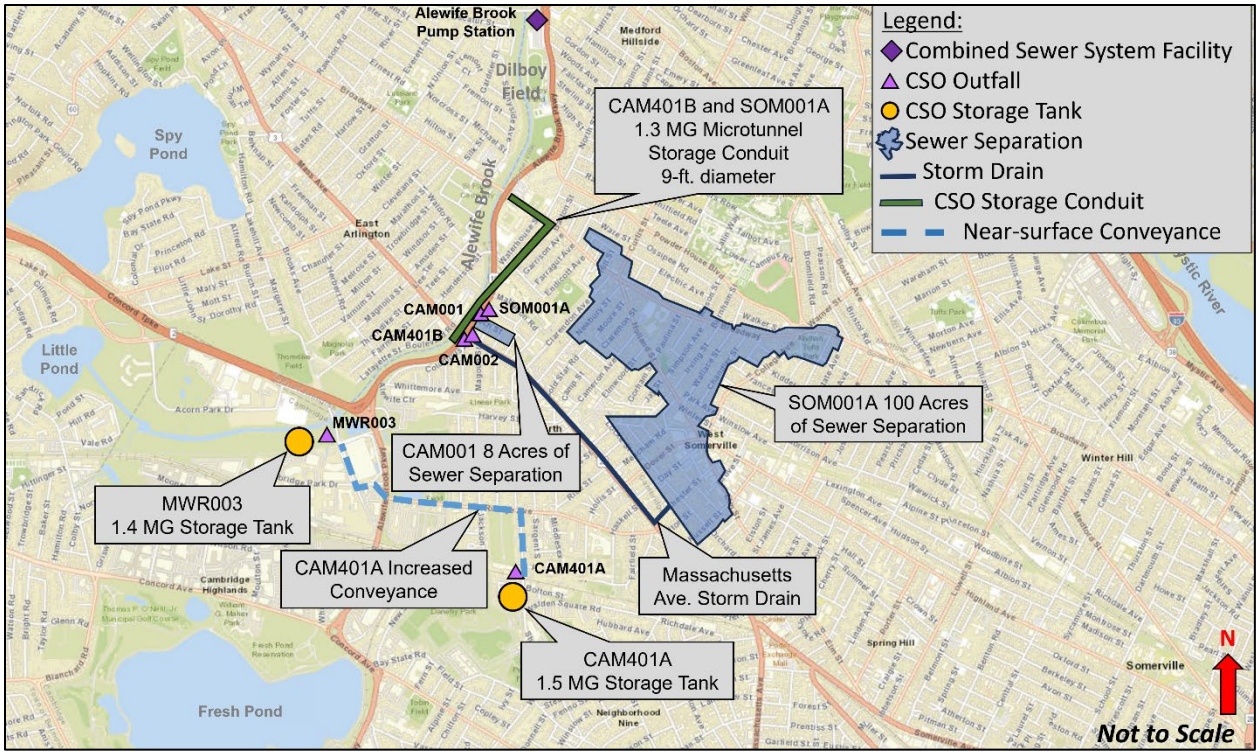



**Figure 9-20. Alternative 2.AB Hybrid 1 (0 CSOs in 2050 TY)**

### 9.5.2.1 Component Descriptions

The individual components of the Alternative 2.AB Hybrid 1 are described below.

- **CAM401A**: A 1.5 MG storage tank would be constructed underground in a City of Cambridge-owned parking lot off of Sherman Street adjacent to the MBTA commuter rail tracks. In addition, the 48-inch diameter combined sewer along Sherman Street and Rindge Avenue between the existing CAM401A regulator and the connection to the ABBS would be replaced with a new 60-inch diameter combined sewer.
- **MWR003:** A 1.4 MG storage tank would be constructed underground at a site in the vicinity of the MWR003 outfall. The tank size increased compared to Alternative 1.AB Integrated due to the additional flow from the Sherman Street/Rindge Avenue conveyance enhancement and the reduced scope of sewer separation for outfall SOM001A.
- **CAM401B/SOM001A:** A 2,900 linear foot, 9-foot diameter storage conduit with a storage capacity of 1.3 MG would be constructed by microtunneling to capture the overflow from outfalls CAM401B and SOM001A. Diversion structures on the CAM401B outfall and at the SOM001A regulator would divert flow into the storage conduit. A preliminary route for the storage conduit would begin near the CAM401B outfall. The potential route would run under the green space between Alewife Brook and Alewife Brook Parkway, then cross under the Parkway between Matignon and Hooker Avenues, run along Waterhouse Street then west on Broadway to the corner of the Stop & Shop parking lot. Pipe jacking shafts, where the microtunneling boring machine is inserted and excavated material is removed, would be located at either end of the route, and at the intersection of Hooker Avenue and Waterhouse Street. Intermediate shafts, where the microtunneling boring machine is removed, would be located at the intersection of Waterhouse Street and Broadway, and at a point approximately mid-way between outfall CAM401B and the jacking shaft at Hooker Avenue. The final

route and shaft locations could change and would be defined after further planning and design. A permanent above-ground structure would be required at the downstream end of the storage conduit for maintenance access and to house electrical and odor control equipment.

- **SOM001A**: In addition to connecting the SOM001A outfall to the microtunneled storage conduit described above, approximately 100 acres of sewer separation would be implemented in the combined sewer area tributary to outfall SOM001A. This work would include development of 1.5 acres of storage for peak stormwater flow attenuation to manage peak stormwater flow into Alewife Brook from the separated areas, and a new 60-inch diameter storm drain along Massachusetts Avenue to convey the separated stormwater to a new stormwater outfall to Alewife Brook.
- **CAM001**: Approximately 8 acres of sewer separation would be implemented in the combined sewer area tributary to outfall CAM001.

#### 9.5.2.2 Implementation Challenges

Challenges to implementing the components of this alternative would include:

CAM401A Storage and Conveyance:

- Similar challenges as described for Alternative 1.AB Integrated; and
- Additionally: space constraints, utility conflicts and traffic impacts associated with installation of new 60-inch combined sewer along Sherman Street and Rindge Avenue.

MWR003 Storage:

- Similar challenges as described for Alternative 1.AB Integrated.

CAM401B/SOM001A Storage Conduit:

- Constructing microtunneling shafts and diversion structures in Alewife Reservation would require Article 97 legislation to authorize a change of use on sites under DCR control;
- Acquisition of jacking shaft/dewatering pump station site;
- Construction impacts to Alewife Reservation, and challenging truck access to sites; and
- Long-term maintenance access needed to storage facility.

SOM001A Sewer Separation:

- Similar challenges as described for Alternative 1.AB Integrated.

CAM001 Sewer Separation:

- Sites have not been identified for stormwater treatment or flow attenuation.

### 9.5.3 Alternative 3.AB Hybrid 2 (0 CSOs in 2050TY)

Alternative 3.AB Hybrid 2 includes a combination of sewer separation, storage tanks, a storage conduit, and conveyance to provide a 2050 TY LOC. This alternative was based on Alternative 2.AB Hybrid, 1 but it eliminated sewer separation upstream of SOM001A and increased the size of the microtunneled storage. This modification aimed to minimize the construction impacts and duration associated with sewer separation. It resulted in a slight increase in the size of the storage tank for outfall MWR003, but other project components from Alternative 2.AB Hybrid 1 remained the same.

**Table 9-25** presents, for each outfall, the Baseline Conditions 2050 TY activations and volume, the project component, the estimated capital cost, and the estimated duration for implementation. A schematic layout of the components of this alternative is presented in **Figure 9-21**.

**Table 9-25. Alternative 3.AB Hybrid 2 (0 CSOs in 2050 TY) Summary**

| Alewife Brook Outfall | Baseline 2050 Typical Year | | CSO Control Technology Description | Preliminary Capital Cost[2] ($million) | Project Duration[3] (years) |
|---|---|---|---|---|---|
| | Activation Frequency | Volume (MG) | | | |
| CAM001 | 1 | 0.02 MG | 8 acres sewer separation | $15 M | 5 - 10 |
| CAM002 | 0 | 0 MG | No action | N/A[1] | N/A |
| CAM401A | 12 | 10.95 MG | Conveyance + 1.5 MG storage tank | $98 M | 5 - 10 |
| CAM401B | 3 | 0.30 MG | Refer to SOM001A below | Refer to SOM001A below | Refer to SOM001A below |
| MWR003 | 3 | 1.08 MG | 1.5 MG storage tank | $52 M | 5 |
| SOM001A | 13 | 8.51 MG | 2.3 MG microtunnel to store CAM401B and SOM001A | $170 M | 10 - 15 |
| **Max/Sum (Untreated)** | **13** | **20.86 MG** | - | **$340 M** | **15** |

**Notes:**
(1) N/A: not applicable.
(2) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.
(3) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

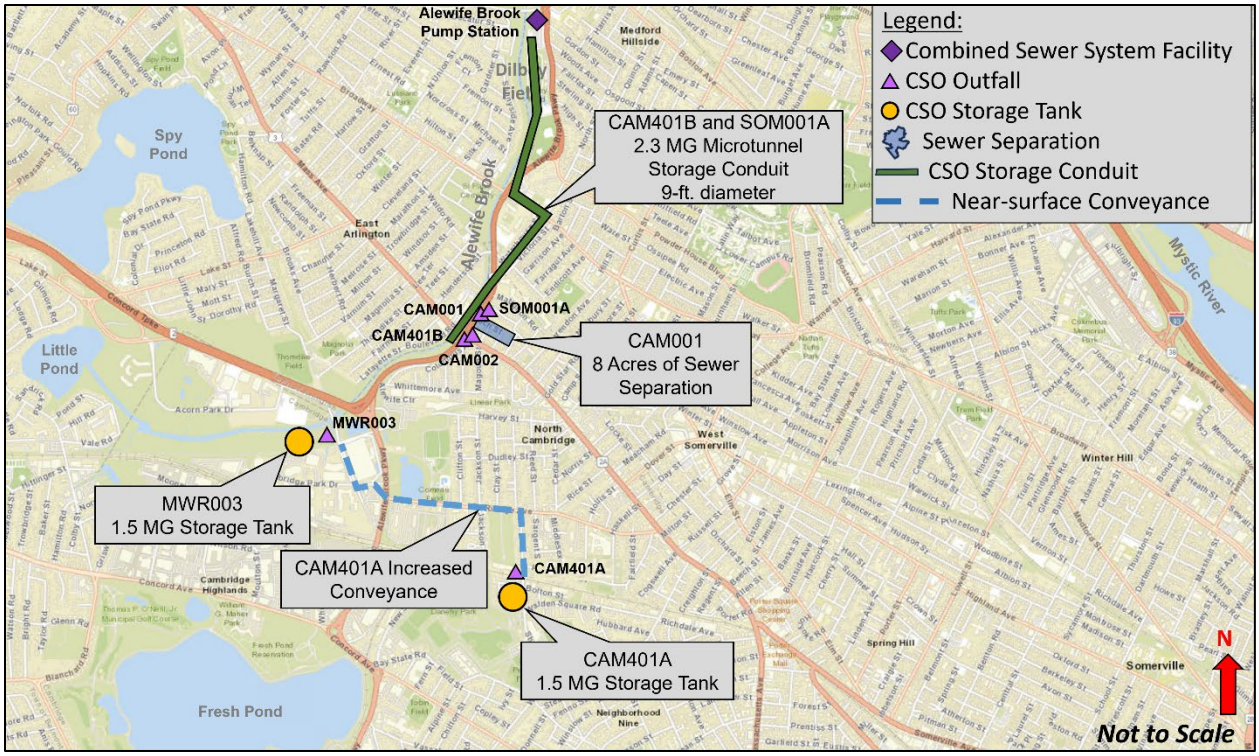



**Figure 9-21. Alternative 3.AB Hybrid 2 (0 CSOs in 2050 TY)**

### 9.5.3.1 Component Descriptions

The individual components of Alternative 3.AB Hybrid 2 are described below.

- **CAM401A:** A 1.5 MG storage tank would be constructed underground in a City of Cambridge-owned parking lot off of Sherman Street adjacent to the MBTA commuter rail tracks. Additionally, the 48-inch diameter combined sewer along Sherman Street and Rindge Avenue between the existing CAM401A regulator and the connection to the ABBS would be replaced with a new 60-inch diameter combined sewer, and the weir in the existing CAM401A regulator would be raised by 1.5 feet.
- **MWR003:** A 1.5 MG storage tank would be constructed underground at a site in the vicinity of the MWR003 outfall.
- **CAM401B/SOM001A:** A 5,400 linear foot, 9-foot diameter microtunnel storage conduit (2.3 MG capacity) would be constructed to capture the overflow from outfalls CAM401B and SOM001A. A preliminary route for the storage conduit would begin near the CAM401B outfall. The potential route would be similar to the route described for Alternative 2.AB Hybrid 1 up to the intersection of Alewife Brook Parkway and Broadway. From that point, the conduit would continue north parallel to Alewife Brook, under the ball fields and Dilboy Stadium to the parking lot between the stadium and the Alewife Brook Pump Station. An additional pipe jacking shaft would be located in that parking lot, and an additional intermediate shaft would be located just south of the basketball courts. The final route and shaft locations could change, and would be defined after further planning and design. A permanent above-ground structure would be required at the downstream end of the storage conduit in the Dilboy Field parking lot for maintenance access and to house electrical and odor control equipment.
- **CAM001:** Approximately 8 acres of sewer separation would be implemented in the combined sewer area tributary to outfall CAM001.

#### 9.5.3.2 Implementation Challenges

The implementation challenges associated with this Alternative are similar to those described in Alternative 2.AB Hybrid 1, except for the challenges associated with SOM001A Sewer Separation which are eliminated and the additional impacts associated with the microtunnel to the Dilboy Field parking lot where a jacking shaft and dewatering pump station would be located.

**Figure 9-22** presents a potential site plan which includes the approximate extent of temporary and permanent construction impacts as well as the approximate locations of a microtunnel jacking shaft at the Dilboy Field parking lot.

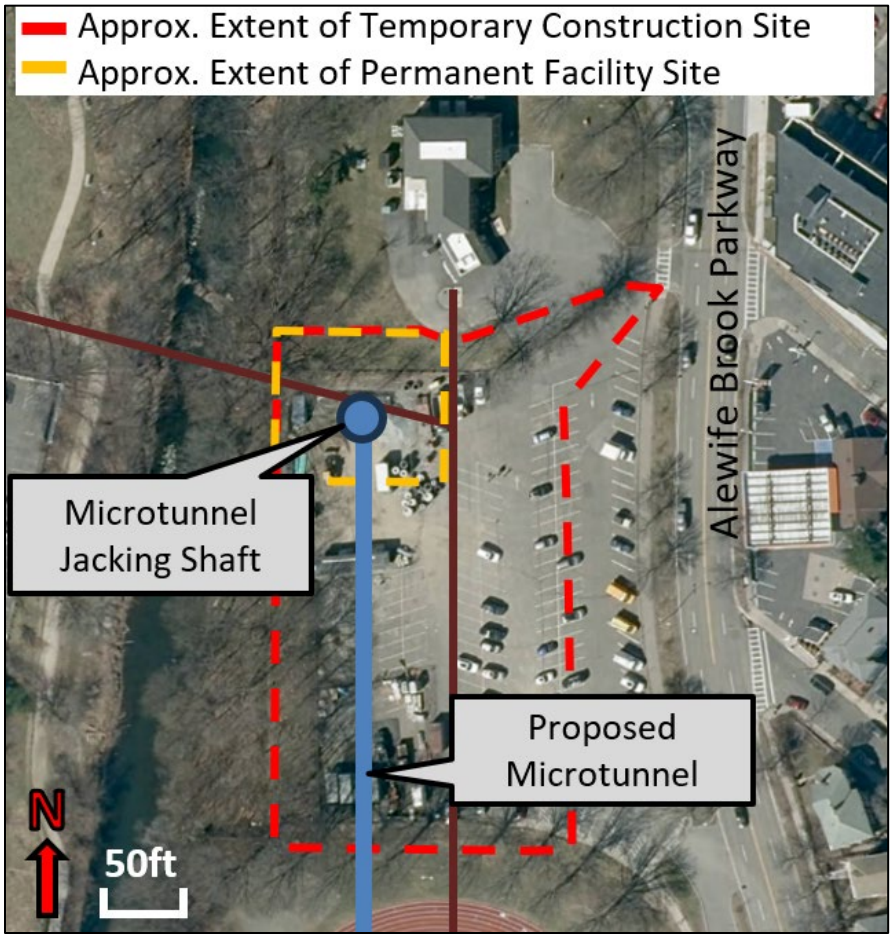



**Figure 9-22. Alternative 3.AB 2050 TY Microtunnel (0 CSOs in 2050 TY) Potential Impacts to Dilboy Field Parking Lot**

### 9.5.4 Alternative 4.AB Tunnel (0 CSOs in the 2050 TY)

Alternative 4.AB Tunnel was developed as a regional storage tunnel to provide a 2050 TY LOC based on the regional analysis conducted in **Section 9.4.7**. The tunnel would capture and store CSOs from outfalls CAM401A, MWR003, CAM401B, CAM001, and SOM001A, with dewatering at the farthest downstream location. As presented in **Section 9.4.7**, the largest storm in the 2050 TY discharged a CSO volume of 4.85 MG, so the tunnel was sized to capture a CSO volume of 4.9 MG.

**Table 9-26** presents, for each outfall, the Baseline Conditions 2050 TY activations and volume, the project component, the estimated capital cost, and the estimated duration for implementation. A schematic layout of the components of this alternative is presented in **Figure 9-23**.

**Table 9-26. Alternative 4.AB Tunnel (0 CSOs in the 2050 TY) Summary**

| Alewife Brook Outfall | Baseline 2050 Typical Year | | CSO Control Technology Description | Preliminary Capital Cost[1] ($million) | Project Duration[2] (years) |
|---|---|---|---|---|---|
| | Activation Frequency | Volume (MG) | | | |
| CAM001 | 1 | 0.02 MG | 4.9 MG 11-ft dia. Storage Tunnel | $600 M | 15 - 20 |
| CAM002 | 0 | 0.00 MG | | | |
| CAM401A | 12 | 10.95 MG | | | |
| CAM401B | 3 | 0.30 MG | | | |
| MWR003 | 3 | 1.08 MG | | | |
| SOM001A | 13 | 8.51 MG | | | |
| **Max/Sum (Untreated)** | **13** | **20.86 MG** | - | - | - |

**Notes:**

(1) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.

(2) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

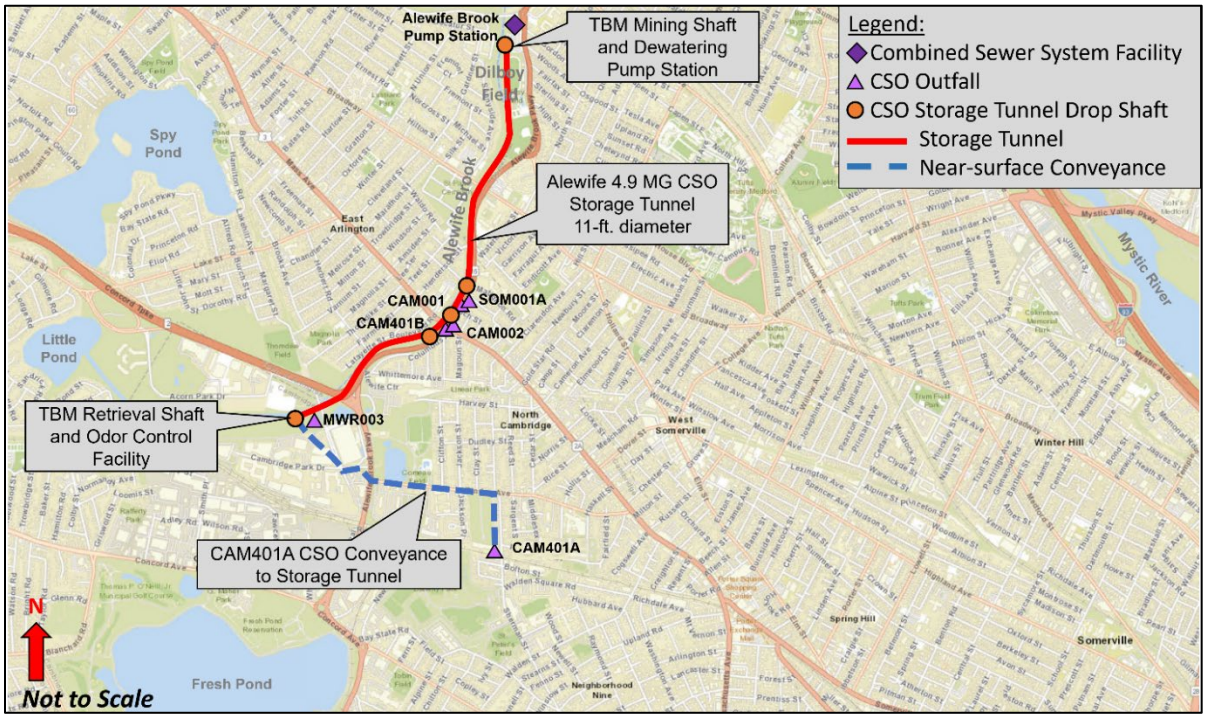



**Figure 9-23. Alternative 4.AB Tunnel (0 CSOs in the 2050 TY)**

#### 9.5.4.1 Component Descriptions

The individual components of Alternative 4.AB Tunnel are described in **Section 9.4.7**. This includes considerations for the tunnel itself, mining/TBM retrieval shafts, tunnel dewatering pump station, diversion structures, and drop shafts.

#### 9.5.4.2 Implementation Challenges

Challenges to implementing the components of this alternative would include:

- Constructing shafts and a dewatering pump station in Alewife Reservation/ property under DCR control would require Article 97 legislation to authorize a change of use of the site;
- Dilboy Field parking lot would not be available for public use during the construction period;
- Dewatering pump station building and tunnel access hatches required in Dillboy Field parking lot;
- Construction impacts to Alewife Reservation, and challenging truck access to site; and
- Long-term maintenance access needed to storage facility.

**Figure 9-24** presents a potential site plan which incudes the approximate extent of temporary and permanent construction impacts as well as the approximate locations of a tunnel mining shaft and pump station at the Dilboy Field parking lot.

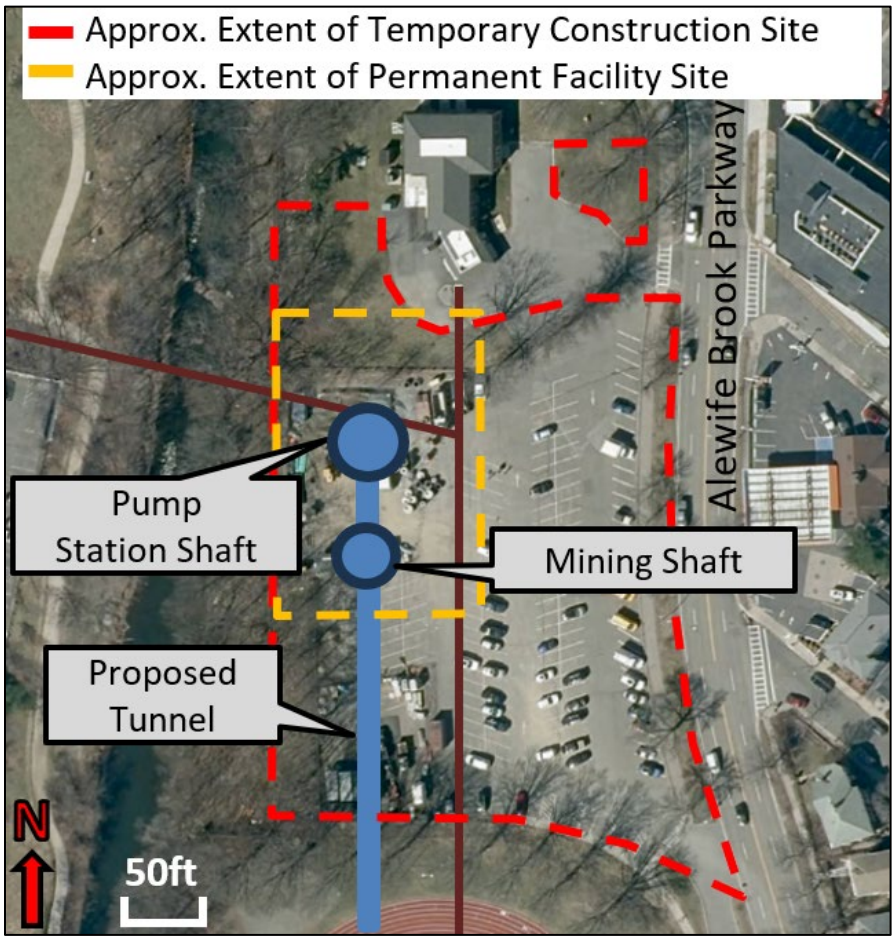



**Figure 9-24. Alternative 4.AB 2050 TY Tunnel (0 CSOs in 2050 TY) Potential Impacts to Dilboy Field Parking Lot**

### 9.5.5 Alternative 5.AB Tunnel + GSI (0 CSOs in 2050 TY)

Alternative 5.AB Tunnel + GSI is a combination of a regional storage tunnel, conveyance and GSI to provide a 2050 TY LOC. **Section 9.2** described how GSI at the regional scale can reduce CSO volume (with limited impact on activations). This alternative augments the Alternative 4.AB Tunnel alternative by adding GSI to assess the impact that regional GSI could have on storage sizing. GSI was sized to capture the first inch of rainfall from 10% of the impervious right-of-way area in the combined sewer areas tributary to Alewife Brook, resulting in an area to be captured by GSI of 35.6 acres. With this level of GSI, the regional tunnel size could be reduced from 4.9 MG (as shown in **Section 9.5.4**) to 4.2 MG, which allows the tunnel to be downsized to 10-foot diameter and 4.2 MG capacity.

**Table 9-27** presents, for each outfall, the Baseline Conditions 2050 TY activations and volume, the project components, the estimated capital cost, and the estimated duration for implementation. A schematic layout of the components of this alternative is presented in **Figure 9-25**.

**Table 9-27. Alternative 5.AB Tunnel + GSI (0 CSOs in 2050 TY) Summary**

| Alewife Brook Outfall | Baseline 2050 Typical Year | | CSO Control Technology Description | Preliminary Capital Cost[1] ($million) | Project Duration[2] (years) |
|---|---|---|---|---|---|
| | Activation Frequency | Volume (MG) | | | |
| CAM001 | 1 | 0.02 MG | 4.2 MG 10-ft dia. Storage Tunnel + GSI (35.6 acres) | $630 M | 20 for tunnel (GSI requires additional time to be determined) |
| CAM002 | 0 | 0.00 MG | | | |
| CAM401A | 12 | 10.95 MG | | | |
| CAM401B | 3 | 0.30 MG | | | |
| MWR003 | 3 | 1.08 MG | | | |
| SOM001A | 13 | 8.51 MG | | | |
| **Max/Sum (Untreated)** | **13** | **20.86 MG** | **-** | **-** | **-** |

**Notes:**

(1) Preliminary Capital Cost is described in **Section 9.3**. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.

(2) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

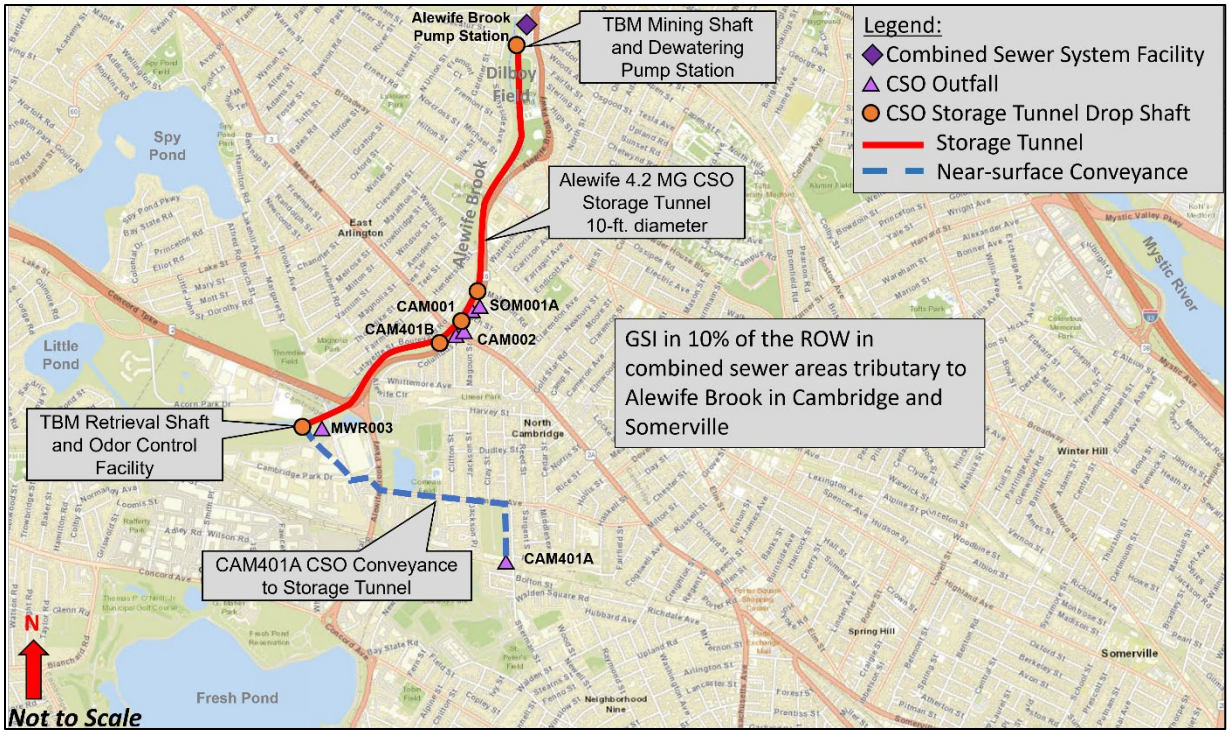



**Figure 9-25. Alternative 5.AB Tunnel + GSI (0 CSOs in 2050 TY)**

#### 9.5.5.1 Component Descriptions

The individual components of Alternative 5.AB Tunnel + GSI are described below.

- **Tunnel, Mining/TBM Retrieval Shafts, Tunnel Dewatering Pump Station, Diversion Structures, Drop Shafts:** These components would all be the same as described for Alternative 4.AB Tunnel except that the GSI implementation would allow the tunnel to be downsized to 10-foot diameter and 4.2 MG capacity. The dewatering pump station would similarly be downsized to 4.2 MGD capacity.
- **GSI:** This alternative would include the implementation of GSI capturing runoff from 10% of the impervious right-of-way area in the combined sewer areas tributary to Alewife Brook in Cambridge and Somerville (35.6 acres).

#### 9.5.5.2 Implementation Challenges

The challenges to implementing the components of this alternative would include all of the challenges listed for the Alternative 4.AB Tunnel, plus the following challenges specific to GSI implementation:

- Identifying appropriate sites for GSI on municipally owned land or on public rights-of-way.

### 9.5.6 Alternative 7.AB Hybrid 1 (Limited CSOs in 2050 TY)

Alternative 7.AB Hybrid 1 includes a combination of sewer separation, conveyance, and storage tanks to provide Limited CSOs in the 2050 TY LOC. This alternative is based on Alternative 2.AB Hybrid 1, but it includes a reduction of storage while leaving the sewer separation components, with the following changes:

- Reduce the storage tank at MWR003. Whereas Alternative 2.AB Hybrid 1 included 1.4 MG of storage at MWR003 to go from 3 activations to 0 activations, the tank is downsized to 0.62 MG, which leaves 1 remaining activation in the 2050 TY.
- Exclude the microtunnel for SOM001A and CAM401B. It includes local CSO storage at CAM401B to capture CSOs, but leaves 5.9 MG CSO volume (from baseline 8.5 MG) remaining in the 2050 TY at SOM001A.

**Table 9-28** presents, for each outfall, the Baseline Conditions 2050 TY activations and volume, the project components, the estimated capital cost, and the estimated project duration. Because this alternative does not eliminate CSOs in the 2050 TY, the table also shows the CSO activations and volumes predicted to remain in the 2050 TY after implementation. A schematic layout of the components of this alternative is presented in **Figure 9-26**.

**Table 9-28. Alternative 7.AB Hybrid 1 (Limited CSOs in 2050 TY) Summary**

| Alewife Brook Outfall | Baseline 2050 TY Act Freq./Vol. (MG) | CSO Control Technology Description | Remaining 2050 TY Act Freq./Vol. (MG) | Preliminary Capital Cost(2) ($million) | Project Duration(3) (years) |
|---|---|---|---|---|---|
| CAM001 | 1 act/0.02 MG | 8 acres sewer separation | 0 act/0 MG | $15 M | 5 - 10 |
| CAM002 | 0 act/0 MG | No action | 0 act/0 MG | N/A(1) | N/A |
| CAM401A | 12 act/10.95 MG | Conveyance + 1.5 MG storage tank | 0 act/0 MG | $98 M | 5 - 10 |
| CAM401B | 3 act/0.30 MG | 0.4 MG storage tank | 0 act/0 MG | $25 M | 5 |
| MWR003 | 3 act/1.08 MG | 0.6 MG storage tank | 1 act/0.7 MG | $31 M | 5 |
| SOM001A | 13 act/8.51 MG | 100 acres sewer separation | 12 act/5.91 MG | $160 M | 20 |
| **Max/Sum (Untreated)** | **13 act/20.86 MG** | **-** | **12 act/6.61 MG** | **$330 M** | **20** |

**Notes:**
(1) N/A: not applicable.
(2) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.
(3) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

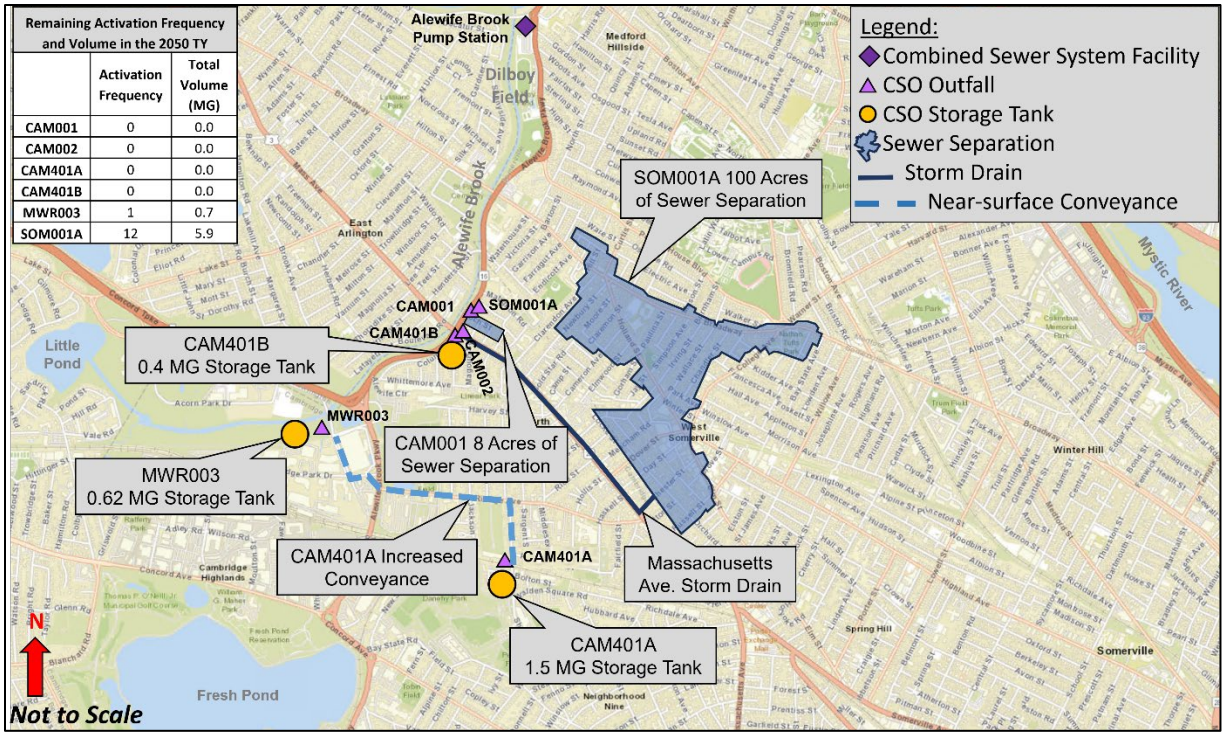



**Figure 9-26. Alternative 7.AB Hybrid 1 (Limited CSOs in 2050 TY)**

### 9.5.6.1 Component Descriptions

The individual components of Alternative 7.AB Hybrid 1 are described below:

- **CAM401A:** A 1.5 MG storage tank would be constructed underground in a City of Cambridge-owned parking lot off of Sherman Street adjacent to the MBTA commuter rail tracks.
- **MWR003:** A 0.6 MG storage tank would be constructed underground at a site in the vicinity of the MWR003 outfall.
- **CAM401B:** A 0.4 MG storage tank would be constructed underground in the grassy area under DCR control along Massachusetts Avenue.
- **SOM001A:** Approximately 100 acres of sewer separation would be implemented in the combined sewer area tributary to outfall SOM001A. This work would include development of 1.5 acres of storage for peak stormwater flow attenuation to manage peak stormwater flow into Alewife Brook from the separated areas, and a new 60-inch diameter storm drain along Massachusetts Avenue to convey the separated stormwater to a new stormwater outfall to Alewife Brook.
- **CAM001:** Approximately 8 acres of sewer separation would be implemented in the combined sewer area tributary to outfall CAM001.

### 9.5.6.2 Implementation Challenges

The implementation challenges associated with this Alternative are entirely similar to those described in Alternative 2.AB Hybrid 1.

### 9.5.7 Alternative 8.AB Hybrid 2 (Limited CSOs in the 2050 TY)

Alternative 8.AB Hybrid 2 includes a combination of sewer separation, conveyance, storage tanks and a storage conduit to provide Limited CSOs in the 2050 TY LOC. This alternative is based on Alternative 3.AB Hybrid 2 and excludes sewer separation upstream of SOM001A, but it includes the following changes:

- Reduce the storage tank at MWR003. Whereas Alternative 3.AB Hybrid 2 included 1.4 MG of storage at MWR003 to go from 3 activations to 0 activations, the tank is downsized in Alternative 8.AB Hybrid 2 to 0.62 MG, which leaves 1 remaining activation in the 2050 TY.
- Reconfigure microtunnel so that it does not extend to CAM401B. As a result, local storage at CAM401B is included to capture CSOs in the 2050 TY. In addition to a reduced length, the microtunnel also has a slightly decreased diameter, which leaves 3 of the 13 CSO activations to occur in the 2050 TY at SOM001A.

**Table 9-29** presents, for each outfall, the Baseline Conditions 2050 TY activations and volume, the project components, the estimated capital cost, and the estimated project duration. Because this alternative does not eliminate CSOs in the 2050 TY, the table also shows the CSO activations and volumes predicted to remain in the 2050 TY after implementation. A schematic layout of the components of this alternative is presented in **Figure 9-27**.

**Table 9-29. Alternative 8.AB Hybrid 2 (Limited CSOs in 2050 TY) Summary**

| Alewife Brook Outfall | Baseline 2050 TY Act Freq./Vol. (MG) | CSO Control Technology Description | Remaining 2050 TY Act Freq./Vol. (MG) | Preliminary Capital Cost[2] ($million) | Project Duration[3] (years) |
|---|---|---|---|---|---|
| CAM001 | 1 act/0.02 MG | 8 acres sewer separation | 0 act/0 MG | $15 M | 5 - 10 |
| CAM002 | 0 act/0 MG | No action | 0 act/0 MG | N/A[1] | N/A |
| CAM401A | 12 act/10.95 MG | Conveyance + 1.5 MG storage tank | 0 act/0 MG | $98 M | 5 - 10 |
| CAM401B | 3 act/0.30 MG | 0.4 MG storage tank | 0 act/0 MG | $25 M | 1 - 2 |
| MWR003 | 3 act/1.08 MG | 0.62 MG storage tank | 1 act/0.8 MG | $31 M | 5 |
| SOM001A | 13 act/8.51 MG | 0.9 MG microtunnel storage | 3 act/3 MG | $76 M | 5 - 10 |
| **Max/Sum (Untreated)** | **13 act/20.86 MG** | **-** | **3 act/3.8 MG** | **$250 M** | **10** |

**Notes:**
(1) N/A: not applicable.
(2) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.
(3) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

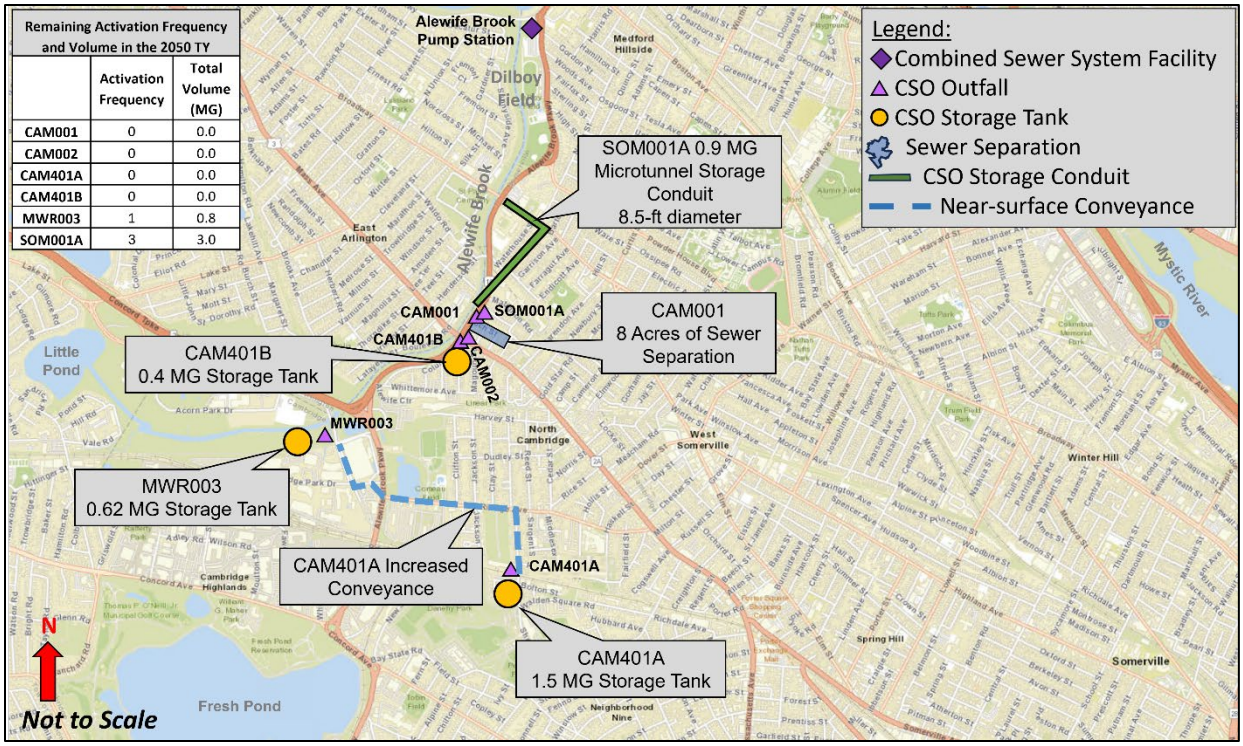



**Figure 9-27. Alternative 8.AB Hybrid 2 (Limited CSOs in 2050 TY)**

### 9.5.7.1 Component Descriptions

The individual components of Alternative 8.AB Hybrid 2 are described below:

- **CAM401A:** A 1.5 MG storage tank would be constructed underground in a City of Cambridge-owned parking lot off of Sherman Street adjacent to the MBTA commuter rail tracks. Additionally, the 48-inch diameter combined sewer along Sherman Street and Rindge Avenue between the existing CAM401A regulator and the connection to the ABBS would be replaced with a new 60-inch diameter combined sewer, and the weir in the existing CAM401A regulator would be raised by 1.5 feet.
- **MWR003:** A 0.62 MG storage tank would be constructed underground at a site in the vicinity of the MWR003 outfall.
- **CAM401B:** A 0.4 MG storage tank would be constructed underground in the grassy area under DCR control along Massachusetts Avenue.
- **SOM001A:** A 2,300 linear foot, 8.5-foot diameter microtunnel storage conduit (0.9 MG capacity) would be constructed to capture the overflow from outfall SOM001A. A preliminary route for the storage conduit would be similar to the route described for Alternative 2.AB Hybrid 1, except that the conduit would begin near the SOM01A outfall instead of the CAM401B outfall.
- **CAM001:** Approximately 8 acres of sewer separation would be implemented in the combined sewer area tributary to outfall CAM001.

#### 9.5.7.2 Implementation Challenges

The implementation challenges associated with this Alternative are entirely similar to those described previously. Most of the challenges are shared with those described for Alternative 3.AB Hybrid 2, and the challenges at CAM401B reflect those described in Alternative 2.AB Hybrid 1.

### 9.5.8 Alternative 9.AB 5-Year Tunnel (0 CSOs in 2050 5-Year)

Alternative 9.AB 5-Year Tunnel was developed as a regional storage tunnel to eliminate CSOs in a 2050 5-year storm. It would capture and store CSOs from outfalls CAM401A, MWR003, CAM401B, CAM001, and SOM001A, with dewatering at the farthest downstream location. This alternative would also result in no CSO discharges to Alewife Brook in the 2050 TY. The 2050 5-year storm volume discharging to Alewife Brook is 20.6 MG, so the tunnel is sized to capture that CSO volume.

**Table 9-30** presents, for each outfall, the predicted CSO volume for the Baseline Condition 2050 5-year storm, the project components, the estimated capital cost, and the estimated project duration. A schematic layout of the components of this alternative is presented in **Figure 9-28**.

**Table 9-30. Alternative 9.AB 5-Year Tunnel (0 CSOs in 2050 5-Year) Summary**

| Alewife Brook Outfall | Baseline 2050 5-Year Storm Vol. (MG) | CSO Control Technology Description | Preliminary Capital Cost[2] ($million) | Project Duration[3] (years) |
|---|---|---|---|---|
| CAM001 | 0.21 MG | 20.6 MG 22-ft dia. Storage Tunnel[1] | $990 M | 12 - 15 |
| CAM002 | 0.20 MG | | | |
| CAM401A | 8.43 MG | | | |
| CAM401B | 1.29 MG | | | |
| MWR003 | 5.63 MG | | | |
| SOM001A | 5.10 MG | | | |
| **Total (Untreated)** | **20.86 MG** | **-** | **-** | **-** |

**Notes:**

(1) The configuration of the drop shafts to the tunnel results in a volume slightly less than the baseline volume due to flow balancing within the interceptor system.

(2) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.

(3) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

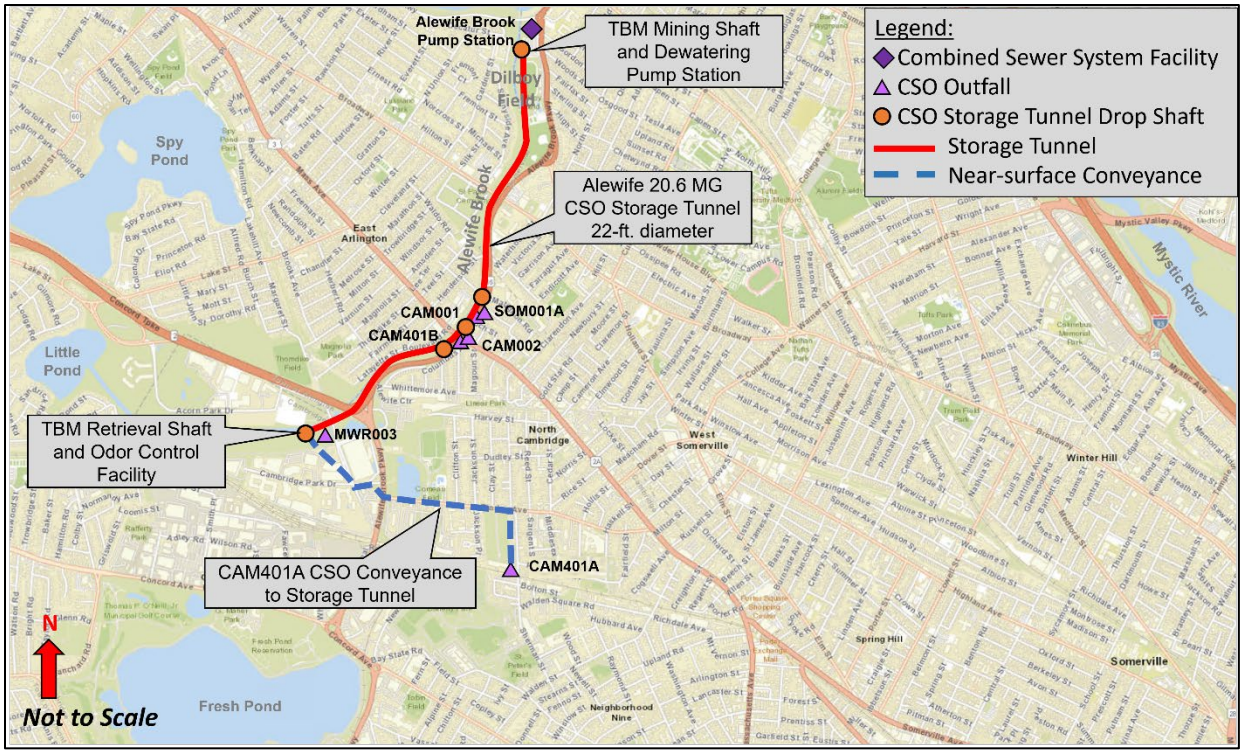



**Figure 9-28. Alternative 9.AB 5-Year Tunnel (0 CSOs in 2050 5-Year)**

### 9.5.8.1 Component Descriptions

The individual components of Alternative 9.AB 5-Year Tunnel are described below:

- **Tunnel, Mining/TBM Retrieval Shafts, Tunnel Dewatering Pump Station, Diversion Structures, Drop Shafts**: These components would all be similar to those described for Alternative 4.AB Tunnel except that the tunnel size would be increased to 22-foot diameter and 20.6 MG capacity. The dewatering pump station would similarly be upsized to 20.6 MGD capacity. The mining and TBM retrieval shafts would increase in diameter, and the tunnel would run deeper to maintain the needed depth of cover.

### 9.5.8.2 Implementation Challenges

The challenges to implementing the components of this alternative would be similar to the challenges listed for Alternative 4.AB Tunnel, although the challenges would be of a higher magnitude due to the substantially increased size of the tunnel, mining/TBM retrieval shafts, and dewatering pump station and limited staging area to perform this work.

**Figure 9-29** presents a potential site plan which includes the approximate extent of temporary construction site, the approximate extent of the permanent facilities sites as well as the approximate locations of a tunnel mining shaft and pump station at the Dilboy Field parking lot.

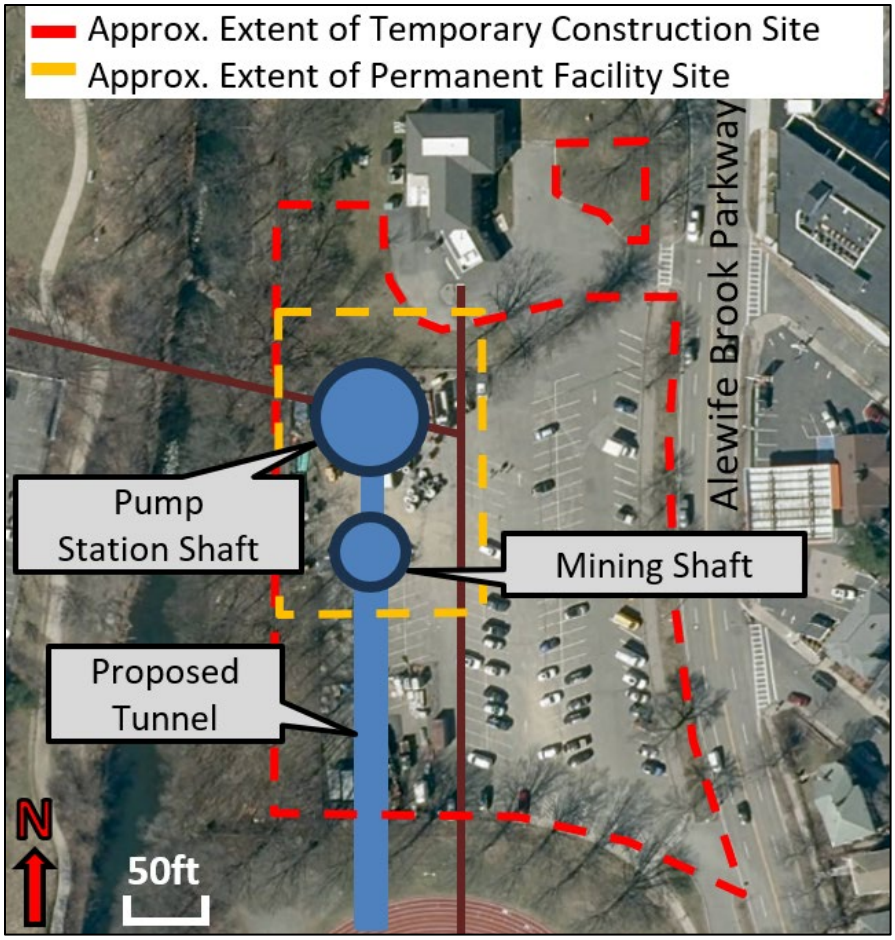



**Figure 9-29. Alternative 9.AB 5-Year Tunnel (0 CSOs in 2050 5-Year) Potential Impacts to Dilboy Field Parking Lot**

### 9.5.9 Alternative 10.AB 5-Year Tunnel + GSI (0 CSOs in 2050 5-Year)

Alternative 10.AB 5-Year Tunnel + GSI includes a combination of a storage tunnel, conveyance and GSI. This alternative was developed to assess the impact that regional GSI could have on sizing regional storage in a large design storm. It is based on Alternative 9.AB 5-Year Tunnel and augments it by adding GSI at a regional scale. With the addition of GSI, the remaining volume to be captured by the tunnel is reduced from 20.6 MG to 20.3 MG. Although there is a reduction in volume, it is not sufficient to downsize the tunnel diameter while maintaining the same length—therefore the tunnel sizes for Alternative 9.AB 5-Year Tunnel and Alternative 10.AB 5-Year Tunnel + GSI are the same. The tunnel length is based on the route described in **Section 9.4.7** and did not change because it needs to capture CSO from the same outfalls.

**Table 9-31** presents, for each outfall, the predicted CSO volume for the Baseline Conditions 2050 5-year storm, the project components, the estimated capital cost, and the estimated project duration. A schematic layout of the components of this alternative is presented in **Figure 9-30**.

## Table 9-31. Alternative 10.AB 5-Year Tunnel + GSI (0 CSOs in 2050 5-Year) Summary

| Alewife Brook Outfall | Baseline 2050 5-Year Storm Vol. (MG) | CSO Control Technology Description | Preliminary Capital Cost[3] ($million) | Project Duration[4] (years) |
|---|---|---|---|---|
| CAM001 | 0.21MG | 20.3 MG 22-ft dia. Storage Tunnel + GSI (35.6 acres)[1][2] | $1,100 M | 12 - 15 for tunnel (GSI requires additional time to be determined) |
| CAM002 | 0.20 MG | | | |
| CAM401A | 8.43 MG | | | |
| CAM401B | 1.29 MG | | | |
| MWR003 | 5.63 MG | | | |
| SOM001A | 5.10 MG | | | |
| **Total (Untreated)** | **20.86 MG** | - | - | - |

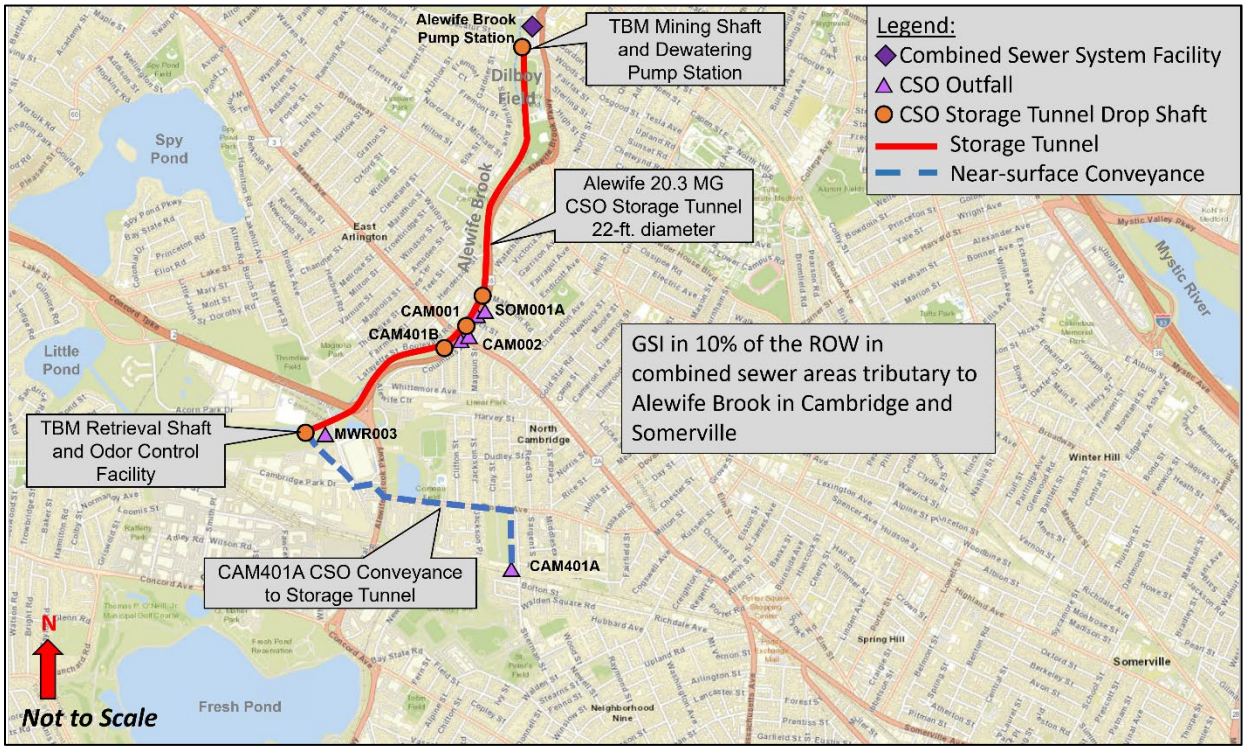
**Notes:**

(1) The configuration of the drop shafts to the tunnel results in a volume slightly less than the baseline volume due to flow balancing within the interceptor system.

(2) The CSO volume to be stored by the tunnel for Alternative 10.AB 5-Year Tunnel is 20.3 MG. Although there was a reduction in volume of CSO to be stored by the tunnel when compared to Alternative 9.AB 5-Year Tunnel, it not sufficient to downsize the tunnel diameter while maintaining the same length – and therefore the tunnel size for Alternative 9.AB 5-Year Tunnel and Alternative 10.AB 5-Year Tunnel + GSI are the same.

(3) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.

(4) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.




## Figure 9-30. Alternative 10.AB 5-Year Tunnel + GSI (0 CSOs in 2050 5-Year Storm)

#### 9.5.9.1 Component Descriptions

The individual components of the Alternative 10.AB 5-Year Tunnel + GSI are described below:

- **Tunnel, Mining/TBM Retrieval Shafts, Tunnel Dewatering Pump Station, Diversion Structures, Drop Shafts**: These components would all be the same as described for Alternative 9.AB 5-Year Tunnel except that the GSI implementation would downsize the tunnel capacity from 20.6 to 20.3 MG. This difference would not change the tunnel diameter, but would marginally reduce the capacity of the dewatering pump station to 20.3 MGD.
- **GSI**: This alternative would include the implementation of GSI capturing runoff from 10% of the impervious right-of-way area in the combined sewer areas tributary to Alewife Brook in Cambridge and Somerville (35.6 acres).

#### 9.5.9.2 Implementation Challenges

The challenges to implementing the components of this alternative would include all of the challenges listed for Alternative 9.AB 5-Year Tunnel, plus the following challenges specific to GSI implementation:

- Identifying appropriate sites for GSI on municipally owned land or on public rights-of-way.

### 9.5.10 Alternative 11.AB 25-Year Tunnel (0 CSOs in 2050 25-Year)

Alternative 11.AB 25-Year Tunnel was developed as a regional storage tunnel to eliminate CSOs in a 2050 25-year storm. It would capture and store CSOs from outfalls CAM401A, MWR003, CAM401B, CAM001, and SOM001A, with dewatering at the farthest downstream location. This alternative would also result in no CSO discharges to Alewife Brook in the 2050 TY. The 2050 25-year storm volume discharging to the Alewife Brook is 41.6 MG, so the tunnel is sized to capture that CSO volume.

**Table 9-32** presents, for each outfall, the predicted CSO volume for the Baseline Condition 2050 25-year storm, the project components, the estimated capital cost, and the estimated project duration. A schematic layout of the components of this alternative is presented in **Figure 9-31**.

**Table 9-32. Alternative 11.AB 25-Year Tunnel (0 CSOs in 2050 25-Year) Summary**

| Alewife Brook Outfall | Baseline 2050 25-Year Storm Vol. (MG) | CSO Control Technology Description | Preliminary Capital Cost[2] ($million) | Project Duration[3] (years) |
|---|---|---|---|---|
| CAM001 | 0.54 MG | 41.6 MG 32-ft dia. Storage Tunnel[1] | $1,700 | 12 - 15 |
| CAM002 | 0.70 MG | | | |
| CAM401A | 16.75 MG | | | |
| CAM401B | 2.82 MG | | | |
| MWR003 | 10.70 MG | | | |
| SOM001A | 8.56 MG | | | |
| **Total (Untreated)** | **40.07** | **-** | **-** | **-** |

**Notes:**

(1) The configuration of the drop shafts to the tunnel results in a volume slightly more than the baseline volume due to flow balancing within the interceptor system.

(2) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.

(3) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

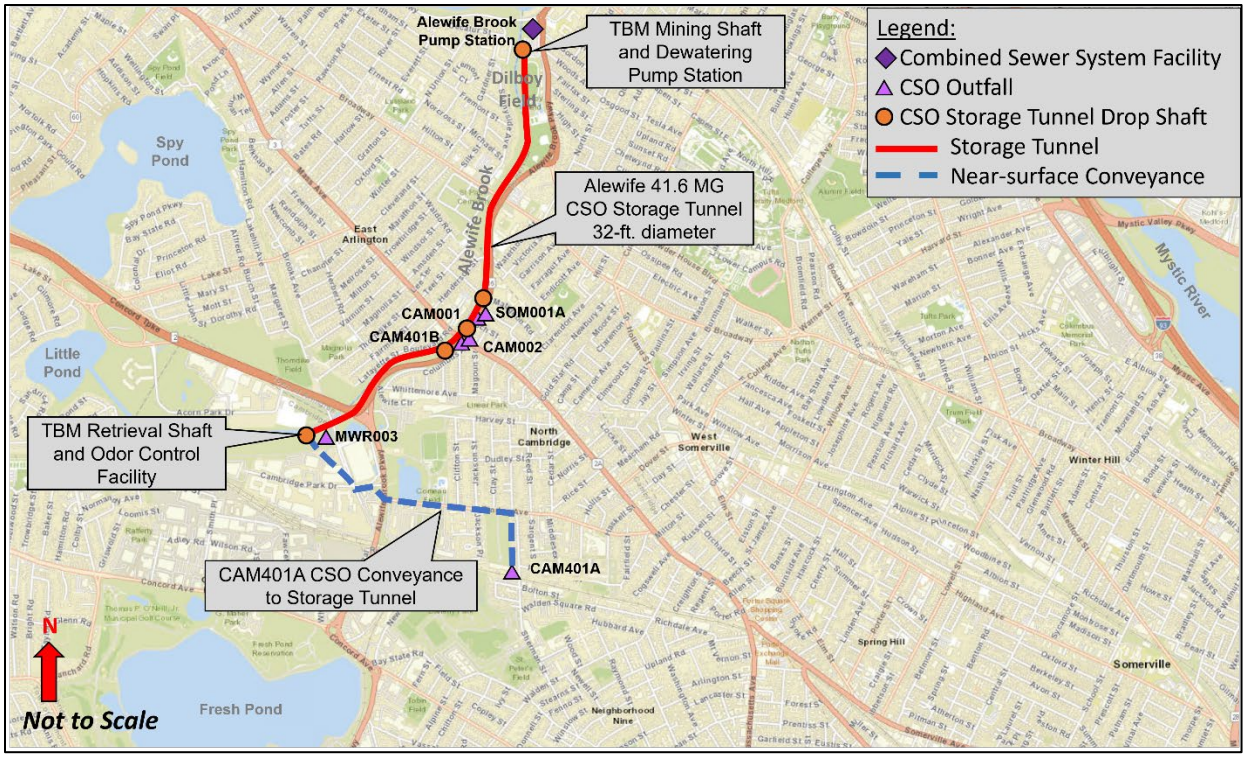



**Figure 9-31. Alternative 11.AB 25-Year Tunnel (0 CSOs in 2050 25-Year)**

### 9.5.10.1 Component Descriptions

The individual components of Alternative 11.AB 25-Year Tunnel are described below:

- **Tunnel, Mining/TBM Retrieval Shafts, Tunnel Dewatering Pump Station, Diversion Structures, Drop Shafts**: These components mirror those described for Alternative 9.AB 5-Year Tunnel except that the tunnel size would be increased to 32-foot diameter and 41.6 MG capacity. The dewatering pump station would similarly be upsized to 41.6 MGD capacity. The mining and TBM retrieval shafts would increase in diameter, and the tunnel would run deeper to maintain the needed depth of cover.

### 9.5.10.2 Implementation Challenges

The challenges to implementing the components of this alternative would be similar to the challenges listed for the Alternative 9.AB 5-Year Tunnel, although the challenges would be of a substantially higher magnitude due to the increased size of the tunnel, mining/TBM retrieval shafts, and dewatering pump station and limited staging area to perform this work. . **Figure 9-32** presents a potential site plan which incudes the approximate extent of temporary and permanent construction impacts as well as the approximate locations of a tunnel mining shaft and pump station at the Dilboy Field parking lot.

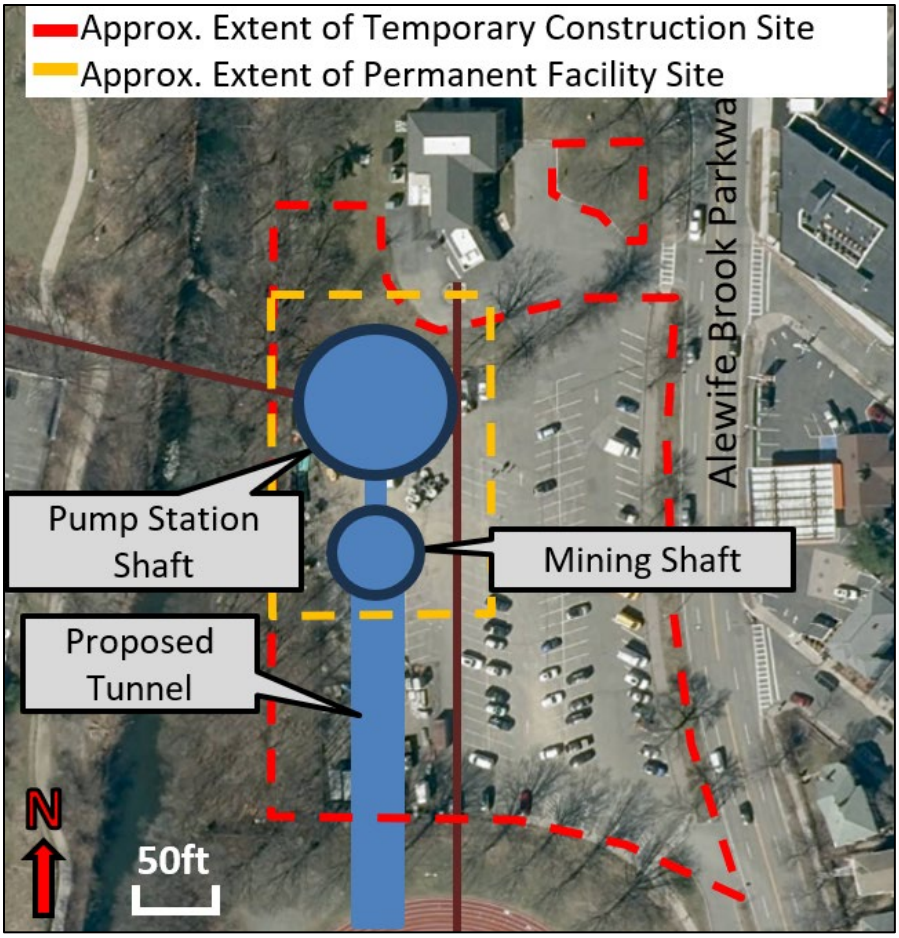



**Figure 9-32. Alternative 9.AB 25-Year Tunnel (0 CSOs in 2050 5-Year) Potential Locations of Project Components and Approximate Extent of Temporary and Permanent Construction Impacts at Dilboy Field Parking Lot**

### 9.5.11 Alternative 12.AB 25-Year Tunnel + GSI Alternative (0 CSOs in 2050 25-Year)

Alternative 12.AB 25-Year Tunnel + GSI includes a combination of a storage tunnel, conveyance and GSI. This alternative was developed to assess the impact that regional GSI could have on sizing regional storage in a larger design storm. It is based on Alternative 11.AB 25-Year Tunnel and augments it by adding GSI at a regional scale. With the addition of GSI, the remaining volume to be captured by the tunnel is reduced from 41.6 MG to 41.0 MG. Although there was a reduction in volume, it is not sufficient to downsize the tunnel diameter while maintaining the same length – therefore the tunnel sizes for Alternative 11.AB 25-Year Tunnel and Alternative 12.AB 25-Year Tunnel + GSI are the same. The tunnel length is based on the route described in Section 9.5.10 and did not change because it needs to capture CSO from the same outfalls.

**Table 9-33** presents, for each outfall, the predicted CSO volume for the Baseline Conditions 2050 25-year storm, the project components, the estimated capital cost, and the estimated project duration. A schematic layout of the components of this alternative is presented in **Figure 9-33**.

## Table 9-33. Alternative 12.AB 25-Year Tunnel + GSI (0 CSOs in 2050 25-Year) Summary

| Alewife Brook Outfall | Baseline 2050 25-Year Storm Vol. (MG) | CSO Control Technology Description | Preliminary Capital Cost[3] ($million) | Project Duration[4] (years) |
|---|---|---|---|---|
| CAM001 | 0.54 MG | 41.0 MG 32-ft dia. Storage Tunnel + GSI (35.6 acres)[1][2] | $1,700 M | 12 - 15 for tunnel (GSI requires additional time to be determined) |
| CAM002 | 0.70 MG | | | |
| CAM401A | 16.75 MG | | | |
| CAM401B | 2.82 MG | | | |
| MWR003 | 10.70 MG | | | |
| SOM001A | 8.56 MG | | | |
| **Total (Untreated)** | **40.07** | - | - | - |

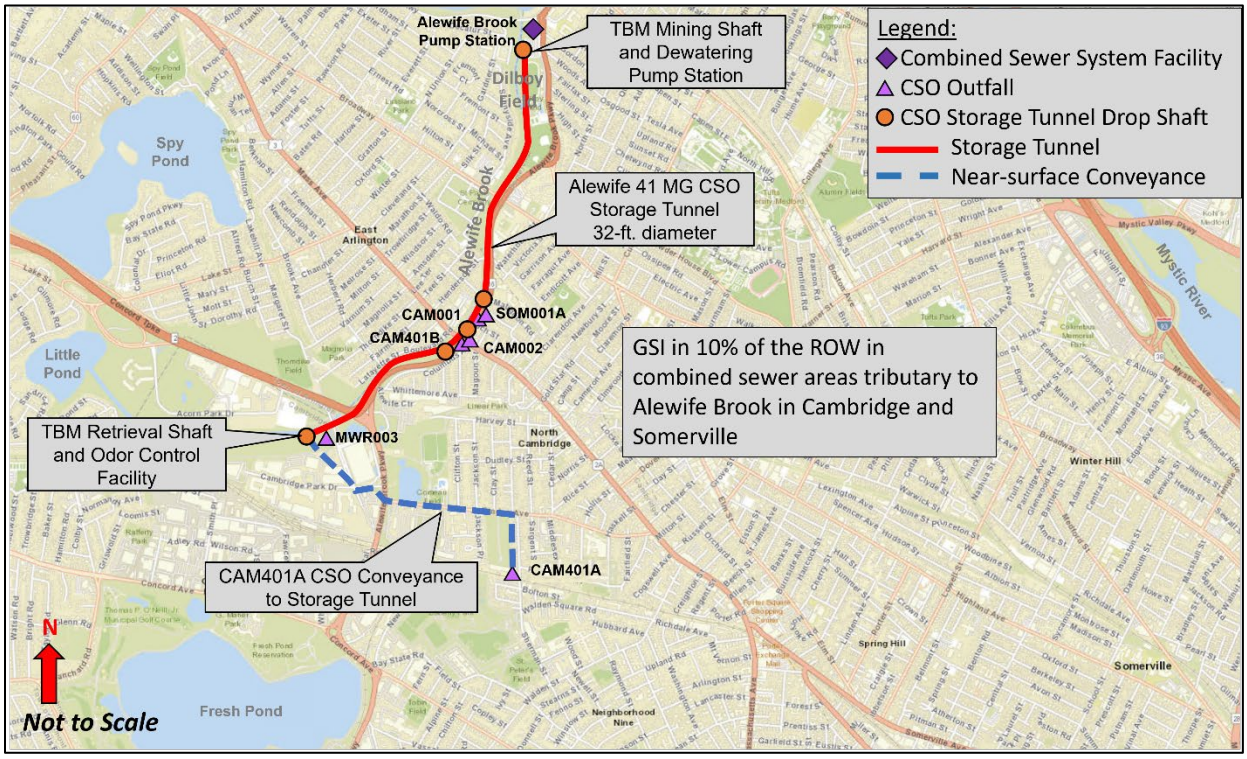
**Notes:**

(1) The configuration of the drop shafts to the tunnel results in a volume slightly less than the baseline volume due to flow balancing within the interceptor system.

(2) The CSO volume to be stored by the tunnel for Alternative 12.AB is 41.0 MG. Although there was a reduction in volume of CSO to be stored by the tunnel when compared to Alt 11.AB, it not sufficient to downsize the tunnel diameter while maintaining the same length – and therefore the tunnel size for 11.AB and 12.AB are the same.

(3) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.

(4) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.




## Figure 9-33. Alternative 12.AB 25-Year Tunnel + GSI (0 CSOs in 2050 25-Year)

#### 9.5.11.1 Component Descriptions

The individual components of Alternative 12.AB 25-Year Tunnel + GSI are described below.

- **Tunnel, Mining/TBM Retrieval Shafts, Tunnel Dewatering Pump Station, Diversion Structures, Drop Shafts:** These components would all be the same as described for Alternative 11.AB 25-Year Tunnel except that the GSI implementation would downsize the tunnel capacity from 41.6 to 41.0 MG. This difference would not change the tunnel diameter but would marginally reduce the capacity of the dewatering pump station to 41 MGD.
- **GSI**: This alternative would include the implementation of GSI capturing runoff from 10% of the impervious right-of-way area in the combined sewer areas tributary to Alewife Brook in Cambridge and Somerville (35.6 acres).

#### 9.5.11.2 Implementation Challenges

The challenges to implementing the components of this alternative would include all of the challenges listed for the Alternative 11.AB 25-Year Tunnel, plus the following challenges specific to GSI implementation:

- Identifying appropriate sites for GSI on municipally owned land or on public rights-of-way.

### 9.5.12 Alternative 6.AB Regional Sewer Separation

This alternative is based on the regional sewer separation analysis in Section 9.4.7 and would include separating the combined sewers tributary to Alewife Brook in Cambridge and Somerville as shown in **Figure 9-34**. The following components, as discussed earlier, are included in this alternative:

- Separating approximately 438 acres of combined sewer area in Cambridge and 448 acres in Somerville, for a total of approximately 900 acres.
- Approximately 14 acres of land for stormwater detention facilities would be needed to attenuate the new stormwater flows so that the peak flow rates to Alewife Brook would not exceed current conditions. In addition, approximately 2.5 acres of land would be needed for pumping and treatment of the new stormwater flows. The acreage for stormwater detention, pumping and treatment are estimated based on factors identified in Appendix E.
- Modeling assumed that 90 percent of the inflow from the combined areas could be captured by the sewer separation work, with 10 percent remaining tributary to the collection system. The remaining 10 percent was intended to reflect roof drains connected to interior building plumbing, and other extraneous sources of inflow that could not be feasibly captured.
- Modeling assumed the CSO regulators would remain open (described in **Section 9.2.4)** so the need for them to remain as relief points could be assessed.

Regional sewer separation for Alewife Brook was predicted to eliminate CSO discharges to Alewife Brook in the 2050 TY. In the 2050 5-year storm, CAM401A was predicted to discharge 0.17 MG; in the 2050 25-year storm, CAM401A was predicted to discharge 0.46 MG. Recall that inflow removal in the 5-year and 25-year storm events was simulated with the same percent inflow removal as the 2050 TY; however, the percent removal may be harder to predict for these events due to additional inflow sources during these larger events. As a result, discharges could occur at other outfalls.

The preliminary capital cost of regional sewer separation for Alewife Brook was estimated to be $1,700 M, with a duration of 50 years. **Table 9-34** provides a breakdown of the assumptions for sewer separation and the application of unit costs presented in **Section 9.3** that generate the preliminary capital cost.

## Table 9-34. Alternative 6.AB Regional Sewer Separation Preliminary Capital Cost Summary

| | | Cambridge | | | Somerville | | | Total |
|---|---|---|---|---|---|---|---|---|
| | Unit Cost ($/separated acre)(1) | Acres | Construction Cost ($M) | Capital Cost ($M) | Acres | Construction Cost ($M) | Capital Cost ($M) | Capital Cost ($M) |
| To Be Separated Pipe Network | $450,000 | 438 | $200 | $340 | 448 | $200 | $350 | **$690** |
| Previously Separated | $50,000 | 0 | $0 | $0 | 0 | $0 | $0 | **$0** |
| Stormwater Treatment (Phosphorus) | $115,000 | 438 | $50 | $86 | 448 | $52 | $88 | **$174** |
| Peak Flow Attenuation Storage | $325,000 | 438 | $140 | $240 | 448 | $150 | $250 | **$490** |
| Pumping (Landlocked/ Low-Lying areas) | $180,000 | 438 | $79 | $140 | 0 | $0 | $0 | **$140** |
| Extraordinary Conveyance | N/A | | $28 | $49 | | $57 | $98 | **$147** |
| Storage Tanks | N/A | | $0 | $0 | | $0 | $0 | **$0** |
| Other | N/A | | $0 | $0 | | $0 | $0 | **$0** |
| **Total** | | | **$500** | **$850** | | **$460** | **$780** | **$1,700** |

**Note:**
(1) Preliminary Unit Costs are described in Section 9.3. Costs for sewer separation components are rounded to two significant figures; total alternative cost was rounded up to two significant figures and therefore may not match the sum.

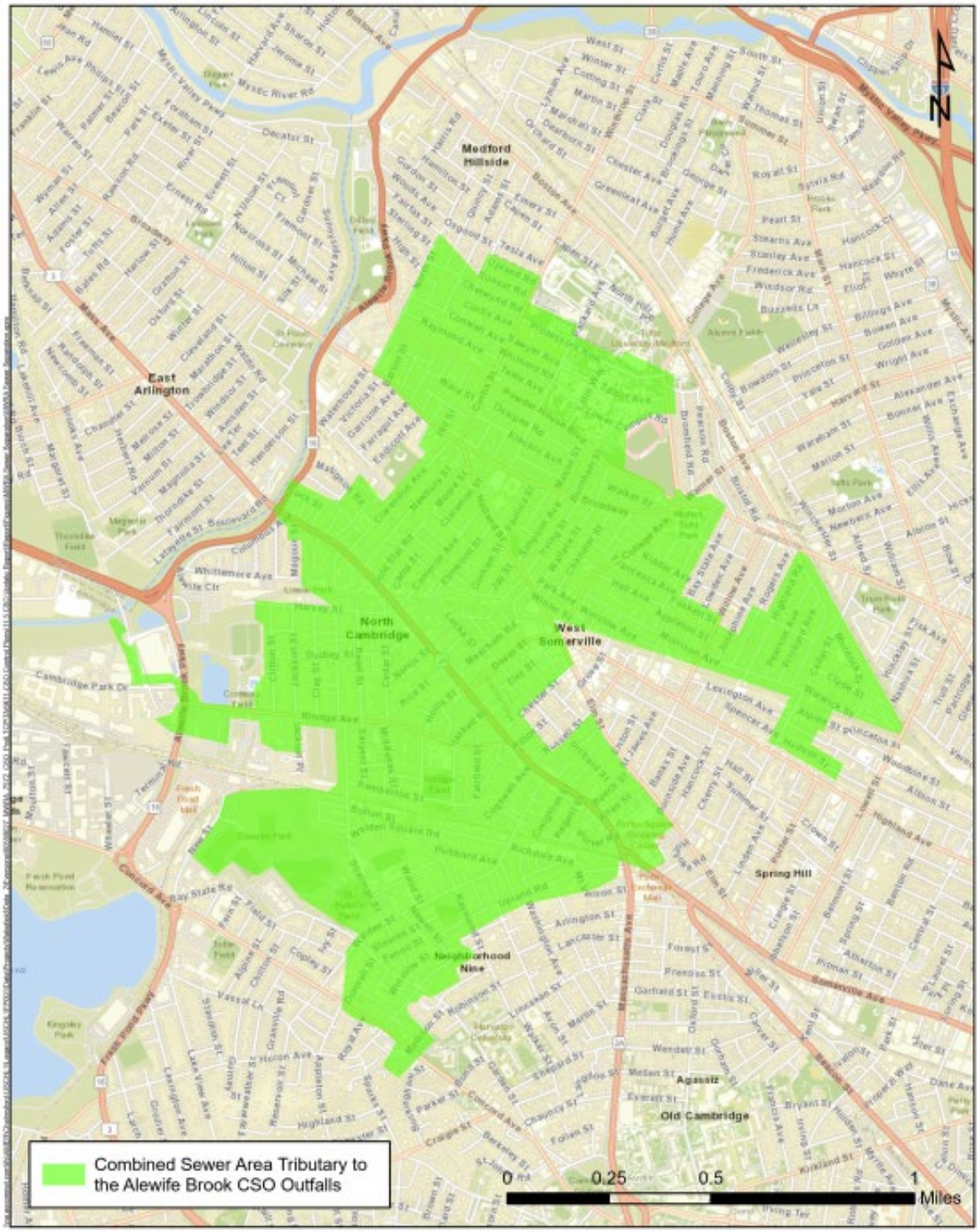



**Figure 9-34. Alternative 6.AB Regional Sewer Separation**

#### 9.5.12.1 Implementation Challenges

Challenges to implementing the components of this alternative would include:

- Construction in densely populated area over a long period;
- Construction of large storm drains in Somerville and Cambridge in highly congested urban areas will likely create important disruptions to residents and businesses and constructability may be challenging due to utility conflicts;
- Sites for pumping, treatment, flow attenuation and GSI have not been identified. Somerville has a more advanced concept for sewer separation and specific challenges that have been identified through this process are listed in Alternative 1.AB; and
- Sewer separation of this magnitude would take decades to complete, and residents in the area would be likely to experience construction fatigue with the potential for multiple mobilizations in each street for utility relocations, separation, and paving.

### 9.5.13 Alewife Brook CSO Control Alternatives Summary

**Table 9-35** provides a summary of the Alewife Brook CSO control alternatives. The table presents the alternative name, the Baseline Conditions CSO activation frequency and volume, the remaining CSO activation frequency and volume after implementation, the preliminary capital cost, and an estimated project duration. The evaluation and comparison of CSO control alternatives is presented in Section 10.

**Table 9-35. Alewife Brook Alternatives Summary**

| Alewife Brook Alternative | Alternative Components | Baseline Activation Frequency/ Volume (MG) | Remaining Activation Frequency/ Volume (MG) | Preliminary Capital Cost ($M) | Project Duration (years)[5] |
|---|---|---|---|---|---|
| **2050 Typical Year Level of Control** | | | | | |
| 1.AB Integrated | 3 tanks (3 MG) + 264 acres of sewer separation | 13 act/20.86 MG | 0 act/0 MG[1] | $600 M | 31 |
| 2.AB Hybrid 1 | 2 tanks (2.9 MG) + 108 acres of sewer separation + 0.75-mile-long conveyance pipe + 0.5 mile-long microtunnel | 13 act/20.86 MG | 0 act/0 MG[1] | $440 M | 20 |
| 3.AB Hybrid 2 | 2 tanks (3 MG) + 8 acres of sewer separation + 0.75-mile-long conveyance pipe + 1 mile-long microtunnel | 13 act/20.86 MG | 0 act/0 MG[1] | $340 M | 15 |
| 4.AB Tunnel | 1.5-mile-long deep tunnel (11 ft. diameter) | 13 act/20.86 MG | 0 act/0 MG[1] | $600 M | 15 - 20 |
| 5.AB Tunnel + GSI | 1.5-mile-long deep tunnel (10 ft diameter) + GSI (36 acres) | 13 act/20.86 MG | 0 act/0 MG[1] | $630 M | 20 for tunnel (GSI requires additional time to be determined) |
| **Limited CSOs in 2050 Typical Year Level of Control** | | | | | |
| 7.AB Hybrid 1 | 3 tanks (2.5 MG) + 108 acres of sewer separation + 0.75-mile-long conveyance pipe | 13 act/20.86 MG | 12 act/7.83 MG[2] | $330 M | 20 |

## Table 9-35. Alewife Brook Alternatives Summary

| Alewife Brook Alternative | Alternative Components | Baseline Activation Frequency/ Volume (MG) | Remaining Activation Frequency/ Volume (MG) | Preliminary Capital Cost ($M) | Project Duration (years)[5] |
|---|---|---|---|---|---|
| 8.AB Hybrid 2 | 3 tanks (2.5 MG) + 8 acres of sewer separation + 0.75-mile-long conveyance pipe + 0.5 mile-long microtunnel | 13 act/20.86 MG | 4 act/5.04 MG[2] | $250 M | 10 - 20 |
| **Greater Than Typical Year Level of Control** | | | | | |
| **2050 5-Year Storm** | | | | | |
| 9.AB 5-Year Tunnel | 1.5-mile-long deep tunnel (22 ft. diameter) | 20.9 MG | 0 MG[3] | $990 M | 12 - 15 |
| 10.AB 5-Year Tunnel + GSI | Same tunnel as 9.AB + GSI (36 acres) | 20.9 MG | 0 MG[3] | $1,100 M | 12 - 15 for tunnel (GSI requires additional time to be determined) |
| **2050 25-Year Storm** | | | | | |
| 11.AB 25-Year Tunnel | 1.5-mile-long deep tunnel (32 ft. diameter) | 40.1 MG | 0 MG[4] | $1,700 M | 12 - 15 |
| 12.AB 25-Year Tunnel + GSI | Same tunnel as 11.AB + GSI (36 acres) | 40.1 MG | 0 MG[4] | $1,700 M | 12 – 15 for tunnel (GSI requires additional time to be determined) |
| **Regional Sewer Separation** | | | | | |
| 6.AB Regional Sewer Separation | 900 acres of sewer separation | 2050 TY: 13 act/20.86 MG | 0 CSO remaining 2050 TY Storm. | $1,700 M[6] | 50 |
| | | 2050 5-Year: 20.9 MG | 0.17 MG of CSO remaining at CAM401A in the 2050 5-Year Storm. | | |
| | | 2050 25-Year: 40.1 MG | 0.46 MG of CSO remaining at CAM401A in the 2050 25-Year storm. | | |

**Notes:**

(1) Alternatives would result in no CSO discharges in the 2050 TY

(2) CSO activation frequency and volume remaining with Alternative implemented in the 2050 TY.

(3) Alternatives would result in no CSO discharges in the 2050 Typical Year and 5-year storm.

(4) Alternatives would result in no CSO discharges in the 2050 Typical Year, 5-year and 25-year storms.

(5) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

(6) Costing for sewer separation, including stormwater peak flow attenuation, pumping, and treatment, was developed using construction bids and estimated costs from recent sewer separation projects in the Greater Boston area. Costs were converted into a dollar per acre of sewer separation using project area size. See Appendix E for more details.

## 9.6 Upper Mystic River - Local and Regional Technology Assessment

One outfall (SOM007A/MWR205A) discharges treated CSO to the Upper Mystic River. MWRA's Somerville Marginal CSO Facility is located directly upstream of SOM007A/MWR205A and provides screening and disinfection of combined sewage from its tributary areas. During dry weather conditions, the combined sewage is conveyed to the Somerville-Medford Branch Sewer and then to the Cambridge Branch Sewer; however, during storm events when the capacity of the connection to MWRA interceptor is overwhelmed by combined flows or the capacity of these interceptors is exceeded, the level upstream of the Somerville Marginal CSO Facility reaches a high level requiring the facility to activate. MWRA is constructing a new gated connection from the Somerville combined system to the MWRA's interceptor to take advantage of available downstream interceptor capacity during smaller storm events. This project is included in the Baseline Condition model.

The Cambridge Branch Sewer system is influenced by flows from Charlestown and the Davis Square area which can also overflow to Prison Point CSO Facility through the SOM009 regulator. Treated effluent from the Somerville Marginal CSO Facility is conveyed to the Somerville Marginal Conduit (SMC) and discharged through outfall MWR205 to the tidal waters of the Lower Mystic River immediately downstream of the Amelia Earhart Dam. Outfall SOM007A/MWR205A functions as a relief outfall for the SMC that discharges to the freshwater reach of the Upper Mystic River upstream of the Amelia Earhart Dam. CSO activations at outfall SOM007A/MWR205A occur when the Somerville Marginal CSO Facility activates and effluent cannot be conveyed to MWR205 due to high flows or the tide elevation resulting in a backwater condition. Note that due to its location downstream of the Amelia Earhart Dam MWR205 is not part of this Updated CSO Control Plan, and just MWR205A/SOM007A is part of the Plan. The location of each of the CSO outfalls is presented in **Figure 9-35**. Separate storm drains also tie in downstream of the Somerville Marginal CSO Facility upstream of the diversion weir to outfall SOM007A/MWR205A. **Figure 9-36** presents a schematic of the system tributary to the Upper Mystic River.

Based on the systemwide screening of CSO control technologies described in **Section 9.2**, sewer separation and storage were evaluated for outfall SOM007A/MWR205A. GSI was included for storage alternatives.




**Figure 9-35. Mystic River CSO Location Plan**

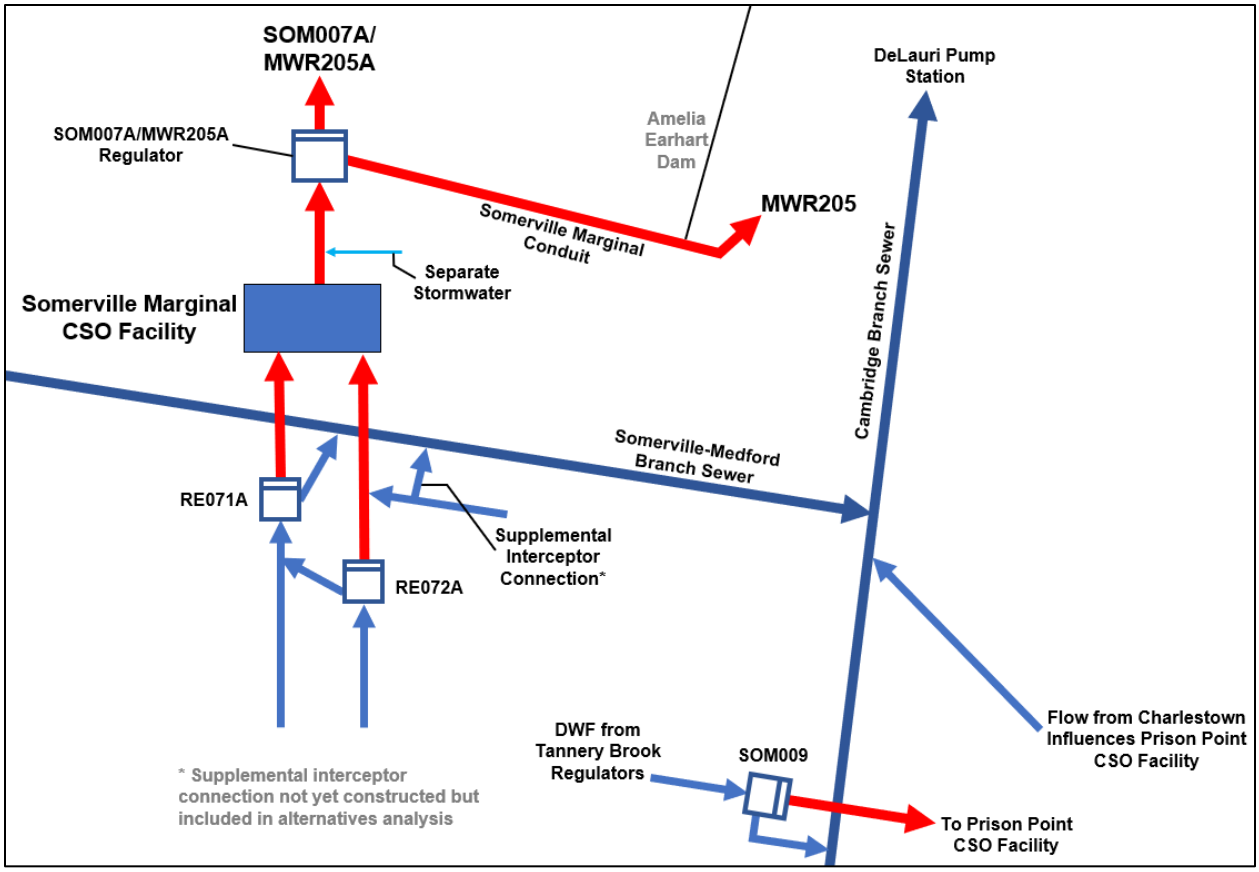



**Figure 9-36. Mystic River Combined Sewer System Schematic**

The following section describes the initial screening of CSO control technologies for the Upper Mystic River CSO outfall SOM007A/MWR205A, including reasons behind the decisions to set aside certain CSO control technologies that were not selected for more detailed evaluation. This section is the second step as illustrated previously in **Figure 9-1**, shown again in **Figure 9-37**.

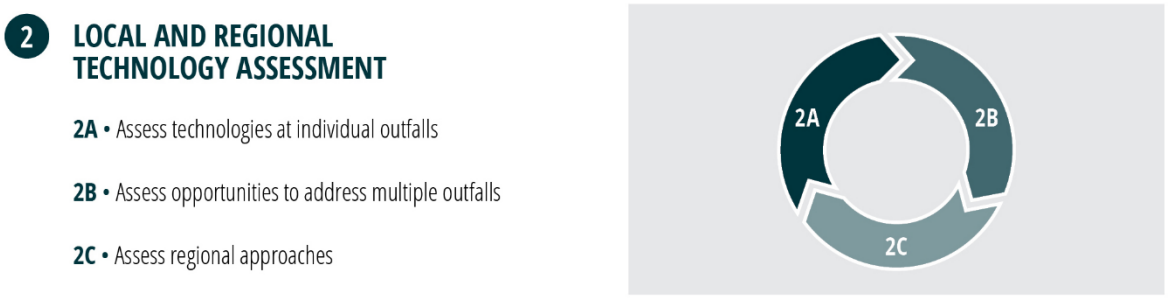



**Figure 9-37. Alternatives Development Step 2 (Upper Mystic River)**

### 9.6.1 SOM007A/MWR205A

**Table 9-36** provides a summary of CSO discharges at SOM007A/MWR205A by storm event in the 2050 TY. A unique aspect of outfall SOM007A/MWR205A is that the activations and volumes at this outfall are heavily influenced by the tide cycle, whereas the Alewife Brook and Charles River CSOs function independent of the tide cycle. As described in Section 6, the Unified Model includes 2050 tidal boundary conditions consisting of a continuous tidal cycle that factors sea level rise projections in the Boston Harbor area by 2050. The 2050 TY volumes presented in **Table 9-36** account for the timing of rainfall with respect to the timing of the tide cycle within the 2050 TY. Under Baseline Conditions, the SOM007A/MWR205A outfall is predicted to activate eight times and discharge 29.31 MG in the 2050 TY.

**Table 9-36. Summary of CSO Discharges at SOM007A/ MWR205A**

| | Baseline Conditions |
|---|---|
| | 2050 TY CSO Volume (MG) (1) |
| 06/07 | 10.51 |
| 04/21 | 7.72 |
| 12/17 | 5.01 |
| 06/12 | 2.61 |
| 07/27 | 1.62 |
| 12/14 | 0.74 |
| 06/27 | 0.62 |
| 09/15 | 0.49 |
| **Total Volume (MG)** | **29.31** |
| **Total Activations** | **8** |

**Notes:**

(1) Model results are based on the baseline conditions model. Model results may vary when evaluated in conjunction with other projects that are hydraulically connected.

(2) Individual storms are presented in order of decreasing volumes and may not add to the total volume due to rounding and/or small inconsistencies when models are run in different environments.

For the 2050 5-year and 25-year design storms, the timing of the rainfall in relation to the tide cycle has to be set in the model, creating a condition of "joint probability". For example, the joint probability of the 5-year storm peak rainfall coinciding exactly with high tide would result in a recurrence interval of greater than 5 years. To assess the impact of the timing of the tide cycle on CSO volumes for the design storms, the storms were run with the peak rainfall occurring at high tide, mid tide and low tide. **Table 9-37** provides the volumes for the 2050 5-year and 25-year storms with rainfall peaks occurring at high tide, mid tide, and low tide.

**Table 9-37. CSO Volumes at SOM007A/ MWR205A as a Function of Mystic Chelsea Confluence Tide(1)**

| | CSO Volume (MG)(1) | |
|---|---|---|
| Tide Condition(2) | 2050 5-Year Storm | 2050 25-Year Storm |
| High Tide | 17.42 | 27.17 |
| Mid Tide | 6.25 | 16.70 |
| Low Tide | 4.06 | 9.95 |

**Notes:**

(1) Model results are based on the baseline conditions model. Model results may vary when evaluated in conjunction with other projects that are hydraulically connected.

(2) Tide condition based on 2050 Spring Tide. Tide condition refers to the tide level when peak rainfall occurs in the simulation.

### Sewer Separation

Sewer separation was considered at SOM007A/MWR205A. The tributary area includes all of the combined sewers tributary to SOM007A/MWR205A in the City of Somerville, as well as combined sewer area in Charlestown that can influence flow in the Cambridge Branch Sewer. In wet weather, the Cambridge Branch Sewer can back up into the Somerville-Medford Branch Sewer, which can contribute to CSO volume at MWRA's Somerville Marginal Facility and SOM007A/MWR205A. The combined sewer areas include 560 acres in Somerville and 127 acres in Charlestown, totaling 687 acres. The work would require installing new sanitary and/or stormwater pipes and the creation of two new stormwater outfalls (one to discharging to the Upper Mystic River and a second one discharging to the Lower Mystic River). **Table 9-38** presents a comparison of the CSO activation frequencies and volumes for the 2050 TY Baseline Conditions versus regional sewer separation.

**Table 9-38. Upper Mystic River 2050 Typical Year Baseline Conditions vs. Regional Sewer Separation**

| | Baseline Conditions | | Regional Sewer Separation | | Baseline Conditions | | Regional Sewer Separation | |
|---|---|---|---|---|---|---|---|---|
| | 2050 TY | | 2050 TY | | 2050 5-Year Storm(1) | 2050 25-Year Storm(1) | 2050 5-Year Storm(1) | 2050 25-Year Storm(1) |
| Outfall | Activation Frequency | Volume (MG) | Activation Frequency | Volume (MG) | Volume (MG) | Volume (MG) | Volume (MG) | Volume (MG) |
| **Upper Mystic River** | | | | | | | | |
| SOM007A/ MWR205A | 8 | 29.31 | 1 | 1.06 | 4.06 to 17.42 | 9.95 to 27.17 | 0.0 to 5.0 | 4.3 to 9.4 |

**Note:**
(1) Volumes reflect a range of CSO volume where the peak rainfall coincides with low tide and high tide.

One CSO activation was predicted to remain with regional sewer separation, with an overflow volume of 1.06 MG to the Upper Mystic River in the 2050 TY. The CSO volume for the 2050 5-year and 25-year storms will vary depending on the tide stage when the storm occurs.

Separation of the 366 acres west of McGrath Highway (green polygon in **Figure 9-38**) would require construction of a 5.5 MG stormwater storage tank near Gilman Square to attenuate excess peak flows that would otherwise flood downstream areas closer to the outfall. This is because downstream pipes do not have enough conveyance capacity to accommodate flows from such a large area. The remaining Mystic River tributary area within Somerville is located east of McGrath Highway (orange polygon in **Figure 9-38**) and amounts to approximately 194 acres. This area would need to drain to a new outfall that would discharge to the Lower Mystic River, which is tidal. Because of the tidal influence on this stormwater outfall, a 0.5 MG stormwater storage tank would be required to absorb excess flows when the rainfall events hit on high tide. The 127 acres of sewer separation in Charlestown would discharge to the Lower Mystic River below the Amelia Earhart Dam as well.

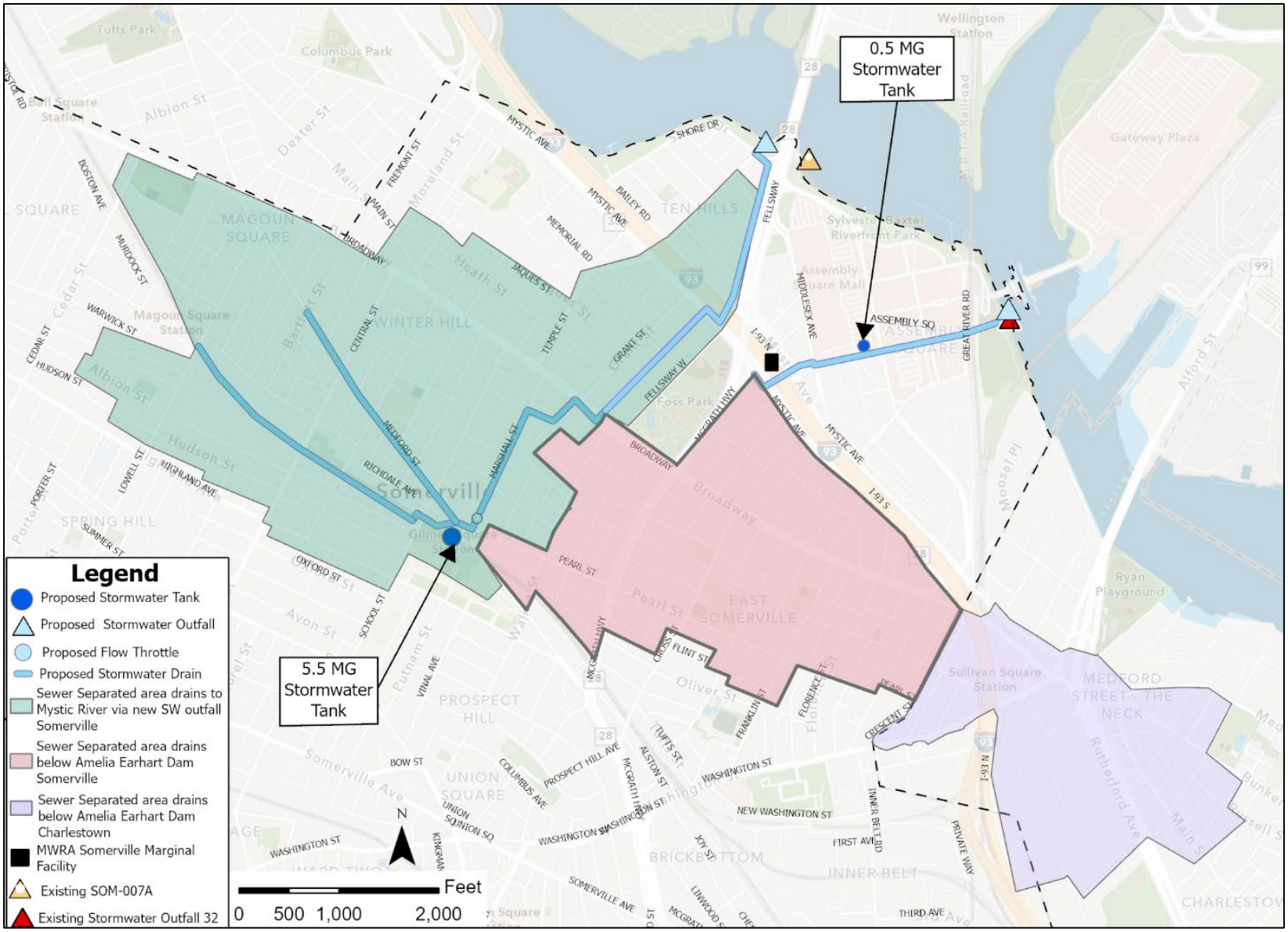



**Figure 9-38. Somerville and Charlestown Combined Sewer Areas Considered for Separation in the Alternatives Analysis**

The main challenges that were identified to perform sewer separation in this area included the following:

(1) The need for new storm drains and outfalls to the Upper and Lower Mystic River so that areas that are progressively separated can immediately drain to a stormwater outfall as opposed to recombining in the existing trunk conduits that lead to the Somerville Marginal Facility.

(2) Even though a new storm drain and outfall would receive flows from some newly separated areas, other areas within the watershed would remain tributary to the culverts along McGrath Highway, which are currently combined sewers. One of these conduits cannot be repurposed as a storm drain until its entire tributary area is fully separated, therefore delaying the CSO reduction benefits until sewer separation of neighborhood areas is 100% complete.

(3) Construction of stormwater storage tanks will require heavy construction in public and private land with the subsequent temporary loss of public use and the need for permanent easements or land purchase. The magnitude of the tank needed to make sewer separation feasible in the Upper Mystic River area (5.5 MG) is likely to bring significant constructability challenges due to the highly limited space available near the location where this infrastructure would be needed (near Gilman Square).

Despite these challenges, full or partial sewer separation of the areas tributary to the Upper Mystic River was carried forward.

**Storage**

Both in-line storage and off-line storage were evaluated at SOM007A/MWR205A. In-line storage was not an effective approach for this outfall because the crest elevation of the overflow weir for SOM007A/MWR205A is approximately equal to the crown of the SMC. As a result, the SMC runs completely full when SOM007A/MWR205A activates, meaning that no in-line storage capacity is available upstream. In-line storage was therefore not evaluated further.

An off-line storage tank at SOM007A/MWR205A could be constructed underground and located in the parking lot at the intersection of Grand Union Boulevard and Fellsway West in Assembly Square. A diversion structure would be constructed along the existing conduit between the SOM007A/MWR205A-regulator and the outfall to divert wet weather flow to the storage facility. After storm flows subside, the stored flow would be pumped back to the Somerville Medford Branch Sewer (SMBS). If the capacity of the storage tank is exceeded in a larger storm, excess flow would be discharged through the existing outfall via the new diversion structure weir. While the tank would be underground, a permanent above-ground structure would be required for maintenance access and to house electrical and odor control equipment.

To investigate the feasibility of storage at SOM007A/MWR205A, preliminary sizing was developed for all four levels of control. CSO volumes for the eight storms which caused overflows at SOM007A/MWR205A in the 2050 TY are presented in **Table 9-39**.

**Table 9-39. Storage Impacts on CSO Volume and Frequency at SOM007A/MWR205A[1]**

| CSO Start Date | Baseline Conditions | 5.01 MG of Storage | 10.51 MG of Storage |
|---|---|---|---|
| | CSO Volume (MG) | Remaining CSO Volume (MG) | Remaining CSO Volume (MG) |
| 06/7 | 10.51 | 5.50 | 0.00 |
| 04/21 | 7.72 | 2.71 | 0.00 |
| 12/17 | 5.01 | 0.00 | 0.00 |
| 06/12 | 2.61 | 0.00 | 0.00 |
| 07/27 | 1.62 | 0.00 | 0.00 |
| 12/14 | 0.74 | 0.00 | 0.00 |
| 06/27 | 0.62 | 0.00 | 0.00 |
| 09/15 | 0.49 | 0.00 | 0.00 |
| **Total Volume (MG)** | **29.31** | **8.23** | **0.00** |
| **Total Activations** | **8** | **2** | **0** |

**Note:**

(1) Model results are based on the baseline conditions model. Model results may vary when evaluated in conjunction with other projects that are hydraulically connected.

As indicated in **Table 9-39**, a 10.51 MG storage tank would be needed to achieve 0 CSOs in the 2050 TY at SOM007A/MWR205A. A 5.01 MG storage tank was selected as the initial sizing for Limited CSOs in the 2050 TY. This selection was based on the relatively larger increment of additional volume to go from two to one activations in the 2050 TY.

The discharge volume at SOM007A/MWR205A for the 2050 5-year and 25-year design storms is dependent on the timing of the peak rainfall with respect to the tide stage. **Table 9-40** presents the 2050 5-year and 25-year storm baseline CSO volumes under the three tidal conditions (peak rainfall coinciding with high, mid, and low tide) compared to three different potential storage tank sizes (6.25 MG, 10.5 MG, and 16.7 MG). If the mid-tide condition was considered the “average” tide condition for the 2050 5-year storm, then a 6.25 MG storage tank would be sufficient to capture the volume from the 2050 5-year storm under that tide condition. However, as indicated in **Table 9-36** above, a 6.25 MG storage tank would not capture all of the volume from outfall SOM007A/MWR205A during the 2050 TY. For this reason, the preliminary sizing of storage for the 2050 5-year level of control was set to 10.5 MG, which would also provide zero discharges in the 2050 TY. As indicated in **Table 9-40**, with a 10.5 MG storage tank, 6.92 MG would still discharge from outfall SOM007A/MWR205A if a 2050 5-year storm hit with the peak coinciding with high tide. No discharge would occur, however, over most of the tidal cycle.

For the 2050 25-year storm, a 16.7 MG storage tank would capture the volume if the peak of the storm hit at mid tide. While about 10.5 MG of discharge would remain if the peak of the 2050 25-year storm hit at high tide, the 16.7 MG tank would result in zero discharges in the 2050 TY, and only 0.72 MG if the peak of the 2050 5-year storm hit at high tide.

**Table 9-40. SOM007A/ MWR205A CSO Volumes in the 2050 5-Year and 25-Year Storms as a Function of Tide – Before and After Storage[1]**

| Tide Condition[2] | 2050 5-Year Storm | | | |
|---|---|---|---|---|
| | Baseline | 6.25 MG Storage | 10.5 MG Storage | 16.7 MG Storage |
| | Volume (MG) | Remaining CSO Volume (MG) | Remaining CSO Volume (MG) | Remaining CSO Volume (MG) |
| High Tide | 17.42 | 11.17 | 6.92 | 0.72 |
| Mid Tide | 6.25 | 0.00 | 0.00 | 0.00 |
| Low Tide | 4.06 | 0.00 | 0.00 | 0.00 |
| Tide Condition[2] | 2050 25-Year Storm | | | |
| | Baseline | 6.25 MG Storage | 10.5 MG Storage | 16.7 MG Storage |
| | Volume (MG) | Remaining CSO Volume (MG) | Remaining CSO Volume (MG) | Remaining CSO Volume (MG) |
| High Tide | 27.17 | 20.92 | 16.67 | 10.47 |
| Mid Tide | 16.7 | 10.45 | 6.20 | 0.00 |
| Low Tide | 9.95 | 3.70 | 0.00 | 0.00 |

**Notes:**

(1) Model results are based on the baseline conditions model. Model results may vary when evaluated in conjunction with other projects that are hydraulically connected.

(2) For design storm simulations, the peak of the rainfall coincided with high tide, mid tide or low tide respectively.

**Figure 9-39** presents the conceptual layout of the 10.5 MG storage tank. The figure shows the approximate location of a diversion structure that would be constructed along the outfall pipe as well as the approximate size of the storage tank. Truck access would be required for system maintenance, including tank cleaning activities following storm events. As noted above, the storage tank would be underground, but a permanent above-ground structure would be required for maintenance access and to house electrical and odor control equipment.

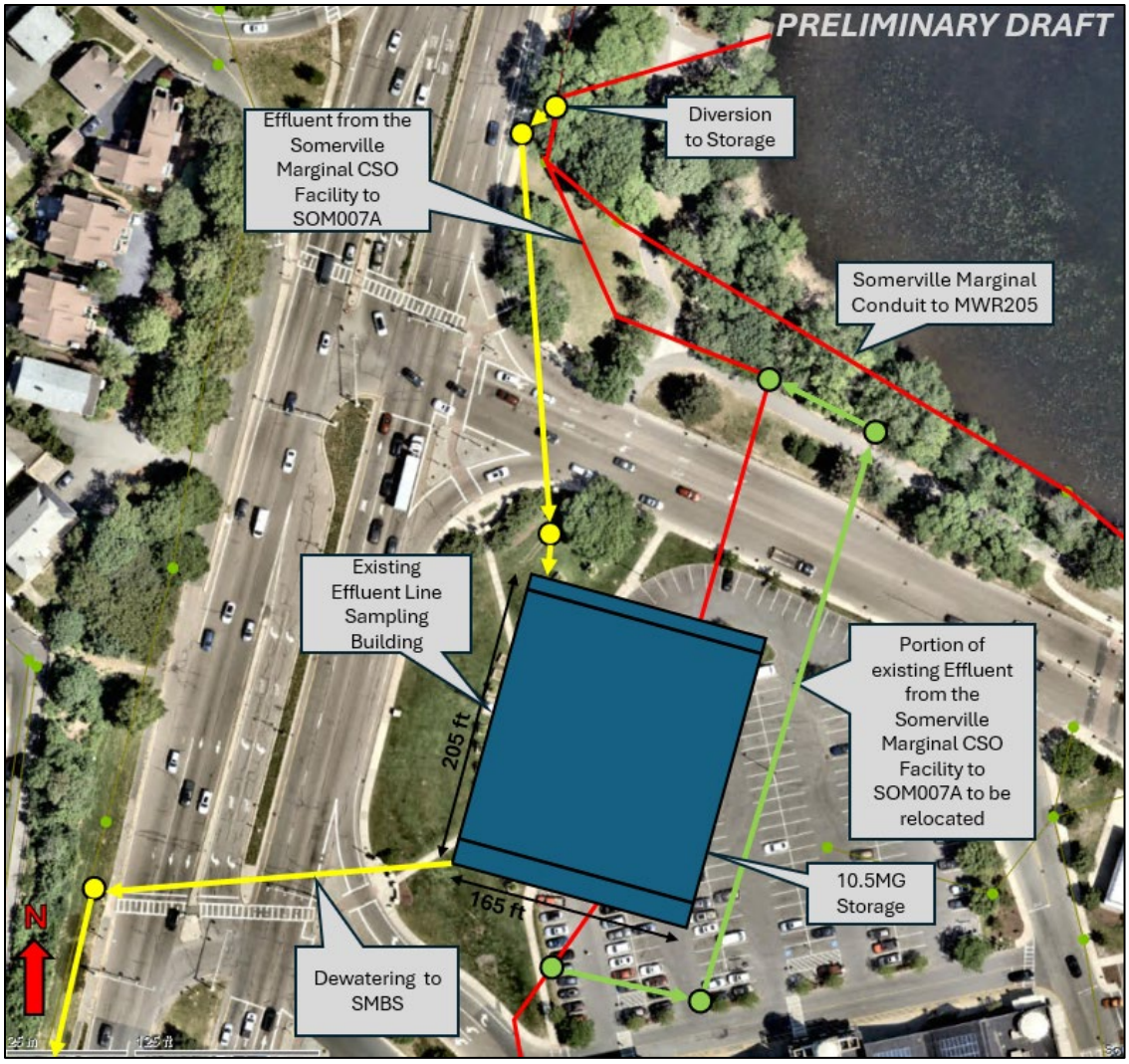



**Figure 9-39. SOM007A/MWR205A Storage Tank Conceptual Layout**

In addition to in-line storage and off-line storage tanks, CSO tunnel and shaft storage was also considered. No reasonable opportunities were identified to consolidate storage for SOM007A/MWR205A with storage for another outfall discharging to either Alewife Brook or the Charles River via a storage tunnel. Providing a storage tunnel just for outfall SOM007A/MWR205A was briefly considered; however, available geotechnical information indicated the presence of deep layers of soft clays in the general area, which would require the tunnel to be hundreds of feet deep in order to be constructed in rock. The mining operation would likely disrupt use of the parking lot shown in **Figure 9-39** to a similar degree as construction of a storage tank. For these reasons, the concept of a dedicated storage tunnel was not considered further.

### Conveyance

As shown previously in **Figure 9-36,** the combined sewer system upstream of the Somerville Marginal CSO Facility connects to the SMBS, which in turn drains to the Cambridge Branch Sewer (CBS) upstream of the DeLauri Pump Station. Initial investigations of conveyance relief alternatives indicated that increasing the capacity of the SMBS alone would not significantly reduce the overflows at SOM007A/MWR205A. If the scope of conveyance relief extended from the SMBS through the CBS and DeLauri

Pump Station to the Chelsea Creek Headworks, the frequency and volume of treated CSO discharged at outfall SOM007A/MWR205A was predicted to be reduced but not eliminated in the 2050 TY. Since downstream conveyance relief was not predicted to fully control CSO discharges in the 2050 TY from SOM007A/MWR205A, downstream conveyance relief was not evaluated further.

Conveyance was also investigated in the form of conveying CSO from outfall SOM007A/MWR205A under the Mystic River to the MWRA's North Metropolitan Interceptor system in Medford. However, in addition to constructability concerns, preliminary modeling indicated that conveying the overflow to the North Metropolitan Interceptor system would result in increased flood risk in that interceptor system. As a result, this option was not evaluated further.

### 9.6.2 Summary of CSO Control Technology Screening for Upper Mystic River

As a result of the preliminary screening of CSO control technologies described above, **Table 9-41** presents the technologies that were carried forward for outfall SOM007A/MWR205A. Technologies that were carried forward for more detailed evaluation for at least one level of control are indicated with a check mark (✓) and technologies that were not considered for further evaluation are indicated with a hyphen (-).

**Table 9-41. CSO Control Technologies Carried Forward for Evaluation in the Upper Mystic River System**

| Outfall | Sewer Separation | Green Stormwater Infrastructure (GSI)(1) | Infiltration/ Inflow (I/I) Reduction | Storage | Conveyance | Treatment |
|---|---|---|---|---|---|---|
| SOM007A/ MWR205A | ✓ | ✓ | - | ✓ | - | - |

**Notes:**
(1) GSI was evaluated in conjunction with sewer separation and CSO storage but was not evaluated as a standalone CSO control technology
"√"- Indicates technology carried forward for more detailed evaluation.
"–" Indicates technology was not considered for further evaluation.

The following sections describe how these CSO control technologies were combined to create alternatives to achieve the 0 CSO in 2050 TY, Limited CSOs in the 2050 TY, and the 2050 5-year and 25-year levels of control for the Upper Mystic River.

## 9.7 Upper Mystic River - CSO Control Alternatives

This section describes how the CSO control technologies were combined to create alternatives for each level of control in the Upper Mystic River. This is the third step as illustrated previously in **Figure 9-1**, shown again in **Figure 9-40**. The Partners developed fourteen total alternatives. Four were developed for the 2050 TY LOC, three for the Limited CSOs in the 2050 TY LOC, three for the 2050 5-year LOC, and three for the 2050 25-year LOC. One regional sewer separation alternative was also developed. Regional storage alternatives that addressed multiple outfalls were not applicable for the Upper Mystic River. The Limited CSOs in the 2050 TY LOC and 2050 TY LOC include combinations of sewer separation and storage. The 5-year and 25-year LOCs include combinations of storage, sewer separation, and GSI.

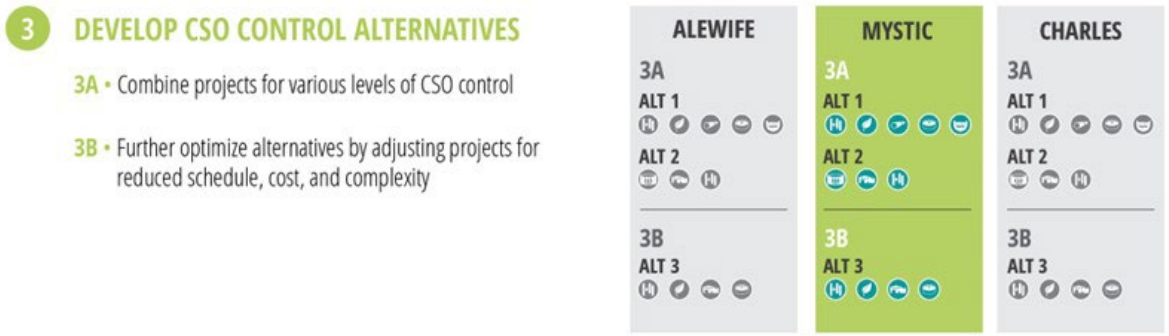



**Figure 9-40. Alternative Development Step 3 (Upper Mystic)**

### 9.7.1 Alternative 1.MR Integrated (0 CSOs in 2050 TY)

Alternative 1.MR Integrated represents the first attempt to combine CSO control technologies at the individual outfall level, as proposed by each Partner, and includes a combination of sewer separation and a storage tank.

**Table 9-42** presents the Baseline Conditions 2050 TY activations and volume, the project components, the estimated capital cost, and the estimated project duration. A schematic layout of the components of this alternative is presented in **Figure 9-41**.

**Table 9-42. Alternative 1.MR Integrated (0 CSOs in 2050 TY) Summary**

| Upper Mystic River Outfall | Baseline 2050 Typical Year | | Alternative Description | Preliminary Capital Cost[1] ($million) | Project Duration[2] (years) |
|---|---|---|---|---|---|
| | Activation Frequency | Volume (MG) | | | |
| MWR205A/ SOM007A | 8 | 29.31 MG | 366 acres sewer separation | $480 M | 25 |
| | | | 4.0 MG storage | $85 M | 5 |
| **Max/Sum (Treated CSO)** | **8** | **29.31 MG** | **-** | **$570 M** | **25** |

**Notes:**
(1) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.
(2) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

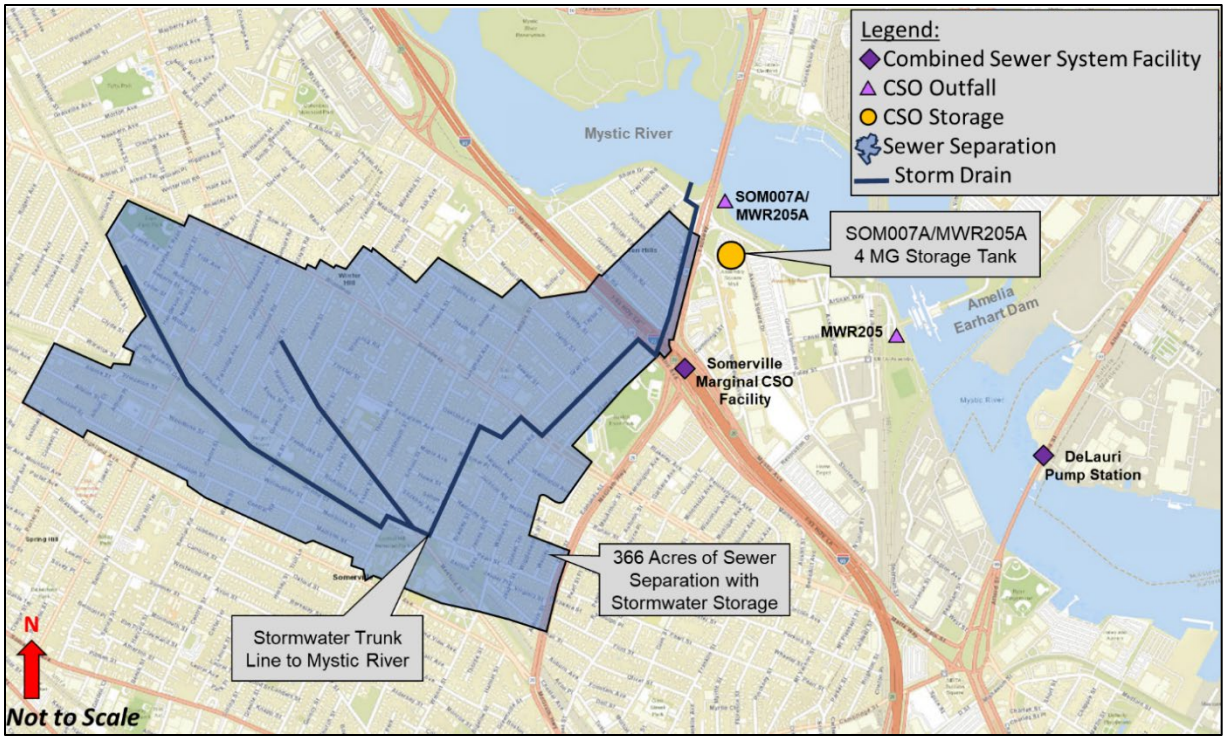



**Figure 9-41. Alternative 1.MR Integrated (0 CSOs in 2050 TY)**

### 9.7.1.1 Component Descriptions

The individual components of Alternative 1.MR Integrated are described below.

- **Sewer Separation:** 366 acres of sewer separation would be implemented in the combined sewer areas tributary to the Somerville Marginal CSO Facility and outfall SOM007A/MWR205A. This sewer separation work would require construction of an underground 5.5 MG stormwater storage tank near Gilman Square to manage peak stormwater flows from the separated areas, as well as a new stormwater trunk drain and outfall to the Upper Mystic River.
- **Storage Tank:** A 4.0 MG storage tank would be constructed underground in a grassed area immediately adjacent to the parking lot serving the north end of the Assembly Square shopping area.

### 9.7.1.2 Implementation Challenges

Challenges to implementing the components of this alternative would include:

Sewer Separation:

- Construction of the proposed storm drain trunk across Mystic Avenue underneath the I-93 overpass. This work would require detailed evaluation of geotechnical conditions and structural supports for the highway infrastructure;
- Potential for utility conflicts due to the high number of sub-surface utilities along the Mystic Avenue, Temple Street, and Fellsway West corridors;
- Sites have not been identified for stormwater treatment or flow attenuation. The likely region for flow attenuation in Gilman Square may be difficult to site flow attenuation, and public resistance may be encountered;

- Sewer separation of this magnitude will take many years to complete, and residents in the area would likely experience construction fatigue and important disruptions during prolonged periods of time;
- This project will require an easement negotiation with MassDOT for the crossing of Mystic Avenue and I-93 overpass with the proposed storm drain; and
- New storm outfall to the Mystic River on DCR owned site would require an easement and meeting Article 97 requirements.

Storage:

- Acquiring the land for the storage facility;
- Coordination with the next phases of Assembly Square redevelopment including reconfiguration of the entrance; and
- Impacts to parking lot during construction.

### 9.7.2 Alternative 2.MR Hybrid 1 (0 CSOs in 2050 TY)

Alternative 2.MR Hybrid 1 includes a combination of sewer separation and a storage tank. This alternative was based on Alternative 1.MR Integrated but assesses the opportunity to reduce construction impacts and duration associated with such a large sewer separation area. Alternative 2.MR Hybrid 1 significantly reduces the sewer separation area from 366 acres to the most readily implementable level of 95 acres, while increasing the capacity of the storage tank to achieve the 2050 TY LOC.

**Table 9-43** presents the Baseline Condition 2050 TY activations and volume, the project components, the estimated capital cost, and the estimated project duration. A schematic layout of the components of this alternative is presented in **Figure 9-42**.

**Table 9-43. Alternative 2.MR Hybrid 1 (0 CSOs in 2050 TY) Summary**

| Upper Mystic River Outfall | Baseline 2050 Typical Year | | Alternative Description | Preliminary Capital Cost[1] ($million) | Project Duration[2] (years) |
|---|---|---|---|---|---|
| | Activation Frequency | Volume (MG) | | | |
| SOM007A/MWR205A | 8 | 29.31 MG | 95 acres sewer separation | $97 M | 5 |
| | | | 7.4 MG storage | $160 M | 5 - 7 |
| **Max/Sum (Treated CSO)** | **8** | **29.31 MG** | **-** | **$260 M** | **5 - 7** |

**Notes:**
(1) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.
(2) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

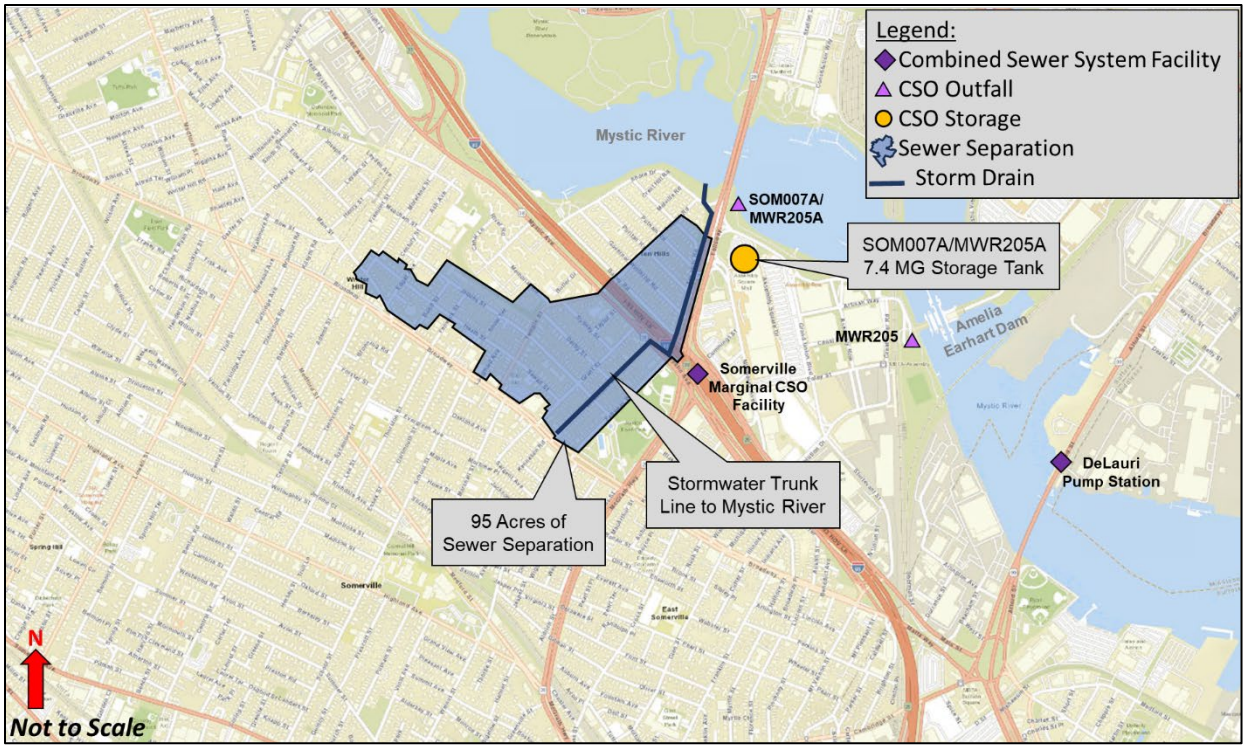



**Figure 9-42. Alternative 2.MR Hybrid 1 (0 CSOs in 2050 TY)**

### 9.7.2.1 Component Descriptions

The individual components of Alternative 2.MR Hybrid 1 are described below.

- **Sewer Separation**: 95 acres of sewer separation would be implemented in the combined sewer areas tributary to the Somerville Marginal CSO Facility and outfall SOM007A/MWR205A. This area would be limited to the east side of the Ten Hills neighborhood as well as areas north of Broadway between Mystic Avenue and Fellsway West. With the reduced scope of separation work, the 5.5 MG stormwater storage tank in Gillman Square would not be needed to manage peak stormwater flows from the separated areas. A new stormwater trunk drain and outfall to the Upper Mystic River would still be required and would be similar in size to the stormwater trunk for Alternative 1.MR Integrated.
- **Storage Tank:** A 7.4 MG storage tank would be constructed underground in a grassed area immediately adjacent to the parking lot serving the north end of the Assembly Square shopping area and extending into the parking lot. The features and operation would be similar to the tank described for Alternative 1.MR. The tank size increased compared to the Alternative 1.MR due to the reduction in scope of the upstream sewer separation. The work would also require relocating the existing MWRA effluent sampling building used to sample the discharge from the Somerville Marginal CSO Facility.

### 9.7.2.2 Implementation Challenges

The implementation challenges associated with this Alternative are entirely similar to those described in Alternative 1.MR Integrated, but it will have a greater impact on the parking area because of the larger tank size. In addition, the reduced sewer separation area eliminates the need for the Gilman Square stormwater storage tank and will have less disruption to the area because the area of sewer separation is smaller.

### 9.7.3 Alternative 3.MR Storage (0 CSOs in 2050 TY)

Alternative 3.MR Storage was developed as a storage tank to eliminate CSOs in the 2050 TY. It would capture and store all CSOs in the 2050 TY from outfall SOM007A/MWR205A with a dewatering pump station.

**Table 9-44** presents the Baseline Conditions 2050 TY activations and volume, the project components, the estimated capital cost, and the estimated project duration. A schematic layout of the components of this alternative is presented in **Figure 9-43.**

**Table 9-44. Alternative 3.MR Storage (0 CSOs in 2050 TY) Summary**

| Upper Mystic River Outfall | Baseline 2050 Typical Year | | Alternative Description | Preliminary Capital Cost[1] ($million) | Project Duration[2] (years) |
|---|---|---|---|---|---|
| | Activation Frequency | Volume (MG) | | | |
| SOM007A/MWR205A | 8 | 29.31 MG | 10.5 MG storage | $200M | 5 - 7 |

**Notes:**
(1) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.
(2) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

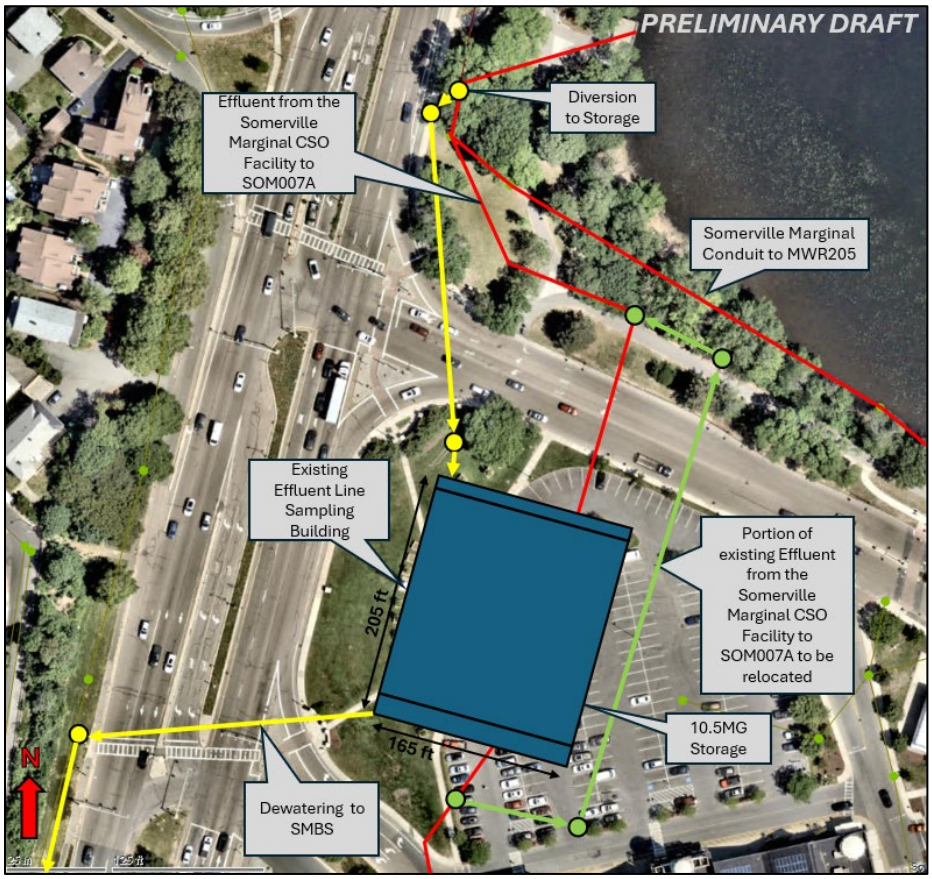



**Figure 9-43. Alternative 3.MR Storage (0 CSOs in 2050 TY)**

#### 9.7.3.1 Component Descriptions

The individual components of Alternative 3.MR Storage are described below:

- **Storage Tank:** A 10.5 MG storage tank would be constructed underground in a grassed area immediately adjacent to the parking lot serving the north end of the Assembly Square area and extending into the parking lot. The features and operation would be similar to the tank described for Alternatives 1.MR Integrated and 2.MR Hybrid 1.

#### 9.7.3.2 Implementation Challenges

The implementation challenges associated with this Alternative are entirely similar to those described in Alternative 1.MR Integrated but will have a greater impact to the parking area because of the larger tank size. The tank design and construction also become more complex with increased risk as the size of the tank increases. In addition, since sewer separation is not included in this alternative, those implementation challenges do not apply.

### 9.7.4 Alternative 4.MR Storage + GSI (0 CSOs in the 2050 TY)

Alternative 4.MR Storage + GSI includes a combination of a storage tank and GSI. This alternative is based on Alternative 3.MR Storage with GSI added at a regional scale. The storage tank in Alternative 4.MR Storge + GSI is sized to capture the CSO volume remaining in the largest storm in the 2050 TY, with the implementation of GSI in the region. In essence, this alternative was developed to assess the impact that regional GSI could have on sizing regional storage. It was determined through modeling that regional GSI would slightly decrease CSO volumes and thus decrease the size of the storage tank accordingly.

**Table 9-45** presents the predicted CSO volume for the Baseline Conditions 2050 TY, the project components, the estimated capital cost, and the estimated project duration. A schematic layout of the components of this alternative is presented in **Figure 9-44**.

**Table 9-45. Alternative 4.MR Storage + GSI (0 CSOs in the 2050 TY) Summary**

| Upper Mystic River Outfall | Baseline 2050 Typical Year | | Alternative Description | Preliminary Capital Cost[1] ($million) | Project Duration[2] (years) |
|---|---|---|---|---|---|
| | Activation Frequency | Volume (MG) | | | |
| SOM007A/ MWR205A | 8 | 29.31 MG | GSI (19.6 acres) | $58 M | 5 - 7 for storage (GSI requires additional time to be determined) |
| | | | 9.4 MG storage | $142 M | |
| **Max/Sum (Treated CSO)** | **8** | **29.31 MG** | | **$200 M** | **5 - 7** |

**Notes:**

(1) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.

(2) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

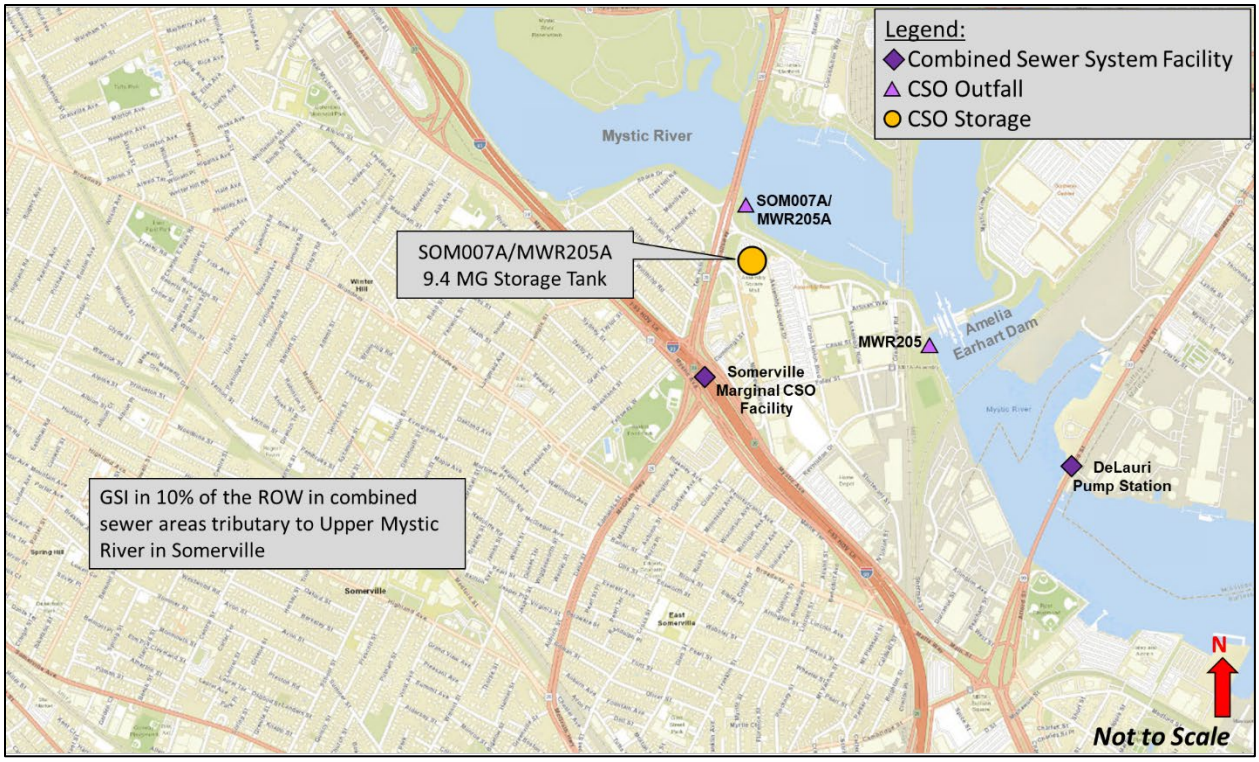



**Figure 9-44. Alternative 4.MR Storage + GSI Summary (0 CSOs in the 2050 TY)**

### 9.7.4.1 Component Descriptions

The individual components of Alternative 4.MR Storage + GSI are described below.

- **Storage Tank:** A 9.4 MG storage tank would be constructed underground in a grassed area immediately adjacent to the parking lot serving the north end of the Assembly Square shopping area and extending into the parking lot.
- **GSI:** This alternative would include the implementation of GSI capturing runoff from 10% of the impervious right-of-way area in the combined sewer areas tributary to the Upper Mystic River in Somerville (19.6 acres).

### 9.7.4.2 Implementation Challenges

The implementation challenges associated with this Alternative are similar to those described in Alternative 1.MR Integrated but will have a greater impact to the parking area because of the larger tank size. In addition, since sewer separation is not included in this alternative, those implementation challenges do not apply. The challenges to implement GSI include identifying appropriate sites for GSI on municipally owned land or on public rights-of-way in a high-density urban area with many conflicts with existing utilities, mature trees, parking spots, etc.

## 9.7.5 Alternative 6a.MR Hybrid 1 (Limited CSOs in 2050 TY)

Alternative 6a.MR Hybrid 1 includes a combination of sewer separation and a storage tank to provide Limited CSOs in the 2050 TY LOC. This alternative is based on Alternative 2.MR but the storage tank volume is reduced; whereas Alternative 2.MR Hybrid 1 included separation plus 7.4 MG of storage to

eliminate all 8 activations, the tank is downsized to 2.7 MG, which leaves 2 remaining activations in the 2050 TY.

**Table 9-46** presents the Baseline Conditions 2050 TY activations and volume, the project components, the estimated capital cost, and the estimated project duration. Because this alternative does not eliminate CSOs in the 2050 TY, the table also shows the CSO activations and volumes predicted to remain in the 2050 TY after implementation. A schematic layout of the components of this alternative is presented in **Figure 9-45**.

**Table 9-46. Alternative 6a.MR Hybrid 1 (Limited CSOs in 2050 TY) Summary**

| Upper Mystic River Outfall | Baseline 2050 TY Act Freq./Vol. (MG) | Remaining 2050 TY Act Freq./Vol. (MG) | Alternative Description | Preliminary Capital Cost(1) ($million) | Project Duration(2) (years) |
|---|---|---|---|---|---|
| SOM007A/MWR205A | 8 act/ 29.31 MG | 2 act/ 6.77 MG | 95 acres sewer separation | $97 M | 5 |
| | | | 2.7 MG storage | $68 M | 5 |
| **Max/Sum (Treated CSO)** | **8 act/ 29.31 MG** | **2 act/ 6.77 MG** | **-** | **$170 M** | **5 – 10** |

**Notes:**
(1) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.
(2) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

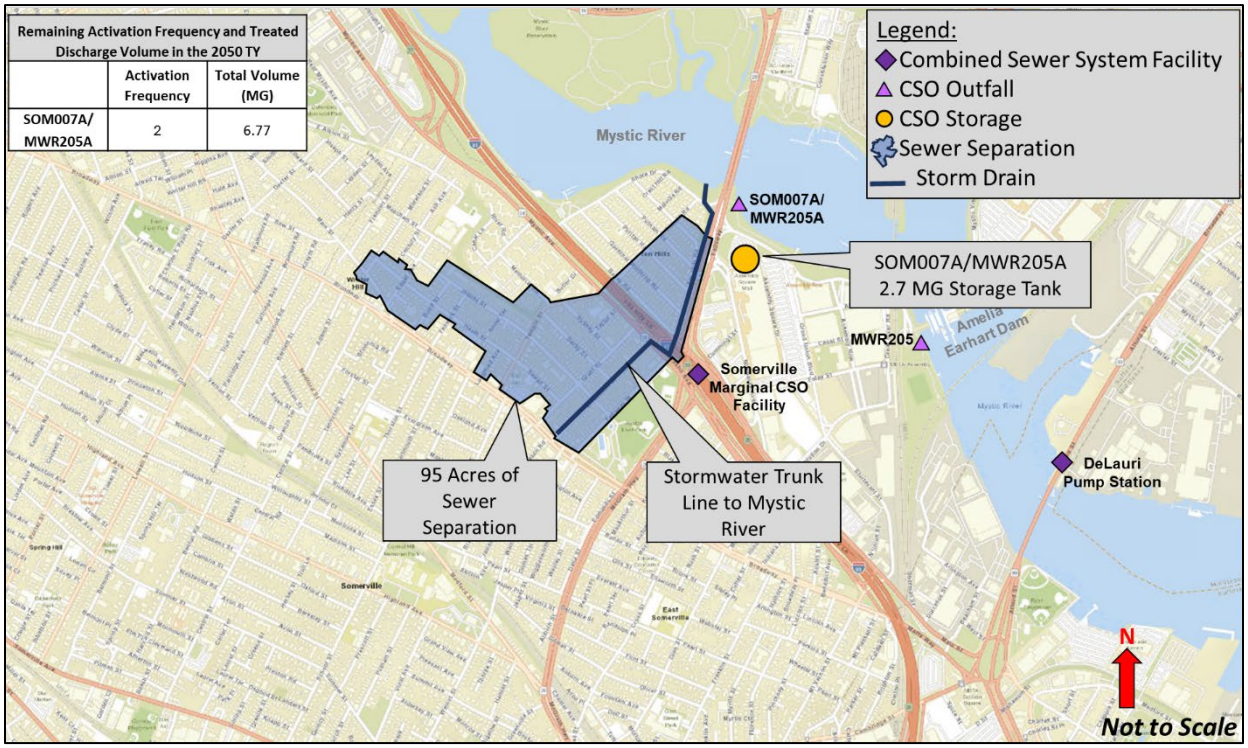



**Figure 9-45. Alternative 6a.MR Hybrid 1 (Limited CSOs in 2050 TY)**

#### 9.7.5.1 Component Descriptions

The individual components of Alternative 6a.MR Hybrid 1 are described below.

- **Sewer Separation:** 95 acres of sewer separation would be implemented in the combined sewer areas tributary to the Somerville Marginal CSO Facility and outfall SOM007A /MWR205A. This area would be limited to the east side of the Ten Hills neighborhood as well as areas north of Broadway between Mystic Avenue and Fellsway West. A new stormwater trunk drain and outfall to the Upper Mystic River would be required.
- **Storage Tank:** A 2.7 MG storage tank would be constructed underground in a grassed area immediately adjacent to the parking lot serving the north end of the Assembly Square shopping area. The features and operation would be similar to the tank described for the other alternatives, and the work would require relocating the existing MWRA effluent sampling building used to sample the discharge from the Somerville Marginal CSO Facility.

#### 9.7.5.2 Implementation Challenges

The implementation challenges associated with this Alternative are similar to those described in Alternative 2. MR Hybrid 1, but with smaller tank impacts because of the smaller tank size.

### 9.7.6 Alternative 6b.MR Hybrid 2 (Limited CSOs in 2050 TY)

Alternative 6b.MR Hybrid 2 includes a storage tank to provide Limited CSOs in the 2050 TY LOC. This alternative is based on Alternative 3.MR Storage but reduces the storage tank volume; whereas Alternative 3.MR Storage included 10.5 MG storage to eliminate all 8 activations in the 2050 TY, the tank is downsized in Alternative 6b.MR Hybrid 2 to 5 MG, which leaves 2 remaining activations in the 2050 TY.

**Table 9-47** presents the Baseline Condition 2050 TY activations and volume, the project components, the estimated capital cost, and the estimated project duration. Because this alternative does not eliminate CSOs in the 2050 TY, the table also shows the CSO activations and volumes predicted to remain in the 2050 TY after implementation. A schematic layout of the components of this alternative is presented in **Figure 9-46**.

**Table 9-47. Alternative 6b.MR Hybrid 2 (Limited CSOs in 2050 TY) Summary**

| Upper Mystic River Outfall | Baseline 2050 TY Act Freq./Vol. (MG) | Remaining 2050 TY Act Freq./Vol. (MG) | Alternative Description | Preliminary Capital Cost(1) ($million) | Project Duration(2) (years) |
|---|---|---|---|---|---|
| SOM007A/MWR205A | 8 act/29.31 MG | 2 act/8.23 MG | 5 MG storage | $120 M | 5 |

**Notes:**

(1) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.

(2) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

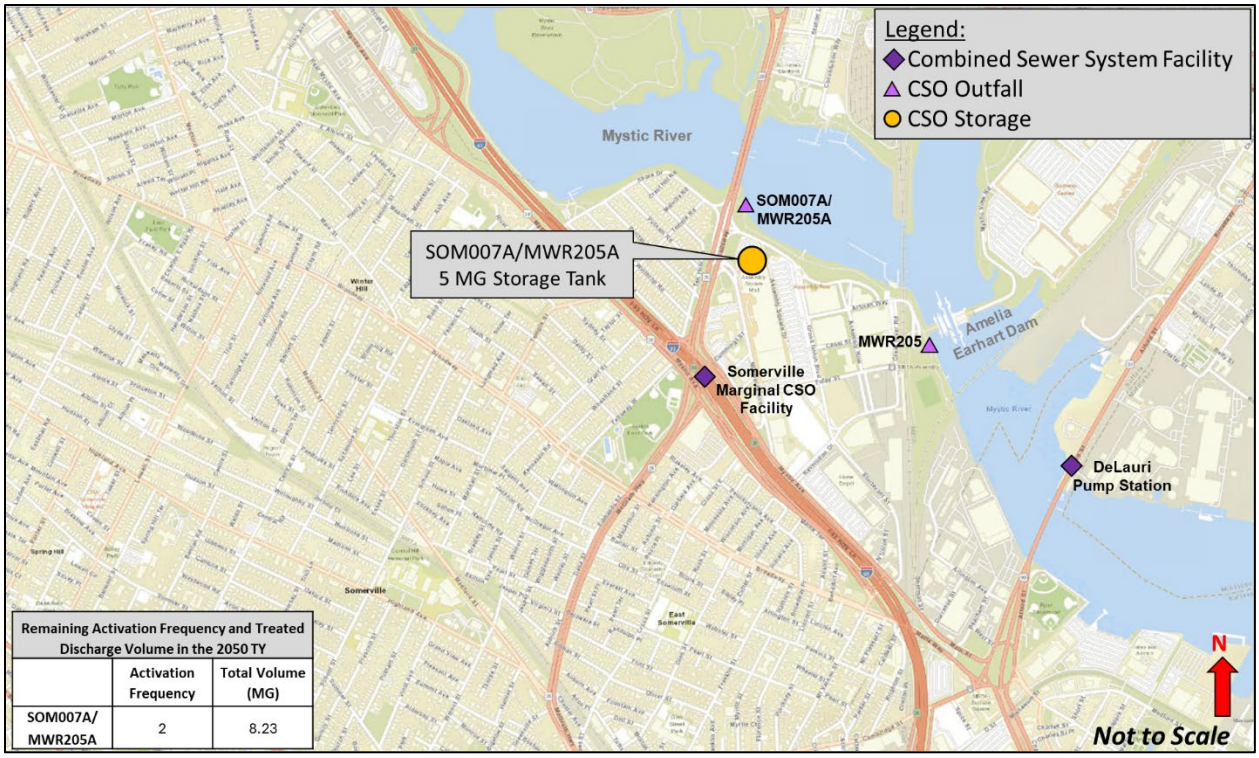



**Figure 9-46. Alternative 6b.MR Hybrid 2 (Limited CSOs in 2050 TY)**

#### 9.7.6.1 Component Descriptions

The individual components of Alternative 6b.MR Hybrid 2 are described below:

- **Storage Tank**: A 5.0 MG storage tank would be constructed underground in a grassed area immediately adjacent to the parking lot serving the north end of the Assembly Square shopping area and extending into the parking lot. The work would require relocating the existing MWRA effluent sampling building used to sample the discharge from the Somerville Marginal CSO Facility. The tank volume increased compared to the Alternative 6a.MR Hybrid 1 due to the elimination of the upstream sewer separation component.

#### 9.7.6.2 Implementation Challenges

The implementation challenges associated with this Alternative are entirely similar to those described in Alternative 3.MR Storage.

### 9.7.7 Alternative 6c.MR Hybrid 3 (Limited CSOs in 2050 TY)

Alternative 6c.MR Hybrid 3 includes the same area of sewer separation in Alternative 2.MR Hybrid 1 as its sole technology to provide Limited CSOs in the 2050 TY LOC, which leaves 5 remaining CSO activations (of the 8 activations in the Baseline) in the 2050 TY.

**Table 9-48** presents the Baseline Conditions 2050 TY activations and volume, the project components, the estimated capital cost, and the estimated project duration. Because this alternative does not eliminate CSOs in the 2050 TY, the table also shows the CSO activations and volumes predicted to remain in the 2050 TY after implementation. A schematic layout of the components of this alternative is presented in **Figure 9-47**.

**Table 9-48. Alternative 6c.MR Hybrid 3 (Limited CSOs in 2050 TY) Summary**

| Upper Mystic River Outfall | Baseline 2050 TY Act Freq./Vol. (MG) | Remaining 2050 TY Act Freq./Vol. (MG) | Alternative Description | Preliminary Capital Cost(1) ($Million) | Project Duration(2) (years) |
|---|---|---|---|---|---|
| SOM007A/MWR205A | 8 act/29.31 MG | 5 act/17.0MG | 95 acres sewer separation | $100 M | 5-10 |

**Notes:**
(1) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.
(2) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

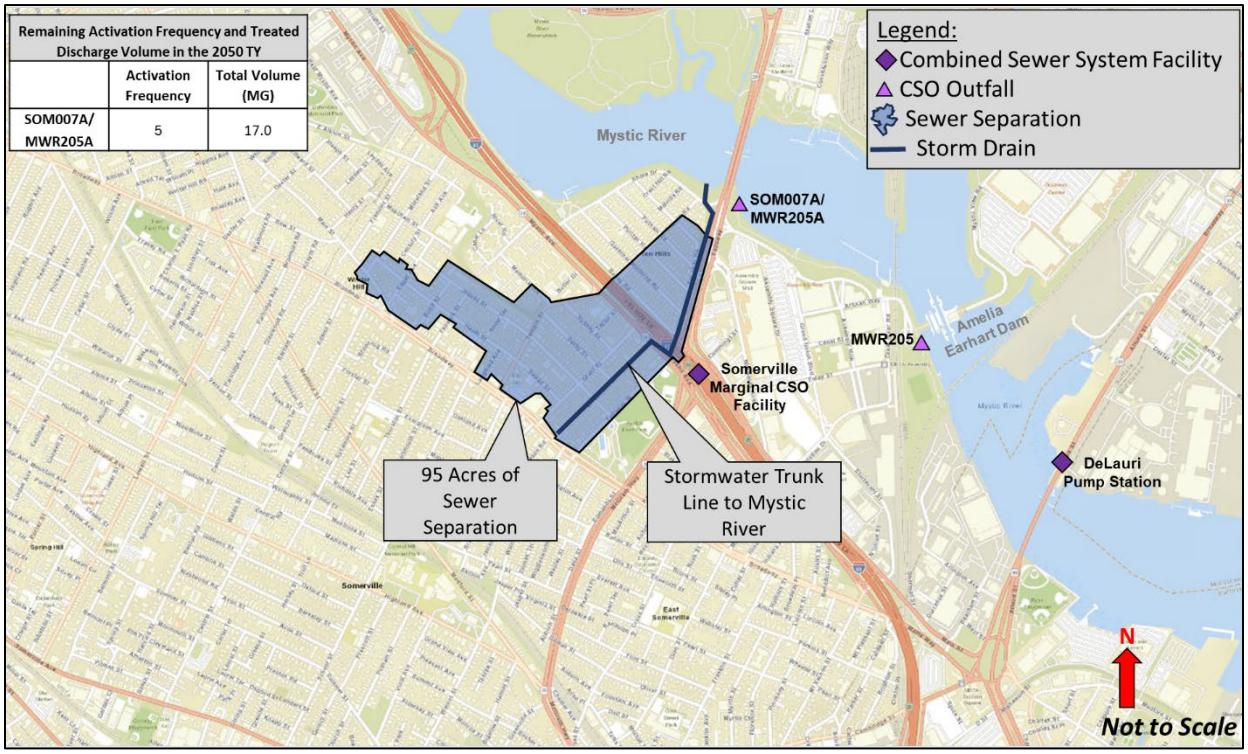



**Figure 9-47. Alternative 6c.MR Hybrid 3 (Limited CSOs in 2050 TY)**

### 9.7.7.1 Component Descriptions

The individual components of Alternative 6c.MR Hybrid 3 are described below:

- **Sewer Separation:** 95 acres of sewer separation would be implemented in the combined sewer areas tributary to the Somerville Marginal CSO Facility and outfall SOM007A/MWR205A. This area would be limited to the east side of the Ten Hills neighborhood as well as areas north of Broadway between Mystic Avenue and Fellsway West. A new stormwater trunk drain and outfall to the Upper Mystic River would be required.

#### 9.7.7.2 Implementation Challenges

The implementation challenges associated with this Alternative are entirely similar to those described in Alternative 2. MR Hybrid 1 but will have no impact to the parking area because a tank is not included in this alternative.

### 9.7.8 Alternative 7.MR 5-Year Storage (0 CSOs in 2050 5-Year)

Alternative 7.MR 5-Year Storage was developed as a large storage tank to eliminate CSOs in a 2050 5-year storm. It would capture and store CSOs in storms up to and including the design storm from outfalls SOM007A/MWR205A and include a dewatering pump station. This alternative would also result in no CSO discharges to the Upper Mystic River in the 2050 TY.

**Table 9-49** presents the predicted treated CSO volume for the Baseline Conditions 2050 5-year storm, the project components, the estimated capital cost, and the estimated project duration. A schematic layout of the components of this alternative is presented in **Figure 9-48**.

This alternative is identical to Alternative 3.MR Storage, as the sizing of the storage tank to control the discharge from outfall SOM007A/MWR205A was complicated by the influence of the tide on the discharge volume at the outfall. As indicated in **Table 9-49**, the predicted discharge volume at outfall SOM007A/MWR205A for a 5-year storm with the peak of the storm occurring at mid-tide was 6.25 MG. For reference, a 5-year storm with the peak of the storm occurring at high tide would generate a volume of 17.2 MG at outfall SOM007A/MWR205A. As shown in **Table 9-44** above for Alternative 3.MR Storage, a 10.5 MG tank would be required to achieve zero discharges in the 2050 TY. That sizing was driven by the peak rainfall in a large storm in the 2050 TY occurring at high tide. Therefore, a 10.5 MG tank would achieve both zero discharges in the 2050 TY and in a 5-year storm with peak rainfall occurring over most of the tidal cycle.

**Table 9-49. Alternative 7.MR 5-Year Storage (0 CSOs in 2050 5-Year) Summary**

| Upper Mystic River Outfall | Baseline 5-Year CSO Vol. (MG) | 5-Year Storage Alt. CSO Vol. (MG) | Alternative Description | Preliminary Capital Cost[3] ($million) | Project Duration[4] (years) |
|---|---|---|---|---|---|
| SOM007A/MWR205A | 6.25 MG [1] | 0 MG [1] | 10.5 MG storage[2] | $200 M | 5 - 10 |

**Notes:**

(1) Volume based on peak of storm occurring at mid-tide. See discussion in **Section 9.6.1**

(2) 10.5 MG represents the largest volume in the 2050 TY; see discussion of tank sizing in text above.

(3) Preliminary Capital Cost is described in **Section 9.3**. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.

(4) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

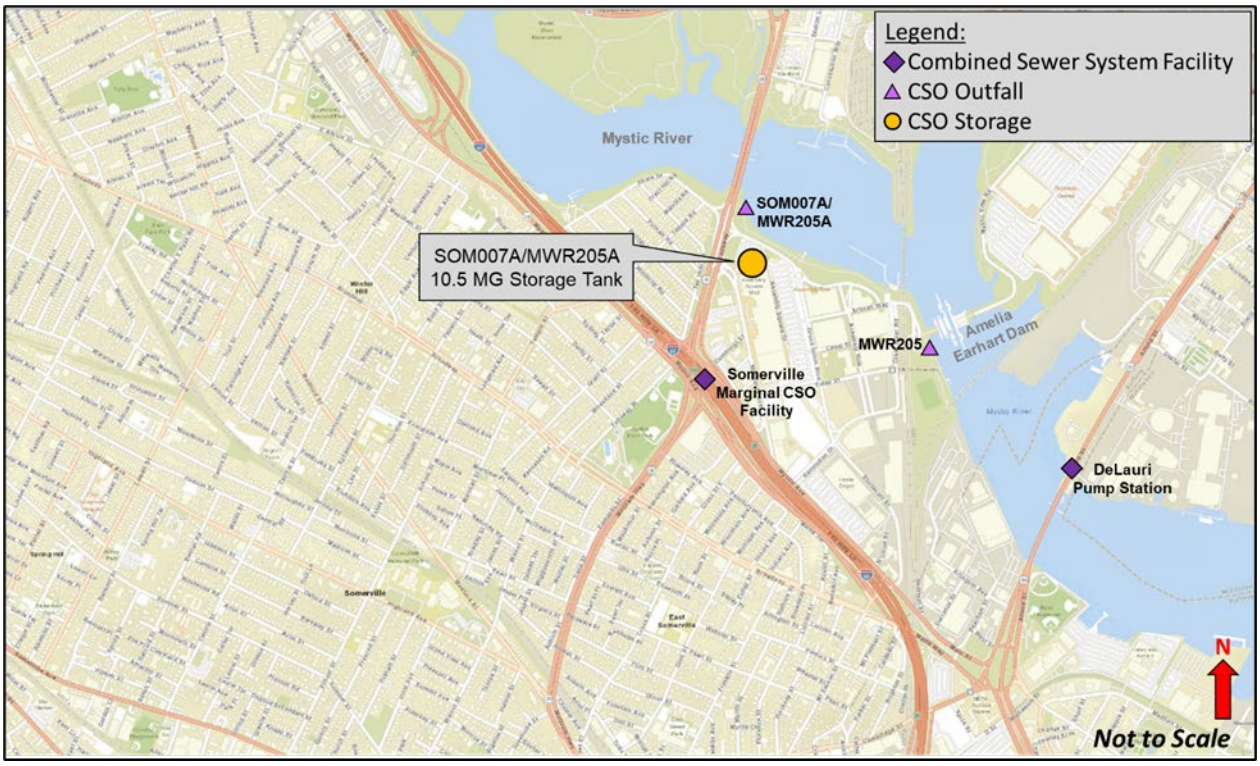



**Figure 9-48. Alternative 7.MR 5-Year Storage (0 CSOs in 2050 5-Year)**

#### 9.7.8.1 Component Descriptions

The individual components Alternative 7.MR 5-Year Storage are described below:

- **Storage Tank:** A 10.5 MG storage tank would be constructed underground in a grassed area immediately adjacent to the parking lot serving the north end of the Assembly Square shopping area and extending into the parking lot. The features and operation would be the same as the tank described for Alternative 3.MR Storage. The work would also require relocating the existing MWRA effluent sampling building used to sample the discharge from the Somerville Marginal CSO Facility.

#### 9.7.8.2 Implementation Challenges

The implementation challenges associated with this Alternative are entirely similar to those described in Alternative 3. MR Storage.

### 9.7.9 Alternative 8.MR 5-Year Storage + GSI (0 CSOs in 2050 5-Year)

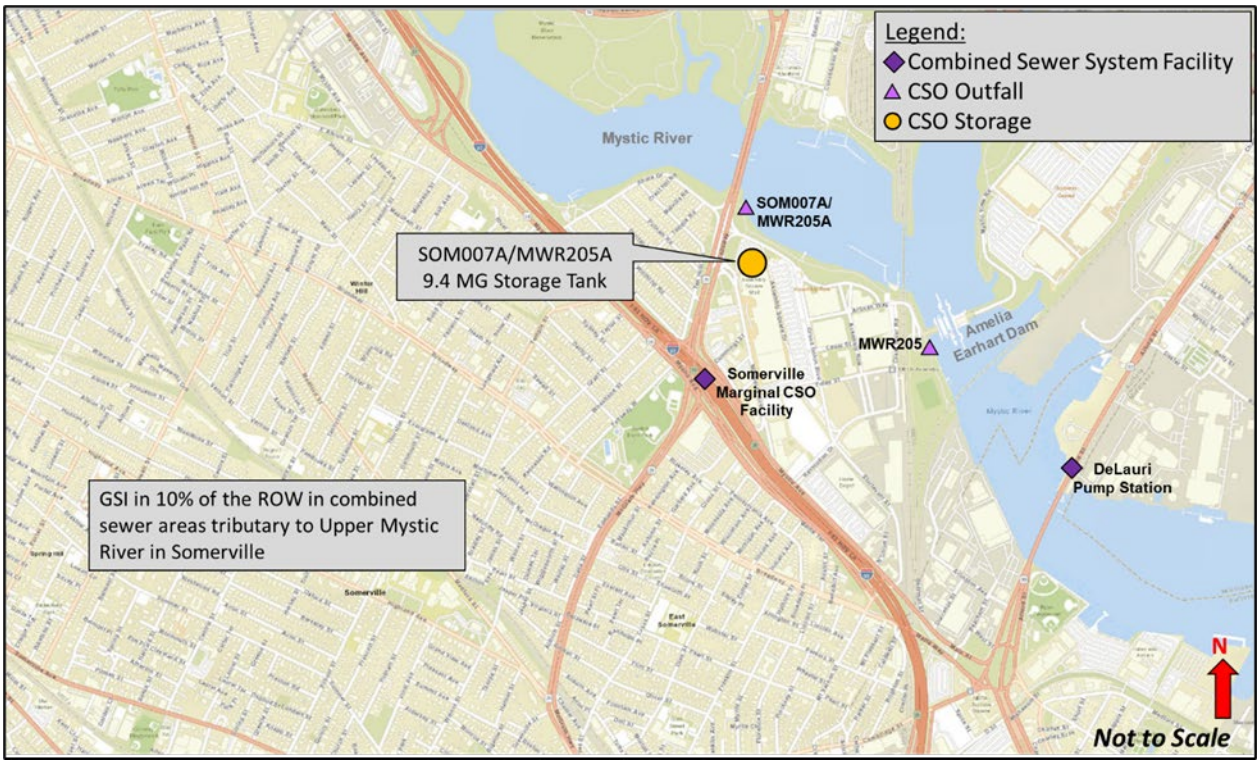
Alternative 8.MR 5-Year Storage + GSI includes a combination of a storage tank and GSI. This alternative was developed to assess the impact that regional GSI could have on sizing regional storage in a large design storm. It is based on Alternative 7.MR Storage and augments it by adding GSI at a regional scale. With the addition of GSI, the remaining volume to be captured by the storage tank is reduced from 10.5 MG to 9.4 MG. This alternative would also result in no CSO discharges to the Upper Mystic River in the 2050 TY.

**Table 9-50** presents the predicted treated CSO volume for the Baseline Conditions 2050 5-year storm, the project components, the estimated capital cost, and the estimated project duration. A schematic layout of the components of this alternative is presented in **Figure 9-49.**

## Table 9-50. Alternative 8.MR 5-Year Storage (0 CSOs in 2050 5-Year) Summary

| Upper Mystic River Outfall | Baseline 5-Year CSO Vol. (MG) | Storage + GSI 5-Year CSO Vol. (MG) | Alternative Description | Preliminary Capital Cost[3] ($million) | Project Duration[4] (years) |
|---|---|---|---|---|---|
| SOM007A/MWR205A | 6.25 MG[1] | 0 MG[1] | GSI (19.6 acres) | $58 M | 5 - 7 for storage (GSI requires additional time to be determined) |
| | | | 9.4 MG storage[2] | $142 M | |
| **Max/Sum (Treated CSO)** | **6.25 MG** | **0 MG** | | **$200 M** | **5 - 7** |

**Notes**:
(1) Volume based on peak of storm occurring at mid-tide. See discussion in **Section 9.6.1.**
(2) See discussion of tank sizing in **Section 9.7.8**.
(3) Preliminary Capital Cost is described in **Section 9.3**. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.
(4) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.




## Figure 9-49. Alternative 8.MR 5-Year Storage Tank (0 CSOs in 2050 5-Year)

#### 9.7.9.1 Component Descriptions

The individual components of Alternative 8.MR 5-Year Storage + GSI are described below:

- **Storage Tank**: A 9.4 MG storage tank would be constructed underground in a grassed area immediately adjacent to the parking lot serving the north end of the Assembly Square shopping area and extending into the parking lot. The features and operation would be similar to the storage tank described above for Alternative 7.MR 5-Year Storage. The tank size decreased compared to Alternative 7.MR 5-Year Storage due to the addition of GSI in the upstream combined sewer area. The work would also require relocating the existing MWRA effluent sampling building used to sample the discharge from the Somerville Marginal CSO Facility.
- **GSI:** This alternative would include the implementation of GSI capturing runoff from 10% of the impervious right-of-way area in the combined sewer areas tributary to the Upper Mystic River in Somerville (19.6 acres).

#### 9.7.9.2 Implementation Challenges

The implementation challenges associated with this Alternative are entirely similar to those described in Alternative 7.MR 5-Year Storage. The challenges to implement GSI include identifying appropriate sites for GSI on municipally owned land or on public rights-of-way in a high-density urban area with many conflicts with existing utilities, mature trees, parking spots, etc.

### 9.7.10 Alternative 9.MR 5-Year Hybrid (0 CSOs in 2050 5-Year)

Alternative 9.MR 5-Year Hybrid includes a combination of sewer separation and a storage tank. This alternative is identical to Alternative 2.MR Hybrid 1. The required storage volume for the 2050 5-year storm with peak at mid tide was less than the volume for the largest storm in the 2050 TY. As a result, a 7.4 MG tank with the identified area of sewer separation would achieve both 0 CSOs in the 2050 TY, and 0 CSOs in a 5-year storm with peak rainfall occurring over most of the tidal cycle.

**Table 9-51** presents the predicted treated CSO volume for the Baseline Conditions 2050 5-year storm, the project components, the estimated capital cost, and the estimated project duration. A schematic layout of the components of this alternative is presented in **Figure 9-50**.

**Table 9-51. Alternative 9.MR 5-Year Hybrid (0 CSOs in 2050 5-Year) Summary**

| Upper Mystic River Outfall | Baseline 5-Year CSO Vol. (MG) | Alternative 9.MR 5-Year Hybrid CSO Vol. (MG) | Alternative Description | Preliminary Capital Cost[3] ($million) | Project Duration[4] (years) |
|---|---|---|---|---|---|
| SOM007A/MWR205A | 6.25 MG[1] | 0 MG[1] | 95 acres sewer separation | $97 M | 5 |
| | | | 7.4 MG storage[2] | $157 M | 5 - 7 |
| **Max/Sum (Treated CSO)** | **6.25 MG[1]** | **0 MG[1]** | **-** | **$260 M** | **5 - 7** |

**Notes:**
(1) Volume based on peak of storm occurring at mid-tide. See discussion in **Section 9.6.1**.
(2) See discussion of tank sizing in **Section 9.7.8**.
(3) Preliminary Capital Cost is described in **Section 9.3**. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.
(4) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

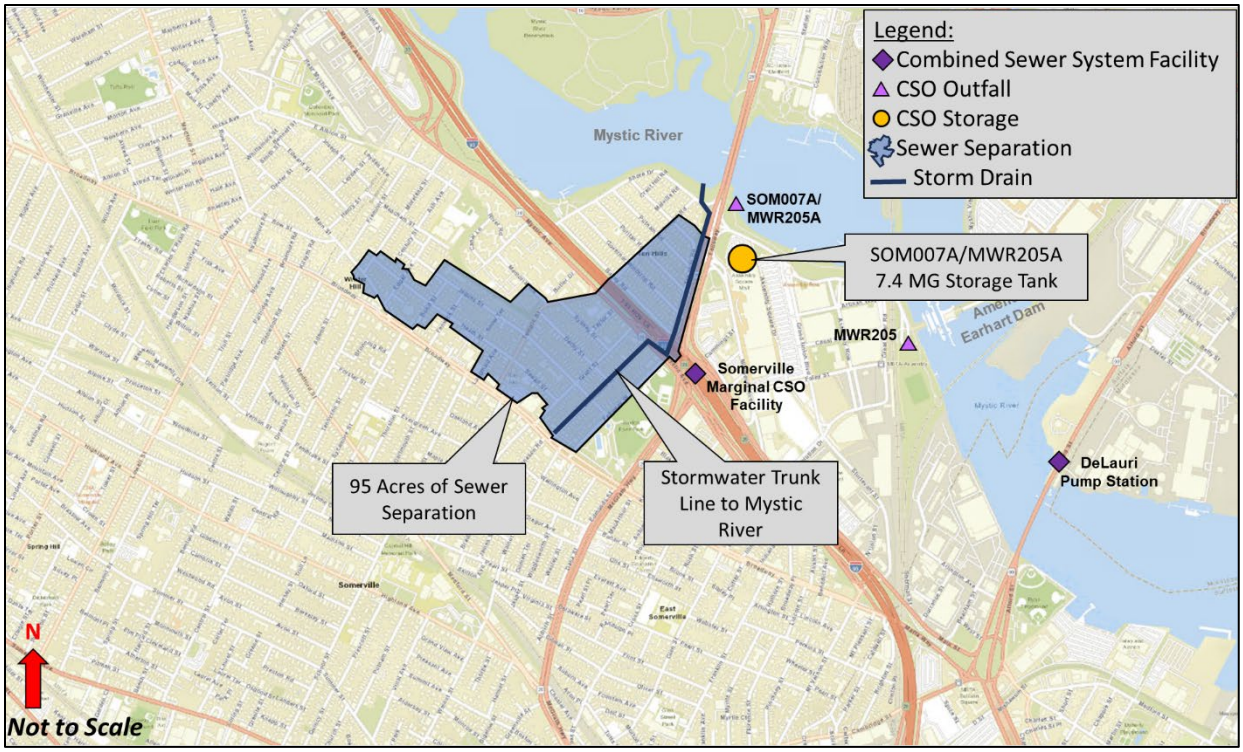



**Figure 9-50. Alternative 9.MR 5-Year Hybrid (0 CSOs in 2050 5-Year)**

### 9.7.10.1 Component Descriptions

The individual components in Alternative 9.MR 5-Year Hybrid are described below:

- **Sewer Separation:** 95 acres of sewer separation would be implemented in the combined sewer areas tributary to the Somerville Marginal CSO Facility and outfall SOM007A/MWR205A. This area would be limited to the east side of the Ten Hills neighborhood as well as areas north of Broadway between Mystic Avenue and Fellsway West. A new stormwater trunk drain and outfall to the Upper Mystic River would be required.
- **Storage Tank**: A 7.4 MG storage tank would be constructed underground in a grassed area immediately adjacent to the parking lot serving the north end of the Assembly Square shopping area and extending into the parking lot. The work would require relocating the existing MWRA effluent sampling building used to sample the discharge from the Somerville Marginal CSO Facility.

### 9.7.10.2 Implementation Challenges

The implementation challenges associated with this Alternative are entirely similar to those described in Alternative 3.MR Hybrid 1.

## 9.7.11 Alternative 10.MR 25-Year Storage (0 CSOs in 2050 25-Year)

Alternative 10.MR 25-Year Storage was developed as a large storage tank to eliminate CSOs in a 2050 25-year storm. It would capture and store CSOs in storms up to and including the design storm from outfalls SOM007A/MWR205A, with a dewatering pump station. This alternative would also result in no CSO discharges to Alewife Brook in the 2050 TY.

**Table 9-52** presents the predicted CSO volume for the Baseline Conditions 2050 25-year storm, the project components, the estimated capital cost, and the estimated project duration. A schematic layout of the components of this alternative is presented in **Figure 9-51**.

As indicated in **Table 9-52**, the predicted discharge volume at outfall SOM007A/MWR205A for the 2050 25-year storm with the peak of the storm occurring at mid-tide was 16.7 MG. For reference, the 2050 25-year storm with the peak of the storm occurring at high tide would generate a volume of 27.2 MG at outfall SOM007A/MWR205A. The mid-tide condition was considered the average tidal condition for the 25-year storm, and sizing the storage tank for the mid-tide condition for the 25-year storm would be sufficient to capture all CSO at outfall SOM007A/MWR205A during the 2050 TY.

**Table 9-52. Alternative 10.MR 25-Year Storage Tank (0 CSOs in 2050 25-Year) Summary**

| Upper Mystic River Outfall | Baseline 25-Year CSO Vol. (MG) | Storage 25-Year CSO Vol. (MG) | Alternative Description | Preliminary Capital Cost[2] ($million) | Project Duration[3] (years) |
|---|---|---|---|---|---|
| SOM007A/MWR205A | 16.7 MG[1] | 0 MG[1] | 16.7 MG storage | $260 M | 5 - 10 |

**Notes:**

(1) Volume based on peak of storm occurring at mid-tide. See discussion in **Section 9.6.1**.

(2) Preliminary Capital Cost is described in **Section 9.3**. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.

(3) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

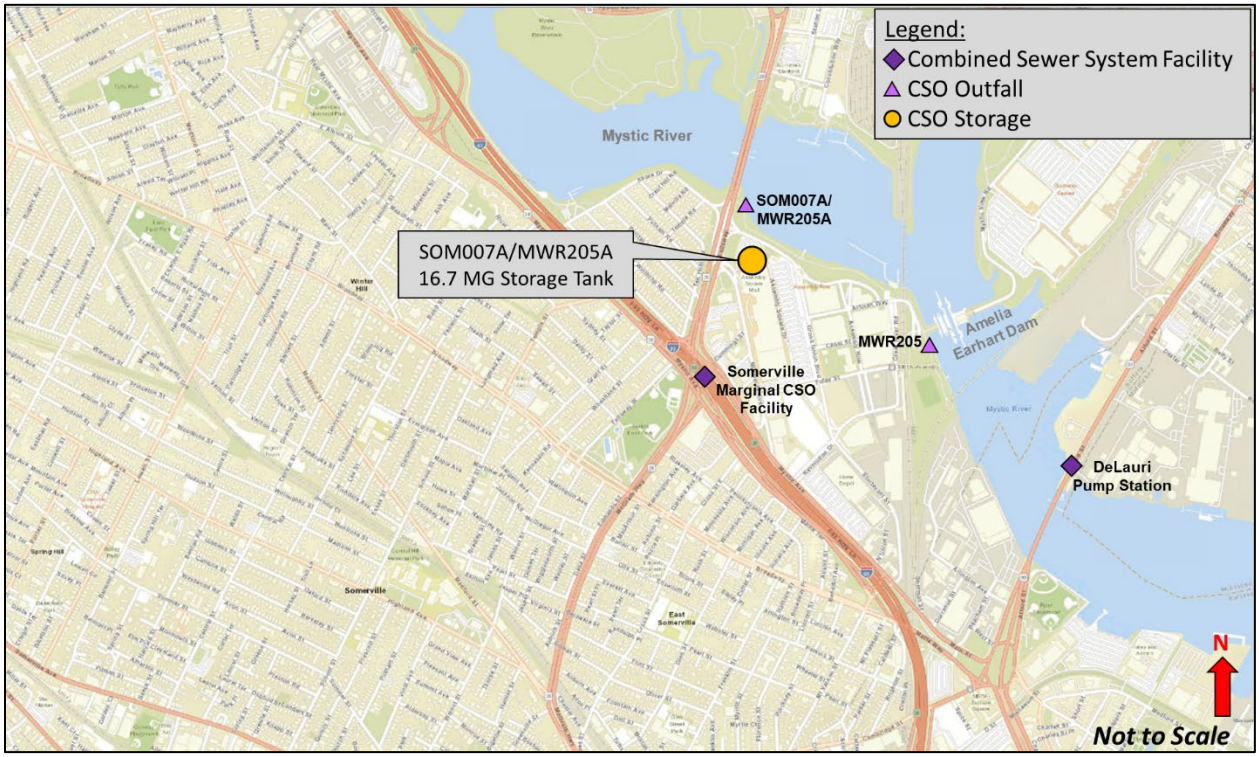



**Figure 9-51. Alternative 10.MR 25-Year Storage (0 CSOs in 2050 25-Year)**

#### 9.7.11.1 Component Descriptions

The individual components of the Alternative 10.MR 25-Year Storage are described below.

- **Storage Tank:** A 16.7 MG storage tank would be constructed underground in a parking lot serving the north end of the Assembly Square shopping area extending into a grassed area immediately adjacent to the parking lot. The features and operation would be similar to the tank described for Alternative 7.MR 5-Year Storage. The work would also require relocating the existing MWRA effluent sampling building used to sample the discharge from the Somerville Marginal CSO Facility.

#### 9.7.11.2 Implementation Challenges

The implementation challenges of this Alternative are entirely similar to the challenges described for Alternative 7.MR 5-Year Storage, but greater impact due to the larger tank size.

### 9.7.12 Alternative 11.MR 25-Year Storage + GSI (0 CSOs in 2050 25-Year)

Alternative 11.MR 25-Year Storage + GSI includes a combination of a storage tank and GSI. This alternative was developed to assess the impact that regional GSI could have on sizing regional storage in a large design storm. It is based on Alternative 10.MR Storage and augments it by adding GSI at a regional scale. With the addition of GSI, the remaining volume to be captured by the storage tank is reduced from 16.7 MG to 15 MG. This alternative would also result in no CSO discharges to the Upper Mystic River in the 2050 TY.

**Table 9-53** presents the predicted treated CSO volume for the Baseline Conditions 2050 25-year storm, the project components, the estimated capital cost, and the estimated project duration. A schematic layout of the components of this alternative is presented in **Figure 9-52**.

**Table 9-53. Alternative 11.MR 25-Year Storage + GSI (0 CSOs in 2050 25-Year) Summary**

| Upper Mystic River Outfall | Baseline 25-Year Vol. (MG) | Storage + GSI 25-Year Vol. (MG) | Alternative Description | Preliminary Capital Cost[2] ($Million) | Project Duration[3] (years) |
|---|---|---|---|---|---|
| SOM007A/MWR205A | 16.7 MG[1] | 0 MG[1] | GSI (19.6 acres) | $71 M | 5 -10 for storage (GSI requires additional time to be determined) |
| | | | 15 MG[1] storage | $189 M | |
| **Max/Sum (Treated CSO)** | **16.7 MG** | **0 MG** | | **$260 M** | **5 -10** |

Notes:
(1) Volume based on peak of storm occurring at mid-tide. See discussion in **Section 9.6.1**.
(2) Preliminary Capital Cost is described in **Section 9.3**. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.
(3) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

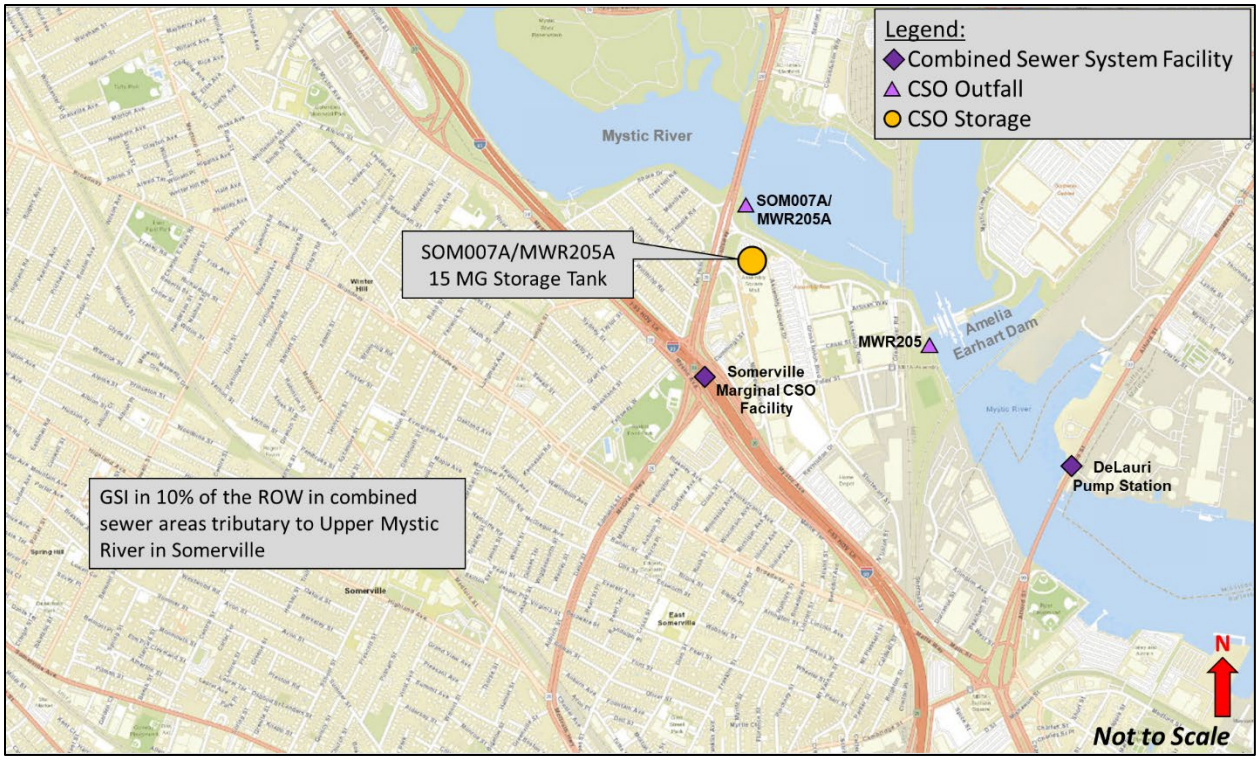



**Figure 9-52. Alternative 11.MR 25-Year Storage + GSI (0 CSOs in 2050 25 Year)**

### 9.7.12.1 Component Descriptions

The individual components of Alternative 11.MR 25-Year Storage + GSI are described below:

- **Storage Tank:** A 15 MG storage tank would be constructed underground in a parking lot serving the north end of the Assembly Square shopping area, extending into a grassed area immediately adjacent to the parking lot. The features and operation would be similar to the storage tank described for Alternative 10.MR 25-Year Storage. The tank size decreased compared to Alternative 10.MR 25-Year Storage due to the addition of GSI in the upstream combined sewer area. The work would also require relocating the existing MWRA effluent sampling building used to sample the discharge from the Somerville Marginal CSO Facility.

- **GSI:** This alternative would include the implementation of GSI capturing runoff from 10% of the impervious right-of-way area in the combined sewer areas tributary to the Upper Mystic River in Somerville (19.6 acres).

### 9.7.12.2 Implementation Challenges

The implementation challenges associated with this Alternative are entirely similar to those described in Alternative 10.MR 25-Year Storage.

## 9.7.13 Alternative 12.MR 25-Year Hybrid (0 CSOs in 2050 25-Year)

Alternative 12.MR 25-Year Hybrid includes a combination of sewer separation and a storage tank. This alternative begins with the same area of sewer separation in Alternative 2.MR Hybrid 1 and adds a storage tank for CSO control in the 2050 25-year storm. It would capture and store CSOs in storms up to and including the design storm from outfalls SOM007A/MWR205A, taking into account the tidal influences

discussed for Alternative 10.MR Storage, and would include a dewatering pump station. The tank is smaller than Alternative 10.MR Storage thanks to the inflow capture achieved by the sewer separation. This alternative would also result in no CSO discharges to the Upper Mystic River in the 2050 TY.

**Table 9-54** presents the predicted treated CSO volume for the Baseline Conditions 2050 25-year storm, the project components, the estimated capital cost, and the estimated project duration. A schematic layout of the components of this alternative is presented in **Figure 9-53**.

**Table 9-54. Alternative 12.MR 25-Year Hybrid (0 CSOs in 2050 25-Year) Summary**

| Upper Mystic River Outfall | Baseline 25-Year CSO Vol. (MG) | Storage + GSI 25-Year CSO Vol. (MG) | Alternative Description | Preliminary Capital Cost(3) ($million) | Project Duration(4) (years) |
|---|---|---|---|---|---|
| SOM007A/MWR205A | 16.7 MG(1) | 0 MG(1) | 95 acres sewer separation | $97 M | 5 |
| | | | 14.2 MG storage(2) | $240 M | 5 - 10 |
| **Max/Sum (Treated CSO)** | 16.7 MG(1) | 0 MG(1) | | **$340 M** | **5 - 10** |

**Notes:**

(1) Volume based on peak of storm occurring at mid-tide. See discussion in **Section 9.6.1**.

(2) Preliminary Capital Cost is described in **Section 9.3**. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.

(3) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

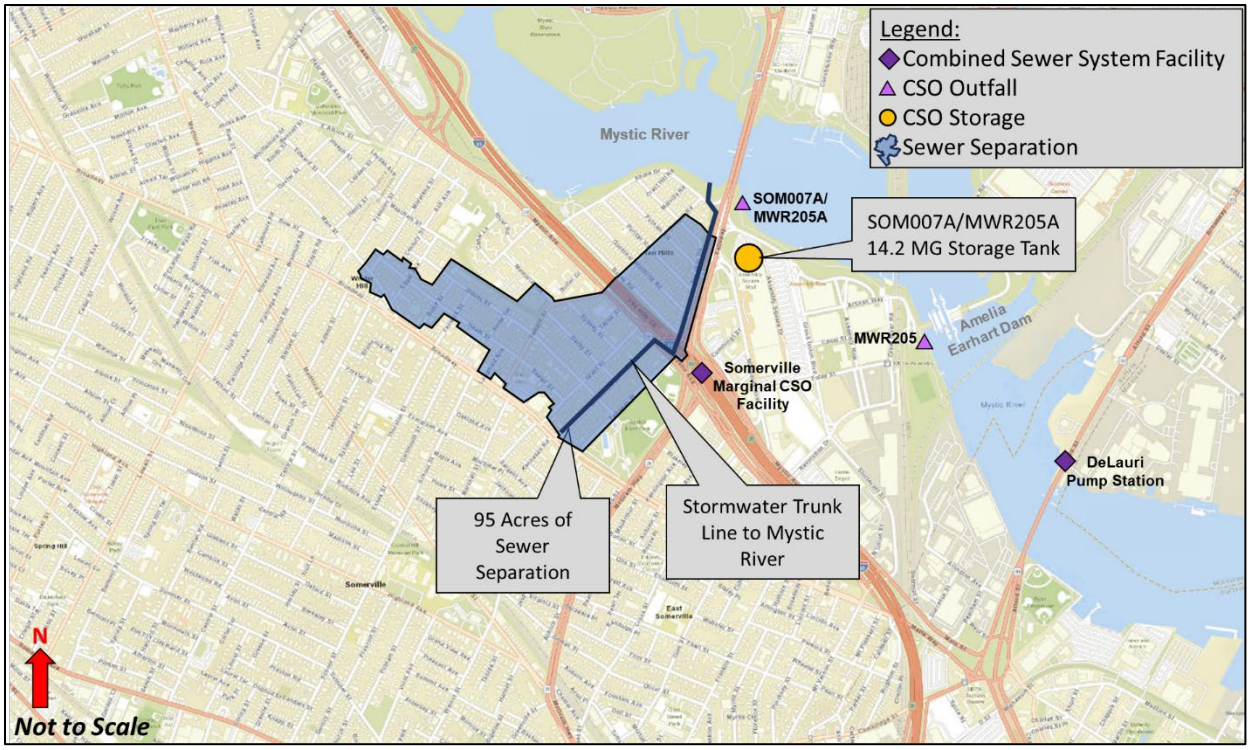



**Figure 9-53. Alternative 12.MR 25-Year Hybrid (0 CSOs in 2050 25-Year) Summary**

### 9.7.13.1 Component Descriptions

The individual components of Alternative 12.MR 25-Year Hybrid are described below:

- **Sewer Separation:** 95 acres of sewer separation would be implemented in the combined sewer areas tributary to the Somerville Marginal CSO Facility and outfall SOM007A/MWR205A. This area would be limited to the east side of the Ten Hills neighborhood as well as areas north of Broadway between Mystic Avenue and Fellsway West. A new stormwater trunk drain and outfall to the Upper Mystic River would be required.
- **Storage Tank**: A 14.2 MG storage tank would be constructed underground in a parking lot serving the north end of the Assembly Square shopping area, extending into a grassed area immediately adjacent to the parking lot. The features and operation would be similar to the tank described for the Alternative 10.MR 25-Year Storage. The work would also require relocating the existing MWRA effluent sampling building used to sample the discharge from the Somerville Marginal CSO Facility.

### 9.7.13.2 Implementation Challenges

Challenges to implementing the components of this alternative would be the same for separation described in Alternative 2.MR Hybrid 1 and for storage the challenges would be similar to those described for Alternative 10.MR 25-Year Storge.

## 9.7.14 Alternative 5.MR Regional Sewer Separation

This alternative is based on the sewer separation analysis in Section 9.6.1 and would include separating all the combined sewers tributary to outfall SOM007A/MWR205A in Somerville and Charlestown as shown in **Figure 9-54**. The following components, as discussed earlier, are included in this alternative:

- The work would require installing new sanitary and/or stormwater pipes in each street currently served by combined sewers in the tributary area, and the creation of two new stormwater outfalls

(one to discharging to the Upper Mystic River and a second one discharging to the Lower Mystic River). The area tributary to the new stormwater outfall in the Upper Mystic River is the same described in Alternative 1.MR Integrated with a total of 366 acres tributary to it.

- This separation would require a 5.5 MG stormwater storage tank near Gilman Square to attenuate excess peak flows that would flood downstream areas closer to the outfall. The rest of the tributary area within Somerville is located east of Broadway and amounts to approximately 194 acres. This area would need to drain to a new outfall that would discharge to the Lower Mystic River, which is tidal.
- Because of the tidal influence on this stormwater outfall, this sewer separation will require a 0.5 MG stormwater storage tank to absorb excess flows when the rainfall events hit on high tide. The stormwater generated by the 127 acres of sewer separation in Charlestown would discharge to the Lower Mystic River below the Amelia Earhart Dam, likely through a new stormwater outfall with a route that is yet to be determined.
- Modeling assumed that 90 percent of the inflow from the combined areas could be captured by the sewer separation work, with 10 percent remaining tributary to the collection system. The remaining 10 percent was intended to reflect roof drains connected to interior building plumbing, and other extraneous sources of inflow that could not be feasibly captured.
- Modeling assumed the CSO regulators would remain open and the Somerville Marginal CSO Facility would remain in operation (described in **Section 9.2.4)** so the need for them to remain as relief points could be assessed.

Regional sewer separation for the Upper Mystic River would not achieve elimination of CSO in the 2050 TY. This alternative was predicted to reduce the treated CSO discharges to the Upper Mystic River in the 2050 TY from 8 activations and 29.31 MG to 1 activation and 1.06 MG. Following regional sewer separation, the treated CSO volume was predicted to be reduced from 17.42 MG to 5.0 MG in the 2050 5-year storm and from 27.19 to 9.4 MG in the 2050 25-year storm, for the peak of the storm hitting at high tide.

Regional sewer separation for the Upper Mystic River would have an ancillary benefit of reducing the treated CSO discharge to the Class SB(CSO) Lower Mystic River at outfall MWR205 (Somerville Marginal CSO Treatment Facility) below the Amelia Earhart Dam and to the Class SB(CSO) Upper Inner Harbor at outfall MWR203. For the 2050 TY the discharges at outfall MWR205 were predicted to be reduced from 27 activations and 79.2 MG to 5 activations and 4 MG. For the 2050 TY the discharges at MWR203 (Prison Point CSO Facility) were predicted to decrease from 386.93 MG to 351.1 MG, however, the number of activations are predicted to remain the same at 20 in the 2050 TY.

The preliminary capital cost of regional sewer separation for the Upper Mystic River was established to be $810 M, with a duration of 35-40 years. **Table 9-55** provides a breakdown of the assumptions for sewer separation and the application of unit costs presented in **Section 9.3** that generate the preliminary capital cost.

## Table 9-55. Alternative 5.MR Regional Sewer Separation Preliminary Capital Cost Summary

| | | Somerville | | | Boston | | | Total |
|---|---|---|---|---|---|---|---|---|
| | Unit Cost ($/separated acre)[1] | Acres | Construction Cost ($M) | Capital Cost ($M) | Acres | Construction Cost ($M) | Capital Cost ($M) | Capital Cost ($M) |
| To Be Separated Pipe Network | $450,000 | 560 | $250 | $430 | 127 | $57 | $98 | **$528** |
| Previously Separated | $50,000 | 0 | $0 | $0 | 0 | $0 | $0 | **$0** |
| Stormwater Treatment (Phosphorus) | $115,000 | 560 | $64 | $110 | 0 | $0 | $0 | **$110** |
| Peak Flow Attenuation Storage | $325,000 | 0 | $0 | $0 | 0 | $0 | $0 | **$0** |
| Pumping (Landlocked/ Low-Lying areas) | $180,000 | 0 | $0 | $0 | 0 | $0 | $0 | **$0** |
| Extraordinary Conveyance | N/A | | $10 | $17 | | $0 | $0 | **$17** |
| Storage Tanks | N/A | | $87 | $150 | | $0 | $0 | **$150** |
| Other | N/A | | $1 | $1 | | $0 | $0 | **$1** |
| **Total** | | | **$410** | **$710** | | **$57** | **$98** | **$810** |

**Note:**
(1) Preliminary Unit Costs are described in **Section 9.3**. Costs for sewer separation components are rounded to two significant figures; total alternative cost was rounded up to two significant figures and therefore may not match the sum.

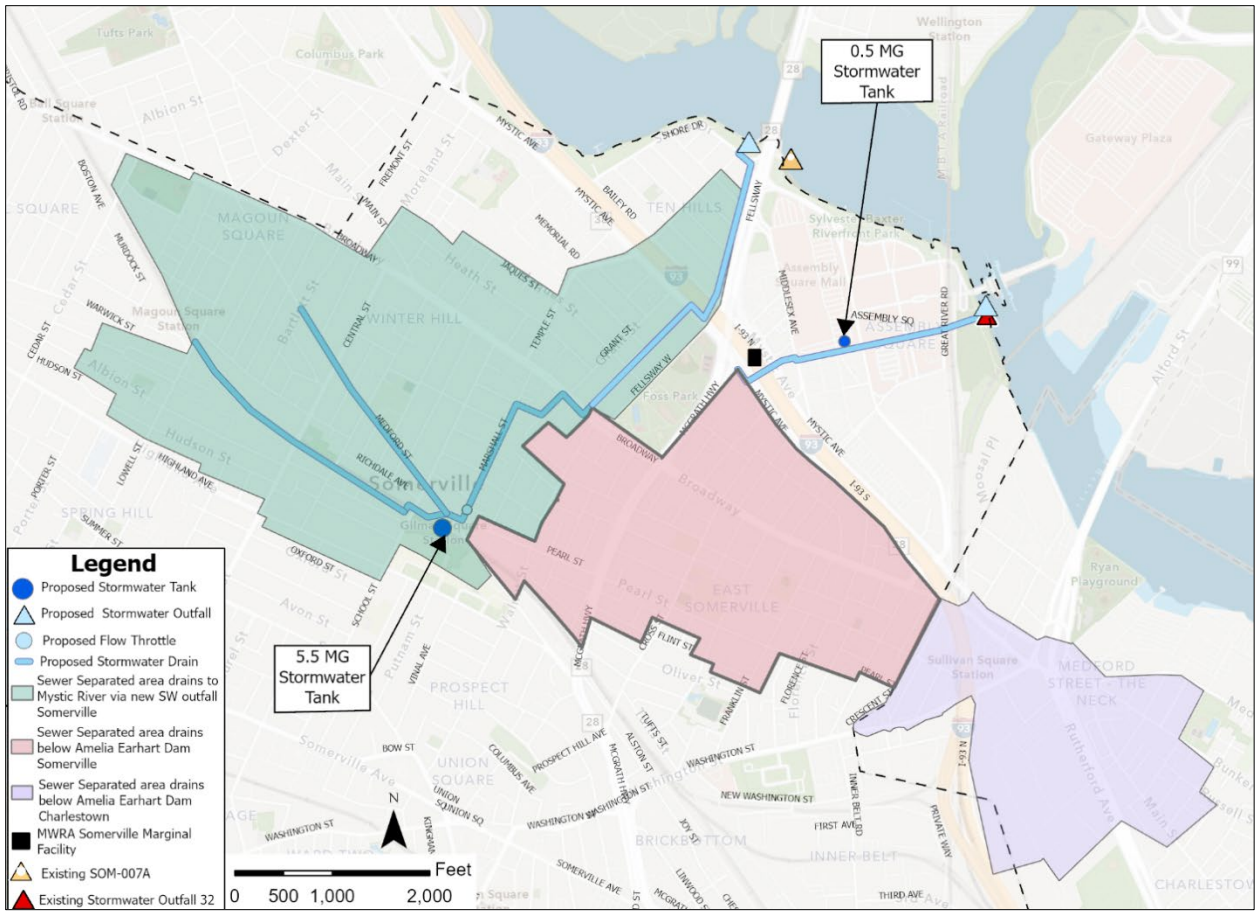



**Figure 9-54. Alternative 5.MR Sewer Separation Summary**

### 9.7.14.1 Implementation Challenges

The implementation challenges associated with this Alternative are entirely similar to those described in Alternative 1.MR, but a CSO storage tank would not have to be constructed in the parking lot. However, the additional area of separation would result in more disruption to the area.

## 9.7.15 Upper Mystic River CSO Alternative Summary

**Table 9-56** provides a summary of the Upper Mystic River CSO control alternatives. The table presents the alternative name, the Baseline Conditions CSO activation frequency and volume, the remaining CSO activation frequency and volume after alternative implementation, the preliminary capital cost, and an estimated project duration. The evaluation and comparison of CSO control alternatives is presented in Section 10.

## Table 9-56. Upper Mystic River Alternatives Summary

| Upper Mystic River Alternative | Alternative Components | Baseline Activation Frequency/ Volume (MG) | Remaining Activation Frequency/ Volume (MG) | Preliminary Capital Cost ($M) | Project Duration (years)[6] |
|---|---|---|---|---|---|
| **2050 Typical Year Level of Control** | | | | | |
| 1.MR Integrated | 1 tank (4 MG) + 366 acres of sewer separation | 8 act/29.31 MG | 0 act/0 MG[2] (in TY) | $570 M | 25 |
| 2.MR Hybrid 1 | 1 tank (7.4 MG) + 95 acres of sewer separation | 8 act/29.31 MG | 0 act/0 MG[2] | $260 M | 5 - 7 |
| 3.MR Storage | 1 tank (10.5 MG) | 8 act/29.31 MG | 0 act/0 MG[2] | $200 M | 5 – 7 |
| 4.MR Storage + GSI | 1 tank (9.4 MG) + GSI (20 acres) | 8 act/29.31 MG | 0 act/0 MG[2] | $200 M | 5 – 7 for storage (GSI requires additional time to be determined) |
| **Limited CSOs in 2050 Typical Year Level of Control** | | | | | |
| 6a.MR Hybrid 1 | 1 tank (2.7 MG) + 95 acres of sewer separation | 8 act/29.31 MG | 2 act/6.77 MG[3] | $170 M | 5 – 10 |
| 6b.MR Hybrid 2 | 1 tank (5 MG) | 8 act/29.31 MG | 2 act/8.23 MG[3] | $120 M | 5 |
| 6c.MR Hybrid 3 | 95 acres of sewer separation | 8 act/29.31 MG | 5 act/17.0MG[3] | $100 M | 5-10 |
| **Greater Than Typical Year Level of Control** | | | | | |
| **2050 5-Year Storm** | | | | | |
| 7.MR 5-Year Storage | 1 tank (10.5 MG) | 6.25 MG[1] | 0 act/0 MG[4] | $200 M | 5 - 7 |
| 8.MR 5-Year Storage + GSI | 1 tank (9.4 MG) + GSI (20 acres) | 6.25 MG[1] | 0 act/0 MG[4] | $200 M | 5 – 7 for storage (GSI requires additional time to be determined) |
| 9.MR 5-Year Hybrid Alternative | 1 tank (7.4 MG) + 95 acres of sewer separation | 6.25 MG[1] | 0 act/0 MG[4] | $260 M | 5 - 7 |
| **2050 25-Year Storm** | | | | | |
| 10.MR 25-Year Storage | 1 tank (16.7 MG) | 16.7 MG[1] | 0 act/0 MG[5] | $260 M | 5 -10 |

**Table 9-56. Upper Mystic River Alternatives Summary**

| Upper Mystic River Alternative | Alternative Components | Baseline Activation Frequency/ Volume (MG) | Remaining Activation Frequency/ Volume (MG) | Preliminary Capital Cost ($M) | Project Duration (years)(6) |
|---|---|---|---|---|---|
| 11.MR 25-Year Storage + GSI | 1 tank (15 MG) + GSI (20 acres) | 16.7 MG(1) | 0 act/0 MG(5) | $260 M | 5 – 10 for storage (GSI requires additional time to be determined) |
| 12.MR 25-Year Hybrid Alternative | 1 tank (14.2 MG) + 95 acres of sewer separation | 16.7 MG(1) | 0 act/0 MG(5) | $340 M | 5 - 10 |
| **Regional Sewer Separation** | | | | | |
| 5.MR Regional Sewer Separation | 690 acres of sewer separation | 2050 TY: 8 act/29.31 MG 2050 5-Year: 6.25 MG(1) 2050 25-Year: 16.7 MG(1) | • 1 activation and 1.06 MG of treated discharge in in 2050 TY<br>• 0 MG of in 2050 5-year storm<br>• 1.65MG of treated discharge in 2050 25-year storm | $810M(7) | 35-40 |

**Notes:**

(1) Volume based on peak of storm occurring at mid-tide.
(2) Alternative would result in no CSO discharges in the 2050 Typical Year.
(3) CSO activation frequency and volume remaining with Alternative implemented in the 2050 TY.
(4) Alternative would result in no CSO discharges in the 2050 TY and 5-year storm.
(5) Alternative would result in no CSO discharges in the 2050 TY, 5-year and 25-year storms.
(6) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.
(7) Costing for sewer separation, including stormwater peak flow attenuation, pumping, and treatment, was developed using construction bids and estimated costs from recent sewer separation projects in the Greater Boston area. Costs were converted into a dollar per acre of sewer separation using project area size. See Appendix E for more details.

## 9.8 Charles River – Local and Regional Technology Assessment

Nine CSO outfalls (CAM005, CAM007, MWR201, MWR010, MWR018, MWR019, MWR020, MWR023, and CAM017) discharge to the Charles River. Outfalls CAM005, CAM007, and CAM017 are owned by and located in Cambridge, outfall MWR201 is owned by MWRA and is located in Cambridge, and MWR010, MWR018, MWR019, MWR020, and MWR023 are owned by MWRA and located in Boston. The location of each the CSO outfalls tributary to the Charles River is presented in **Figure 9-55**. The location of each of the open regulators tributary to outfall MWR023 is presented in **Figure 9-56**. A schematic representation of the combined sewer system upstream of the outfalls that discharge to the Charles River is presented in **Figure 9-57**.

As indicated in **Figure 9-57**, four of the CSO outfalls (CAM005, CAM007, MWR201, and MWR010) provide relief to an interceptor system tributary to Ward Street Headworks (WSHW), and four CSO outfalls (MWR018, MWR019, MWR020, and CAM017) provide relief to a system tributary to Chelsea Creek Headworks. Combined flows passing by these four CSO regulators as well as from internal

regulators on the Cambridge Branch (SOM009 Regulator) and Charlestown Branch (Rutherford Ave. Regulator) are conveyed to the Prison Point CSO facility. Prison Point has a dry weather pumping capacity which conveys flows through the Chelsea Creek Headworks for treatment at DITP. Flows in excess of the dry weather pumping capacity cause levels to rise upstream of Prison Point until an activation elevation is reached, causing the wet weather influent gates to open. CSO discharge from Prison Point is pumped to Boston's inner harbor downstream of the Charles River Dam. MWR023 only discharges combined sewage when one or more of the upstream RE046 regulators discharge into the Stonybrook Conduit which passes through the Fens Gatehouse prior to entering the Charles River. Given its ability to convey CSO from RE046 regulators, the Stony Brook discharge is also MWRA-permitted CSO outfall MWR023. The RE046 regulators are located upstream in Roxbury and regulate flow to the Stonybrook interceptor system tributary to WSHW. Boston Gatehouses No. 1 and 2 discharge at outfall BOS046 to the Muddy River, which is a Class B(CSO) waterbody (314 CMR 4.06(6)(b), Table 5 Charles River Basin) and is not covered under the Charles River Variance. CAM009 and CAM011, which are located downstream of CAM007 and upstream of Cottage Farm, are currently permitted outfalls that have been temporarily closed, pending hydraulic evaluation; modeling for this Updated CSO Control Plan represented these two outfalls as closed.

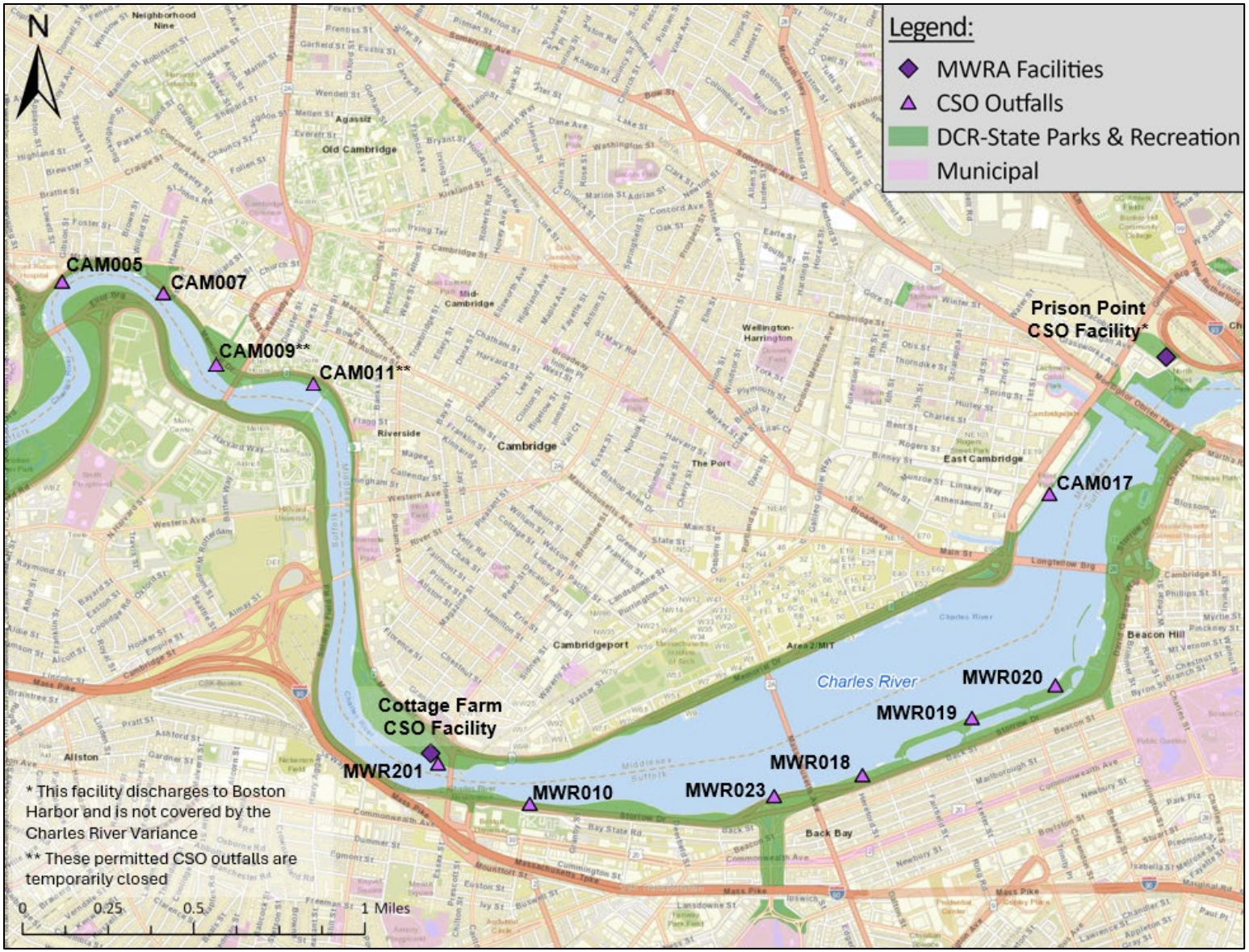



**Figure 9-55. Charles River CSO Outfalls Location Plan**

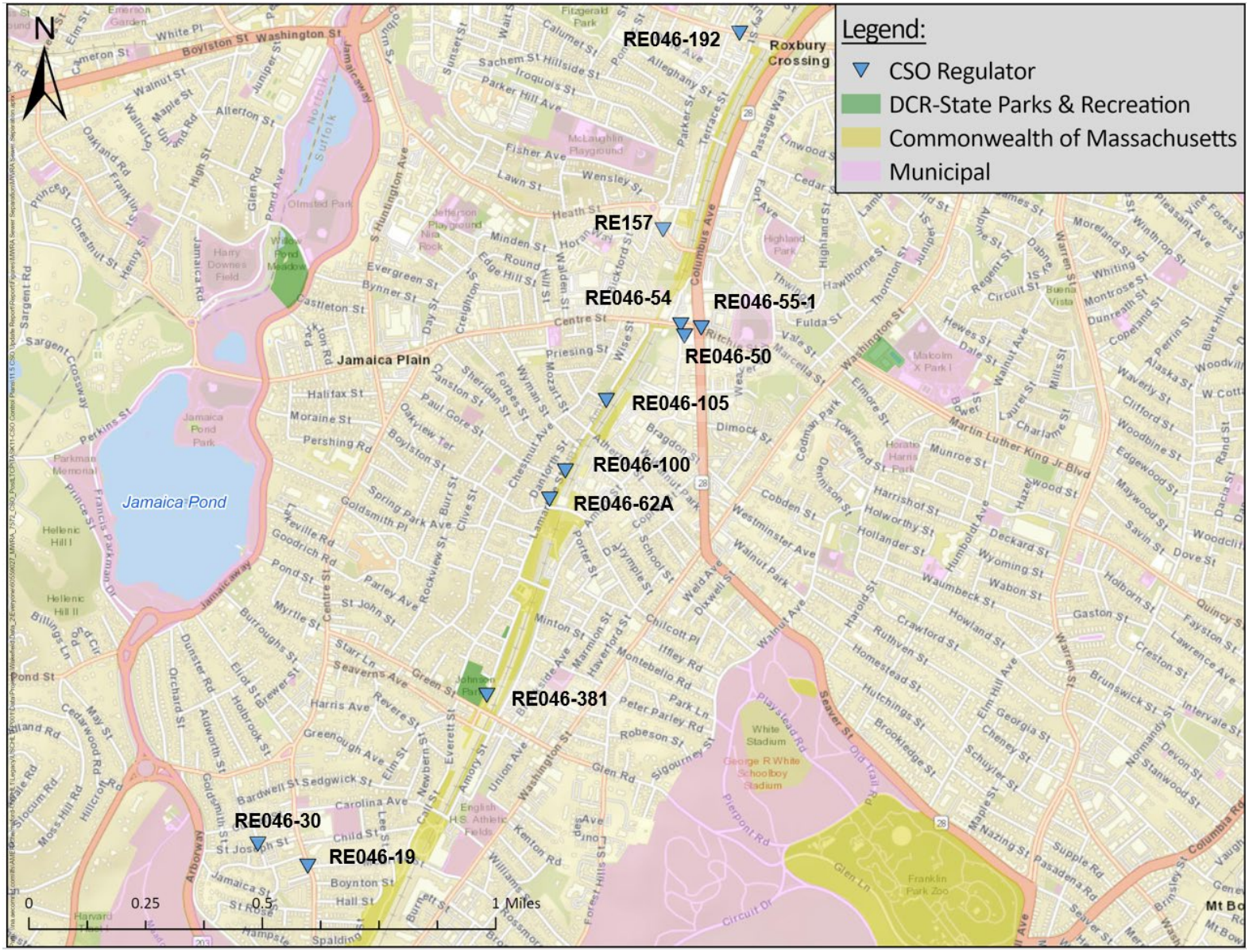



**Figure 9-56. Regulators Tributary to Outfall MWR023 Location Plan**

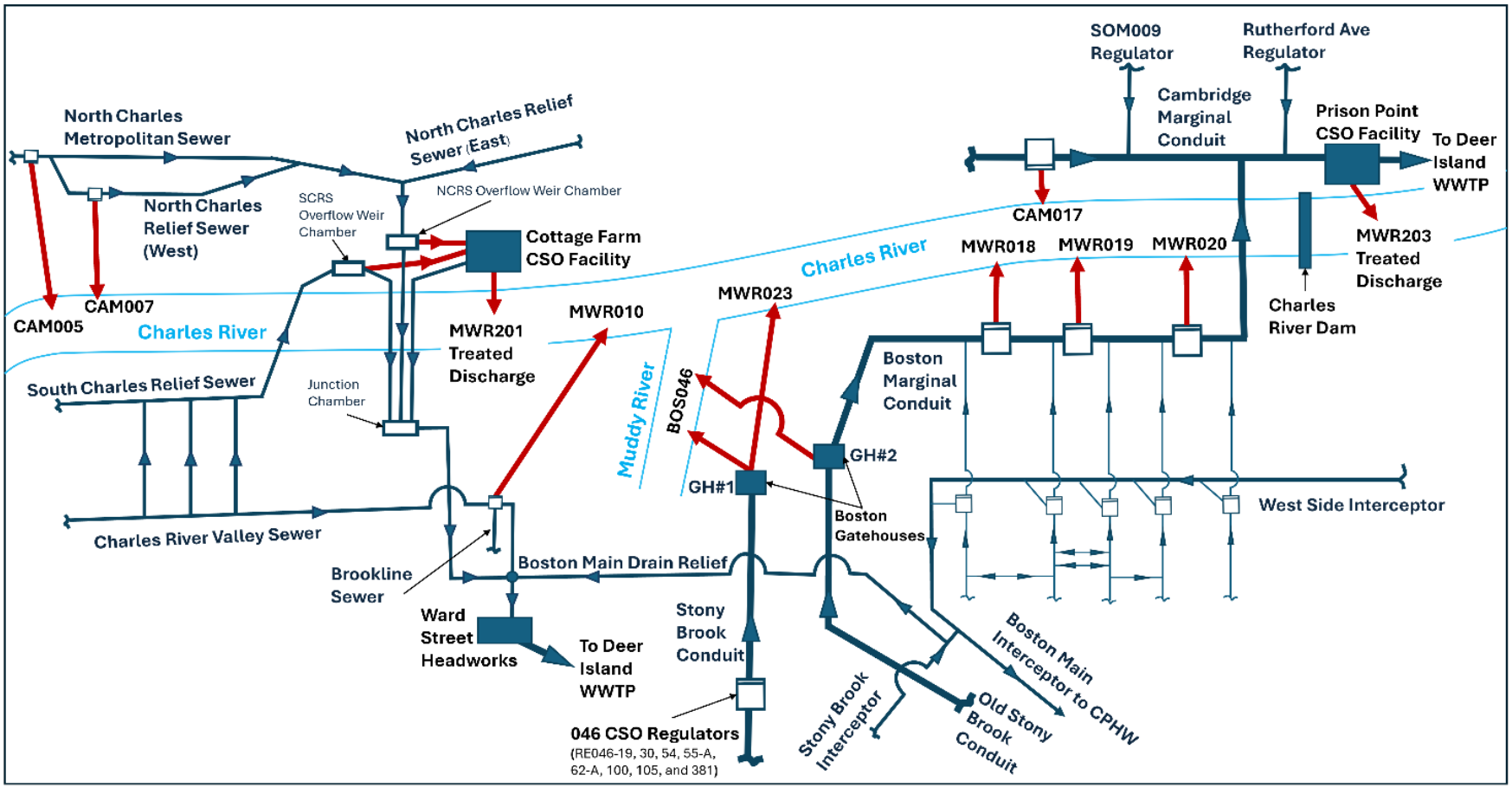



**Figure 9-57. Charles River Combined Sewer System Schematic**

Based on the systemwide screening of CSO control technologies described in **Section 9.2**, sewer separation and storage were evaluated for each individual Charles River CSO outfall. GSI was included for consolidated regional solutions.

The following section describes the initial screening of CSO control technologies for the Charles River CSO outfalls, including reasons behind the decisions to set aside certain CSO control technologies that were not selected for more detailed evaluation. This is the second step as illustrated previously in **Figure 9-1**, shown again in **Figure 9-58**.




**Figure 9-58. Alternative Development Step 2 (Charles River)**

### 9.8.1 CAM005

**Table 9-57** provides a summary of CSO discharges at CAM005.

**Table 9-57. CAM005 Summary of CSO Discharges – Baseline Conditions**

| | Baseline Conditions[1] | | |
|---|---|---|---|
| | 2050 TY CSO Start Date/Volume (MG) | 2050 5-Year Storm Volume (MG) | 2050 25-Year Storm Volume (MG) |
| **Baseline CSO volume per event[2]** | 06/12: 0.26<br>08/14: 0.19<br>12/17: 0.15<br>09/2: 0.07<br>07/16: 0.03<br>07/18: 0.03 | **1.61** | **4.13** |
| **Baseline CSO activations** | **6** | | |
| **Baseline CSO total volume (MG)** | **0.73** | | |

**Notes:**

(1) Model results are based on the baseline conditions model. Model results may vary when evaluated in conjunction with other projects that are hydraulically connected.

(2) Individual storms are presented in order of decreasing volumes and may not add to the total volume due to rounding and/or small inconsistencies when models are run in different environments.

#### Sewer Separation

The combined tributary area upstream of CAM005 is a total of 240 acres. A portion of this area ("Aberdeen area" shown in **Figure 9-59**), is mostly already separated. The separated storm drain from the Aberdeen area currently returns to the combined system near the intersection of Mt. Auburn Street and Aberdeen Avenue, roughly 4,000 feet from the Charles River. It is also a neighborhood vulnerable to flooding, most often observed between Aberdeen Avenue and Homer Avenue.

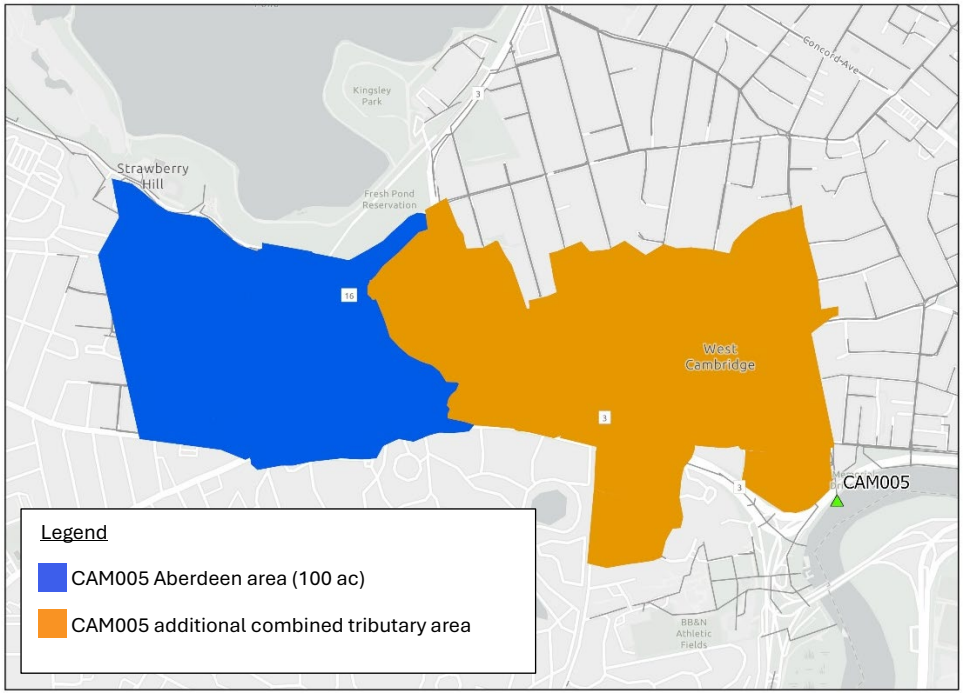



**Figure 9-59. CAM005 Tributary Combined Sewer and Aberdeen Neighborhood**

Removal of the Aberdeen area separated stormwater from the combined system was prioritized since much of the separation work is already done. This would require a new 4-foot diameter pipe along the 4,000 feet to the outfall on the Charles River or pumping that distance with a forcemain. Modeling indicated that this would eliminate CSOs at CAM005 in the 2050 TY but would not provide significant flood reduction benefit, and it was therefore not prioritized as a standalone CSO control technology.

**Storage**

Storage was considered for CAM005 but ultimately determined to be a less effective technology for this outfall. Off-line storage of CSO volumes that overtop the CAM005 regulator would require a diversion and approximately 300 linear feet of 30-inch diameter sewer to send flows to a storage tank in the City of Cambridge-owned Riverbend Park. The tank would need to be 0.3 MG to capture the largest spill (see **Table 9-57**) and would also require a flap gate to prevent stormwater entering the outfall pipe downstream from backflowing into the storage tank. Off-line storage alone would not provide any flood reduction benefit and was therefore not prioritized as a standalone CSO control.

In-line storage was considered by raising the CAM005 regulator weir in the regulator structure. This would raise the hydraulic grade line needed for an overflow to occur and would increase flows sent to the MWRA interceptor. Iterations of the weir height were run to minimize CSO reduction without increasing flooding in vulnerable upstream neighborhoods. MWRA is raising the CAM005 weir by one foot as part of the 2006 LTCP compliance; further raising of the weir would increase localized flooding.

**Conveyance**

Conveyance was not considered for CAM005 because the only location to convey flows would be the MWRA Charles River Marginal Conduit downstream, and its ability to accept conveyed flows is limited because those interceptors are already full in the larger 2050 TY rain events. Lowering the downstream hydraulic gradeline would require regional improvements through storage, further downstream conveyance, and/or modification to facility operation such as modifying the control rules at Cottage Farm

to reduce hydraulic gradelines in the interceptor, resulting in additional treated CSO discharges from Cottage Farm.

**CSO-Stormwater Hybrid**

Due to historical flooding issues in this area, the City developed a project to have dual benefits locally – both CSO control and flood reduction. The concept is to limit stormwater flows from the existing separated Aberdeen area into the combined sewer near the intersection of Mt. Auburn Street and Aberdeen Avenue. The storm drain connection would be significantly downsized from 42-inch to approximately 8- to 10-inch and create an underflow connection that limits the peak flow rate into the combined sewer. Peak stormwater flows would be diverted to a 2.5 MG storage tank in the vicinity of the Collins Branch Library. A dewatering pump station would return flows to the combined system after flows recede, thus maximizing stormwater treatment. This project was shown through modeling to eliminate all CSOs in the 2050 TY, and it would also substantially reduce surface flooding from approximately 800,000 gallons to 200,000 gallons in a 2030 10-year storm event. The extent of flooding also significantly reduces, as shown below in **Figure 9-60**. It was not practical to address all surface flooding since the MWRA interceptor controls the hydraulic grade line in the area and is full in such a large event.



**Figure 9-60. Flood Extents for Baseline (left) versus with 2.5 MG Stormwater Storage (right) upstream of CAM005**

The stormwater storage tank would involve significant excavation, ideally located in one of the existing parking lot areas in the vicinity. With excavation of impervious surface, the City anticipates a possibility to install green infrastructure as part of the project, which would be evaluated during design.

This CSO-Stormwater hybrid approach was incorporated into CAM005 CSO control alternatives because it would eliminate CSOs in the 2050 TY and would simultaneously address an additional City priority to reduce flood risk in the adjacent neighborhood.

### 9.8.2 CAM007

**Table 9-58** provides a summary of CSO discharges at CAM007.

**Table 9-58. CAM007 Summary of CSO Discharges – Baseline Conditions**

| | Baseline Conditions[1] | | |
|---|---|---|---|
| | 2050 TY CSO Start Date/Volume (MG) | 2050 5-Year Storm Volume (MG) | 2050 25-Year Storm Volume (MG) |
| **Baseline CSO volume per event** | 0 | **5.92** | **15.72** |
| **Baseline CSO activations** | **0** | | |
| **Baseline CSO total volume (MG)** | **0** | | |

**Note:**

(1) Model results are based on the baseline conditions model. Model results may vary when evaluated in conjunction with other projects that are hydraulically connected.

CAM007 does not activate in the 2050 TY. Therefore, it was evaluated for CSO control only in regional alternatives for full sewer separation and for larger design storms. See **Sections 9.8.8**.

### 9.8.3 MWR201 (Cottage Farm CSO Facility)

**Table 9-59** provides a summary of the CSO discharges at MWR201.

**Table 9-59. MWR201 (Cottage Farm CSO Facility) Summary of CSO Discharges – Baseline Conditions**

| | Baseline Conditions[1] | | |
|---|---|---|---|
| | 2050 TY CSO Start Date/Volume (MG) | 2050 5-Year Storm Volume (MG) | 2050 25-Year Storm Volume (MG) |
| **Baseline CSO volume per event[2]** | 12/17: 11.21 | **33.84** | **55.92** |
| | 06/7: 10.12 | | |
| | 04/22: 4.46 | | |
| | 06/12: 4.02 | | |
| **Baseline CSO activations** | **4** | | |
| **Baseline CSO total volume (MG)** | **29.81** | | |

**Notes:**

(1) Model results are based on the baseline conditions model. Model results may vary when evaluated in conjunction with other projects that are hydraulically connected.

(2) Individual storms are presented in order of decreasing volumes and may not add to the total volume due to rounding and/or small inconsistencies when models are run on different computers.

#### Sewer Separation

Preliminary modeling of 300 acres of sewer separation in the combined sewer areas upstream of MWR201 indicated that the localized sewer separation would not eliminate treated discharges at MWR201 in the 2050 TY. Activations at outfall MWR201 are also influenced by flows in the MWRA's South Charles Relief Sewer (see **Figure 9-57** above), as well as backwater from Ward Street Headworks when wet weather flows exceed the capacity of the Headworks facility. As a result, localized sewer separation was not considered further for this outfall.

### Storage

Storage was evaluated for MWR201. In-line storage would not be an effective approach for outfall MWR201. During storm events that result in CSO activations at MWR201, the interceptor system is surcharged and additional in-system capacity is not available. In-line storage was therefore not evaluated further for MWR201.

An off-line storage tank could be constructed underground at a site located in parkland adjacent to the existing Cottage Farm CSO Facility. Flow would be diverted to the storage tank from the existing Cottage Farm CSO Facility sedimentation tank influent channel, downstream of the existing influent pumps. When the tank is full, remaining influent flow at the existing Cottage Farm facility would continue to the existing sedimentation tanks, then discharge to the Charles River when the tanks were full. After storm flows subside, a dewatering pump station would pump the stored flow back to the MWRA interceptor system adjacent to the Cottage Farm facility. While the tank structure would be underground, a permanent above-ground structure would be required for maintenance access and to house electrical and odor control equipment.

To investigate the feasibility of storage at MWR201, preliminary sizing was developed for an 11.2 MG storage tank to provide storage for the largest storm in the 2050 TY. **Figure 9-61** presents the conceptual layout for the storage tank. The figure shows the approximate location of the gravity pipe to storage, the dewatering pump station connection, existing infrastructure, and the approximate size of the storage tank.

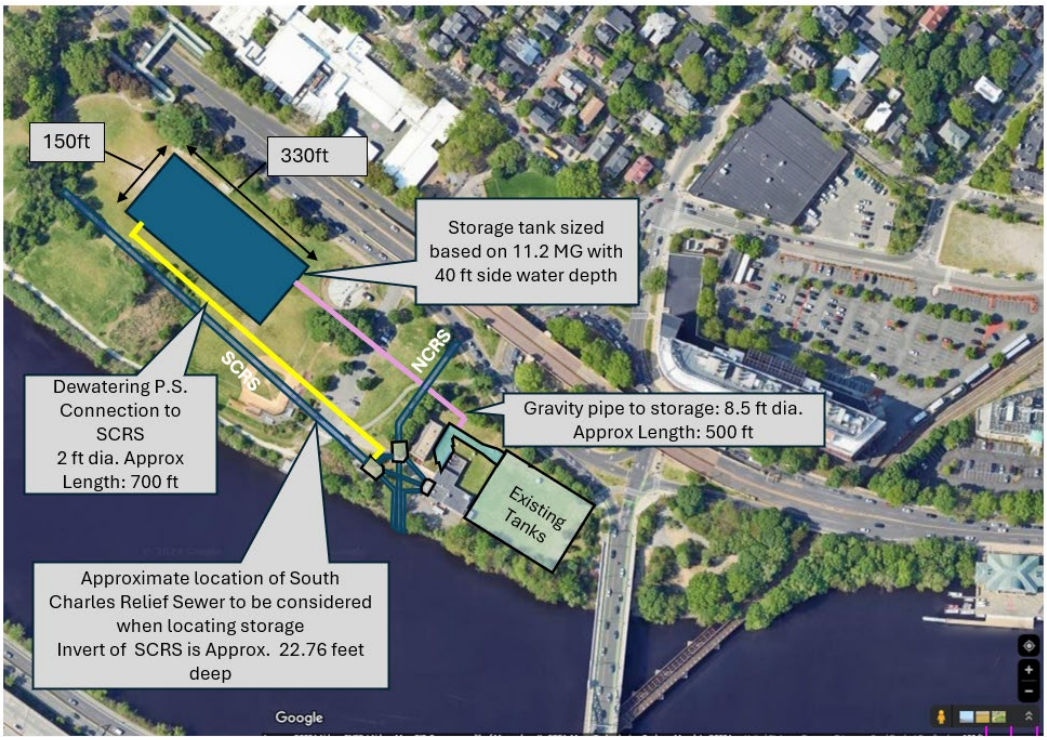



**Figure 9-61. Cottage Farm (MWR201); 11.2 MG Storage Tank Conceptual Layout**

The existing Cottage Farm CSO facility is located in Cambridge along Memorial Drive between Magazine Beach and the Boston University Bridge. Constraints to siting storage adjacent to the Cottage Farm facility would include underground infrastructure (the North Charles Relief Sewer, the South Charles Relief Sewer, diversion chambers and related piping), other possible utility conflicts including a new underground electric transmission line that will extend across Magazine Beach park that Eversource is planning to construct, playing fields in the park adjacent to the facility, a parking area for the playing

fields, Memorial Drive and the adjacent bike path, and the presence of mature trees. Additionally, storage siting in Magazine Beach Park would require Article 97 legislation to authorize the change of use of the site.

Storage for MWR201 was also investigated in the form of a storage tunnel to capture the overflow from outfall MWR201 for the 2050 TY. The main components of the CSO storage tunnel concept would include a diversion structure to divert flow from the existing Cottage Farm CSO Facility influent gate structure, a circular mining shaft, the storage tunnel, and a dewatering pump station which would include influent screens and odor control. An overflow connection would be provided from the mining shaft to the Charles River to provide relief if the tunnel filled to capacity.

Preliminary sizing of a storage tunnel for outfall MWR201 was developed for the 2050 TY level of control. The relationship between tunnel length and the tunnel diameter needed to provide 11.2 MG of storage is presented in **Table 9-60**.

**Table 9-60. Cottage Farm (MWR201) 11.21 MG Storage Tunnel Parameters**

| | Configuration 1 | Configuration 2 | Configuration 3 |
|---|---|---|---|
| Length (LF)(1) | 5,000 | 7,000 | 10,000 |
| Diameter (ft) (1)(2) | 21 | 17 | 15 |

**Notes:**

(1) Model results and storage tank parameters are based on the baseline conditions model. Dimensions of the various storage tanks are preliminary and subject to change based on geological investigations and other design factors.

(2) Diameters are rounded up to the nearest foot for constructability. After rounding, the resulting tunnel storage volume will be larger than the tunnel storage volumes reported above.

**Figure 9-62** shows potential layouts for the three tunnel configurations shown in **Table 9-60**. As indicated in **Figure 9-62**, all three configurations would bring the storage tunnel close to outfalls MWR018, MWR019 and MWR020, with the 7,000 and 10,000 linear feet configurations overlapping with at least one of the three outfalls. As a result, if a tunnel were considered for storing the overflow from outfall MWR201, it would be more cost-effective to also capture the overflow from outfalls MWR018/019/020 into the same tunnel than to consider an entirely separate project for those outfalls (see **Section 9.8.5** for discussion of alternatives just for outfalls MWR018/019/020). Therefore, a storage tunnel at Cottage Farm was only considered at a regional level in **Section 9.8.8**.

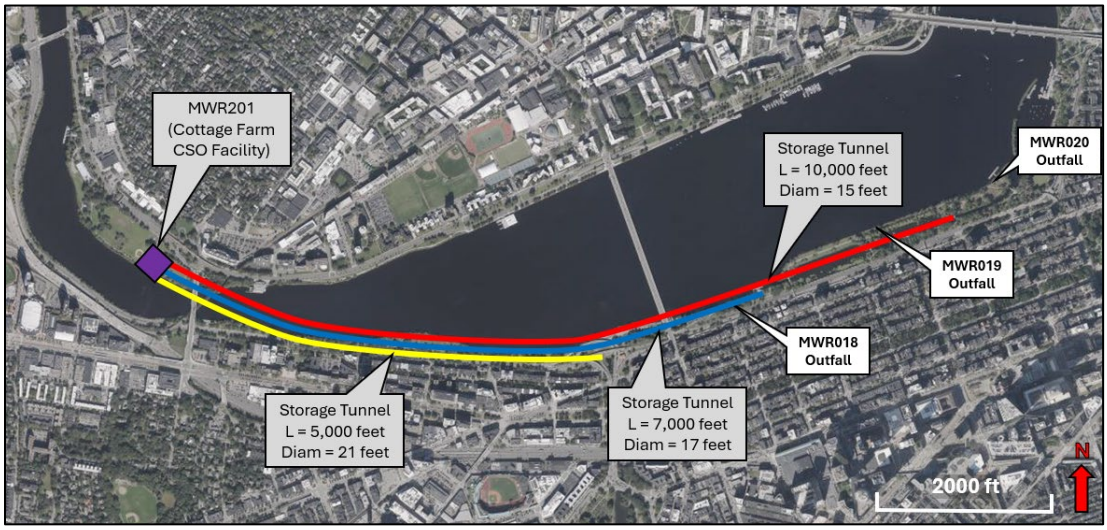



**Figure 9-62. Approximate Layout for Cottage Farm (MWR201) CSO Tunnel Configurations**

### Conveyance

Increasing the conveyance capacity of the interceptor system downstream of outfall MWR201 would result in more flow being conveyed towards Ward Street Headworks, which is already at capacity during storms that cause MWR201 to activate in the 2050 TY. Since the headworks could not accept the additional flow, conveyance relief of the interceptor system would have minimal impact on activations at outfall MWR201. The capacity of Ward Street Headworks is balanced with the capacity of the Columbus Park Headworks in South Boston, and the capacity of the Boston Main Drainage Tunnel to the DITP. Conveyance improvements to provide CSO reductions at MWR201 would require the following:

- Increasing the capacity of WSHW (described in Section 9.2.5.3);
- Increasing the size of the interceptors for approximately 2.5 miles upstream of WSHW;
- Downstream conveyance improvements including increasing the conveyance capacity of the approximately 5-mile Boston Main Drainage Tunnel between WSHW and the DITP; and
- Increasing the capacity the DITP treatment and outfall tunnel.

Due to these extensive improvements this approach was not considered to be practical and was not considered further.

## 9.8.4 MWR010

**Table 9-61** provides a summary of CSO discharges at MWR010.

**Table 9-61. MWR010 Summary of CSO Discharges – Baseline Conditions**

| | Baseline Conditions(1) | | |
|---|---|---|---|
| | 2050 TY CSO Start Date/Volume (MG) | 2050 5-Year Storm Volume (MG) | 2050 25-Year Storm Volume (MG) |
| **Baseline CSO volume per event** | 0 | **1.32** | **3.62** |
| **Baseline CSO activations** | **0** | | |
| **Baseline CSO total volume (MG)** | **0** | | |

**Note:**

(1) Model results are based on the baseline conditions model. Model results may vary when evaluated in conjunction with other projects that are hydraulically connected.

MWR010 does not activate in the 2050 TY, but it is predicted to activate during the 2050 5-year and 25-year design storms. The discussion below therefore focuses on approaches to capturing overflows from outfall MWR010 for those two design storms.

### Sewer Separation

The area directly tributary to outfall MWR010 has been separated, and the remaining activations this outfall during large storms are driven by the residual inflow in the separated system and the upstream combined flow and I/I contributions from separate communities. As the scope and feasibility of work to remove that residual inflow could not be defined, sewer separation was not evaluated further individually for this outfall.

### Storage

In-line storage would not be an effective approach for MWR010. During storm events that result in CSO activations at MWR010, the interceptor system is surcharged and additional in-system capacity is not available. In-line storage was therefore not evaluated further for MWR010.

Off-line storage was evaluated in the form of linear storage in the vicinity of the MWR010 regulators (RE037 and RE036-9) along Commonwealth Avenue. To divert to storage in this configuration, regulator RE037 would be relocated downstream along the Charles River Valley Sewer on the other side of St. Marry's Street to be closer to regulator RE036-9. To store the overflow from the MWR010 regulators for the 2050 5-year storm CSO volume, multiple linear storage configurations were considered ranging in size from a 6,850 foot long, 6-foot diameter conduit, to a 2,500 foot-long, 10-foot diameter conduit. Constructing such large-diameter storage conduits along Commonwealth Avenue would result in substantial impacts to the MBTA Green Line, traffic, and pedestrians, and the storage conduits would be difficult to access for maintenance. Since providing a diversion structure and drop shaft to a regional storage conduit would be less expensive and less intrusive to construct, this storage conduit option was not evaluated further. The same logic applied to capturing the 2050 25-year storm volume at MWR010. As a result, MWR010 storage was further evaluated as part of regional tunnel storage alternatives which are discussed further below.

**Conveyance**

Conveyance relief of the interceptor system between outfall MWR010 and Ward Street Headworks was predicted to have no impact on outfall MWR010 without also increasing the capacity of Ward Street Headworks, the Boston Main Drain Tunnel, and the DITP. As a result, increasing the conveyance capacity downstream of the MWR010 regulators was not evaluated further.

Conveyance was also evaluated through increasing the flow sharing capacity between the Charles River Valley Sewer and the South Charles Relief Sewer through existing interconnections upstream of outfall MWR010. During storm events, flow from the Charles River Valley Sewer can overtop weirs at three interconnections and be conveyed to the South Charles Relief Sewer. The model was used to evaluate the impact of lowering these weirs as a means of conveying more flow to the South Charles Relief Sewer and away from the Charles River Valley Sewer and outfall MWR010. However, this approach was predicted to result in limited CSO reduction at MWR010 with a substantial increase in CSO volume at the Cottage Farm CSO Facility, and it was therefore not considered for further evaluation.

### 9.8.5 MWR018/019/020

**Table 9-62** provides a summary of CSO discharges at MWR018/019/020.

**Table 9-62. MWR018/019/020 Summary of CSO Discharges – Baseline Conditions**

| | Baseline Conditions(1) | | |
|---|---|---|---|
| | 2050 TY CSO Start Date/Volume (MG) | 2050 5-Year Storm Volume (MG) | 2050 25-Year Storm Volume (MG) |
| **Baseline CSO volume per event(2)** | 06/7: 3.21<br>12/17: 2.16<br>06/12: 0.94<br>04/22: 0.03 | **9.98** | **15.58** |
| **Total activations** | **4** | | |
| **Total volume (MG)** | **6.33** | | |

**Notes:**

(1) Model results are based on the baseline or intermediate baseline conditions model and assume storage at MWR018/019/020 is the only project in place. Model results may vary when evaluated in conjunction with other projects that are hydraulically connected.

(2) Individual storms are presented in order of decreasing volumes and may not add to the total volume due to rounding and/or small inconsistencies when models are run in different environments.

### Sewer Separation

Sewer separation was evaluated for outfalls MWR018/019/020 alone and in conjunction with storage. Approximately 1,176 acres are tributary to the Boston Marginal Conduit (**Figure 9-63**). Of those 1,176 acres, 481 acres are served by combined sewers. The remaining 695 acres are served by separate sewers and storm drains that tie into the combined sewer system. To separate those areas, it was assumed that the existing separate storm drains would be tied into new storm drains constructed as part of the separation of downstream combined sewer areas. As part of separation work, new storm drains would need to be microtunneled under the Boston Marginal Conduit and Storrow Drive to convey the separated stormwater to the Charles River. Small-diameter connections would be provided from the new storm drains to the Boston Marginal Conduit to recapture stormwater from smaller storms that would not cause CSOs to activate**.** Based on input from the BWSC, GSI would be provided in areas to be separated to help recharge local groundwater with captured stormwater runoff. Stormwater pump stations may be needed to convey stormwater out of certain low-lying areas to be separated.

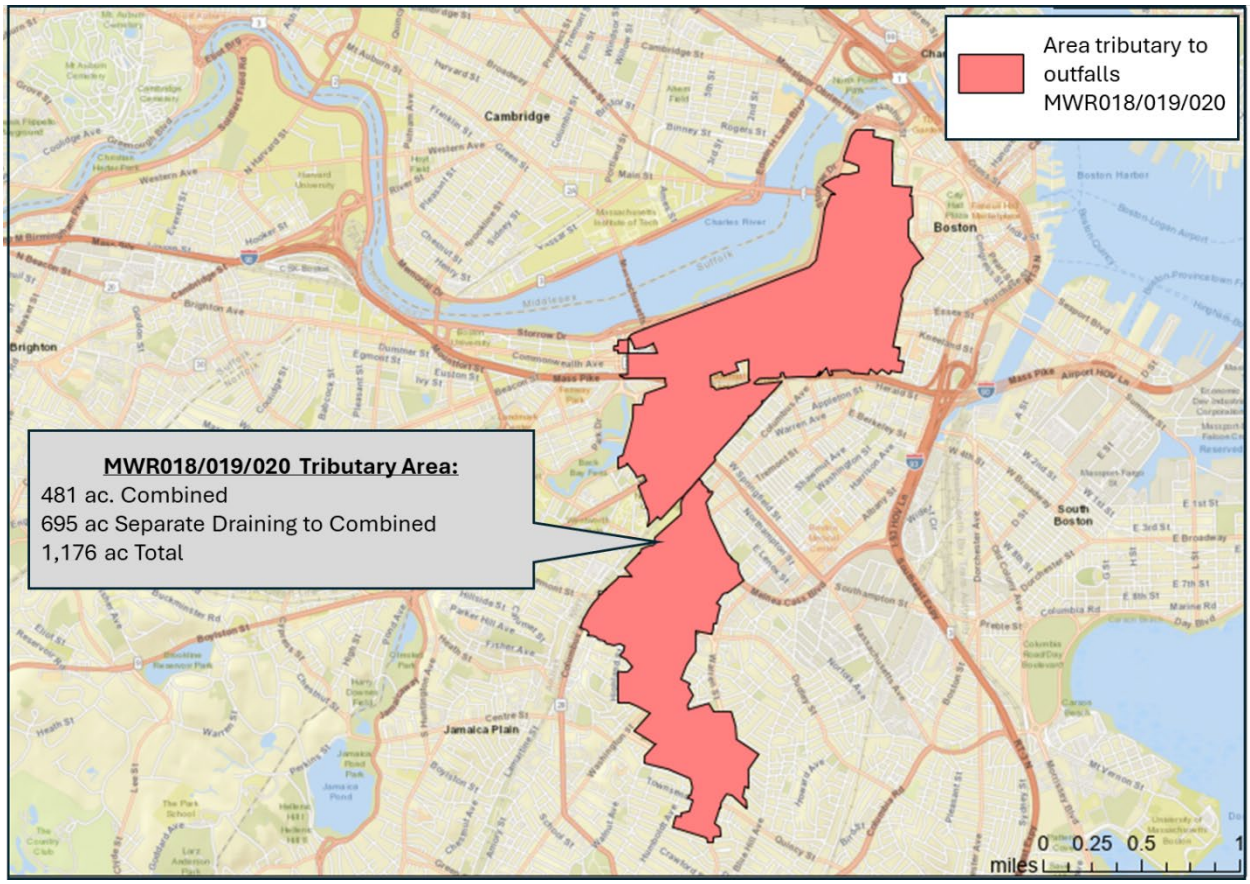



**Figure 9-63. Area Tributary to Outfalls MWR018/019/020**

Based on iterative model runs, separation of 139 acres of combined sewer area, and relocating 49 acres of already-separated stormwater (188 acres total) was predicted to reduce the discharges at outfalls MWR018/019/020 to 2 activations and 2.48 MG in the 2050 TY. Separation of 224 acres of combined sewer area, and relocating 142 acres of already-separated stormwater (366 acres total) was predicted to eliminate the discharges at outfalls MWR018/019/020 in the 2050 TY. Separating the entire area tributary to MWR018/019/020 (1,176 acres) through sewer separation (481 acres) and capture of already separated areas (695 acres) that tie into the combined system was predicted to result in 0 activations in

the 2050 TY and 5-year storm, but discharges would remain for the 2050 25-year storm. **Table 9-63** summarizes these results, which reflect baseline conditions elsewhere in the system.

**Table 9-63. MWR018/019/020 Sewer Separation**

| 2050 TY CSO Start Date | Baseline Conditions | 188 acres of Separation and Stormwater Removal: Limited CSO in 2050 TY[2] | 366 acres of Separation and Stormwater Removal: 0 CSO in 2050 TY[3] |
|---|---|---|---|
| | CSO Volume (MG)[1][4] | Remaining CSO Volume (MG)[1][4] | Remaining CSO Volume (MG)[1] |
| 6/7 | 3.21 | 1.48 | 0.00 |
| 12/17 | 2.16 | 0.99 | 0.00 |
| 6/12 | 0.94 | 0.00 | 0.00 |
| 4/22 | 0.03 | 0.00 | 0.00 |
| **Total Volume (MG)** | **6.33** | **2.48** | **0.00** |
| **Total Activations** | **4** | **2** | **0** |

| 2050 Design Storm | Baseline Conditions | 1,176 acres of Separation and Stormwater Removal |
|---|---|---|
| | CSO Volume (MG)[1] | Remaining CSO Volume (MG)[1] |
| **2050, 5-Year Storm** | **9.98** | **0.00** |
| **2050, 25-Year Storm** | **15.58** | **3.39** |

**Notes:**

(1) Model results are based on the baseline conditions model. Model results may vary when evaluated in conjunction with other projects that are hydraulically connected.
(2) Separating 188 acres for the Limited CSO in 2050 TY LOC includes 139 acres of sewer separation and 49 acres of stormwater removal.
(3) Separating 366 acres for the 2050 TY LOC includes 224 acres of sewer separation and 142 acres of stormwater removal.
(4) Individual storms are presented in order of decreasing volumes and may not add to the total volume due to rounding and/or small inconsistencies when models are run in different environments.

### Storage

Storage for outfalls MWR018/019/020 was evaluated in the form of off-line microtunneled storage conduits. Storage tanks were not evaluated because of the limited space available adjacent to the MWR018/019/020 outfalls. In-line storage would not be effective due to the surcharged condition of the collection system during storms that would cause activations at outfalls MWR018/019/020.

Under existing conditions, flow is diverted from the Boston Marginal Conduit (BMC) to MWR018/019/020 through large weir structures located along each outfall adjacent to the BMC. The controlling overflow elevations for each outfall are set by stop log structures just downstream of the large weir structures. The elevations of the top of the stop logs were set above the weir crest elevations in the large weir structures to optimize the capture of CSO in the BMC. For the microtunneled storage conduits, diversion structures would be constructed along the existing MWR018, MWR019 and MWR020 outfalls just downstream of the existing weir structures for each outfall along the BMC. The diversion structures would essentially replace the existing stop log structures. Flow in each outfall would be diverted to the storage conduit until the storage conduit reached its capacity, at which point remaining flows would be conveyed through the existing outfalls to the Charles River. The diversion structures would be configured to efficiently move flow into the storage conduit, resulting in lower peak hydraulic grade lines along the BMC. As a result of this hydraulic efficiency, the volume to be captured in the storage conduit would be slightly higher than the volume that currently discharges from these outfalls.

**Table 9-64** presents the CSO volumes for the four storms which caused CSOs at MWR018/019/020 in the 2050 TY under Baseline Conditions, and the volume that would be diverted to the storage conduit with the diversion structures as described above. Also presented are the storage volumes required to reduce the maximum activation frequency at outfalls MWR018/019/020 to two in the 2050 TY (Limited CSO in 2050 TY) and to 0 in the 2050 TY.

**Table 9-64. Storage Impacts on CSO Volume and Frequency at Outfalls MWR018/019/020 in the 2050 TY**

| 2050 TY CSO Start Date | Baseline Conditions<br>CSO Volume (MG)(2) | Baseline Conditions with Regulator Adjustments to Divert Flow to Storage<br>CSO Volume (MG)(2) | Limited CSO in 2050 TY 1.24 MG of Storage(1)<br>Remaining CSO Volume (MG)(2) | 2050 TY 4.33 MG of Storage(1)<br>Remaining CSO Volume (MG) |
|---|---|---|---|---|
| 6/7 | 3.21 | 4.33 | 3.09 | 0.00 |
| 12/17 | 2.16 | 3.11 | 1.87 | 0.00 |
| 6/12 | 0.94 | 1.24 | 0.00 | 0.00 |
| 4/22 | 0.03 | 0.03 | 0.00 | 0.00 |
| **Total Volume (MG)** | **6.33** | **8.71** | **4.97** | **0.00** |
| **Total Activations** | **4** | **4** | **2** | **0** |

**Notes:**

(1) Storage volumes are based on the model configuration with the regulator adjustments to divert flow to storage. Model results may vary when evaluated in conjunction with other projects that are hydraulically connected.

(2) Individual storms are presented in order of decreasing volumes and may not add to the total volume due to rounding and/or small inconsistencies when models are run in different environments.

The estimated storage conduit length and diameter and dewatering pump station size for the storage volumes presented in **Table 9-64** are shown below in **Table 9-65**. For the Limited CSO in 2050 TY volume of 1.24 MG, the 8-foot diameter storage conduit would fall within the typical range for microtunnel construction. The 15-foot diameter conduit needed to capture the 4.33 MG for zero discharges in the 2050 TY; however, would be outside of the range of microtunneling technology. This storage conduit would need to be constructed using a TBM, with a large-diameter mining shaft at one end and a TBM removal shaft at the other end. Given the sensitive location of the outfalls along the Esplanade, siting a traditional tunnel mining operation in that area was deemed infeasible. As a result, providing a storage conduit by itself to control the 2050 TY volume at outfalls MWR018/019/020 was not evaluated further. As discussed further below, however, pairing a storage conduit with upstream sewer separation was evaluated in more detail as an alternative to achieve zero discharges in the 2050 TY.

**Table 9-65. MWR018/019/020 Storage Tunnel Parameters**

| Parameter | Limited CSO in 2050 TY 1.24 MG Tunnel(1) | 2050 TY 4.33 MG Tunnel(1) |
|---|---|---|
| **Length (ft)** | 3,500 | 3,500 |
| **Diameter (ft)(2)** | 8 | 15 |
| **Dewatering Pump Rate (MGD)** | 1.24 | 4.33 |

**Notes:**

(1) Storage volumes are based on the model configuration with the regulator adjustments to divert flow to storage. Model results may vary when evaluated in conjunction with other projects that are hydraulically connected.

(2) Diameters are rounded up to the nearest foot for constructability. After rounding, the resulting storage volume will be larger than the storage volumes reported above.

**Figure 9-64** shows the potential configuration for the 1.24 MG microtunneled storage conduit. Dimensions shown are preliminary and subject to change based on geological investigations and other design factors. The route would begin to the west of outfall MWR018 and run under the Esplanade to the vicinity of outfall MWR020. It is anticipated that two pipe jacking shafts and two receiving shafts would be located along the microtunnel route. The jacking shafts are where the microtunneling boring machine is inserted and excavate is removed. The receiving shafts are where the microtunneling boring machine is removed. The final route and shaft locations could change and would be defined after further planning and design. A permanent above-ground structure would be required at the downstream end of the storage conduit for maintenance access and to house electrical and odor control equipment. As described above, the existing stop log structures along the outfall pipes for outfalls MWR018/019/020 would be modified to create diversion structures to divert flow to the storage conduit, while allowing CSO to continue to discharge in larger storm events if the tunnel was full. The diversion structures may include gates that would be triggered to close when the tunnel is full.

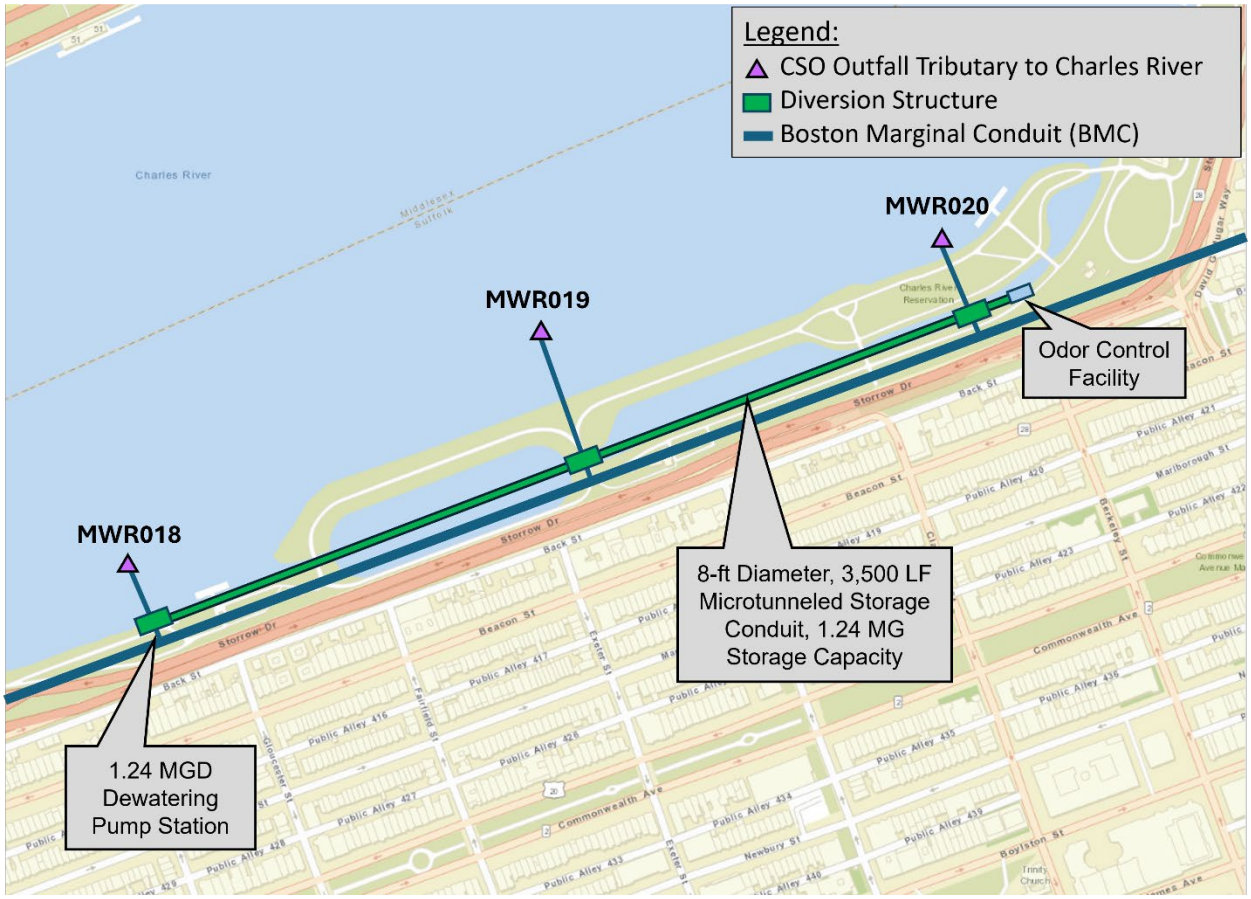



**Figure 9-64. Preliminary Layout of MWR018/019/020 Microtunneled Storage**

### Conveyance

Outfalls MWR018/019/020 provide relief off the BMC, which conveys flow to MWRA's Prison Point CSO Facility. Preliminary assessments of increasing the conveyance capacity of the Boston Marginal Conduit showed limited benefit in terms of reduction in CSO volume at outfalls MWR018/019/020, while substantially increasing the volume of treated discharge from the Prison Point CSO Facility to Boston Harbor. Construction of additional conveyance capacity parallel to the existing BMC, along Storrow Drive

and the Esplanade, would also be extremely challenging. For these reasons, conveyance was not evaluated further for these outfalls.

### 9.8.6 MWR023

Outfall MWR023 is located at the downstream end of the Stony Brook Conduit. As part of the MWRA's 2006 LTCP, the combined sewer areas tributary to the Stony Brook Conduit were separated. However, due to residual inflow sources, such as buildings with internal drains connected to the sewer system and infiltration during high groundwater periods that could not be readily removed, 11 CSO regulators in the Stony Brook system remained open after completion of the separation work to provide relief in larger storm events. Those remaining CSO regulators are the only sources of CSO to the Stony Brook Conduit. Under high flow conditions, Boston Gatehouse No. 1 can divert flow from the Stony Brook Conduit to the Muddy River through outfall BOS046. Model tracer studies have shown that if the upstream regulators discharge CSO to the Stony Brook Conduit, approximately 25% of the CSO will discharge to the Charles River at outfall MWR023, and 75% will discharge to the Muddy River at outfall BOS046. The Muddy River is a Class B(CSO) waterway (314 CMR 4.06(6)(a)(Table 5)) and is not covered under the Charles River Variance. However, the CSO component discharging at outfall MWR023 cannot realistically be addressed separately from the component discharging at outfall BOS046. With these considerations in mind, the quantification of CSO volumes for this system is presented in terms of volumes discharging to the Stony Brook Conduit from the upstream regulators, and the approaches to CSO control are focused on controlling the discharges at those upstream regulators. Therefore, alternatives resulting in zero CSOs from these upstream regulators would result in zero CSOs from MWR023 to the Charles River as well as from BOS046 to the Muddy River.

Two of the upstream RE046 regulators that discharge into the Stony Brook Conduit are predicted to be active in the 2050 TY, five are predicted to be active in the 2050 5-year storm, and eight are predicted to be active in the 2050 25-year storm. **Table 9-66** provides a summary of the CSO discharges from the two RE046 regulators that are active in the 2050 TY by individual storm event. As indicated in **Table 9-66**, those regulators are predicted to activate a maximum of six times and discharge a total of 0.51 MG in the 2050 TY. **Table 9-67** provides a summary of the volumes from the RE046 regulators that are active in the 2050 5-year and 2050 25-year storms. As indicated in **Table 9-67**, the five active regulators in the 2050 5-year storm are predicted to discharge a total of 1.05 MG, and the eight active regulators in the 2050 25-year storm are predicted to discharge a total of 2.27 MG.

**Table 9-66. RE046 Regulator CSO Activations to the Stony Brook Conduit in the 2050 TY**

| | Baseline Conditions[1] | |
|---|---|---|
| | RE046-100 Volume (MG)[2] | RE046-381 Volume (MG) [2] |
| 06/12 | 0.16 | 0.08 |
| 06/27 | 0.02 | 0.00 |
| 07/16 | 0.05 | 0.00 |
| 08/14 | 0.06 | 0.04 |
| 09/2 | 0.03 | 0.00 |
| 12/17 | 0.07 | 0.00 |
| **Total Volume (MG)** | 0.39 | 0.12 |
| **Total Activations** | **6** | **2** |

**Notes:**

(1) Model results are based on the baseline conditions model.
(2) Volumes represent the total volume over the weirs. See text above for additional information on volume that discharges at outfall MWR023 vs. volume that discharges at Boston Gatehouse 1.

**Table 9-67. RE046 Regulator CSO Activations to the Stony Brook Conduit in the 2050 TY, 5-Year, and 25-Year Storms**

| Regulator ID | Baseline Conditions | | |
|---|---|---|---|
| | 2050 TY Annual Volume (MG)[1] | 2050, 5-Year Storm Volume (MG)[1] | 2050, 25-Year Storm Volume (MG)[1] |
| RE046-19 | 0.00 | 0.00 | 0.03 |
| RE046-30 | 0.00 | 0.00 | 0.02 |
| RE046-54 | 0.00 | 0.04 | 0.02 |
| RE046-55-1 | 0.00 | 0.07 | 0.31 |
| RE046-62A | 0.00 | 0.00 | 0.07 |
| RE046-100 | 0.39 | 0.51 | 0.66 |
| RE046-105 | 0.00 | 0.01 | 0.15 |
| RE046-381 | 0.12 | 0.42 | 1.01 |
| **Total Volume** | **0.51** | **1.05** | **2.27** |

**Note:**

(1) Model results are based on the baseline conditions model.

### Sewer Separation

As noted above, the tributary areas upstream of the regulators predicted to discharge to the Stony Brook Conduit were previously separated by the BWSC as part of MWRA's 2006 LTCP, and the remaining activations at these regulators are driven by the residual inflow in the separated system. As the scope and feasibility of work to remove that residual inflow could not be defined, sewer separation was not evaluated further for those regulators.

### Storage

Storage in the form of off-line storage conduits was evaluated to capture the overflow from the active regulators in the MWR023 system. In-line storage would not be effective due to the surcharged state of the upstream system during storms large enough to cause activations at those regulators.

CSO volumes for the six storms which caused overflows in the 2050 TY are presented in **Table 9-68**. Also presented are the storage volumes required to reduce the maximum activation frequency of the active regulators to two in the 2050 TY (Limited CSO in 2050 TY) and to 0 in the 2050 TY. As indicated in **Table 9-68**, to achieve two activations in the 2050 TY, 0.06 MG of storage would be required at RE046-100, and no project would be needed for regulator RE046-381. To get to 0 CSOs in the 2050 TY, 0.16 MG of storage would be needed at regulator RE046-100 and 0.08 MG at regulator RE046-381.

### Table 9-68. RE046 Regulator CSO Activations to the Stony Brook Conduit in the 2050 TY – Before and After Storage

| 2050 TY CSO Start Date | Baseline Conditions | | Limited CSO in 2050 TY 0.06 MG Storage (RE046-100) No action (RE046-381) | | 2050 TY 0.16 MG Storage (RE046-100) 0.08 MG Storage (RE046-381) | |
|---|---|---|---|---|---|---|
| | CSO Volume (MG)[1] | | Remaining CSO Volume (MG)[1] | | Remaining CSO Volume (MG)[1] | |
| | RE046-100 | RE046-381 | RE046-100 | RE046-381 | RE046-100 | RE046-381 |
| 6/12 | 0.16 | 0.08 | 0.10 | 0.08 | 0.00 | 0.00 |
| 6/27 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7/16 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8/14 | 0.06 | 0.04 | 0.00 | 0.04 | 0.00 | 0.00 |
| 9/2 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 12/17 | 0.07 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| **Total Volume (MG)** | **0.39** | **0.12** | **0.11** | **0.12** | **0.00** | **0.00** |
| **Total Activations** | **6** | **2** | **2** | **2** | **0** | **0** |

**Note:**
(1) Model results are based on the baseline conditions model.

As shown in **Figure 9-65** and **Figure 9-66**, RE046-100 and RE046-381 are located in residential areas with limited available site for storage tanks. Therefore, the storage volumes noted in above were assumed to be captured in linear storage conduits. The preliminary sizing for the storage conduits is shown below in **Table 9-69**. Dimensions of the storage conduits, including whether they would be circular pipes or rectangular box sections, are preliminary and subject to change based on geological investigations and other design factors.

### Table 9-69. RE046 Regulator Storage Conduit Parameters

| | Limited CSOs in 2050 TY | 2050 TY (Box Storage) | |
|---|---|---|---|
| Regulator ID | RE046-100 | RE046-100 | RE046-381 |
| Storage Volume Required (MG)[1] | 0.06 | 0.16 | 0.08 |
| Length (ft) | 300 | 300 | 320 |
| Width (ft)[2] | - | 9 | 6 |
| Height (ft)[2] | - | 9 | 6 |
| Diameter (ft)[2][3] | 6 | - | - |
| Dewatering Pump Rate (MGD) | 0.06 | 0.16 | 0.08 |

**Notes:**
(1) Model results are based on the baseline conditions model. Model results may vary when evaluated in conjunction with other projects that are hydraulically connected.
(2) Width, height, and diameter are rounded up to the nearest foot for constructability. After rounding, the resulting microtunnel storage volume will be larger than the tunnel storage volumes reported above.
(3) Diameter only applies to the breakpoint TY storage conduit as this is a circular pipe. Box conduit storage was evaluated for the 2050 TY.

**Figure 9-65** presents a conceptual layout for the RE046-100 storage conduit. The storage conduit for RE046-100 could be located in the public right-of-way adjacent to Southwest Corridor Park which is owned by the MBTA. The alignment shown in **Figure 9-65** would be similar for both the 0.06 MG and 0.16 MG storage options described in **Table 9-69**. The storage conduit would be below-grade; however, the dewatering pump station and odor control facility would likely require small, above-ground structures.

In addition, truck access would be required for system maintenance including cleaning activities following storm events.

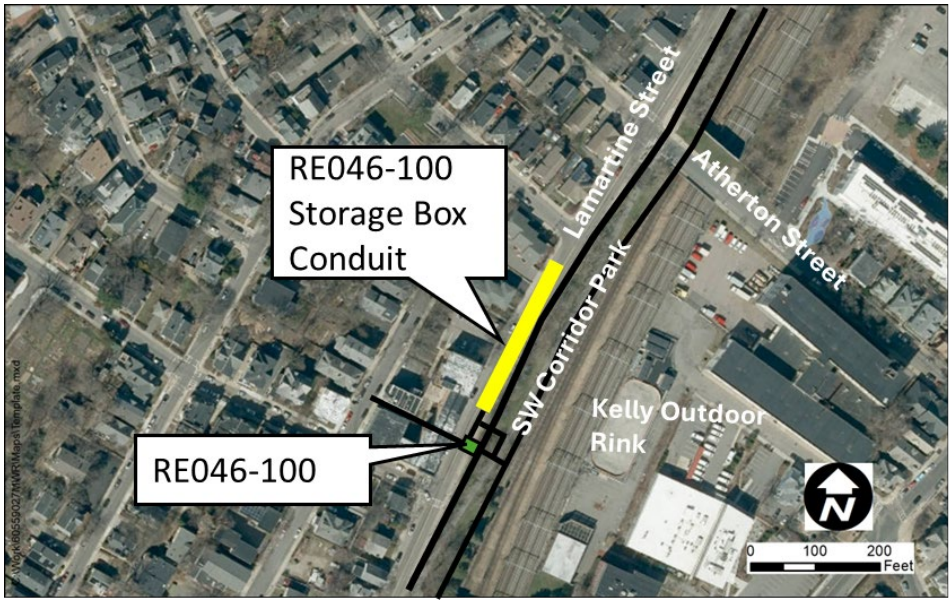



**Figure 9-65. Storage Conduit at RE046-100 (MWR023)**

**Figure 9-66** presents the conceptual layout for the 0.08 MG storage conduit for RE046-381. The storage conduit would be underground on land owned by MBTA adjacent to Johnson Park which is under DCR control. The dewatering pump station and odor control facility would likely require small, above-ground structures. In addition, truck access would be required for system maintenance including tank cleaning activities following storm events.

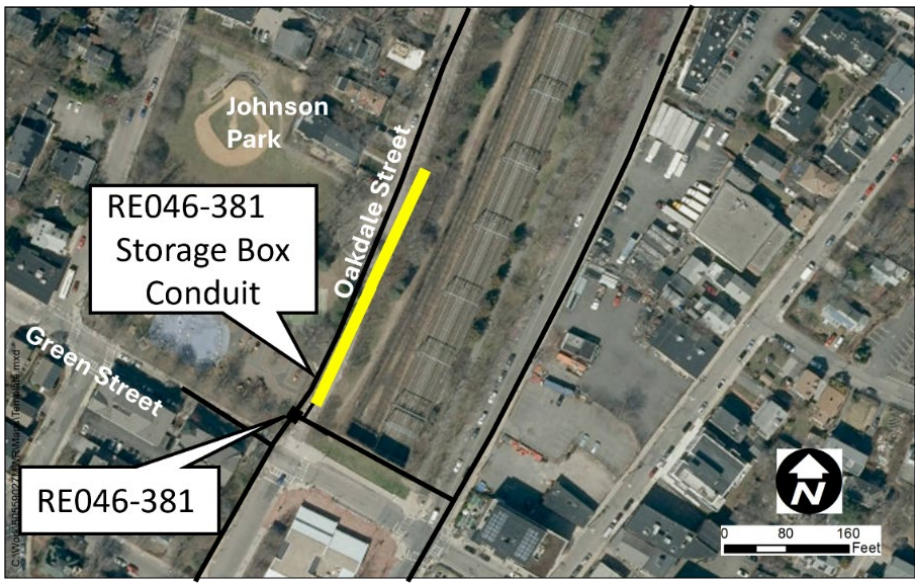



**Figure 9-66. 0.08 MG Storage Conduit at RE046-381 (MWR023)**

CSO volumes at RE046 regulator for the 2050 5-year and 25-year storms are presented below in **Table 9-70**. As indicated in **Table 9-70**, a total of 1.05 MG of storage from five regulators is required to capture the volume for the 2050 5-year storm event, and 2.27 MG of storage from a total of eight regulators is needed for the 2050 25-year storm.

**Table 9-70. RE046 Regulator CSO Activations to the Stony Brook Conduit in the 2050 5-Year and 25-Year Storms – Before and After Storage**

| | 2050 5-Year Storm | | 2050 25-Year Storm | |
|---|---|---|---|---|
| | Baseline Conditions | 1.05 MG Storage | Baseline Conditions | 2.27 MG Storage |
| | CSO Volume (MG)(1) | Remaining CSO Volume (MG)(1) | CSO Volume (MG)(1) | Remaining CSO Volume (MG)(1) |
| RE046-19 | 0.00 | 0.00 | 0.03 | 0.00 |
| RE046-30 | 0.00 | 0.00 | 0.02 | 0.00 |
| RE046-54 | 0.04 | 0.00 | 0.02 | 0.00 |
| RE046-55 1 | 0.07 | 0.00 | 0.31 | 0.00 |
| RE046-62A | 0.00 | 0.00 | 0.07 | 0.00 |
| RE046-100 | 0.51 | 0.00 | 0.66 | 0.00 |
| RE046-105 | 0.01 | 0.00 | 0.15 | 0.00 |
| RE046-381 | 0.42 | 0.00 | 1.01 | 0.00 |
| **SUM** | **1.05** | **0.00** | **2.27** | **0.00** |

**Note:**

(1) Model results are based on the baseline conditions model. Model results may vary when evaluated in conjunction with other projects that are hydraulically connected.

For the 2050 5-year LOC, the five regulators tributary to MWR023 that activate near one another, running parallel to Lamartine St and Southwest Corridor Park. As such, individual storage conduits were not considered and instead, a 1.05 MG microtunneled storage conduit was investigated which would capture CSO from all of the active regulators in one storage facility. **Figure 9-67** presents a conceptual layout for the 1.05 MG microtunneled storage conduit. The microtunnel could be constructed in the public right-of-way adjacent to Southwest Corridor Park, which is owned by the MBTA, and would have to pass under the Southwest Corridor tracks near Centre Street. The dewatering pump station and odor control facility would likely require small, above-ground, permanent structures at the upstream and downstream ends. In addition, truck access would be required for system maintenance including cleaning activities following storm events. As indicated in **Figure 9-67**, the preliminary layout includes a 5,450-foot long, 6-foot diameter microtunnel, with a 1.05 MGD dewatering pump station.




**Figure 9-67. 1.05 MG Microtunneled Storage Conduit for RE046 Regulators - 2050 5-Year Level of Control**

As shown in **Table 9-70**, eight RE046 regulators activate in the 2050 25-year storm event for a total of 2.27 MG. Six of these regulators are the same regulators that could be captured by the microtunnel storage presented for the 2050 5-year level of control above. The two additional regulators that activate, RE046-19 and RE046-30, are located more than half a mile away. As a result, the 2.27 MG of storage needed was split between two storage conduits. A microtunneled storage conduit would capture the overflow from regulators RE046-381, 100, 105, 62A, 54 and 55-1, resulting in a volume of 2.22 MG while RE046-19 and RE046-30 would be controlled by a 0.05 MG storage conduit installed by open-cut construction. The layout of the microtunneled storage conduit would be similar to the microtunnel described for the 5-year storm, but the diameter would be increased to 9 feet, and the dewatering pump station capacity would be increased to 2.22 MGD.

**Figure 9-68** presents the conceptual layout for the 0.05 MG storage conduit, which would be located along St. Joseph and South Streets, adjacent to St. Thomas Aquinas Parish in Jamaica Plain. The preliminary layout includes an 815-foot long, 4-foot wide by 4-foot tall box conduit with a 0.05 MGD dewatering pump station. The dewatering pump stations and odor control facilities would likely require

small, above-ground, permanent structures. In addition, truck access would be required for system maintenance including cleaning activities following storm events.




**Figure 9-68. 0.05 MG Storage Conduit for RE046-19 and RE046-30 - 2050 25-year Level of Control**

**Conveyance**

The regulators in the Stony Brook System convey dry weather flow to either the Southwest Corridor Interceptor or the Stony Brook Interceptor, both of which are tributary to Ward Street Headworks through the Boston Main Drain Relief Sewer. Localized conveyance relief along these interceptors downstream of the active regulators was predicted to increase activations and volumes at other regulators further downstream along the interceptors. Relieving the interceptors all the way to Ward Street Headworks would have limited benefit as Ward Street Headworks would not have capacity to accept additional flow from those interceptors. For these reasons, conveyance relief was not evaluated further for these regulators.

### 9.8.7 CAM017

**Table 9-71** provides a summary of CSO discharges at CAM017.

**Table 9-71. CAM017 Summary of CSO Discharges – Baseline Conditions**

| | Baseline Conditions[1] | | |
|---|---|---|---|
| | 2050 TY CSO Start Date/Volume (MG) | 2050 5-Year Storm Volume (MG) | 2050 25-Year Storm Volume (MG) |
| **Baseline CSO volume per event[2]** | 12/17: 0.55<br>06/7: 0.21<br>06/12: 0.16 | **12.54** | **24.96** |
| **Baseline CSO activations** | **3** | | |
| **Baseline CSO total volume (MG)** | **1.04** | | |

**Notes:**

(1) Model results are based on the baseline conditions model. Model results may vary when evaluated in conjunction with other projects that are hydraulically connected.

(2) Individual storms are presented in order of decreasing volumes and may not add to the total volume due to rounding and/or small inconsistencies when models are run in different environments. This discrepancy may be more pronounced for CAM017 than other outfalls, as small changes in the hydraulic gradeline can activate the pumps at Prison Point earlier or later in a given storm.

### Separation

Sewer separation was modeled to determine what portion of the 190 acre tributary area would need to be separated to achieve 0 CSOs in the 2050 TY. It was determined that an 80-acre portion of the CAM017 contributing area that drains to Hampshire Street could be separated, with stormwater connecting to the Broadway drain after the Broadway Drain Extension project is complete. Any additional sewer separation would not be accommodated the Broadway Drain Extension, even though it was built at the maximum capacity feasible, and there is no space for an additional stormwater drain pipe in the existing corridor. The identified 80 acres of sewer separation would eliminate the three (3) CSO activations in the 2050 TY (See **Figure 9-69)**. The additional stormwater may require treatment for removal of phosphorous and/or other pollutants of concern. Due to the scale of this sewer separation work, Cambridge anticipates opportunities to implement GSI and street corridor improvements within the project area, which will be evaluated during design. This sewer separation is incorporated into CAM017 CSO control alternatives and will further the City of Cambridge's long-term commitment to sewer separation.

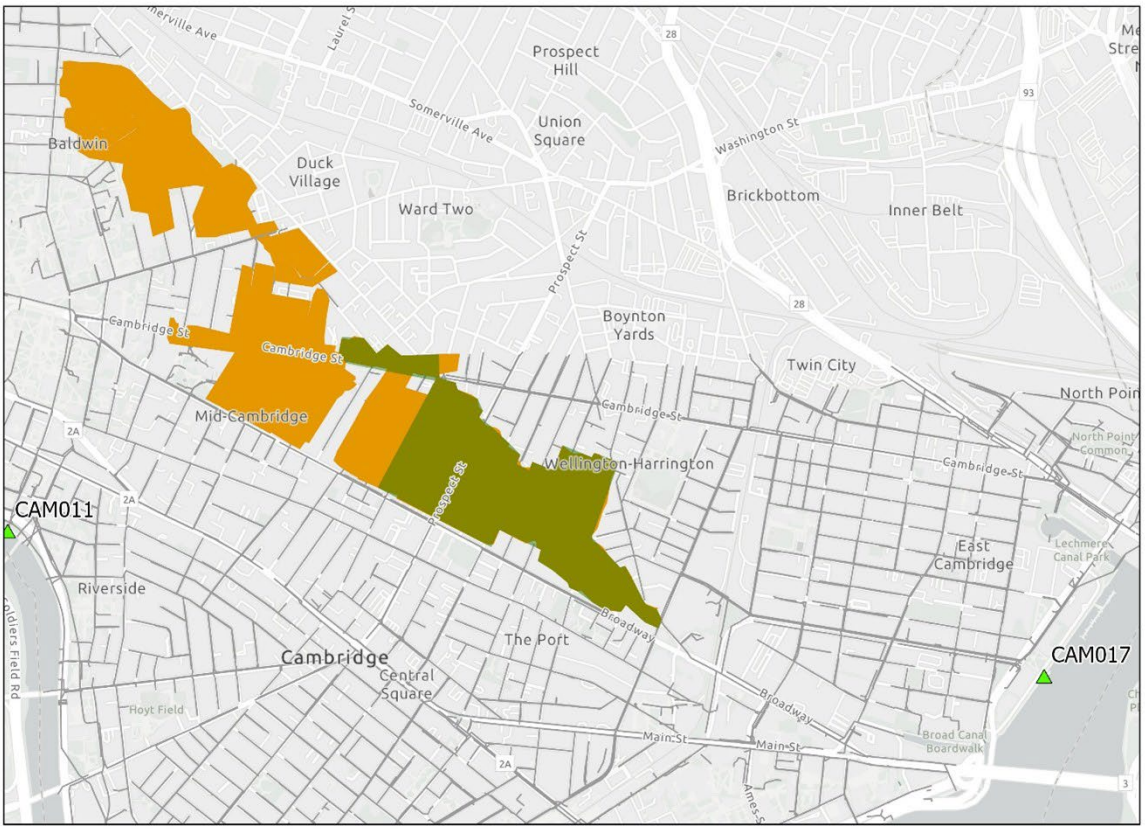



**Figure 9-69. CAM017 Tributary Combined Sewer (190 ac) and Smaller Separation Area (80 ac)**

Sewer separation in Charlestown was also evaluated. Charlestown is outside of Cambridge, southeast of the area shown in **Figure 9-69** above, and although it is not directly tributary to CAM017, separation of this area would lower the hydraulic gradeline in the MWRA system at Prison Point, which directly impacts overflows at CAM017. Charlestown is 845 acres, part of which is already separated. Simulating full Charlestown separation (with no other upstream separation in Cambridge) resulted in reduction of CAM017 spills to one spill of 0.08 MG in the 2050 TY, which could be addressed locally with storage or separation. Charlestown separation also removes one spill at Cottage Farm and reduces total volume spilled at Prison Point by 31 MG.

**Storage**

Off-line storage of CSO volumes that overtop the CAM017 regulator would require a diversion weir and approximately 100-150 linear feet of 30-inch diameter sewer to a storage tank in the Cambridge-owned Front Park, or alternatively in Land Boulevard adjacent to the regulator. The tank would be approximately 0.6 MG to contain the largest CSO volume (see **Table 9-71**) to eliminate all three CSO activations in the 2050 TY. Off-line CSO storage was initially included in the early alternatives developed, but subsequent alternatives instead address CAM017 CSOs through sewer separation to further Cambridge's long-term separation objectives. Off-line storage in the 2050 5-year and 25-year storms were consolidated to regional storage solutions discussed in **Section 9.8.8**.

In-line storage was not evaluated for CAM017 as there are many low-lying neighborhoods, such as the Port, with historic flooding issues in storms less than the 2050 TY. In-line storage requires upsizing pipe sizes to create capacity, and in these dense, low-lying neighborhoods, there isn't sufficient elevation or physical space available for upsizing.

### Conveyance

Conveyance was not considered for CAM0017 because the only location to convey flows would be the MWRA North Charles Relief Sewer downstream and the ability to accept conveyed flows is limited because those interceptors are already full in the larger TY rain events. Lowering the downstream hydraulic gradeline would require regional improvements through storage, further downstream conveyance, and/or modification to facility operation such as modifying the control rules at Prison Point to reduce hydraulic gradelines in the interceptor. A backflow preventer on the MWRA interceptor was evaluated, but it did not reduce CSO activations at CAM017 and only slightly reduced CSO volume compared to Baseline Conditions.

## 9.8.8 Charles River Regional

**Table 9-72** provides a summary of CSO discharges to the Charles River for the 2050 TY, 5-year, and 25-year storms. Technologies investigated to address CSOs to the Charles River at a regional level included sewer separation and storage.

**Table 9-72. Charles River Baseline Conditions Volumes and Activations**

| Charles River Outfall | Baseline Conditions | | | |
|---|---|---|---|---|
| | 2050 TY Activation Frequency | 2050 TY Annual Volume (MG) | 5-Year Storm Volume (MG) [1] | 25-Year Storm Volume (MG) [1] |
| CAM005 | 6 | 0.73 | 1.61 | 4.13 |
| CAM007 | 0 | 0 | 5.92 | 15.72 |
| CAM017 | 3 | 1.04 | 12.54 | 24.96 |
| MWR018 | 4 | 1.86 | 2.14 | 3.24 |
| MWR019 | 3 | 1.33 | 1.63 | 2.48 |
| MWR020 | 3 | 3.14 | 6.21 | 9.86 |
| MWR023 | 6 | 0.13[2] [3] | 0.26[2] [4] | 0.57[2] [5] |
| MWR010 | 0 | 0.00 | 1.32 | 3.62 |
| MWR201 (Cottage Farm - Treated) | 4 | 29.81 | 33.84 | 55.92 |
| **Max/Sum** | **6** | **38.04** | **65.46** | **120.5** |
| **Treated** | **4** | **29.81** | **33.84** | **55.92** |
| **Untreated** | **6** | **8.23** | **31.62** | **64.58** |

**Notes:**

(1) Model results are based on the baseline conditions model. Model results may vary when evaluated in conjunction with other projects that are hydraulically connected.

(2) Values represent the portion of CSO discharge to the Charles River from the 046 regulators that activate and discharge at outfall MWR023 when Boston Gatehouse No. 1 is open. Approximately 25% of the volume from the 046 regulators discharges at outfall MWR023 when Boston Gatehouse No. 1 is open.

(3) RE046 regulators that activate in the 2050 TY include RE046-100 and RE046-381.

(4) RE046 regulators that activate in the 2050, 5-year storm include RE046-54, RE046-55-1, RE046-100, RE046-105, and RE046-381.

(5) RE046 regulators that activate in the 2050, 25-year storm include RE046-19, RE046-30, RE046-54, RE046-55-1, RE046-62A, RE046-100, RE046-105, and RE046-381.

### Sewer Separation

Sewer separation was considered as a regional alternative for the approximately 3,600 acres of combined sewer area tributary to the Charles River CSO outfalls. The work would include separating approximately 1,155 acres of combined sewer area in Cambridge, 1,045 acres in Somerville, and 481 acres in Boston. In addition, there are some areas—about 182 acres in Cambridge and 695 acres in Boston—have already begun undergoing separation but currently return to the combined sewer system and would therefore require rerouting (and treating) the stormwater. Thus, the total area requiring work under this alternative would be approximately 3,600 acres. As described in **Section 9.2.4**, sewer separation was assumed to remove 90% of the inflow from the combined sewer system. **Table 9-73** presents a comparison of the CSO activation frequencies and volumes for the Charles River for the 2050 TY, and

the 2050 5-year and 25-year storms for Baseline Conditions versus with regional sewer separation tributary to the Charles River.

**Table 9-73. Charles River 2050 Typical Year Baseline Conditions vs. Sewer Separation**

| | Baseline Conditions[1] | | Regional Sewer Separation | | Baseline Conditions[1] | | Regional Sewer Separation | |
|---|---|---|---|---|---|---|---|---|
| | 2050 TY | | 2050 TY | | 5-Year Storm | 25-Year Storm | 5-Year Storm | 25-Year Storm |
| Outfall | Activation Frequency | Volume (MG) | Activation Frequency | Volume (MG) | Volume (MG) | Volume (MG) | Volume (MG) | Volume (MG) |
| **Charles River** | | | | | | | | |
| CAM005 | 6 | 0.73 | 0 | 0.00 | 1.61 | 4.13 | 0.00 | 0.39 |
| CAM007 | 0 | 0.00 | 0 | 0.00 | 5.92 | 15.72 | 0.00 | 1.62 |
| CAM017 | 3 | 1.04 | 0 | 0.00 | 12.54 | 24.96 | 0.00 | 0.00 |
| MWR010 | 0 | 0.00 | 0 | 0.00 | 1.31 | 3.62 | 0.19 | 2.16 |
| MWR018 | 4 | 1.86 | 0 | 0.00 | 2.14 | 3.24 | 0.00 | 0.37 |
| MWR019 | 3 | 1.33 | 0 | 0.00 | 1.63 | 2.48 | 0.00 | 0 |
| MWR020 | 3 | 3.14 | 0 | 0.00 | 6.21 | 9.86 | 0.00 | 0 |
| MWR201 (Cottage Farm) | 4 | 29.81 | 1 | 0.03 | 33.84 | 55.92 | 17.66 | 32.21 |
| MWR023 | 6 | 0.13[2] [3] | 6 | 0.12[3] | 0.26[2] [4] | 0.57[2] [5] | 0.23[2] [4] | 0.52[2] [5] |
| **Charles River Max/Total** | **6** | **38.04** | **6** | **0.15** | **65.46** | **120.50** | **18.08** | **37.27** |

**Notes:**
(1) Model results are based on the baseline conditions model. Model results may vary when evaluated in conjunction with other projects that are hydraulically connected.
(2) Values represent the portion of CSO discharge to the Charles River from the 046 regulators that activate and discharge at outfall MWR023 when Boston Gatehouse No. 1 is open. Approximately 25% of the volume from the 046 regulators discharges at outfall MWR023 when Boston Gatehouse No. 1 is open.
(3) RE046 regulators that activate in the 2050 TY include RE046-100 and RE046-381.
(4) RE046 regulators that activate in the 2050, 5-year storm include RE046-54, RE046-55-1, RE046-100, RE046-105, and RE046-381.
(5) RE046 regulators that activate in the 2050, 25-year storm include RE046-19, RE046-30, RE046-54, RE046-55-1, RE046-62A, RE046-100, RE046-105, and RE046-381.

As indicated in **Table 9-73**, regional sewer separation for the Charles River was predicted to eliminate untreated CSO discharges from most of the outfalls in the 2050 TY; 0.03 MG of treated discharge was predicted to remain at outfall MWR201 (Cottage Farm facility), and 0.12 MG of untreated discharge was predicted to remain at outfall MWR023.

In the 2050 5-year storm, the remaining treated volume at outfall MWR201 is predicted to be 17.66 MG, and the remaining untreated volume is predicted to be 0.42 MG from outfalls MWR023 and MWR010. In the 2050 25-year storm, the remaining treated volume at outfall MWR201 is predicted to be 32.21 MG, and the remaining untreated volume is predicted to be 5.06 MG across multiple outfalls. CAM017,

MWR019, and MWR020 are the only CSO outfalls not predicted to activate to the Charles River in the 2050 25-year storm.

New conveyance systems would be constructed to convey the stormwater to the Charles River. While flow attenuation would not be necessary for the new stormwater discharging to the Charles River, stormwater treatment would be needed. Regional sewer separation was carried forward as a possible CSO control alternative for further evaluation.

**Storage**

Regional storage in the form of a consolidated storage tunnel that would capture the volume from CSO outfalls along the Charles River was carried forward as a possible CSO control alternative for further evaluation. In-line storage would not be effective regionally because during CSO events, the interceptor systems that service the Charles River tributary area are surcharged, with no capacity available in the pipes for in-line storage. As a result, regional in-line storage was not considered further.

For the consolidated off-line storage tunnel alternative, diversion structures would be provided to divert CSO from each outfall to the tunnel. As described above in **Section 9.8.5**, for the outfall MWR018/019/020 storage conduit, the diversion structures for these outfalls would be configured to efficiently move flow into the storage tunnel, resulting in lower peak hydraulic grade lines along the BMC. A consequence of this hydraulic efficiency, however, would be that the volume to be captured in the storage conduit would be slightly higher compared to the baseline conditions. A similar condition would exist with the diversion structure for outfall CAM007. Due to the limited space between the CAM007 regulator weir and the outfall headwall along the bank of the Charles River, the overflow at outfall CAM007 would need to be captured by drawing down the water level in the North Charles Relief Sewer. As a result, the volume diverted into the storage tunnel would be larger than the Baseline Conditions discharge volume at outfall CAM007.

The volume to the tunnel at outfalls MWR010 and MWR201 also increases compared to the Baseline Conditions volumes. At outfall MWR010, relocation of one of the regulators to facilitate connection to the conveyance pipe to the drop shaft would affect the volume to the tunnel in the 2050 5-year and 25-year storms, while at outfall MWR201, the volume to the tunnel increased because the diversion to the tunnel from the existing Cottage Farm CSO Facility influent gate structure would bypass the existing Cottage Farm CSO Facility tanks.

Two configurations for a regional storage tunnel were considered for the Charles River. The first configuration would capture the overflows from outfalls MWR201, MWR018, MWR019, and MWR020, and was sized for 0 CSOs in the 2050 TY. A representation of this tunnel configuration is presented as part of Alternative 1.CR in **Figure 9-72.** The second configuration would capture the overflows from all the Charles River CSO outfalls. Versions of this configuration were sized for the 2050 TY, 2050 5-year and 2050 25-year LOC. The version sized for the 2050 TY would not pick up outfalls MWR010 and CAM007, which are not active in the 2050 TY. A representation of this tunnel configuration is presented as part of Alternative 10.CR in **Figure 9-80**.

**Table 9-74** presents a summary of the CSO discharges to the Charles River for each storm in the 2050 TY for outfalls MWR201, MWR018, MWR019, and MWR020 for baseline conditions, and the volume of CSO to be captured in the tunnel assuming the additional hydraulic capacity at the diversion structures noted above.

**Table 9-74. Charles River 2050 Typical Year Baseline Conditions CSO Volumes, and Volumes Diverted to Storage for Outfalls MWR201, MWR010, MWR018, MWR019, and MWR020**

| | Volume (MG) [1] | |
|---|---|---|
| 2050 TY Date of Activation | Baseline Conditions | Volume Diverted to Storage[2] |
| 6/7 | 13.33 | 17.18 |
| 12/17 | 13.37 | 16.22 |
| 6/12 | 4.96 | 9.09 |
| 4/22 | 4.49 | 6.43 |
| **Max** | **13.37** | **17.18** |

**Notes:**

(1) Model results are based on the baseline conditions model. Model results may vary when evaluated in conjunction with other projects that are hydraulically connected.

(2) Individual storms are presented in order of decreasing volume to storage.

As indicated in **Table 9-74**, approximately 17.2 MG of storage capacity is required for the storage tunnel to achieve a 2050 TY level of control for outfalls MWR201, MWR018, MWR019, and MWR020. A deep rock, TBM-bored storage tunnel to provide 17.2 MG of storage for those outfalls would be approximately 11,700 feet long, with a finished inside diameter of 17 feet. The route would begin from a mining shaft in parkland adjacent to the MWRA's Cottage Farm CSO Facility, cross under the Charles River, and run under the Esplanade to a TBM removal shaft located north of the Union Boat Club Boathouse. Most of the construction activity would be focused at the mining shaft, where excavated material would be removed to the surface for disposal. Based on preliminary geotechnical information, the tunnel would be constructed entirely in rock, over 300 feet deep, due to the depth of soft clays under the Charles River. The vertical alignment of the tunnel would be refined following more detailed geotechnical investigations.

The mining shaft in the parkland adjacent to the Cottage Farm facility would be approximately 50 feet in inside diameter while the TBM removal shaft would be approximately 35 feet in inside diameter. Once the tunnel construction was completed, screening equipment would be installed in the mining shaft upstream of the dewatering pump station. Ventilation and odor control equipment would be provided at the upstream TBM removal shaft.

The tunnel dewatering pump station would be constructed underground in a cavern constructed in the bedrock, with two access shafts to the surface. An approximately 100 x 100-foot building would be provided at the surface over the access shafts. The pump station would have a capacity of approximately 17.2 MGD, to allow the contents of a full tunnel to be dewatered in one day. The pump station would discharge to a force main that would tie into the MWRA's interceptor system adjacent to the existing Cottage Farm CSO Facility.

As noted above, the existing weir structures along the outfall pipes for outfalls MWR018/019/020 would be modified to create diversion structures to divert flow to the tunnel, while allowing CSO to continue to discharge in larger storm events if the tunnel was full. The diversion structures may include gates that would be triggered to close when the tunnel is full. At the existing Cottage Farm CSO Facility, flow would be diverted to the tunnel from a connection to the existing facility influent gate structure. An overflow connection would be provided from the mining shaft to the Charles River to provide relief if the tunnel filled to capacity.

Flow from the diversion structures would be conveyed to drop shafts, where the flow would be conveyed down to the storage tunnel. It is anticipated that individual drop shafts would be provided for each outfall (MWR201, MWR018, MWR019 and MWR020). Once the drop shafts are constructed, the sites would be restored with manhole covers/hatches at grade to allow access.

The second configuration for the regional storage tunnel would extend in each direction to also capture overflows from outfalls CAM005, CAM007, MWR010 and CAM017. **Table 9-75** presents a summary of the CSO discharges to the Charles River for each storm in the 2050 TY and the 2050 5-year and 25-year storms with the exception of MWR023 for Baseline Conditions, and the volume of CSO to be captured in the tunnel assuming the additional hydraulic capacity at the diversion structures as noted above. The version sized for the 2050 TY would not pick up outfalls MWR010 and CAM007, which are not active in the 2050 TY.

**Table 9-75. Summary of Charles River CSO Activations with and without Regulator Adjustments to Divert Flow to Storage; Outfalls: CAM005, CAM007, MWR201, MWR010, MWR018, MWR019, MWR020, and CAM017[1][3]**

| | Largest Volume from Single Storm in 2050 TY[2] | | 2050 5-Year | | 2050 25-Year | |
|---|---|---|---|---|---|---|
| | Baseline Conditions (MG) | Volume Diverted to Storage (MG)[4] | Baseline Conditions (MG) | Volume Diverted to Storage (MG)[4] | Baseline Conditions (MG) | Volume Diverted to Storage (MG)[4] |
| CAM005 | 0.00 | 0.00 | 1.61 | 1.14 | 4.13 | 3.40 |
| CAM007 | 0.00 | 0.00 | 5.92 | 8.16 | 15.72 | 19.36 |
| MWR201 | 10.12 | 12.95 | 33.84 | 35.20 | 55.92 | 57.98 |
| MWR010 | 0.00 | 0.00 | 1.31 | 1.55 | 3.62 | 4.59 |
| MWR018 | 0.92 | 2.13 | 2.14 | 5.54 | 3.24 | 8.58 |
| MWR019 | 0.67 | 0.91 | 1.63 | 2.59 | 2.48 | 4.08 |
| MWR020 | 1.62 | 1.28 | 6.21 | 5.47 | 9.86 | 9.36 |
| CAM0017 | 0.70 | 0.54 | 12.54 | 12.25 | 24.96 | 24.77 |
| **Storage Tunnel Volume (MG)[3]** | **14.03** | **17.81** | **65.2** | **71.9** | **119.9** | **132.1** |

**Notes:**

(1) Model results are based on the baseline conditions model. Model results may vary when evaluated in conjunction with other projects that are hydraulically connected.

(2) 2050 TY volumes represent the storm event that resulted in the largest storage tunnel volume.

(3) Volumes at individual outfalls may not add to the total volume due to rounding and/or small discrepancies when models are run in different environments.

(4) The volume diverted to storage accounts for modifications to the regulator structures.

As indicated in **Table 9-75**, approximately 17.8 MG of storage capacity is required for the storage tunnel to achieve a 2050 TY LOC. A deep rock, TBM-bored storage tunnel to provide 17.8 MG of storage for those outfalls would be approximately 23,700 feet long, with a finished inside diameter of 12 feet. **Figure 9-70** presents the approximate alignment of the tunnel route. The tunnel would consist of an east and a west branch. The route of the east branch would begin at a mining shaft in parkland adjacent to the MWRA's Cottage Farm CSO Facility, cross under the Charles River, run under the Esplanade past outfall MWR020, then cross back under the Charles River to a TBM removal shaft located adjacent to outfall CAM017. The west branch would run from the same mining shaft adjacent to the Cottage Farm Facility about parallel to the riverbank, to a TBM removal shaft adjacent to outfall CAM005. Other components of the tunnel such as diversion structures, drop shafts, mining and retrieval shafts, and dewatering would be similar to those described for the tunnel from outfalls MWR201 to MWR020. Odor control facilities would be provided at the TBM removal shafts adjacent to outfalls CAM005 and CAM017.

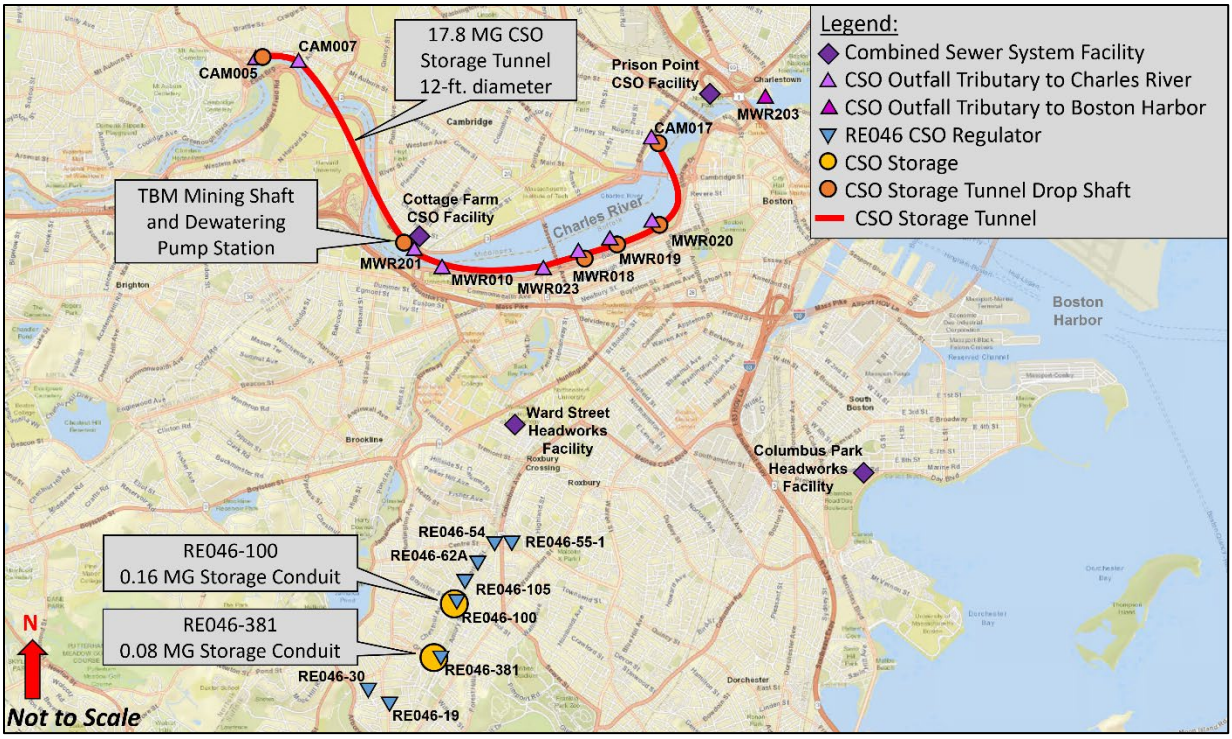



**Figure 9-70. Charles River Tunnel (0 CSOs in 2050 TY)**

For the 2050 5-year and 25-year LOCs, the project components would be similar to those for the 2050 TY except that the size of each component would increase with the level of control and CSOs from outfalls CAM007 and MWR010 would be stored in the tunnel. For the 2050 5-year storm, the tunnel diameter would increase to 24 feet, and for the 2050 25-year storm, the tunnel diameter would increase to 32 feet.

### 9.8.9 Summary of CSO Control Technology Screening for the Charles River

As a result of the preliminary screening of CSO control technologies described above, **Table 9-76** presents the technologies that were carried forward into alternatives development. Technologies that were carried forward for more detailed evaluation for at least one level of control are indicated with a check mark (✓) and technologies that were not considered for further evaluation are indicated with a hyphen (-).

### Table 9-76. CSO Control Technologies Carried Forward for Evaluation in the Charles River System

| Outfall | Sewer Separation | Green Stormwater Infrastructure (GSI) | Infiltration/ Inflow (I/I) Reduction | Storage | Conveyance | Treatment |
|---|---|---|---|---|---|---|
| CAM005 | ✓ | ✓ | - | ✓ | - | - |
| CAM007(1) | | - | - | ✓ | - | - |
| CAM017 | ✓ | ✓ | - | ✓ | - | - |
| MWR010(1) | - | - | - | ✓ | - | - |
| MWR018 | ✓ | ✓ | - | ✓ | - | - |
| MWR019 | ✓ | ✓ | - | ✓ | - | - |
| MWR020 | ✓ | ✓ | - | ✓ | - | - |
| MWR201 | - | - | - | ✓ | - | - |
| MWR023 | - | - | - | ✓ | - | - |
| Regional Charles | ✓ | ✓ | - | ✓ | - | - |

**Notes:**

(1) Outfalls CAM007 and MWR010 do not activate in the 2050 TY and therefore were not evaluated individually for CSO control in the 2050 TY. These outfalls were only included in regional alternatives for CSO control in larger design storms.

"✓"- Indicates technology carried forward for more detailed evaluation.

"–" Indicates technology was not considered for further evaluation.

For the 2050 5-year and 25-year LOCs, siting of individual storage facilities for each outfall was considered to be infeasible due to the size of the storage tanks required. Thus, CSO capture in a consolidated storage tunnel with or without regional GSI implementation was carried forward for further evaluation for those levels of control. Sewer separation of the combined sewer area tributary to the Charles River was also carried forward as a regional alternative.

The following sections describe how these CSO control technologies were combined to create alternatives to achieve the 0 CSO in 2050 TY, Limited CSOs in the 2050 TY, and the 2050 5-year and 25-year levels of control for the Charles River.

## 9.9 Charles River – CSO Control Alternatives

This section describes how the CSO control technologies were combined to create alternatives for each level of control in the Charles River. This is the third step as illustrated previously in **Figure 9-1**, shown again in **Figure 9-71**. Thirteen CSO control alternatives were developed for the Charles River. Six were developed for the 2050 TY level of control, two for the Limited CSOs in the 2050 TY level of control, two for the 5-year level of control, and two for the 25-year level of control. One regional sewer separation alternative was also developed. The 2050 TY level of control had the most alternatives because a wider range of CSO control technologies were found to be applicable. The Limited CSOs in the 2050 TY level of control includes only two alternatives which focus on combinations of sewer separation and storage. To meet the 5-year and 25-year levels of control storage tunnels were required which limited the number of alternatives. Storage alternatives were evaluated with and without GSI.

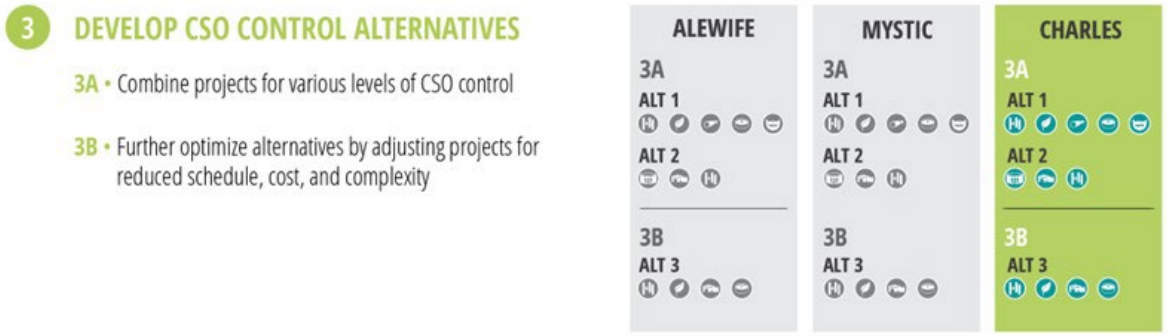



**Figure 9-71. Alternative Development Step 3 (Charles River)**

### 9.9.1 Alternative 1.CR Integrated (0 CSOs in 2050 TY)

Alternative 1.CR Integrated represents the first attempt to combine CSO control technologies at the individual outfall level, as proposed by each Partner, and includes a combination of storage tanks, storage conduits, a storage tunnel, and underflow restriction.

**Table 9-77** presents, for each outfall, the Baseline Conditions 2050 TY activations and volumes, the project components, the estimated capital cost, and the estimated project duration. A schematic layout of the components of this alternative is presented in **Figure 9-72**.

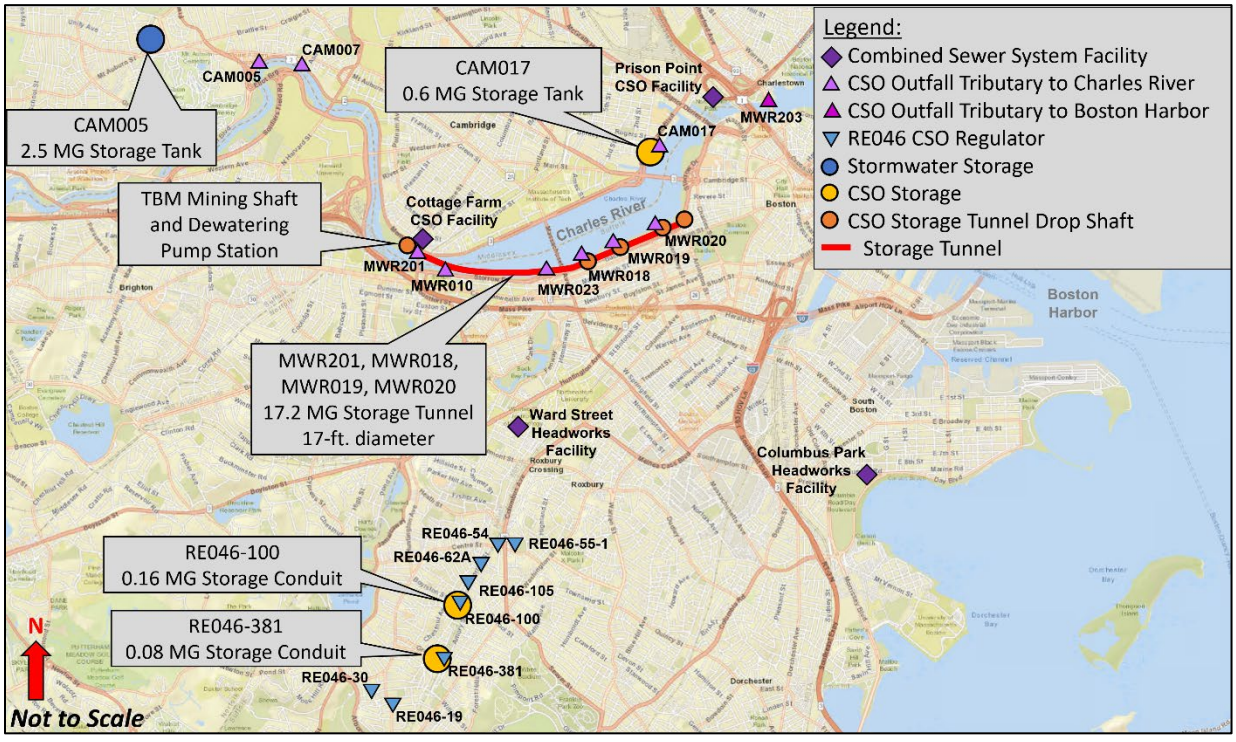
**Table 9-77. Alternative 1.CR Integrated (0 CSOs in 2050 TY) Summary**

| Charles River Outfall | Baseline 2050 Typical Year | | Alternative Description | Preliminary Capital Cost[2] ($million) | Project Duration[3] (years) |
|---|---|---|---|---|---|
| | Activation Frequency | Volume (MG) | | | |
| CAM005 | 6 | 0.73 MG | 2.5 MG storage with underflow restrictions | $83 M | 5 |
| CAM007 | 0 | 0 MG | No action | N/A[1] | N/A |
| MWR201 (Cottage Farm - Treated) | 4 | 30.12 MG | 17.2 MG storage tunnel to store MWR201, MWR018, MWR019, and MWR020 | $940 M | 12 - 15 |
| MWR010 | 0 | 0 MG | No action | N/A | N/A |
| MWR018 | 4 | 1.86 MG | See MWR201 (Cottage Farm) above | See MWR201 (Cottage Farm) Above | See MWR201 (Cottage Farm) Above |
| MWR019 | 3 | 1.33 MG | | | |
| MWR020 | 3 | 3.14 MG | | | |
| CAM017 | 3 | 1.04 MG | 0.6 MG storage tank | $27 M | 5 |

## Table 9-77. Alternative 1.CR Integrated (0 CSOs in 2050 TY) Summary

| Charles River Outfall | Baseline 2050 Typical Year | | Alternative Description | Preliminary Capital Cost[2] ($million) | Project Duration[3] (years) |
|---|---|---|---|---|---|
| | Activation Frequency | Volume (MG) | | | |
| MWR023 (RE046-100) | 6 | 0.39 MG | 0.16 MG storage | $11 M | 5 - 7 |
| MWR023 (RE046-381) | 2 | 0.12 MG | 0.08 MG storage | $7.6 M | 5 - 7 |
| **Max/Sum** | **6** | **38.73 MG** | - | **$1,100 M** | **15** |
| **Treated** | **4** | **30.12 MG** | - | - | - |
| **Untreated** | **6** | **8.61 MG** | - | - | - |

**Notes:**
(1) N/A: not applicable.
(2) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.
(3) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.




## Figure 9-72. Alternative 1.CR Integrated (0 CSOs in 2050 TY)

#### 9.9.1.1 Component Descriptions

The individual components of Alternative 1.CR Integrated are described below:

- **CAM005**: To address CSO and flooding objectives for this neighborhood the CSO/Stormwater Hybrid approach was included (**Section 9.8.1**). A 2.5 MG stormwater storage tank would be needed, and a potential location for this large tank would be under the parking lot behind the Collins Branch Library (privately owned) to capture separate stormwater that currently flows into the combined sewer system upstream of outfall CAM005. The connection between the separate stormwater system and the downstream combined system would also be restricted to facilitate diversion of stormwater to the tank and limit the flow of stormwater towards the CAM005 regulator.
- **MWR201/MWR018/019/020:** A 17.2 MG deep rock, TBM-bored storage tunnel would be constructed to provide storage for outfalls MWR201, MWR018, MWR019, and MWR020. The tunnel would be approximately 11,700 feet long with a finished inside diameter of 17 feet. The route would begin from a mining shaft in parkland adjacent to the MWRA's Cottage Farm CSO Facility, cross under the Charles River, and run under the Esplanade to a TBM removal shaft located north of the Union Boat Club Boathouse. The dewatering pump station would be constructed at Magazine Beach Park and the ventilation and odor control equipment would be provided at the upstream TBM removal shaft.

  The existing weir structures along the outfall pipes for outfalls MWR018/019/020 would be modified to create diversion structures to divert flow to the tunnel, while allowing CSO to continue to discharge in larger storm events if the tunnel was full. The diversion structures may include gates that would be triggered to close when the tunnel is full. At the existing Cottage Farm CSO Facility, flow would be diverted to the tunnel from a connection to the existing facility influent gate structure. An overflow connection would be provided from the mining shaft to the Charles River to provide relief if the tunnel filled to capacity.

  Flow from the diversion structures would be conveyed to drop shafts, where the flow would be conveyed down to the storage tunnel. It is anticipated that individual drop shafts would be provided for each outfall (MWR201, MWR018, MWR019 and MWR020). Once the drop shafts are constructed, the sites would be restored with manhole covers/hatches at grade to allow access.

- **CAM017:** A 0.6 MG storage tank would be constructed underground at a site located in Front Park or Land Boulevard, adjacent to the CAM017 outfall. A diversion structure would be constructed along the existing CAM017 outfall to divert wet weather flow to the storage facility. After storm flows subside, the stored flow would be pumped back to the Cambridge Marginal Conduit via a dewatering pump station. If the capacity of the storage tank is exceeded in a larger storm, excess flow would be discharged to the existing CAM017 outfall via the new diversion structure weir. While the tank structure would be underground, a permanent above-ground structure would be required for maintenance access and to house electrical and odor control equipment.
- **RE046-100**: 0.16 MG of storage would be provided to capture the overflow volume from regulator RE046-100. The storage would likely be provided in the form of a storage conduit. A 300-foot long 9x9 foot box conduit would be an example configuration that could provide that volume of storage. The final configuration would be developed as part of additional planning and design. A 0.16 MGD dewatering pump facility would be provided at the low end of the storage conduit. Stored flows would likely be dewatered to the Southwest Corridor Interceptor for conveyance to Ward Street Headworks.
- **RE046-381:** 0.08 MG of storage would be provided to capture the overflow volume from regulator RE046-381. The storage would likely be provided in the form of a storage conduit. A 360-foot long 6x6 foot box conduit would be an example of a configuration that could provide that volume of storage. The final configuration would be developed as part of additional planning and design. A 0.08 MGD dewatering pump facility would be provided at the low end of the storage conduit. Stored flows would likely be dewatered to the Southwest Corridor Interceptor for conveyance to Ward Street Headworks.

#### 9.9.1.2 Implementation Challenges

Challenges to implementing the components of this alternative would include:

CAM005 Storage:

- Easement or acquisition of privately owned parking lot.

MWR201/MWR018/019/020 Storage Tunnel:

- Constructing the mining shaft and dewatering pump station in parkland, and for drop shafts/diversion structures along the Esplanade would require Article 97 legislation to authorize a change of use of the site;
- Tank construction within Magazine Beach Park will require coordination with Eversource who are working to install a major electrical duct bank through the park. Construction impacts and partial loss of public access to Magazine Beach and the Esplanade and challenging truck access to site for construction equipment and removal of excavated material;
- Long-term loss of parkland due to above-ground dewatering pump station building required at Magazine Beach and odor control facility near the Union Club Boat House;
- Long-term maintenance access needed to storage facility, odor control facility, and diversion structures; and
- Permanent loss of park space.

CAM017 Storage:

- Construction of the storage tank on Cambridge-owned Front Park would likely require Article 97 legislation to authorize a change of use of the site; and
- Does not address significant upstream flooding.

RE046-100 Storage:

- RE046-100 would be constructed in public right-of-way adjacent to SW Corridor Park owned by MBTA;
- Construction impacts to park;
- Small above-ground buildings to remain at each site permanently; and
- Long-term maintenance access needed to storage facilities.

RE046-381 Storage:

- RE046-381 would be constructed on land owned by MBTA adjacent to Johnson Park which is under DCR control;
- Construction impacts to park;
- Small above-ground buildings to remain at each site permanently; and
- Long-term maintenance access needed to storage facilities.

### 9.9.2 Alternative 2.CR Hybrid 1 (0 CSOs in 2050 TY)

Alternative 2.CR Hybrid 1 includes a combination of storage tanks, storage conduits, a storage tunnel, partial sewer separation, and underflow restriction. This alternative was based on Alternative 1.CR

Integrated but it replaces the storage at CAM017 with 80 acres of sewer separation based on the City of Cambridge's preference to further the City's long-term commitment to sewer separation. **Table 9-78** presents, for each outfall, the Baseline Conditions 2050 TY activations and volumes, the project components, the estimated capital cost, and the estimated project duration. A schematic layout of the components of this alternative is presented in **Figure 9-73**.

**Table 9-78. Alternative 2.CR Hybrid 1 Summary (0 CSOs in 2050 TY) Summary**

| Charles River Outfall | Baseline 2050 Typical Year | | Alternative Description | Preliminary Capital Cost[4] ($million) | Project Duration[5] (years) |
|---|---|---|---|---|---|
| | Activation Frequency | Volume (MG) | | | |
| CAM005 | 6 | 0.73 MG | 2.5 MG storage with underflow restrictions | $83 M | 5 |
| CAM007 | 0 | 0 MG | No action | N/A[3] | N/A |
| MWR201 (Cottage Farm - Treated) | 4 | 29.81 MG | 17.0 MG storage tunnel to store MWR201, MWR018, MWR019, and MWR020 | $940 M | 12 - 15 |
| MWR010 | 0 | 0 MG | No action | N/A | N/A |
| MWR018 | 4 | 1.86 MG | See MWR201 (Cottage Farm) below | See MWR201 (Cottage Farm) Below | See MWR201 (Cottage Farm) Below |
| MWR019 | 3 | 1.33 MG | | | |
| MWR020 | 3 | 3.14 MG | | | |
| CAM017 | 3 | 1.04 MG | 80 acres sewer separation | $77 M | 10 |
| RE046-100 (MWR023) | 6 | 0.39 MG[1] | 0.16 MG storage | $11 M | 5 - 7 |
| RE046-381 (MWR023) | 2 | 0.12 MG[1] | 0.08 MG storage | $7.6 | 5-7 |
| **Max/Sum** | **6** | **38.04 MG[2]** | **-** | **$1,200 M** | **15** |
| **Treated** | **4** | **29.31 MG** | **-** | **-** | **-** |
| **Untreated** | **6** | **8.73 MG** | **-** | **-** | **-** |

**Notes:**

(1) Volume reflects the full volume over the regulator weir.

(2) Volume reflects that only 25% of the flow over the RE046 regulator weirs would discharge to the Charles River via outfall MWR023

(3) N/A: not applicable.

(4) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.

(5) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

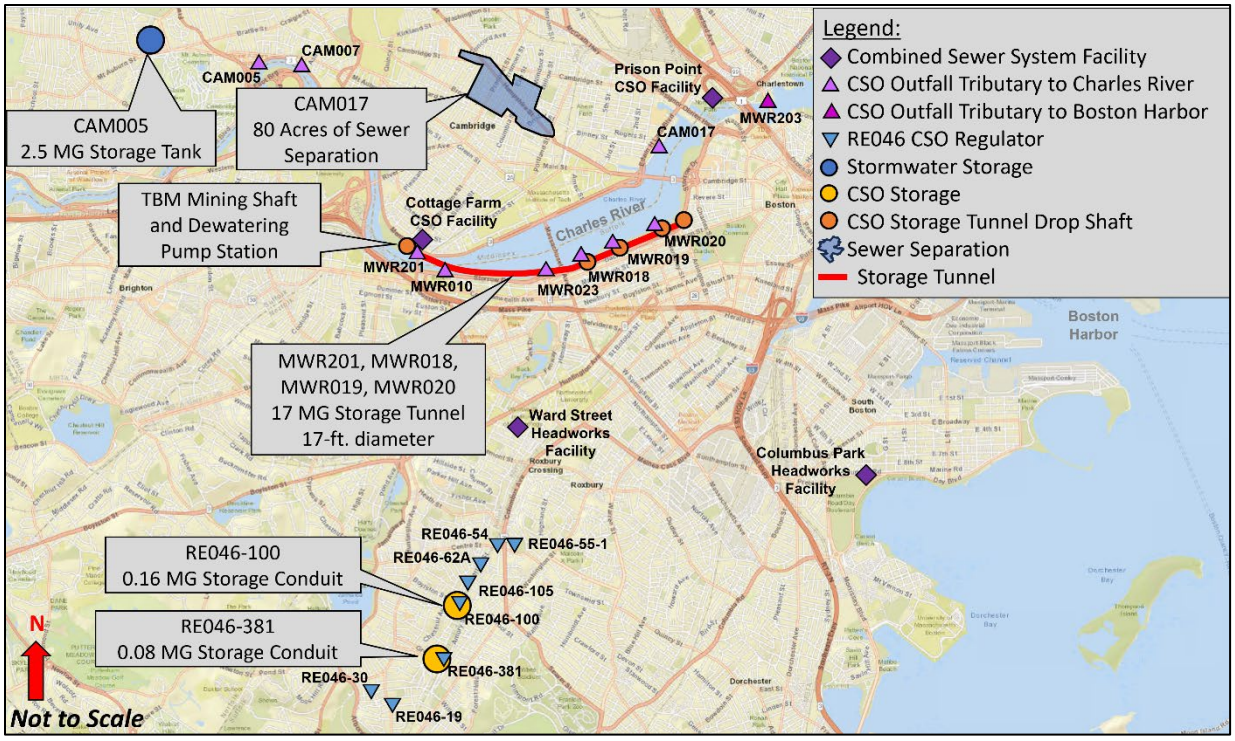



**Figure 9-73. Alternative 2.CR Hybrid 1 (0 CSOs in 2050 TY)**

### 9.9.2.1 Component Descriptions

The individual components of Alternative 2.CR Hybrid 1 are described below:

- **CAM005:** The 2.5 MG stormwater storage tank and flow restriction would be the same as described for Alternative 1.CR Integrated.
- **MWR201/MWR018/019/020:** The storage tunnel and appurtenant components would be the same as described for Alternative 1.CR Integrated. The design volume to capture would be 17.0 MG, a slight reduction from Alternative 1.CR Integrated due to the reduced inflow to the Prison Point tributary system associated with the CAM017 sewer separation project. That slight reduction in design volume would not affect the size of the tunnel components.
- **CAM017:** Approximately 80 acres of combined sewer area in the vicinity of Hampshire Street would be separated, with the separated stormwater connecting to the (future) Broadway Drain. GSI would be included where appropriate.
- **RE046-100 and RE046-381:** The 0.16 MG and 0.08 MG storage conduits for regulators RE046-100 and RE046-381 would be the same as described for Alternative 1.CR Integrated.

### 9.9.2.2 Implementation Challenges

Challenges to implementing the storage components of this alternative would be similar to those described for Alternative 1.CR Integrated. Implementation challenges for implementing the CAM017 sewer separation would include the following:

- Sites have not been identified for stormwater treatment.

### 9.9.3 Alternative 3.CR Hybrid 2 (0 CSOs in 2050 TY)

Alternative 3.CR Hybrid 2 includes a combination of storage tanks, near surface storage conduits, sewer separation, and underflow restriction. This alternative is based on Alternative 2.CR Hybrid 1 reduces the high cost associated with the deep tunnel by replacing it with approximately 200 acres of sewer separation upstream of MWR018/019/020 with microtunneled storage for remaining CSOs from those outfalls, plus a storage tank for outfall MWR201.

**Table 9-79** presents, for each outfall, the Baseline Conditions 2050 TY activations and volumes, the project components, the estimated capital cost, and the estimated project duration. A schematic layout of the components of this alternative is presented in **Figure 9-74**.

**Table 9-79. Alternative 3.CR Hybrid 2 (0 CSOs in 2050 TY) Summary**

| Charles River Outfall | Baseline 2050 Typical Year | | Alternative Description | Preliminary Capital Cost[4] ($million) | Project Duration (years)[5] |
|---|---|---|---|---|---|
| | Activation Frequency | Volume (MG) | | | |
| CAM005 | 6 | 0.73 MG | 2.5 MG storage with underflow restrictions | $83 M | 5 |
| CAM007 | 0 | 0 MG | No action | N/A[3] | N/A |
| CAM017 | 3 | 1.04 MG | 80 acres sewer separation | $77 M | 10 |
| MWR018 | 4 | 1.86 MG | 204 acres partial sewer separation + 1.73 MG microtunnel | $380 M | 20 |
| MWR019 | 3 | 1.33 MG | | | |
| MWR020 | 3 | 3.14 MG | | | |
| RE046-100 (MWR023) | 6 | 0.39 MG[1] | 0.16 MG storage conduit | $11 M | 5 - 7 |
| RE046-381 (MWR023) | 2 | 0.12 MG[1] | 0.08 MG storage conduit | $7.6 M | 5-7 |
| MWR010 | 0 | 0 MG | No action | N/A | N/A |
| MWR201 (Cottage Farm - Treated) | 4 | 29.31 MG | 10.2 MG storage tank | $190 M | 5 - 10 |
| **Max/Sum** | **6** | **38.04 MG[2]** | **-** | **$750 M** | **20** |
| **Treated** | **4** | **29.81 MG** | **-** | **-** | **-** |
| **Untreated** | **6** | **8.73 MG** | **-** | **-** | **-** |

**Notes:**
(1) Volume reflects the full volume over the regulator weir.
(2) Volume reflects that only 25% of the flow over the RE046 regulator weirs would discharge to the Charles River via MWR023.
(3) N/A: not applicable.
(4) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.
(5) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

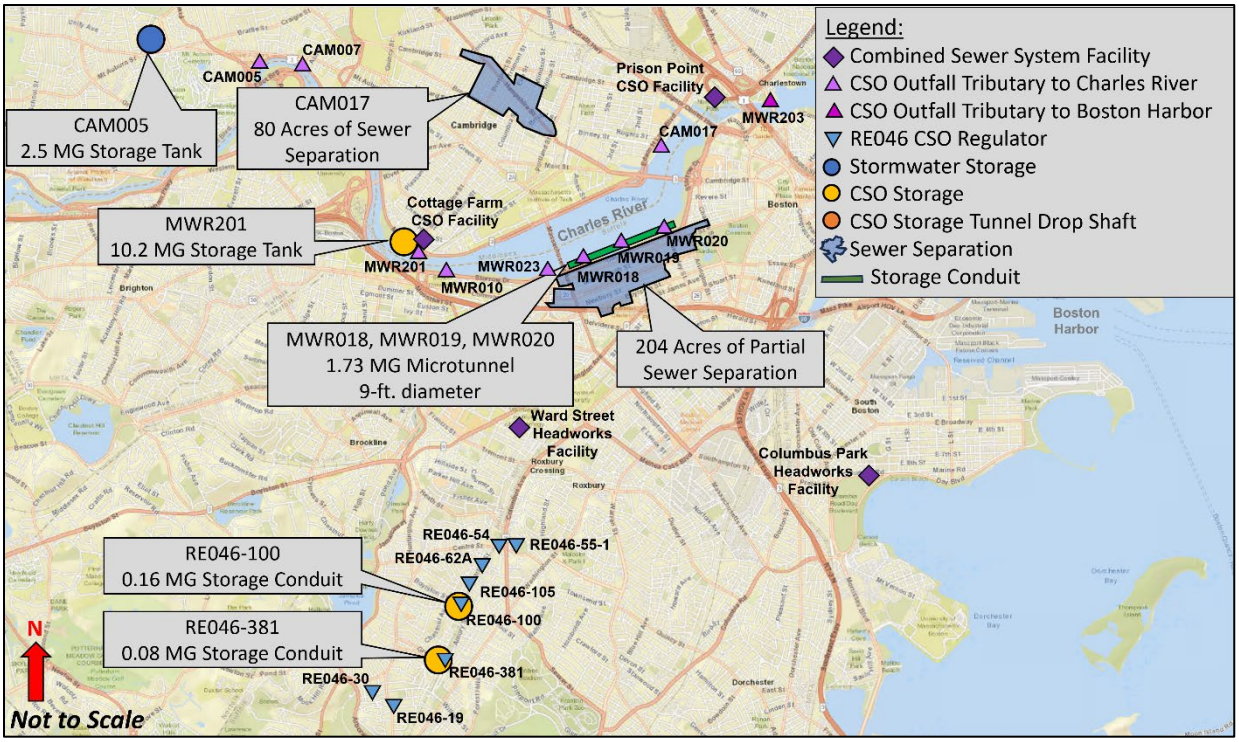



**Figure 9-74. Alternative 3.CR Hybrid 2 (0 CSOs in 2050 TY)**

### 9.9.3.1 Component Descriptions

The individual components of Alternative 3.CR Hybrid 2 are described below:

- **CAM005:** The 2.5 MG stormwater storage tank and flow restriction would be the same as described for Alternative 1.CR Integrated.
- **MWR201:** A 10.2 MG storage tank would be constructed underground at a site located in parkland adjacent to the existing Cottage Farm CSO Facility. The required storage volume is less than the 11.2 MG storage tank described in **Section 9.8.3** because it was evaluated in combination with the other alternative components of sewer separation in Boston and Cambridge.
- **MWR018/019/020:** A 3,800 linear foot, 9-foot diameter storage conduit with a storage capacity of 1.73 MG would be constructed by microtunneling to capture the overflow from outfalls MWR018, MWR019 and MWR020.
- **MWR018/019/020:** Approximately 204 acres of area tributary to the Boston Marginal Conduit would be separated.
- **CAM017:** The 80 acres of sewer separation upstream of outfall CAM017 would be the same as described for the Alternative 1.CR Integrated.
- **RE046-100 and RE046-381:** The 0.16 MG and 0.08 MG storage conduits for regulators RE046-100 and RE046-381 would be the same as described for Alternative 1.CR Integrated.

#### 9.9.3.2 Implementation Challenges

Challenges to implementing the components of this alternative would include:

CAM005 Storage:

- Similar challenges as described for Alternative 1.CR Integrated.

MWR201 Storage Tank:

- Constructing the storage facility in Magazine Beach Park would require Article 97 legislation to authorize the change of use of the site;
- Extensive impacts and loss of public access to Magazine Beach Park during construction. A new above-ground building would remain at the site permanently;
- Tank construction within Magazine Beach Park will require coordination with Eversource who are working to install a major electrical duct bank through the park. Deep excavation adjacent to Charles River in Magazine Beach Park; and
- Long-term maintenance access needed to the storage facility at Magazine Beach.

MWR018/019/020 Storage Conduit:

- Constructing the shafts, dewatering pump station, and odor control facility in parkland along the Esplanade would require Article 97 legislation to authorize a change of use of the site and permanent loss of park space;
- Construction impacts and partial loss of public access to the Esplanade and challenging truck access to site for construction equipment and removal of excavated material; and
- Long-term maintenance access needed to storage facility.

MWR018/019/020 Partial Sewer Separation:

- Construction in densely populated area over a long period;
- Construction of large storm drains in Back Bay and microtunnels under BMC/Storrow Drive;
- Construction of stormwater microtunnels under the BMC may require Article 97 legislation to authorize the change of use of the site;
- Microtunneling and chamber construction will impact public use of the Charles River Esplanade, and may require removal of trees to perform the work; and
- Sites have not been identified for stormwater treatment, flow attenuation, stormwater pumping, or GSI.

RE046-100 Storage, RE046-381 Storage:

- Similar challenges as described for Alternative 1.CR Integrated.

CAM017 Sewer Separation:

- Similar challenges as described for Alternative 2.CR Hybrid 1.

### 9.9.4 Alternative 4.CR Hybrid 3 (0 CSOs in 2050 TY)

Alternative 4.CR Hybrid 3 includes a combination of storage tanks, storage conduits, partial sewer separation, and underflow restriction. This alternative is based on Alternative 3.CR Hybrid 2 but expands

the sewer separation area to approximately 366 acres, thus eliminating the need for microtunnel storage in the Esplanade. As a result of the inflow removal associated with the additional sewer separation scope, the size of the storage tank needed at outfall MWR201 was slightly reduced.

**Table 9-80** presents, for each outfall, the Baseline Conditions 2050 TY activations and volumes, the project components, the estimated capital cost, and the estimated project duration. A schematic layout of the components of this alternative is presented in **Figure 9-75**.

**Table 9-80. Alternative 4.CR Hybrid 3 (0 CSOs in 2050 TY) Summary**

| Charles River Outfall | Baseline 2050 Typical Year | | Alternative Description | Preliminary Capital Cost[4] ($Millions) | Project Duration[5] (years) |
|---|---|---|---|---|---|
| | Activation Frequency | Volume (MG) | | | |
| CAM005 | 6 | 0.73 MG | 2.5 MG storage with underflow restrictions | $83 M | 5 |
| CAM007 | 0 | 0 MG | No action | N/A[3] | N/A |
| MWR201 (Cottage Farm - Treated) | 4 | 29.81 MG | 10.1 MG storage tank | $190 M | 5 - 10 |
| MWR010 | 0 | 0 MG | No action | N/A | N/A |
| MWR018 | 4 | 1.86 MG | 366 acres partial sewer separation | $320 M | 20 |
| MWR019 | 3 | 1.33 MG | | | |
| MWR020 | 3 | 3.14 MG | | | |
| CAM017 | 3 | 1.04 MG | 80 acres sewer separation | $77 M | 10 |
| RE046-100 (MWR023) | 6 | 0.39 MG[1] | 0.16 MG storage conduit | $11 M | 5 - 7 |
| RE046-381 (MWR023) | 2 | 0.12 MG[1] | 0.08 MG storage conduit | $7.6 M | 5 - 7 |
| **Max/Sum** | **6** | **38.04 MG[2]** | **-** | **$690 M** | **20** |
| **Treated** | **4** | **29.31 MG** | **-** | **-** | **-** |
| **Untreated** | **6** | **8.73 MG** | **-** | **-** | **-** |

**Notes:**

(1) Volume reflects the full volume over the regulator weir.

(2) Volume reflects that only 25% of the flow over the RE046 regulator weirs would discharge to the Charles River via MWR023.

(3) N/A: not applicable.

(4) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.

(5) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

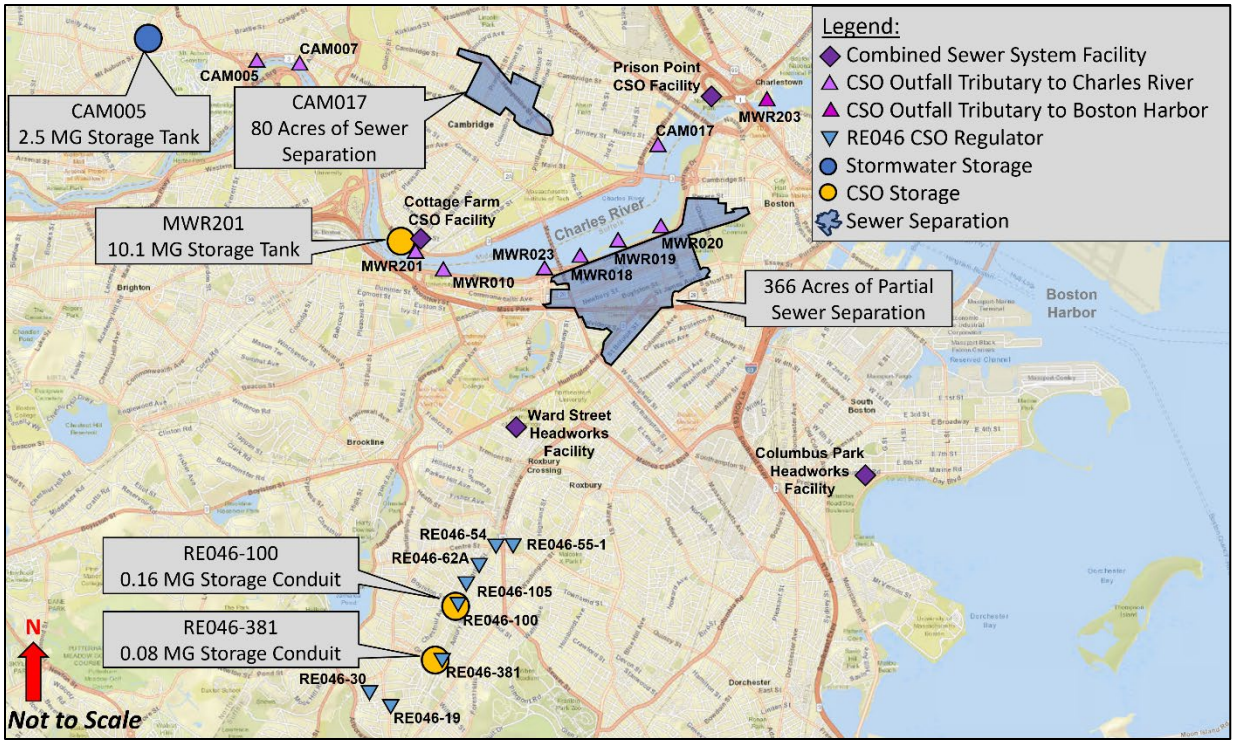



**Figure 9-75. Alternative 4.CR Hybrid 3 (0 CSOs in 2050 TY)**

### 9.9.4.1 Component Descriptions

The individual components of Alternative 4.CR Hybrid 3 are described below:

- **CAM005:** The 2.5 MG stormwater storage tank and flow restriction would be the same as described for the Alternative 1.CR Integrated.
- **MWR201:** A 10.1 MG storage tank would be constructed underground at a site located in parkland adjacent to the existing Cottage Farm CSO Facility. The features and operation would be similar to the tank described for Alternative 3.CR Hybrid 2.
- **MWR018/019/020**: Approximately 366 acres area tributary to the BMC would be separated.
- **RE046-100 and RE046-381:** The 0.16 MG and 0.08 MG storage conduits for regulators RE046-100 and RE046-381 would be the same as described for Alternative 1.CR Integrated.
- **CAM017:** The 80 acres of sewer separation upstream of outfall CAM017 would be the same as described for the Alternative 1.CR Integrated.

### 9.9.4.2 Implementation Challenges

The implementation challenges associated with this alternative are similar to those described previously. CAM005, RE046-100, and RE046-31 storage challenges reflect those described in Alternative 1.CR Integrated, the challenges associated with the MWR201 storage tank and the MWR018/019/020 partial sewer separation are described in Alternative 3.CR Hybrid 2, and the challenges described for CAM017 sewer separation are described in Alternative 2.CR Hybrid 1.

### 9.9.5 Alternative 5.CR Tunnel (0 CSOs in 2050 TY)

Alternative 5.CR Tunnel was developed as a regional storage tunnel to eliminate CSOs in the 2050 TY. It includes a deep rock storage tunnel to capture and store CSOs from outfalls CAM005, CAM017, MWR018, MWR019, MWR020, and MWR201, with a dewatering pump station. Regulators RE046-100 and RE046-381, which are substantially inland, would be captured by local storage conduits. The tunnel is sized to capture the CSO volume remaining during the largest storm in the 2050 TY. As presented in **Section 9.8.8,** the largest storm in the 2050 TY resulted in a CSO volume of 17.8 MG, so the tunnel for is sized to capture that CSO volume.

**Table 9-81** presents, for each outfall, the Baseline Conditions 2050 TY activations and volumes, the project components, the estimated capital cost, and the estimated project duration. A schematic layout of the components of this alternative is presented in **Figure 9-76**.

**Table 9-81. Alternative 5.CR Tunnel (0 CSOs in 2050 TY) Summary**

| Charles River Outfall | Baseline 2050 Typical Year | | Alternative Description | Preliminary Capital Cost[4] ($million) | Project Duration[5] (years) |
|---|---|---|---|---|---|
| | Activation Frequency | Volume (MG) | | | |
| CAM005 | 6 | 0.73 MG | See MWR201 (Cottage Farm) below | $54.3 M | 5 |
| CAM007 | 0 | 0 MG | No action | N/A[3] | N/A |
| MWR201 (Cottage Farm - Treated) | 4 | 29.81 MG | 17.8 MG 12-ft dia. storage tunnel to store CAM005, MWR201, MWR018, MWR019, MWR020, and CAM017 | $1,300 M | 10-15 |
| MWR010 | 0 | 0 MG | No action | N/A | N/A |
| MWR018 | 4 | 1.86 MG | See MWR201 (Cottage Farm) above | N/A | N/A |
| MWR019 | 3 | 1.33 MG | | | |
| MWR020 | 3 | 3.14 MG | | | |
| CAM017 | 3 | 1.04 MG | See MWR201 (Cottage Farm) above | N/A | N/A |
| RE046-100 (MWR023) | 6 | 0.39 MG[1] | 0.16 MG storage conduit | $11 M | 5 - 7 |
| RE046-381 (MWR023) | 2 | 0.12 MG[1] | 0.08 MG storage conduit | $7.6 M | 5-7 |
| **Max/Sum** | **6** | **38.73 MG** | **-** | **$1,400 M** | **15** |
| **Treated** | **4** | **30.12 MG** | **-** | **-** | **-** |
| **Untreated** | **6** | **8.61 MG** | **-** | **-** | **-** |

**Notes:**
(1) Volume reflects the full volume over the regulator weir.
(2) Volume reflects that only 25% of the flow over the RE046 regulator weirs would discharge to the Charles River via MWR023.
(3) N/A: not applicable.
(4) Preliminary Capital Cost is described in **Section 9.3**. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.
(5) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

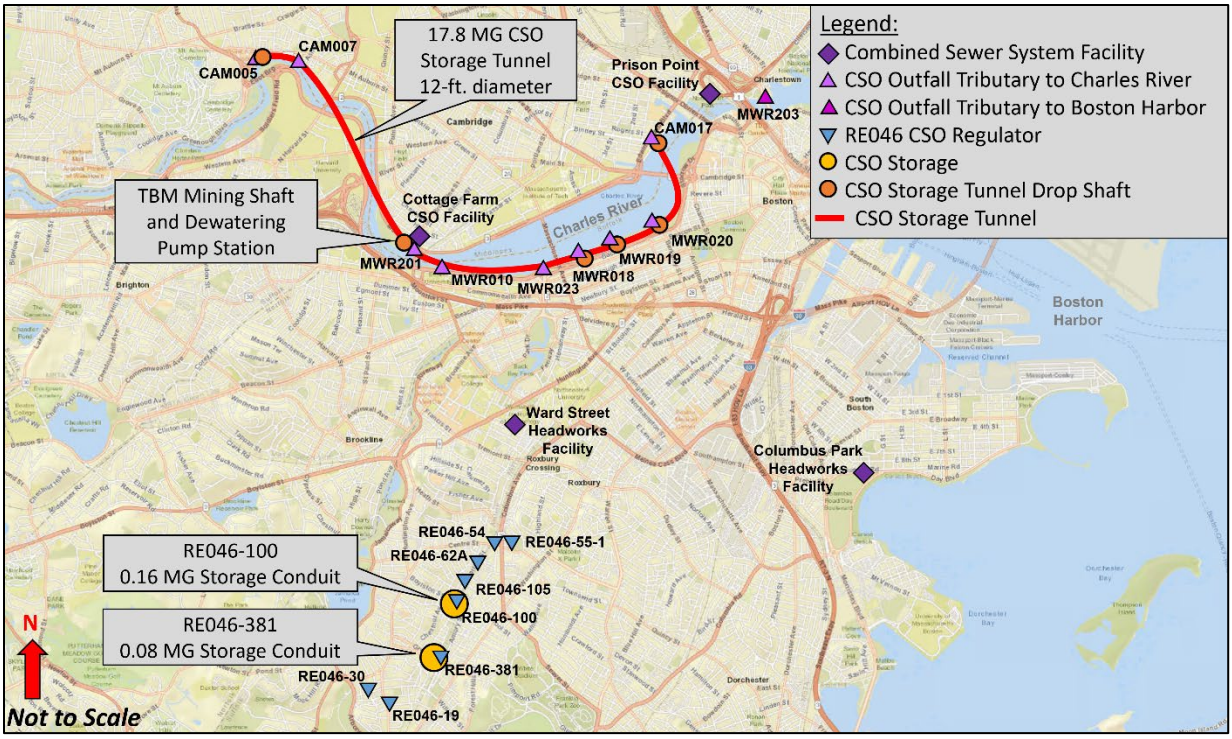



**Figure 9-76. Alternative 5.CR Tunnel (0 CSOs in 2050 TY)**

### 9.9.5.1 Component Descriptions

The individual components of Alternative 5.CR Tunnel are described below:

**CAM005/MWR201/MWR018/019/020/CAM017:** A 17.8 MG deep rock, TBM-bored storage tunnel would be constructed to provide storage for outfalls CAM005, MWR201, MWR018, MWR019, MWR020, and CAM017. The tunnel would be approximately 23,700 feet long with a finished inside diameter of 12 feet. **Figure 9-70** presents the approximate alignment of the tunnel route. The tunnel would consist of an east and a west branch. The route of the east branch would begin at a mining shaft in parkland adjacent to the MWRA's Cottage Farm CSO Facility, cross under the Charles River, run under the Esplanade past outfall MWR020, then cross back under the Charles River to a TBM removal shaft located adjacent to outfall CAM017. The west branch would run from the same mining shaft adjacent to the Cottage Farm Facility about parallel to the riverbank, to a TBM removal shaft adjacent to outfall CAM005. Other components of the tunnel such as diversion structures, drop shafts, mining and retrieval shafts, and dewatering would be similar to those described for the tunnel from outfalls MWR201 to MWR020. Odor control facilities would be provided at the TBM removal shafts adjacent to outfalls CAM005 and CAM017.The storage tunnel and appurtenant components are described further in in Section **9.8.8.**

- **RE046-100 and RE046-381:** The 0.16 MG and 0.08 MG storage conduits for regulators RE046-100 and RE046-381 would be the same as described for Alternative 1.CR Integrated.

### 9.9.5.2 Implementation Challenges

Challenges to implementing the components of this alternative would be similar to those described for Alternative 1.CR Integrated.

### 9.9.6 Alternative 6.CR Tunnel + GSI (0 CSOs in 2050 TY)

Alternative 6.CR Tunnel + GSI includes a combination of deep tunnel storage, GSI, and a storage conduit. This alternative is based on Alternative 5.CR Tunnel with GSI added at a regional scale. GSI was sized to capture the first inch of rainfall from 10% of the impervious right-of-way area in the combined sewer areas tributary to Charles River, resulting in an area to be captured by GSI of 89.6 acres. The volume of CSO to be captured in the storage tunnel has been reduced to account for the inflow capture achieved by GSI. The CSO volume for the same storm with the implementation of regional GSI was reduced to 17.1 MG (from 17.8 MG). Although there was a reduction in volume of CSO to be stored by the tunnel, the reduction was not sufficient to downsize the tunnel diameter while maintaining the same length; therefore the tunnel size for 5.CR Tunnel and 6.CR Tunnel + GSI are both 12 feet in diameter. The tunnel length is based on the route described in **Section 9.8.8**. The route did not change with the addition of GSI because the CSO from the same outfalls needs to be captured. The GSI also did not change the size of the local storage conduits for regulators RE046-100 and RE046-381.

**Table 9-82** presents, for each outfall, the Baseline Conditions 2050 TY activations and volumes, the project components, the estimated capital cost, and the estimated duration for implementation. A schematic layout of the components of this alternative is presented in **Figure 9-77**.

**Table 9-82. Alternative 6.CR Tunnel + GSI (0 CSOs in 2050 TY) Summary**

| Charles River Outfall | Baseline 2050 Typical Year | | Alternative Description | Preliminary Capital Cost[5] ($Million) | Project Duration[6] (years) |
|---|---|---|---|---|---|
| | Activation Frequency | Volume (MG) | | | |
| CAM005 | 6 | 0.73 MG | See MWR201 (Cottage Farm) below | NA/[4] | N/A |
| CAM007 | 0 | 0 MG | No action | N/A | N/A |
| MWR201 (Cottage Farm - Treated) | 4 | 29.81 MG | 17.1 MG 12-ft dia. storage tunnel[3] + GSI (89.6 acres) to store CAM005, MWR201, MWR018, MWR019, MWR020, and CAM017 | $1,400 M | 10-15 for tunnel (GSI requires additional time to be determined) |
| MWR010 | 0 | 0 MG | No action | N/A | N/A |
| CAM017 | 3 | 1.04 MG | See MWR201 (Cottage Farm) above | N/A | N/A |
| MWR018 | 4 | 1.86 MG | | | |
| MWR019 | 3 | 1.33 MG | | | |
| MWR020 | 3 | 3.14 MG | | | |
| RE046-100 (MWR023) | 6 | 0.39 MG[1] | 0.16 MG Storage Conduit | $11 M | 5 - 7 |
| RE046-381 (MWR023) | 2 | 0.12 MG[1] | 0.08 MG Storage Conduit | $7.6 M | 5-7 |
| **Max/Sum** | **6** | **38.04 MG[2]** | **-** | **$1,500 M** | **15** |

**Table 9-82. Alternative 6.CR Tunnel + GSI (0 CSOs in 2050 TY) Summary**

| Charles River Outfall | Baseline 2050 Typical Year | | Alternative Description | Preliminary Capital Cost[5] ($Million) | Project Duration[6] (years) |
|---|---|---|---|---|---|
| | Activation Frequency | Volume (MG) | | | |
| **Treated** | **4** | **29.31 MG** | - | - | - |
| **Untreated** | **6** | **8.73 MG** | - | - | - |

**Notes:**
(1) Volume reflects the full volume over the regulator weir.
(2) Volume reflects that only 25% of the flow over the RE046 regulator weirs would discharge to the Charles River via MWR023.
(3) The CSO volume to be stored by the tunnel for Alternative 6.CR. is 17.1 MG. Although there was a reduction in volume of CSO to be stored by the tunnel when compared to Alt 5.CR, it not sufficient to downsize the tunnel diameter while maintaining the same length – and therefore the tunnel size for 5.CR and 6.CR are the same.
(4) N/A: not applicable.
(5) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.
(6) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

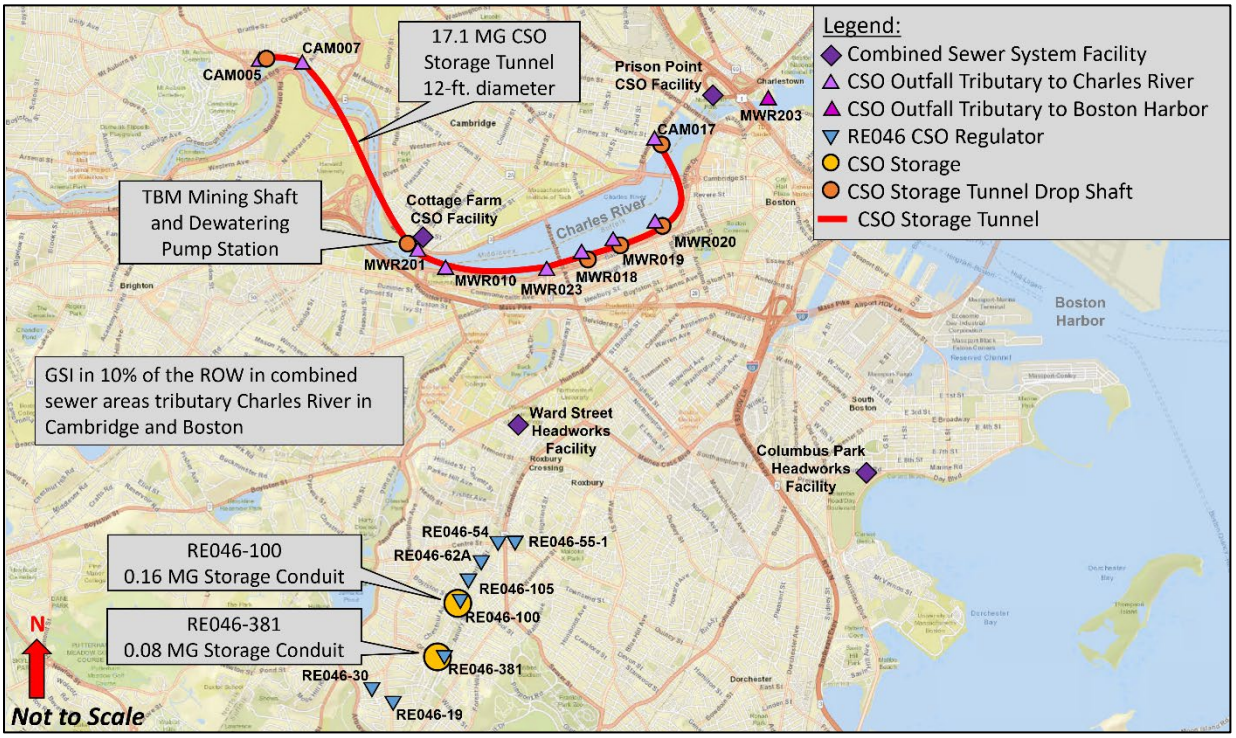



**Figure 9-77. Alternative 6.CR Tunnel + GSI (0 CSOs in 2050 TY)**

### 9.9.6.1 Component Descriptions

The individual components of Alternative 6.CR Tunnel + GSI are described below:

- **Storage Tunnel:** The deep rock storage tunnel would have the same configuration as described for Alternative 5.CR Tunnel, but the largest volume captured in the 2050 TY would be 17.1 MG, and the dewatering pump station would be sized for 17.1 MGD.
- **GSI:** This alternative would include the implementation of GSI capturing runoff from 10% of the impervious right-of-way area in the combined sewer areas tributary to the Charles River in Cambridge and Boston (89.6 acres).
- **RE046-100 and RE046-381:** The 0.16 MG and 0.08 MG storage conduits for regulators RE046-100 and RE046-381 would be the same as described for Alternative 1.CR Integrated.

#### 9.9.6.2 Implementation Challenges

The implementation challenges associated with this Alternative are similar to those described previously with the exception of the GSI. The implementation challenges associated with the storage tunnel reflect those described in Alternative 5.CR Tunnel, and the implementation challenges associated with RE046-100, and RE046-31 storage reflect those described in Alternative 1.CR Integrated. Challenges to implementing GSI would include identifying appropriate sites for GSI on municipally owned land or on public rights-of-way.

### 9.9.7 Alternative 8.CR Hybrid 1 (Limited CSOs in 2050 TY)

Alternative 8.CR Hybrid 1 includes a combination of a storage tank, a storage conduit, partial sewer separation, and underflow restriction for the Limited CSOs in the 2050 TY LOC. This alternative was based on Alternative 4.CR Hybrid 3, but it primarily assesses a significant reduction of sewer separation area and storage tanks. The following adjustments were made to this alternative:

- Reduce the area of sewer separation for MWR018/019/020 to approximately 188 acres;
- Reduce the storage tank at RE046-100. Whereas Alternative 4.CR Hybrid 3 included 0.16 MG of storage at RE046-100 to go from 6 activations to 0 activations, the tank is downsized in Alternative 8.CR Hybrid 1 to 0.06 MG, which leaves 2 remaining activation in the 2050 TY;
- Exclude the small storage tank at RE046-381, thus leaving those two small activations in the 2050 TY; and
- Exclude the large storage tank at MWR201, thus leaving four treated activations in the 2050 TY. It should be noted that the CSO volume from MWR201 is reduced due to the inflow reduction from other areas of sewer separation in Boston and Cambridge.

**Table 9-83** presents, for each outfall, the Baseline Conditions 2050 TY activations and volumes, the project components, the estimated capital cost, and the estimated project duration. Because this alternative does not eliminate CSOs in the 2050 TY, the table also shows the CSO activations and volumes predicted to remain in the 2050 TY after implementation. A schematic layout of the components of this alternative is presented in **Figure 9-78**.

## Table 9-83. Alternative 8.CR Hybrid 1 (Limited CSOs in 2050 TY) Summary

| Charles River Outfall | Baseline 2050 TY Act Freq./Vol. (MG) | Alternative Description | Remaining 2050 TY Act Freq./Vol. (MG) | Preliminary Capital Cost [4] ($Million) | Project Duration[5] (years) |
|---|---|---|---|---|---|
| CAM005 | 6 act/0.73 MG | 2.5 MG storage with underflow restrictions | 0 act/0 MG | $83 M | 5 |
| CAM007 | 0 act/0 MG | No action | 0 act/0 MG | N/A[3] | N/A |
| CAM017 | 3 act/1.04 MG | 80 acres sewer separation | 0 act/0 MG | $77 M | 10 |
| MWR018 | 4 act/1.86 MG | 188 acres partial sewer separation | 2 act/0.88 MG | $190 M | 25 |
| MWR019 | 3 act/1.33 MG | | 2 act/0.54 MG | | |
| MWR020 | 3 act/3.14 MG | | 2 act/0.94 MG | | |
| RE046-100 (MWR023) | 6 act /0.39 MG[1] | 0.06 MG storage | 2 act/0.11 MG | $6.6 M | 5 |
| RE046-381 (MWR023) | 2 act/0.12 MG[1] | No action | 2 act/0.12 MG | N/A | N/A |
| MWR010 | 0 act/0 MG | No action | 0 act/0 MG | N/A | N/A |
| MWR201 (Cottage Farm - Treated) | 4 act/29.81 MG | No action | 4 act/26.81 MG | N/A | N/A |
| **Max/Sum** | **6 act/38.04 MG[2]** | **-** | **4 act/29.4 MG** | **$360 M** | **25** |
| **Treated** | **4 act/29.31 MG** | **-** | **4 act/26.81 MG** | **-** | **-** |
| **Untreated** | **6 act/8.73 MG** | **-** | **2 act/2.59 MG** | **-** | **-** |

**Notes:**

(1) Volume reflects the full volume over the regulator weir.
(2) Volume reflects that only 25% of the flow over the RE046 regulator weirs would discharge to the Charles River via MWR023.
(3) N/A: not applicable.
(4) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.
(5) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

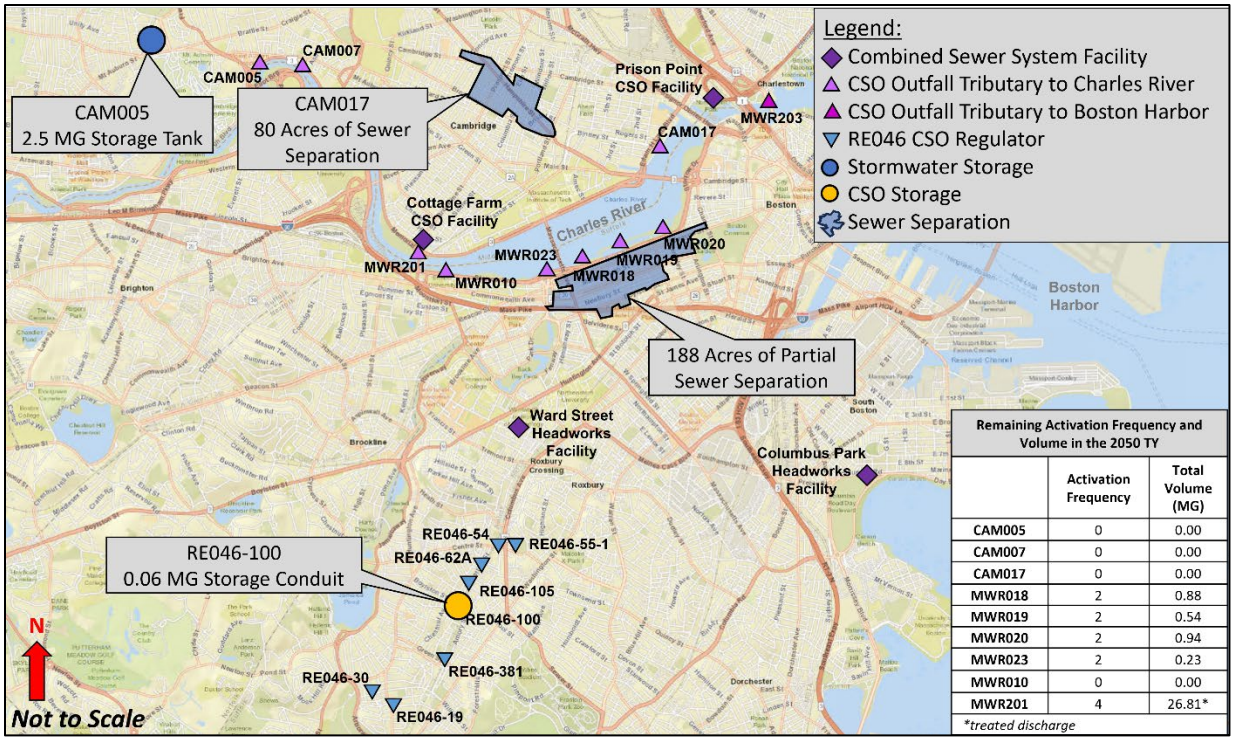



**Figure 9-78. Alternative 8.CR Hybrid 1 (Limited CSOs in 2050 TY)**

### 9.9.7.1 Component Descriptions

The individual components of Alternative 8.CR Hybrid 1 are described below:

- **CAM005:** The 2.5 MG stormwater storage tank and flow restriction would be the same as described for Alternative 1.CR Integrated.
- **MWR018/019/020:** Approximately 188 acres of runoff area tributary to the Boston Marginal Conduit would be separated.
- **RE046-100:** A 0.06 MG of storage would be provided to capture the overflow volume from regulator RE046-100. The storage would likely be provided in the form of a storage conduit. A 6-foot diameter conduit extending for 300 feet would be an example of a configuration that could provide that volume of storage. The final configuration would be developed as part of additional planning and design. A 0.06 MGD dewatering pump facility would be provided at the low end of the storage conduit. Stored flows would likely be dewatered to the Southwest Corridor Interceptor for conveyance to Ward Street Headworks.
- **CAM017:** The 80 acres of sewer separation upstream of outfall CAM017 would be the same as described for the Alternative 1.CR Integrated.

### 9.9.7.2 Implementation Challenges

The implementation challenges associated with this alternative are similar to those described previously. CAM005 and RE046-100 storage challenges reflect those described in Alternative 1.CR Integrated, the challenges associated with MWR018/019/020 partial sewer separation are described in Alternative 3.CR Hybrid 2, and the challenges described for CAM017 sewer separation are described in Alternative 2.CR Hybrid 1.

### 9.9.8 Alternative 9.CR Hybrid 2 (Limited CSOs in 2050 TY)

Alternative 9.CR Hybrid 2 includes a combination of a storage tank, near surface storage conduits, sewer separation, and underflow restriction for Limited CSOs in the 2050 TY. This alternative was based on Alternative 3.CR Hybrid 2 but focuses on microtunneled storage for MWR018/019/020 (without upstream sewer separation) and also reduces storage tanks similar to 8.CR Hybrid 1. It includes the following changes:

- Reduce the size of the microtunnel for MWR018/019/020 CSOs and exclude the upstream sewer separation. Whereas Alternative 3.CR Hybrid 2 included a 1.73 MG microtunnel plus 204 acres of sewer separation to go from 4 to 0 activations at MWR018/019/020, the microtunnel is downsized in Alternative 9.CR Hybrid 2 to 1.19 MG and the sewer separation is eliminated, which leaves 2 remaining activations in the 2050 TY for these outfalls.
- Reduce the size storage tank at RE046-100. Whereas Alternative 4.CR Hybrid 3 included 0.16 MG of storage at RE046-100 to go from 6 activations to 0 activations, the tank is downsized in Alternative 8.CR Hybrid 1 to 0.06 MG, which leaves 2 remaining activation in the 2050 TY.
- Exclude the small storage tank at RE046-381, thus leaving those two small activations in the 2050 TY.
- Exclude the large storage tank at MWR201, thus leaving four treated activations in the 2050 TY. It should be noted that the CSO volume from MWR201 is reduced due to the inflow reduction from nearby sewer separation.

**Table 9-84** presents, for each outfall, the Baseline Conditions 2050 TY activations and volumes, the project components, the estimated capital cost, and the estimated project duration. Because this alternative does not eliminate CSOs in the 2050 TY, the table also shows the CSO activations and volumes predicted to remain in the 2050 Typical Year after implementation. A schematic layout of the components of this alternative is presented in **Figure 9-79**.

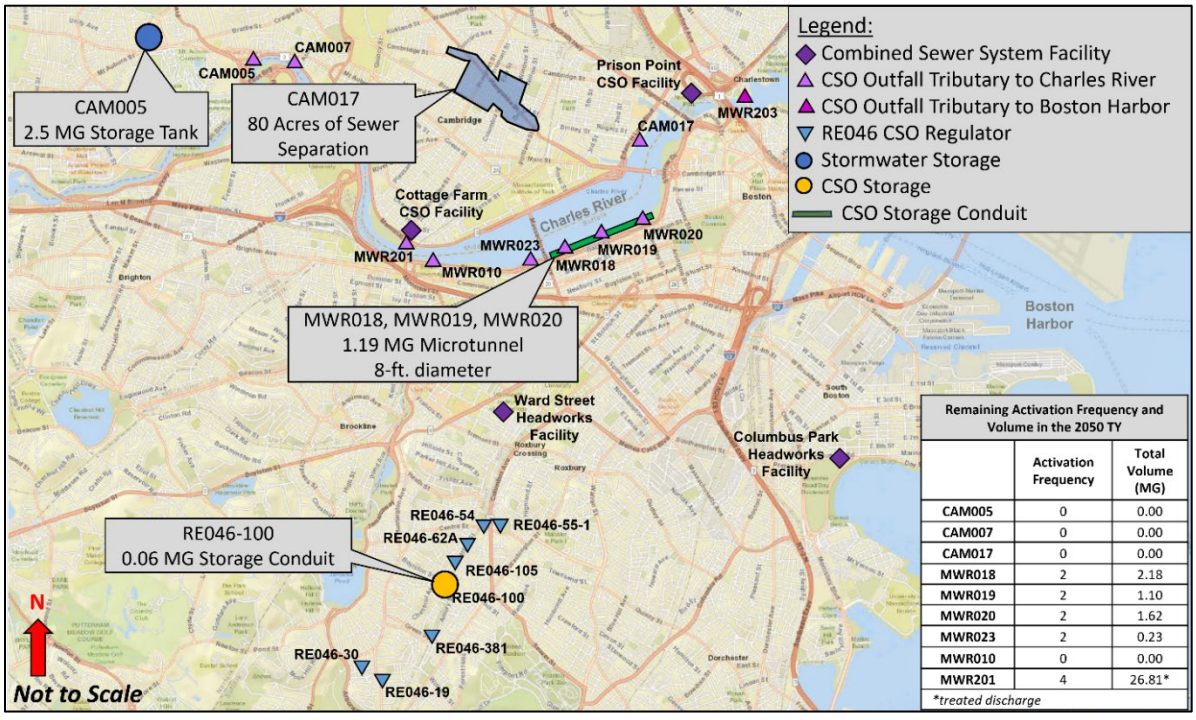
**Table 9-84. Alternative 9.CR Hybrid 2 (Limited CSOs in 2050 TY) Summary**

| Charles River Outfall | Baseline 2050 TY Act Freq./Vol. (MG) | Alternative Description | Remaining 2050 TY Act Freq./Vol. (MG) | Preliminary Capital Cost[5] ($Million) | Project Duration[6] (years) |
|---|---|---|---|---|---|
| CAM005 | 6 act/0.73 MG | 2.5 MG storage with underflow restrictions | 0 act/0 MG | $83 M | 5 |
| CAM007 | 0 act/0 MG | No action | 0 act/0 MG | N/A[4] | N/A |
| CAM017 | 3 act/1.04 MG | 80 acres sewer separation | 0 act/0 MG | $77 M | 10 |
| MWR018 | 4 act/1.86 MG | 1.19 MG microtunnel | 2 act/2.18 MG[3] | $130 M | 5 |
| MWR019 | 3 act/1.33 MG | | 2 act/1.10 MG | | |
| MWR020 | 3 act/3.14 MG | | 2 act/1.62 MG | | |
| RE046-100 (MWR023) | 6 act /0.39 MG[1] | 0.06 MG storage | 2 act/0.11 MG | $6.6 M | 5 |
| RE046-381 (MWR023) | 2 act/0.12 MG[1] | No action | 2 act/0.12 MG | N/A | N/A |

## Table 9-84. Alternative 9.CR Hybrid 2 (Limited CSOs in 2050 TY) Summary

| Charles River Outfall | Baseline 2050 TY Act Freq./Vol. (MG) | Alternative Description | Remaining 2050 TY Act Freq./Vol. (MG) | Preliminary Capital Cost[5] ($Million) | Project Duration[6] (years) |
|---|---|---|---|---|---|
| MWR010 | 0 act/0 MG | No action | 0 act/0 MG | N/A | N/A |
| MWR201 (Cottage Farm) | 4 act/29.31 MG | No action | 4 act/27.83 MG | N/A | N/A |
| **Max/Sum** | **6 act/38.04 MG[2]** | - | **4 act/32.96 MG** | **$300 M** | **10** |
| **Treated** | **4 act/29.81 MG** | - | **4 act/27.83 MG** | - | - |
| **Untreated** | **6 act/8.73 MG** | - | **2 act/5.13 MG** | - | - |

**Notes:**
(1) Volume reflects the full volume over the regulator weir.
(2) Volume reflects that only 25% of the flow over the RE046 regulator weirs would discharge to the Charles River via MWR023.
(3) The volume at MWR018 increases because the diversion structure was modified to convey flow to the microtunnel. The total volume for MWR018, MWR019 and MWR020 in the 2050TY is reduced from 6.33 MG to 4.9 MG.
(4) N/A: not applicable.
(5) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.
(6) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.




## Figure 9-79. Alternative 9.CR Hybrid 2 (Limited CSOs in 2050 TY)

#### 9.9.8.1 Component Descriptions

The individual components of Alternative 9.CR Hybrid 2 are described below:

- **CAM005:** The 2.5 MG stormwater storage tank and flow restriction would be the same as described for Alternative 1.CR Integrated.
- **MWR018/019/020:** A 3,500 linear foot, 8-foot diameter storage conduit with a storage capacity of 1.19 MG would be constructed by microtunneling to capture the overflow from outfalls MWR018, MWR019 and MWR020.
- **RE046-100:** The 0.06 MG storage conduit would be the same as described for Alternative 8.CR Hybrid 1.
- **CAM017:** The 80 acres of sewer separation upstream of outfall CAM017 would be the same as described for the Alternative 1.CR Integrated.

#### 9.9.8.2 Implementation Challenges

The implementation challenges associated with this alternative are similar to those described previously. CAM005 and RE046-100 storage challenges reflect those described in Alternative 1.CR Integrated, the challenges associated with the MWR018/019/020 storage conduit are described in Alternative 3.CR Hybrid 2, and the challenges described for CAM017 sewer separation are described in Alternative 2.CR Hybrid 1.

### 9.9.9 Alternative 10.CR 5-Year Tunnel (0 CSOs in 2050 5-Year)

Alternative 10.CR 5-Year Tunnel was developed as a regional deep rock storage tunnel to eliminate CSOs in a 2050 5-year storm except for regulators RE046-381, RE046-100, RE046-105, RE046-54 and RE046-55-1, which would be captured by a local storage conduit. This alternative would also result in no CSO discharges to Charles River in the 2050 TY. As presented in **Section 9.8.8**, the 5-year storm CSO volume was 71.9 MG, so the tunnel is sized to capture that CSO volume.

**Table 9-85** presents, for each outfall, the predicted CSO volumes for the Baseline Conditions 2050 5-year storm, the project components, the estimated capital cost, and the estimated project duration. A schematic layout of the components of this alternative is presented in **Figure 9-80**.

## Table 9-85. Alternative 10.CR 5-Year Tunnel (0 CSOs in 2050 5-Year) Summary

| Charles River Outfall | Baseline 5-Year Vol. (MG) | Alternative Description | Preliminary Capital Cost[4] ($Million) | Project Duration[5] (years) |
|---|---|---|---|---|
| CAM005 | 1.61 | 71.9 MG 24-ft diameter storage tunnel[3] to store CAM005, CAM008, MWR201, MWR010, MWR018, MWR019, MWR020, and CAM017 | $1,600 M | 15 - 20 |
| CAM007 | 5.92 | | | |
| MWR201 (Cottage Farm - Treated) | 33.84 | | | |
| MWR010 | 1.32 | | | |
| MWR018 | 2.14 | | | |
| MWR019 | 1.63 | | | |
| MWR020 | 6.21 | | | |
| CAM0017 | 12.54 | | | |
| RE046-381, 100, 105, 62A, 54 and 55-1 (MWR023) | 1.05[1] | 1.05 MG storage microtunnel | $170 M | 5 - 10 |
| **Total Untreated** | **31.63[2]** | **-** | **$1,900 M** | **15 - 20** |
| **Total Treated** | **33.84** | **-** | **-** | **-** |
| **Overall Total** | **65.47** | **-** | **-** | **-** |

**Notes:**

(1) Volume reflects the full volume over the regulator weir.

(2) Volume reflects that only 25% of the flow over the RE046 regulator weirs would discharge to the Charles River via MWR023.

(3) The storage tunnel volume exceeds the sum of the 5-year storm volumes at the outfalls to be captured due to the diversion structure configurations at outfalls CAM007, MWR019, MWR019, and MWR020 which provide additional relief of the peak hydraulic grade line.

(4) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.

(5) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

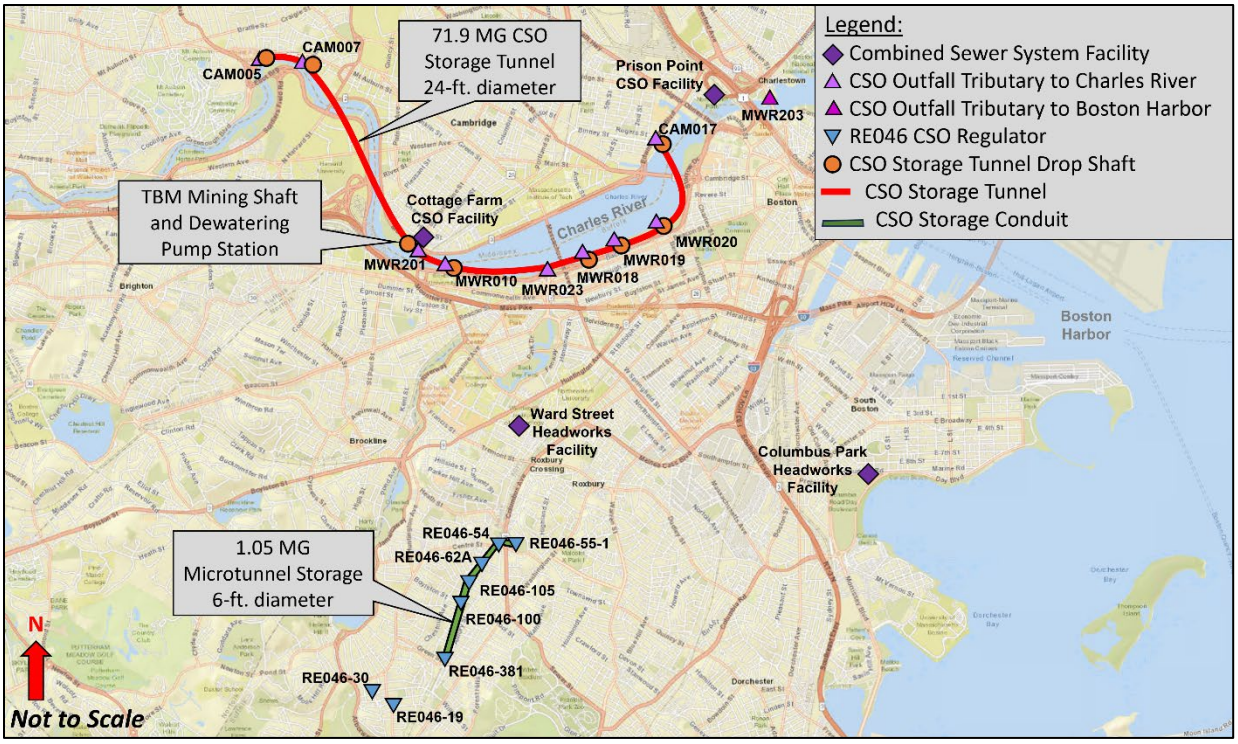



**Figure 9-80. Alternative 10.CR 5-Year Tunnel (0 CSOs in 2050 5-Year)**

### 9.9.9.1 Component Descriptions

The individual components of Alternative 10.CR 5-Year Tunnel are described below:

- **CAM005/CAM007/MWR201/MWR010/MWR018/019/020/CAM017:** A deep rock, TBM-bored storage tunnel would be constructed to capture overflow from CAM005, CAM007, MWR201, MWR010, MWR018, MWR019, MWR020 and CAM017. The storage tunnel would be approximately 23,700 linear feet long, with a finished inside diameter of 24 feet, and would provide approximately 71.9 MG of storage. The route, features and components of the tunnel would be similar to the tunnel described for the Alternative 5.CR Tunnel, but with a larger tunnel diameter and dewatering pump station, as well as the addition of diversion structures and drop shafts at outfalls CAM007 and MWR010.
- **RE046-381, RE046-100, RE046-105, RE046-54 and RE046-55-1:** A 1.05 MG storage conduit would be provided to capture the overflow volume from regulators RE046-381, RE046-100, RE046-105, RE046-54 and RE046-55-1. The storage conduit would be 6-foot diameter extending for 5,450 feet between regulators RE046-381 and RE046-55-1. The conduit would likely be constructed by microtunneling. A preliminary route for the storage conduit would begin adjacent to regulators RE046-381 and run along Lamartine and Center Streets to regulator RE046-55-1. It is anticipated that three pipe jacking shafts, where the microtunneling boring machine is inserted and excavate is removed, would be located along the route, along with potentially four retrieval shafts, where the microtunneling boring machine is removed. The final route and shaft locations could change and would be defined after further planning and design. A 1.05 MGD dewatering pump station would be located at the downstream end. A permanent above-ground structure would be required at the downstream end of the storage conduit for maintenance access and to house electrical and odor control equipment. Stored flows would likely be dewatered to the Stony Brook Valley Sewer for conveyance to Ward Street Headworks.

#### 9.9.9.2 Implementation Challenges

Challenges to implementing the components of this alternative would include:

CAM005/CAM007/MWR201/MWR010/MWR018/019/020/CAM017 Storage Tunnel:

- Similar challenges as described for Alternative 5.CR Tunnel, but more extensive construction-period impacts due to the larger tunnel diameter and volume of excavate.

RE046-381, RE046-100, RE046-105, RE046-54 and RE046-55-1 Storage:

- Diversion structure/jacking/receiving shafts would be constructed in public right-of-way adjacent to SW Corridor Park owned by MBTA;
- Need to microtunnel under Southwest Corridor tracks;
- Small above-ground buildings to remain at upstream and downstream sites permanently; and
- Long-term maintenance access needed to storage facilities.

### 9.9.10 Alternative 11.CR 5-Year Tunnel + GSI (0 CSOs in 2050 5-Year)

Alternative 11.CR 5-Year Tunnel + GSI includes a combination of deep tunnel storage, GSI, and a storage conduit. This alternative developed to assess the impact that regional GSI could have on sizing regional storage in a large design storm. This alternative is based on Alternative 10.CR 5-Year Tunnel and augments it by adding GSI at a regional scale. With the addition of GSI, the remaining volume to be captured by the tunnel is reduced from 71.9 MG to 71.43 MG. Although there is a reduction in volume, it is not sufficient to downsize the tunnel diameter while maintaining the same length—therefore the tunnel sizes for Alternative 10.CR 5-Year Tunnel and Alternative 11.CR 5-Year Tunnel + GSI are the same. The tunnel length is based on the route described in **Section 9.8.8** and did not change because it needs to capture CSO from the same outfalls. GSI implementation also did not change the size of the local storage conduit for regulators RE046-381, RE046-100, RE046-105, RE046-54 and RE046-55-1.

**Table 9-86** presents, for each outfall, the predicted CSO volume for the Baseline Conditions 2050 5-year storm, the project components, the estimated capital cost, and the estimated project duration. A schematic layout of the components of this alternative is presented in **Figure 9-81**.

## Table 9-86. Alternative 11.CR 5-Year Tunnel + GSI (0 CSOs in 2050 5-Year) Summary

| Charles River Outfall | Baseline 5-Year Vol. (MG) | Alternative Description | Preliminary Capital Cost[5] ($Million) | Project Duration[6] (years) |
|---|---|---|---|---|
| CAM005 | 1.61 | 71.4 MG 24-ft dia. storage tunnel with GSI (89.6 acres) [3] [4] to store CAM005, CAM008, MWR201, MWR010, MWR018, MWR019, MWR020, and CAM017 | $1,700 M | 15 - 20 for tunnel (GSI requires additional time to be determined) |
| CAM007 | 5.92 | | | |
| MWR201 (Cottage Farm - Treated) | 33.84 | | | |
| MWR010 | 1.32 | | | |
| MWR018 | 2.14 | | | |
| MWR019 | 1.63 | | | |
| MWR020 | 6.21 | | | |
| CAM0017 | 12.54 | | | |
| RE046-381, 100, 105, 62A, 54 and 55-1 (MWR023) | 1.05[1] | 1.05 MG storage microtunnel | $170M | 5 - 10 |
| **Total Untreated** | **31.63[2]** | **-** | **$2,000 M** | **15 - 20** |
| **Total Treated** | **33.84** | **-** | **-** | **-** |
| **Overall Total** | **65.47** | **-** | **-** | **-** |

**Notes:**
(1) Volume reflects the full volume over the regulator weir.
(2) Volume reflects that only 25% of the flow over the RE046 regulator weirs would discharge to the Charles River via MWR023.
(3) The storage tunnel volume exceeds the sum of the 5-year storm volumes at the outfalls to be captured due to the diversion structure configurations at outfalls CAM007, MWR019, MWR019, and MWR020 which provide additional relief of the peak hydraulic grade line.
(4) The CSO volume to be stored by the tunnel for Alternative 11.CR. is 71.43 MG. Although there was a reduction in volume of CSO to be stored by the tunnel when compared to Alt 10.CR, it not sufficient to downsize the tunnel diameter while maintaining the same length – and therefore the tunnel size for 10.CR and 11.CR are the same.
(5) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.
(6) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

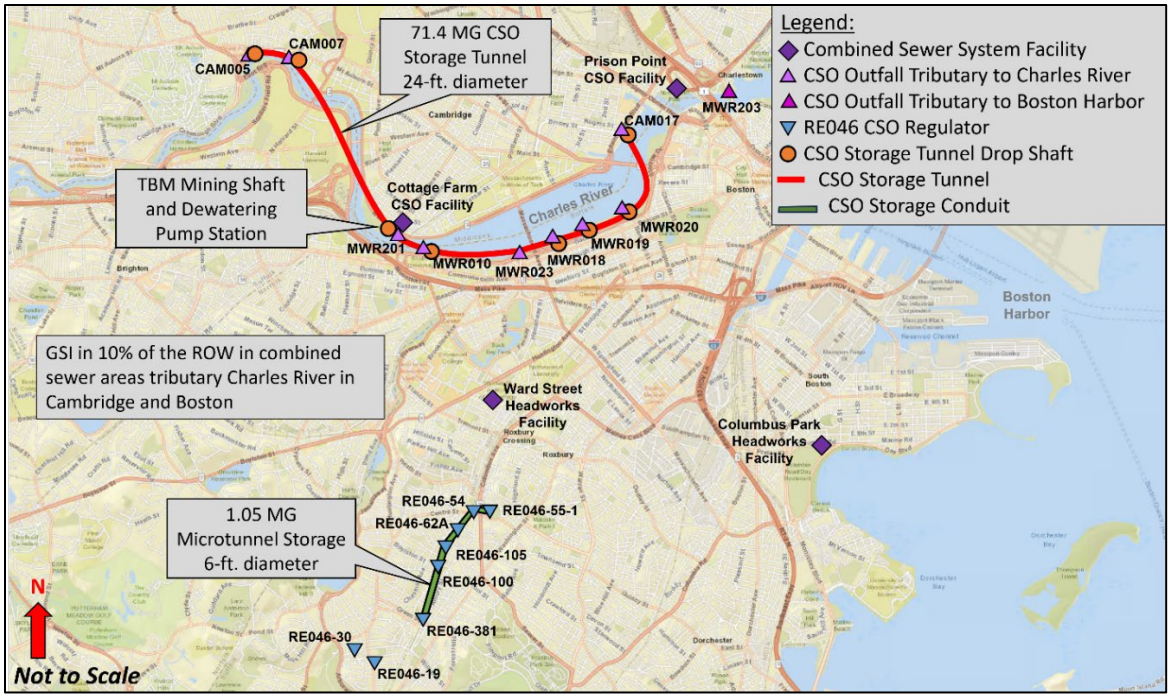



**Figure 9-81. Alternative 11.CR 5-Year Tunnel + GSI (0 CSOs in 2050 5-Year)**

### 9.9.10.1 Component Descriptions

The individual components of Alternative 11.CR 5-Year Tunnel are described below.

- **CAM005/CAM007/MWR201/MWR010/MWR018/019/020/CAM017:** A deep rock, TBM-bored storage tunnel would be constructed to capture overflow from CAM005, CAM007, MWR201, MWR010, MWR018, MWR019, MWR020 and CAM017. The storage tunnel would be approximately 23,700 linear feet long, with a finished inside diameter of 24 feet, and would provide approximately 71.4 MG of storage. The route, features and components of the tunnel would be similar to the tunnel described for Alternative 10.CR 5-Year Tunnel.
- **GSI:** This alternative would include the implementation of GSI capturing runoff from 10% of the impervious right-of-way area in the combined sewer areas tributary to the Charles River in Cambridge and Boston (89.6 acres).
- **RE046-381, RE046-100, RE046-105, RE046-54 and RE046-55-1:** A 1.05 MG of storage conduit would be provided to capture the overflow volume from regulators RE046-381, RE046-100, RE046-105, RE046-54 and RE046-55-1. The route, features and components of the storage conduit would be the same as described for Alternative 10.CR 5-Year Tunnel.

### 9.9.10.2 Implementation Challenges

Challenges to implementing the components of this alternative would include:

GSI:

- Identifying appropriate sites for GSI on municipally owned land or on public rights-of-way.

CAM005/CAM007/MWR201/MWR010/MWR018/019/020/CAM017 Storage Tunnel:

- Similar challenges as described for Alternative 10.CR 5-Year Tunnel.

RE046-381, RE046-100, RE046-105, RE046-54 and RE046-55-1 Storage:

- Similar challenges as described for Alternative 10.CR 5-Year Tunnel.

### 9.9.11 Alternative 12.CR 25-Year Tunnel (0 CSOs in 2050 25-Year)

Alternative 12.CR 25-Year Tunnel was developed as a regional deep rock storage tunnel to eliminate CSOs in a 2050 25-year storm except for regulators RE046-381, RE046-100, RE046-62A, RE046-105, RE046-54 and RE046-55-1, and for RE-046-30 and RE046-19, which would be captured by local storage conduits. As presented in **Section 9.8.8**, the 25-year storm CSO volume was 132 MG, so the tunnel is sized to capture that CSO volume. This alternative would also result in no CSO discharges to Charles River in the 2050 TY.

**Table 9-87** presents, for each outfall, predicted CSO volumes for the Baseline Conditions 2050 25-year storm, the project components, the estimated capital cost, and the estimated project duration. A schematic layout of the components of this alternative is presented in **Figure 9-82**.

**Table 9-87. Alternative 12.CR 25-Year Tunnel (0 CSOs in 2050 25-Year) Summary**

| Charles River Outfall | Baseline 25-Year Vol. (MG) | Alternative Description | Preliminary Capital Cost [4] ($Million) | Project Duration[5] (years) |
|---|---|---|---|---|
| CAM005 | 4.13 | 132 MG 32-ft dia. storage tunnel[3] to store CAM005, CAM008, MWR201, MWR010, MWR018, MWR019, MWR020, and CAM017 | $2,300 M | 15 - 20 |
| CAM007 | 15.72 | | | |
| MWR201 (Cottage Farm - Treated) | 55.92 | | | |
| MWR010 | 3.62 | | | |
| MWR018 | 3.24 | | | |
| MWR019 | 2.48 | | | |
| MWR020 | 9.86 | | | |
| CAM0017 | 24.96 | | | |
| RE046-54, 55-1, 62A, 105, 100, 381 (MWR023) | 2.26[1] | 2.22 MG microtunnel storage | $230 M | 5 - 10 |
| RE046-19 and 30 (MWR023) | | 0.05 MG storage conduit | $6.3 M | 5 |
| **Total Untreated** | **64.58[2]** | **-** | **$2,600 M** | **15 - 20** |
| **Total Treated** | **55.92** | **-** | **-** | **-** |
| **Overall Total** | **120.5** | **-** | **-** | **-** |

**Notes:**
(1) Volume reflects the full volume over the regulator weir.
(2) Volume reflects that only 25% of the flow over the RE046 regulator weirs would discharge to the Charles River via MWR023.
(3) The storage tunnel volume exceeds the sum of the 25-year storm volumes at the outfalls to be captured due to the diversion structure configurations at outfalls CAM007, MWR019, MWR019, and MWR020 which provide additional relief of the peak hydraulic grade line.
(4) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.
(5) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

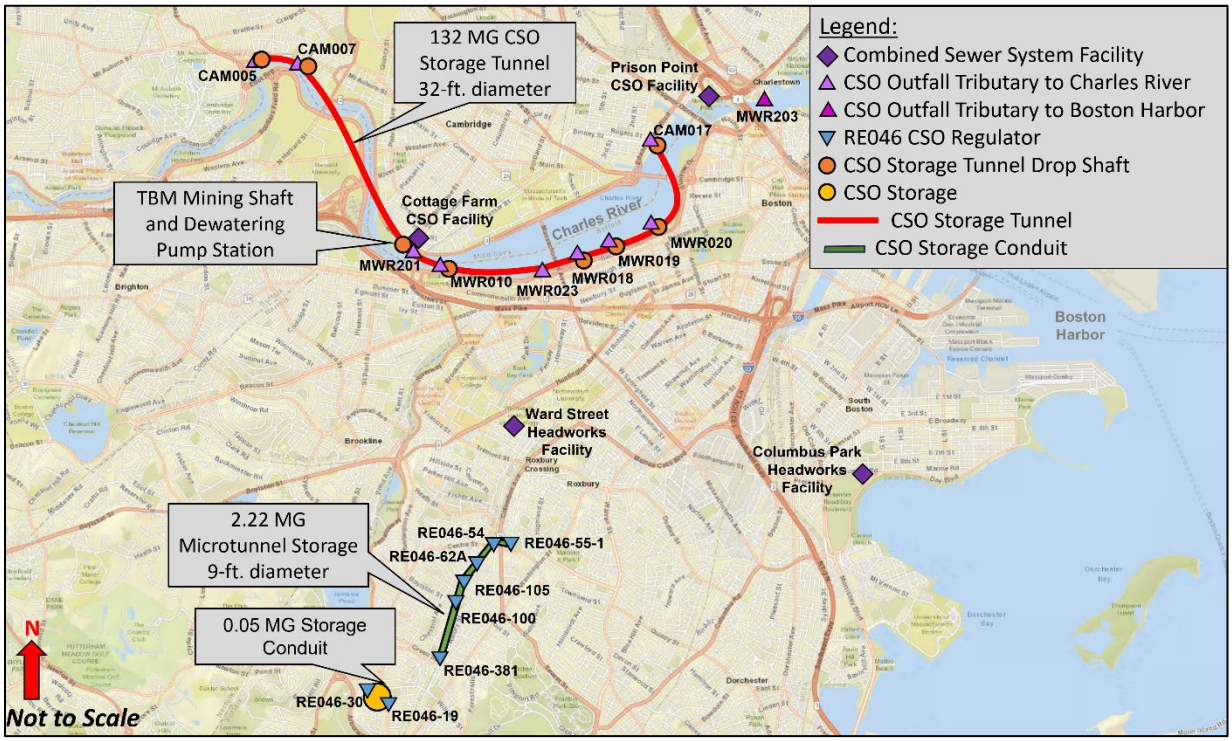



**Figure 9-82. Alternative 12.CR 25-Year Tunnel (0 CSOs in 2050 25-Year)**

### 9.9.11.1 Component Descriptions

The individual components of Alternative 12.CR 25-Year Tunnel are described below.

- **CAM005/CAM007/MWR201/MWR010/MWR018/019/020/CAM017:** A deep rock, TBM-bored storage tunnel would be constructed to capture overflow from CAM005, CAM007, MWR201, MWR010, MWR018, MWR019, MWR020 and CAM017. The storage tunnel would be approximately 23,700 linear feet long, with a finished inside diameter of 32 feet, and would provide approximately 132 MG of storage. The route, features and components of the tunnel would be similar to the tunnel described for the Alternative 5.CR Tunnel, with the exceptions of the larger tunnel diameter and dewatering pump station, as well as the addition of diversion structures and drop shafts at outfalls CAM007 and MWR010.

- **RE046-381, RE046-100, RE046-105, RE046-62A, RE046-54 and RE046-55-1:** A 2.22 MG of storage conduit would be provided to capture the overflow volume from regulators RE046-381, RE046-100, RE046-105, RE046-62A, RE046-54 and RE046-55-1. The storage conduit would be 9-foot diameter extending for 5,450 feet between regulators RE046-381 and RE046-55-1. The conduit would likely be constructed by microtunneling. A preliminary route for the storage conduit would begin adjacent to regulators RE046-381 and run along Lamartine and Center Streets to regulator RE046-55-1. It is anticipated that three pipe jacking shafts, where the microtunneling boring machine is inserted and excavate is removed, would be located along the route, along with potentially four retrieval shafts, where the microtunneling boring machine is removed. The final route and shaft locations could change and would be defined after further planning and design. A 2.22 MGD dewatering pump station would be located at the downstream end. A permanent above-ground structure would be required at the downstream end of the storage conduit for maintenance access and to house electrical and odor control equipment. Stored flows would likely be dewatered to the Stony Brook Valley Sewer for conveyance to Ward Street Headworks.
- **RE046-19, RE046-30:** A 0.05 MG of storage conduit would be provided to capture the overflow volume from regulators RE046-19 and RE046-30. The storage conduit would be 4-foot diameter extending for 815 feet. A preliminary route for the storage conduit would begin adjacent to regulator RE046-30 and run along Saint Joseph and South Streets to regulator RE046-19. The storage conduit would likely be constructed by open-cut excavation. The final route and shaft locations could change and would be defined after further planning and design. A 0.05 MGD dewatering pump station would be located at the downstream end. A permanent above-ground structure would be required at the downstream end of the storage conduit for maintenance access and to house electrical and odor control equipment. Stored flows would likely be dewatered to the Southwest Corridor Interceptor for conveyance to Ward Street Headworks.

#### 9.9.11.2 Implementation Challenges

Challenges to implementing the components of this alternative would include:

CAM005/CAM007/MWR201/MWR010/MWR018/019/020/CAM017 Storage Tunnel:

- Similar challenges as described for Alternative 10.CR 5-Year Tunnel, but more extensive construction-period impacts due to the larger tunnel diameter and volume of excavate.

RE046-381, RE046-100, RE046-62A, RE046-105, RE046-54 and RE046-55-1 Storage Conduit;

- Similar challenges as described for Alternative 10.CR 5-Year Tunnel.

RE046-30, RE046-19 Storage Conduit:

- Diversion structures and piping would be constructed in public right-of-way adjacent to St. Thomas Aquinas church;
- Small above-ground structure to remain at site permanently; and
- Long-term maintenance access needed to storage facility.

### 9.9.12 Alternative 13.CR 25-Year Tunnel + GSI (0 CSOs in 2050 25-Year)

Alternative 13.CR 25-Year Tunnel + GSI includes a combination of deep tunnel storage, GSI, and storage conduits. This alternative developed to assess the impact that regional GSI could have on sizing regional storage in a large design storm. This alternative is based on Alternative 12.CR 25-Year Tunnel and augments it by adding GSI at a regional scale. With the addition of GSI, the remaining volume to be captured by the tunnel is reduced from 132 MG to 131.43 MG. Although there was a reduction in volume, it is not sufficient to downsize the tunnel diameter while maintaining the same length—therefore the

tunnel sizes for Alternative 12.CR 25-Year Tunnel and Alternative 13.CR 25-Year Tunnel + GSI are the same. The tunnel length is based on the route described in **Section 9.8.8** and did not change because it needs to capture CSO from the same outfalls. GSI implementation also did not change the size of the local storage conduits for regulators RE046-381, RE046-100, RE046-62A, RE046-105, RE046-54 and RE046-55-1, and for RE-046-30 and RE046-19.

**Table 9-88** presents, for each outfall, the predicted CSO volume for Alternative 12.CR 25-Year Tunnel + GSI the estimated capital cost, and the estimated project duration. A schematic layout of the components of this alternative is presented in **Figure 9-83**.

**Table 9-88. Alternative 12.CR 25-Year Tunnel + GSI (0 CSOs in 2050 25-Year) Summary**

| Charles River Outfall | Baseline 25-Year Vol. (MG) | Alternative Description | Preliminary Capital Cost[5] ($Million) | Project Duration[6] (years) |
|---|---|---|---|---|
| CAM005 | 4.13 | 131.4 MG 32-ft dia. storage tunnel + GSI (89.6 acres) [3][4] to store CAM005, CAM008, MWR201, MWR010, MWR018, MWR019, MWR020, and CAM017 | $2,400 M | 15 - 20 for tunnel (GSI requires additional time to be determined) |
| CAM007 | 15.72 | | | |
| MWR201 (Cottage Farm - Treated) | 55.92 | | | |
| MWR010 | 3.62 | | | |
| MWR018 | 3.24 | | | |
| MWR019 | 2.48 | | | |
| MWR020 | 9.86 | | | |
| CAM0017 | 24.96 | | | |
| RE046-54, 55-1, 62A, 105, 100, 381 (MWR023) | 2.26[1] | 2.22 MG microtunnel storage[1] | $230M | 5 - 10 |
| RE046-19 and 30 (MWR023) | | 0.05 MG storage conduit[1] | $6.3 M | 5 |
| **Total Untreated** | **64.58[2]** | **-** | **$2,700M** | **15 - 20** |
| **Total Treated** | **55.92** | **-** | **-** | **-** |
| **Overall Total** | **120.5** | **-** | **-** | **-** |

**Notes:**
(1) Volume reflects the full volume over the regulator weirs.
(2) Volume reflects that only 25% of the flow over the RE046 regulator weirs would discharge to the Charles River via MWR023.
(3) The storage tunnel volume exceeds the sum of the 25-year storm volumes at the outfalls to be captured due to the diversion structure configurations at outfalls CAM007, MWR019, MWR019, and MWR020 which provide additional relief of the peak hydraulic grade line.1.
(4) The CSO volume to be stored by the tunnel for Alternative 13.CR 25-Year Tunnel + GSI. is 131.4 MG. Although there was a reduction in volume of CSO to be stored by the tunnel when compared to Alt 12.CR 25-Year Tunnel, it not sufficient to downsize the tunnel diameter while maintaining the same length – and therefore the tunnel size for Alternatives 12.CR 25-Year Tunnel and 13.CR 25-Year Tunnel + GSI are the same.
(5) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.
(6) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

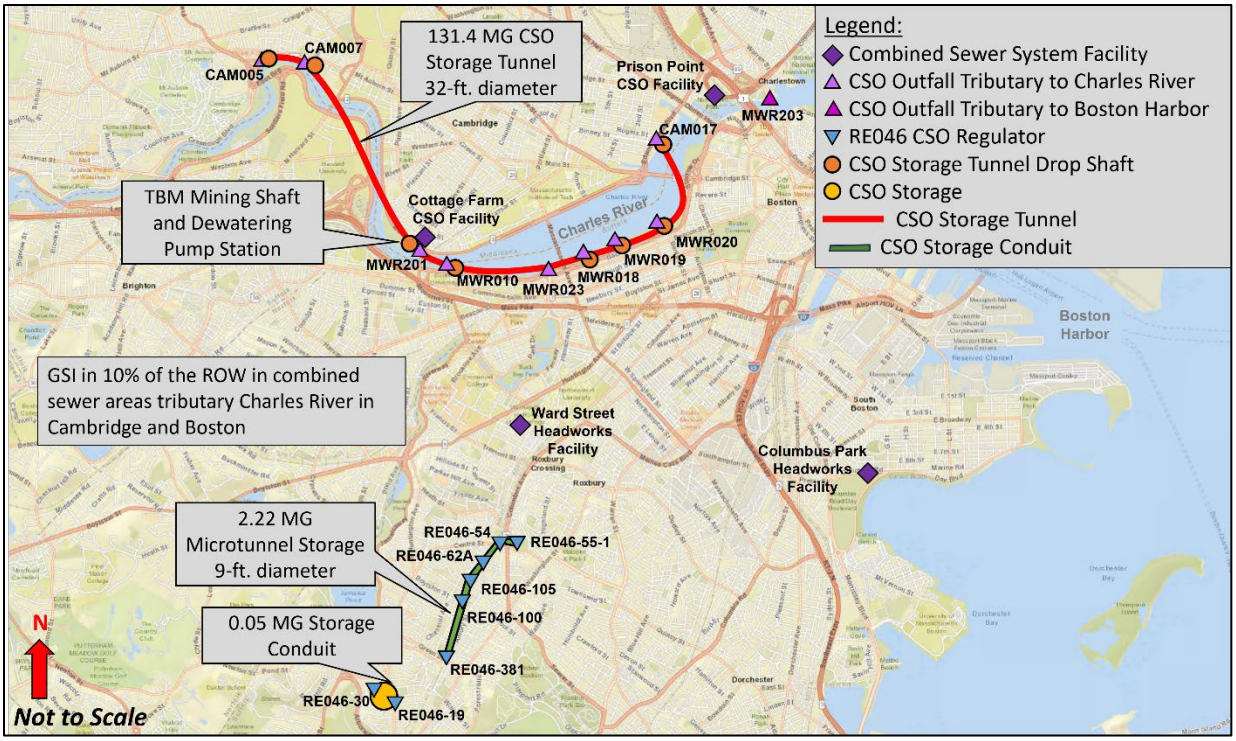



**Figure 9-83. Alternative 13.CR Charles River 2050 25-Year Tunnel + GSI (0 CSOs in 2050 25-Year)**

### 9.9.12.1 Component Descriptions

The individual components of Alternative 13.CR 25-Year Tunnel + GSI are described below:

- **CAM005/CAM007/MWR201/MWR010/MWR018/019/020/CAM017:** A deep rock, TBM-bored storage tunnel would be constructed to capture overflow from CAM005, CAM007, MWR201, MWR010, MWR018, MWR019, MWR020 and CAM017. The storage tunnel would be approximately 23,700 linear feet long, with a finished inside diameter of 32 feet, and would provide approximately 131.4 MG of storage. The route, features and components of the tunnel would be similar to the tunnel described for Alternative 12.CR 25-Year Tunnel.
- **GSI:** This alternative would include the implementation of GSI capturing runoff from 10% of the impervious right-of-way area in the combined sewer areas tributary to the Charles River in Cambridge and Boston (89.6 acres).
- **RE046-381, RE046-100, RE046-62A, RE046-105, RE046-54 and RE046-55-1:** A 2.22 MG storage conduit would be provided to capture the overflow volume from regulators RE046-381, RE046-100, RE046A, RE046-105, RE046-54 and RE046-55-1. The storage conduit would be 6-foot diameter extending for 5,450 feet between regulators RE046-381 and RE046-55-1. The conduit would likely be constructed by microtunneling. A preliminary route for the storage conduit would begin adjacent to regulators RE046-381 and run along Lamartine and Center Streets to regulator RE046-55-1. It is anticipated that three pipe jacking shafts, where the microtunneling boring machine is inserted and excavate is removed, would be located along the route, along with potentially four retrieval shafts, where the microtunneling boring machine is removed. The final route and shaft locations could change and would be defined after further planning and design. A 1.05 MGD dewatering pump station would be located at the downstream end. A permanent above-ground structure would be required at the downstream end of the storage conduit for maintenance access and to house

electrical and odor control equipment. Stored flows would likely be dewatered to the Stony Brook Valley Sewer for conveyance to Ward Street Headworks.

#### 9.9.12.2 Implementation Challenges

Challenges to implementing the components of this alternative would include:

GSI:

- Identifying appropriate sites for GSI on municipally owned land or on public rights-of-way.

CAM005/CAM007/MWR201/MWR010/MWR018/019/020/CAM017 Storage Tunnel:

- Similar challenges as described for Alternative 12.CR 25-Year Tunnel.

RE046-381, RE046-100, RE046-62A, RE046-105, RE046-54 and RE046-55-1 Storage Conduit:

- Similar challenges as described for Alternative 12.CR 25-Year Tunnel.

RE046-30, RE046-19 Storage Conduit:

- Similar challenges as described for Alternative 12.CR 25-Year Tunnel.

### 9.9.13 Alternative 7.CR Regional Sewer Separation

This alternative is based on the regional sewer separation analysis in **Section 9.8.8** and would include separating all the combined sewers tributary to the Charles River in Cambridge, Somerville, and Boston, as shown in **Figure 9-84**. The following components, as discussed earlier, are included in this alternative:

- Separating approximately 1,155 acres of combined sewer area in Cambridge, 1,045 acres in Somerville, and 481 acres in Boston; additionally some areas that have begun separation work but currently return all flows to the combined sewer system would also require rerouting (and treating) the stormwater – approximately 182 acres in Cambridge and 695 acres in Boston (no areas needing rerouting identified in Somerville). Thus, the total area requiring work under this alternative would be approximately 3,600 acres. The work would require installing new sanitary and/or stormwater pipes in each street currently served by combined sewers in the tributary area, and likely the creation of new stormwater outfalls to the Charles River.
- Approximately 16 total acres of land would be needed for pumping and treatment of the new stormwater flows. The acreage for stormwater pumping and treatment are estimated based on factors identified provided in Appendix E.
- Modeling assumed that 90 percent of the inflow from the combined areas could be captured by the sewer separation work, with 10 percent remaining tributary to the collection system. The remaining 10 percent was intended to reflect roof drains connected to interior building plumbing, and other extraneous sources of inflow that could not be feasibly captured.
- Modeling assumed the CSO regulators would remain open (described in **Section 9.2.4**) so the need for them to remain as relief points could be assessed.

Regional sewer separation for the Charles River was predicted to eliminate untreated CSO discharges to the Charles River from most of the outfalls in the 2050 TY, but 0.03 MG of treated discharge was predicted to remain at outfall MWR201 (Cottage Farm facility), and 0.12 MG of untreated discharge was predicted to remain in the Stony Brook regulators upstream of outfall MWR023.

In the 2050 5-year storm, the remaining treated volume at outfall MWR201 is predicted to be 17.66 MG, and the remaining untreated volume would be 0.42 MG from the Stony Brook regulators and outfall MWR010. In the 2050 25-year storm, the remaining treated volume at outfall MWR201 would be 32.21 MG, and the remaining untreated volume would be 5.06 MG. CAM017, MWR019, and MWR020 are the only CSO outfalls not predicted to activate to the Charles River in the 25-year storm. The preliminary capital cost of regional sewer separation for the Charles River was estimated to be $4,500 M, with a duration of 50 years. **Table 9-89** provides a breakdown of the assumptions for sewer separation and the application of unit costs presented in **Section 9.3** that generate the preliminary capital cost.

## Table 9-89. Alternative 7.CR Regional Sewer Separation Preliminary Capital Cost Summary

| | | Cambridge | | | Somerville | | | Boston | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Unit Cost ($/separated acre)[1] | Acres | Construction Cost ($M) | Capital Cost ($M) | Acres | Construction Cost ($M) | Capital Cost ($M) | Acres | Construction Cost ($M) | Capital Cost ($M) | Capital Cost ($M) |
| To Be Separated Pipe Network | $450,000 | 1155 | $520 | $890 | 1045 | $470 | $810 | 481 | $220 | $370 | **$2,070** |
| Previously Separated | $50,000 | 182 | $9 | $16 | 0 | $0 | $0 | 695 | $35 | $60 | **$76** |
| Stormwater Treatment (Phosphorus) | $115,000 | 1337 | $150 | $260 | 1045 | $120 | $210 | 695 | $80 | $140 | **$610** |
| Peak Flow Attenuation Storage | $325,000 | 0 | $0 | $0 | 0 | $0 | $0 | 0 | $0 | $0 | **$0** |
| Pumping (Landlocked/ Low-Lying areas) | $180,000 | 1008 | $180 | $310 | 1045 | $190 | $320 | 1176 | $210 | $360 | **$990** |
| Extraordinary Conveyance | N/A | | $41 | $70 | | $39 | $67 | | $350 | $590 | **$727** |
| Storage Tanks | N/A | | $0 | $0 | | $0 | $0 | | $0 | $0 | **$0** |
| Other | N/A | | $0 | $0 | | $0 | $0 | | $0 | $0 | **$0** |
| **Total** | | | **$900** | **$1,500** | | **$820** | **$1,400** | | **$890** | **$1,500** | **$4,500** |

**Note:**
Preliminary Unit Costs are described in Section **9.3**. Costs for sewer separation components are rounded to two significant figures; total alternative cost was rounded up to two significant figures and therefore may not match the sum.

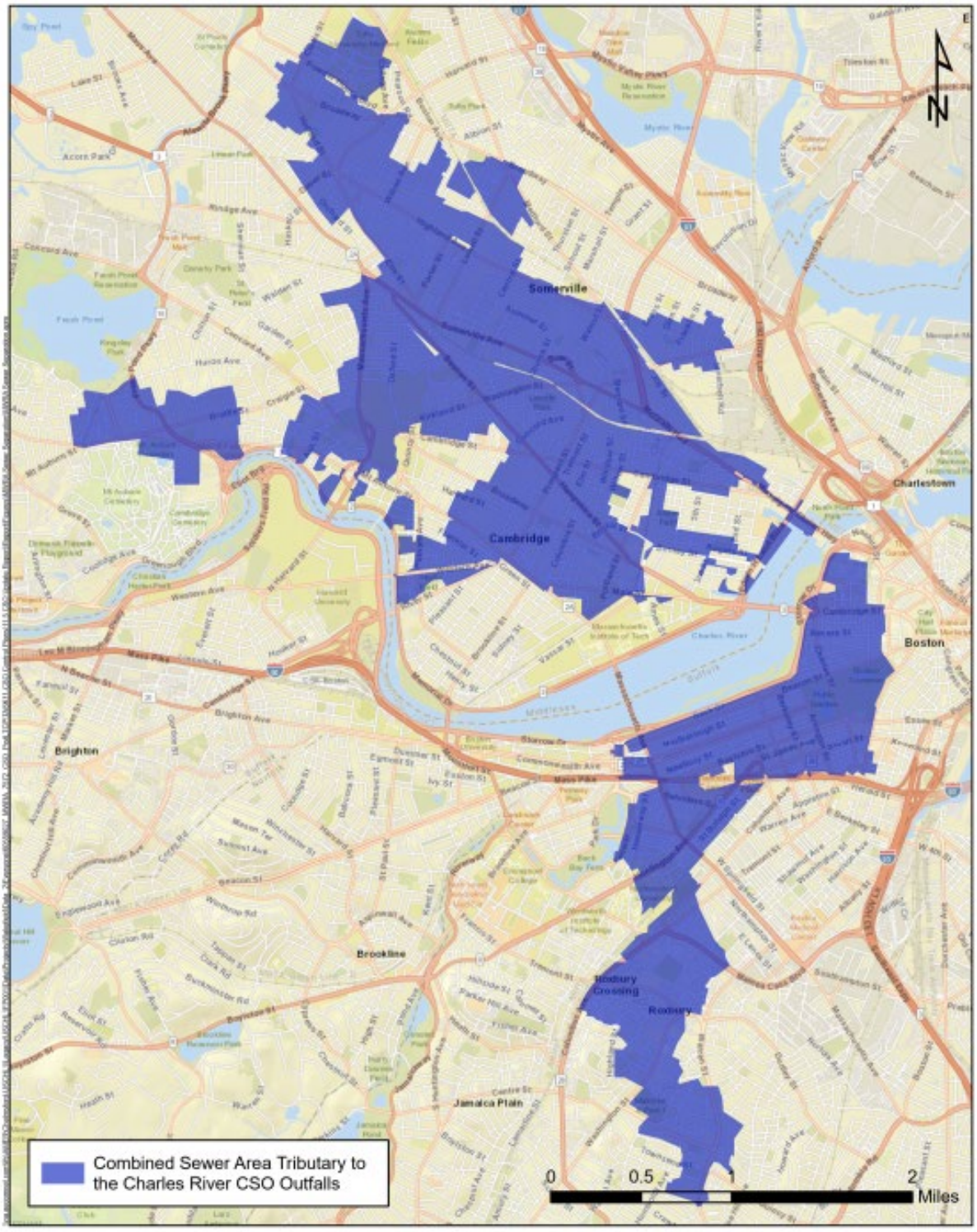



**Figure 9-84. Alternative 7.CR Regional Sewer Separation**

#### 9.9.13.1 Implementation Challenges

Challenges to implementing the components of this alternative would include:

- Construction in highly congested urban areas over a long period;
- Construction of large storm drains and microtunnels in Cambridge, Back Bay under BMC/Storrow Drive in highly congested urban areas will likely create significant disruptions to residents and businesses and constructability may be challenging due to utility conflicts;
- Construction of stormwater microtunnels under the BMC may require Article 97 legislation to authorize the change of use of the site;
- Sites have not been identified for stormwater treatment, flow attenuation, stormwater pumping, or GSI; and
- Sewer separation of this magnitude would take many years to complete, and residents in the area would be likely to experience construction fatigue, with the potential for multiple mobilizations in each street for utility relocations, separation, and paving.

### 9.9.14 Charles River CSO Alternative Summary

**Table 9-90** provides a summary of the previously presented Charles River CSO control alternatives. The table presents the alternative name, the Baseline Conditions CSO activation frequency and volume, the remaining CSO activation frequency and volume after implementation, the preliminary capital cost, and an estimated project duration. The evaluation and comparison of CSO control alternatives is presented in Section 10.

**Table 9-90. Charles River Alternatives Analysis Summary**

| Charles River Alternative | Alternative Components | Baseline Act Freq./Vol. (MG) | Remaining Act Freq./Vol. (MG) | Preliminary Capital Cost ($M) | Project Duration (years)[5] |
|---|---|---|---|---|---|
| **2050 Typical Year Level of Control** | | | | | |
| 1.CR Integrated | 2 tanks (3.1 MG) + 2-mile-long deep tunnel (17 ft diameter) + 2 storage conduits | 6 act/38.04 MG | 0 act/0 MG[1] | $1,100 M | 15 |
| 2.CR Hybrid 1 | 1 tank (2.5 MG) + 80 acres of sewer separation +2-mile-long deep tunnel (17 ft diameter) | 6 act/38.04 MG | 0 act/0 MG[1] | $1,200 M | 15 |
| 3.CR Hybrid 2 | 2 tanks (12.7 MG) + 284 acres of sewer separation + 0.75 mile-long microtunnel + 2 storage conduits | 6 act/38.04 MG | 0 act/0 MG[1] | $750 M | 25 |
| 4.CR Hybrid 3 | 2 tanks (12.6 MG) + 446 acres of sewer separation + 2 storage conduits | 6 act/38.04 MG | 0 act/0 MG[1] | $690 M | 30 |
| 5.CR Hybrid 4 | 4.5-mile-deep tunnel (12 ft diameter) + 2 storage conduits | 6 act/38.04 MG | 0 act/0 MG[1] | $1,400 M | 15 - 20 |

## Table 9-90. Charles River Alternatives Analysis Summary

| Charles River Alternative | Alternative Components | Baseline Act Freq./Vol. (MG) | Remaining Act Freq./Vol. (MG) | Preliminary Capital Cost ($M) | Project Duration (years)[5] |
|---|---|---|---|---|---|
| 6.CR Hybrid 5 | Same tunnel as 5.CR + GSI (90 acres) + 2 storage conduits | 6 act/38.04 MG | 0 act/0 MG[1] | $1,500 M | 15 - 20 for tunnel (GSI requires additional time to be determined) |
| **Limited CSOs in 2050 Typical Year Level of Control** | | | | | |
| 8.CR Hybrid 1 | 1 tank (2.5 MG) + 268 acres of sewer separation + 1 storage conduit | 6 act/38.04 MG | 4 act/29.4 MG[2] | $360 M | 25 |
| 9.CR Hybrid 2 | 1 tank (2.5 MG) + 80 acres of sewer separation + 0.75 mile-long microtunnel + storage conduit | 6 act/38.04 MG | 4 act/32.96 MG[2] | $300 M | 10 |
| **Greater Than Typical Year Level of Control** | | | | | |
| **2050 5-Year Storm** | | | | | |
| 10.CR 5-Year Tunnel | 4.5-mile-long deep tunnel (24 ft diameter) +1-mile-long microtunnel | 65.47 | 0 act/0 MG[3] | $1,900 M | 15 - 20 |
| 11.CR 5-Year Tunnel + GSI | Same tunnel as 10.CR + GSI (90 acres) + 1-mile-long microtunnel (same tunnel as 10. CR) | 65.47 | 0 act/0 MG[3] | $2,000 M | 15 - 20 for tunnel (GSI requires additional time to be determined) |
| **2050 25-Year Storm** | | | | | |
| 12.CR 25-Year Tunnel | Same tunnel as 10.CR + GSI (90 acres) + 1-mile-long microtunnel (same tunnel as 10. CR) | 120.5 | 0 act/0 MG[4] | $2,600 M | 15 - 20 |
| 13.CR 25-Year Tunnel + GSI | Same tunnel as 12.CR + GSI (90 acres) + 1-mile-long microtunnel + 1 storage conduit | 120.5 | 0 act/0 MG[4] | $2,700 M | 15 - 20 for tunnel (GSI requires additional time to be determined) |

**Table 9-90. Charles River Alternatives Analysis Summary**

| Charles River Alternative | Alternative Components | Baseline Act Freq./Vol. (MG) | Remaining Act Freq./Vol. (MG) | Preliminary Capital Cost ($M) | Project Duration (years)(5) |
|---|---|---|---|---|---|
| **Regional Sewer Separation** | | | | | |
| 7.CR Regional Separation | 3,600 acres | 2050 TY: 6 act/38.04 MG | MWR201: 1 act/0.03 MG in 2050 TY<br>MWR023: 6 act/0.12 MG in 2050 TY | $4,500 M(6) | 50 |
| | | 2050 5-Year: 65.47MG | 2050 5-year: 18.08 MG Remaining | | |
| | | 2050 25-Year: 120.5 MG | 2050 25-year: 37.27 MG Remaining | | |

**Notes:**
(1) Alternatives would result in no CSO discharges in the 2050 TY.
(2) CSO activation frequency and volume remaining with Alternative implemented in the 2050 TY.
(3) Alternatives would result in no CSO discharges in the 2050 TY and 5-year storm.
(4) Alternatives would result in no CSO discharges in the 2050 TY, 5-year and 25-year storms.
(5) Project Duration is a preliminary estimate of design and construction duration and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.
(6) Costing for sewer separation, including stormwater peak flow attenuation, pumping, and treatment, was developed using construction bids and estimated costs from recent sewer separation projects in the Greater Boston area. Costs were converted into a dollar per acre of sewer separation using project area size. See Appendix E for more details.

## 9.10 Summary

The preceding sections summarized the initial development of alternatives to provide a range of levels of control for the Alewife Brook, Upper Mystic River, and Charles River. A total of thirty-nine alternatives were developed including twelve for the Alewife Brook which are summarized in **Table 9-35** (Section **9.5.13**), fourteen for the Upper Mystic River which are summarized in **Table 9-56** (**Section 9.7.15**), and thirteen for the Charles River which are summarized in **Table 9-90** in **Section 9.9.14** The process of further evaluating these alternatives and selecting a preferred alternative is presented in Section 10.

# 10. Evaluation of CSO Control Alternatives

## 10.1 Process Overview

A stipulation in each of the Variances is to evaluate "the costs and water quality benefits of further CSO control alternatives, up to and including elimination of CSO discharges." This section documents the multi-step evaluation approach undertaken by the Partners to satisfy this condition. The process thus far has resulted in the development of 39 distinct alternatives that span three waterbodies, 16 outfalls, and four unique levels of control.

The screening and evaluation presented in this section first considers a wider array of benefits and constraints in addition to strict water quality – for example, alternatives that reduce flood risk, renew existing infrastructure, and/or include greenspace or groundwater replenishment. Then, after narrowing the pool of alternatives to the preliminary preferred alternatives in each water body, spanning the LOCs, the Partners performed a more direct cost-benefit evaluation on the preliminary preferred alternatives across LOCs. This tiered evaluation methodology is presented in **Figure 10-1.**

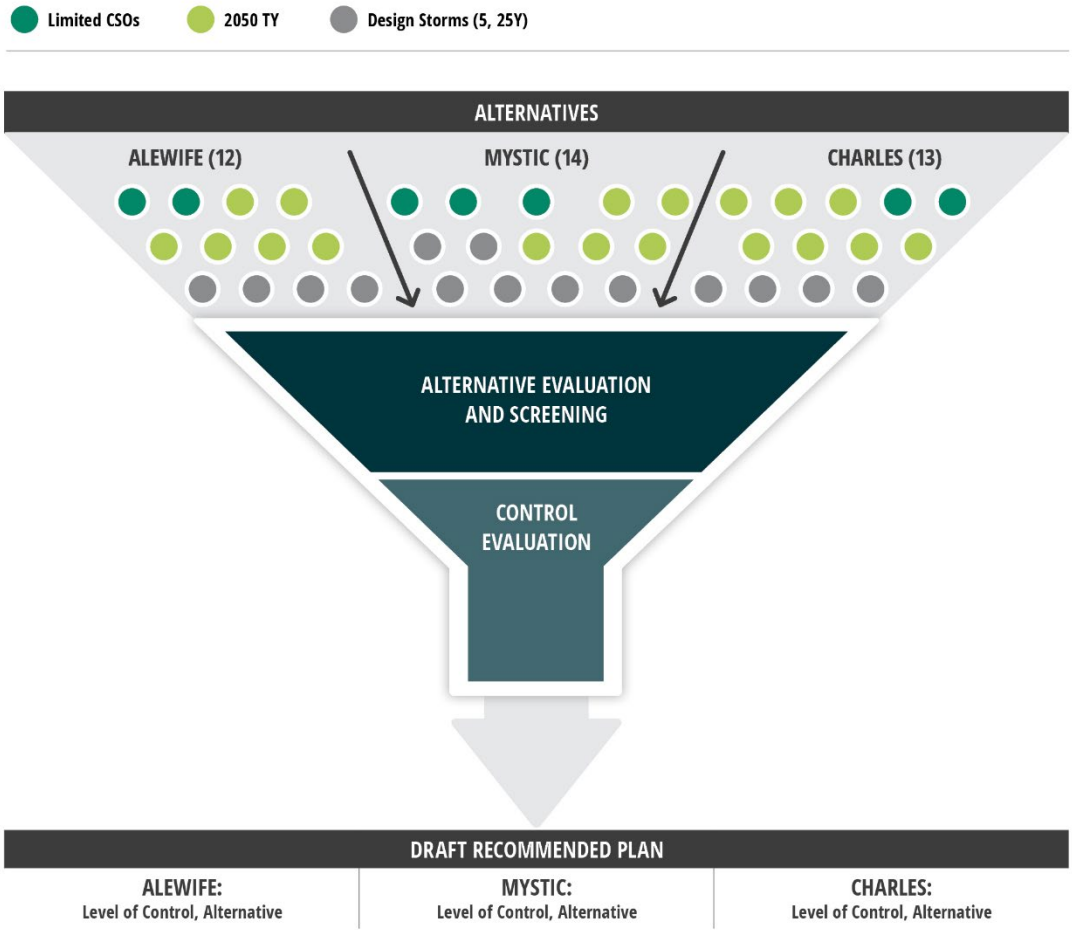



**Figure 10-1. Multi-Step Evaluation Process**

The evaluation process shown in **Figure 10-1** contains the following steps:

- Step 1. Alternatives Evaluation and Screening:
  - 2050 TY Alternatives Screening: First, the Partners sought to compare the larger and more varied group of alternatives for 0 CSOs in the 2050 TY to better understand the benefits of each alternative that meet the same LOC and identify preliminary preferred alternatives to carry forward. This narrows the largest group of alternatives to a preliminary preferred alternative for this LOC. The evaluation criteria are presented in **Section 10.2**, and the evaluation is described in **Section 10.3.1**.
  - Preferred Alternatives in Other Levels of Control: For the alternatives in the other LOCs, there were typically only 2-3 alternatives per LOC. The Partners used the lessons learned from the 2050 TY evaluation, including an understanding of the types of alternatives that performed well in that analysis, to winnow down the alternatives across each LOC to identify one preferred alternative for each LOC. Considerations for regional sewer separation are summarized in **Section 10.3.2**, and the considerations for other LOCs are presented in **Section 10.3.3**.
- Step 2: Control Evaluation: The Partners then sought to evaluate the remaining alternatives across levels of control. This evaluation focused on balancing considerations including regional system performance limitations, LOC, cost, timeline to CSO reduction benefits, additional water quality benefits, implementation considerations, overall impacts such as neighborhood disruption, and temporary and permanent loss of recreational areas. Some of these considerations were evaluated on a regional level to inform the overall system, and then local and site-specific considerations were evaluated to recommend an ultimate alternative for each waterbody. This process is presented in **Section 10.4.**

The characteristics and dynamics of the Alewife Brook, Mystic River, and Charles River are each unique, and the resulting decision processes for each waterbody aimed to reflect those unique characteristics. Therefore, the evaluations shown in this section result in a tailored recommendation for each waterbody that proposes an independent level of control and dedicated alternative for each.

## 10.2 Criteria for 0 CSOs in 2050 TY Alternative Evaluation

This section describes the alternative evaluation process and scoring rubric that was used to compare alternatives within the limited and zero CSOs in the 2050 TY LOC to narrow down the suite of possible options. As a result of this process, the preliminary preferred alternatives within the LOCs were identified and brought forth into the LOC evaluation.

Throughout the engagement process described in Section 5, one key takeaway was the desire for an alternatives evaluation process that accounted for the multiple potential benefits and co-benefits of each alternative beyond simply CSO reduction. In response, and also through reviewing similar CSO LTCPs across the country, the Partners developed this evaluation process that relies on ten (10) distinct evaluation criteria that can be used to characterize an alternative's benefits. These criteria were derived based on a variety of factors:

- Local context: for example, what other water quality parameters are important to the Alewife, Mystic, and Charles; how do impacts to waterways that are and are not subject to the Variances impact the alternative prioritization process?
- Community input garnered from MassDEP and EPA, stakeholder groups, and the general public (through meetings and a public survey as documented in Section 5): for example, this input highlighted desires for alternatives that can be completed in a short amount of time and alternatives that promote habitat, recreation, and other community co-benefits.
- Takeaways from large capital projects: how do lessons learned from large projects the Partners have constructed inform making smart decisions to ensure the recommended Plan is implementable?

Examples include constructability with deep excavation and how permitting can impact a project's scope and timeline.

Scoring for each criterion was based on a scale from 0 – 5, with a score of 5 being the most beneficial and a score of 0 being the least beneficial. **Table 10-1** below lists the criteria, with a more detailed description of each criterion and rubric in the subsections that follow.

**Table 10-1. Alternative Evaluation Criteria**

| Evaluation Criteria | Description |
|---|---|
| Change in Nutrient Loading | Net reduction in phosphorous loading in a 2050 Typical Year. |
| Schedule: Duration to CSO Reduction Benefit | Fastest possible implementation schedule to achieve the full level of CSO control and/or achievement of partial CSO reductions. |
| Construction Impacts | Temporary impacts to access and use of public facilities and temporary disruption to residential / commercial neighborhoods. |
| Construction Complexity and Risk | Evaluation of depth of excavation and construction complexity. |
| Operation and Maintenance Considerations | Operation and maintenance burden. |
| Provide Resiliency and Adaptability | Ability to be resilient and adaptable to future conditions. |
| Renewal of Existing Infrastructure | Renewal or replacement of existing infrastructure. |
| Flooding: sewer/storm flood risk | Reduced hydraulic grade line in collection system(s) where flood risk is present. |
| Community Co-benefits and Long-term Site Impacts | Permanent community co-benefits and permanent impacts to access and use of public facilities. |
| Impacts to Non-Variance CSOs | Reduced CSO volume to non-Variance CSOs. |

### 10.2.1 Change in Nutrient Loading

**Table 10-2. Scoring Rubric for Change in Nutrient Loading Criterion**

| Evaluation Criteria | Scoring Rubric | Example Factors Leading to a High Score | Example Factors Leading to a Lower Score |
|---|---|---|---|
| Change in Nutrient Loading | Quantitative Evaluation:<br>5 – 100% reduction of calculated phosphorous loading to waterways<br>3 – 60% reduction of calculated phosphorous loading to waterways<br>1 – 20% reduction of calculated phosphorous loading to waterways<br>0 – No reduction in calculated phosphorous loading to waterways<br>Score of 0-5 is scaled according to the percent reduction.<br>Any increase in phosphorous loads to waterways gets a score of zero and is documented as a project risk outside of scoring | Greater CSO volume reduction | Greater area of sewer separation, which leads to stormwater discharge |

The first criterion evaluated was change in nutrient loading, which is especially relevant to this region due to the Total Maximum Daily Load (TMDL) requirements that apply to the waterways within the Variances (see Section 2.1.4). Nutrient reduction was represented by the net reduction in phosphorous loading to these waterways in a 2050 TY, accounting for reduction of phosphorous from CSO volumes and increase of phosphorus from stormwater volumes. It should be noted that phosphorous loading is not evaluated over a Typical Year for permitting purposes; this method was used to evaluate CSO control alternatives because it offered a way to compare CSO volumes and stormwater volumes. The method of calculation was as follows:

1. Calculate baseline Phosphorous (P) Load: Derive CSO volume to the waterway in baseline 2050 TY. This volume comes from the unified model. Multiply the volume with typical combined sewer concentration of 3.1. mg/L (EPA Alternative TMDL for Mystic River).

$$Volume_{BL\ CSO\ 2050\ TY}\ \frac{MG}{TY}\ x\ 3.1\frac{mg}{L}\ x\ 8.34\frac{lb}{gal} = P_{Load}, Baseline\frac{lb}{TY}$$

2. Calculate with-alternative P Load:

   a. Derive CSO volume to the waterway for the alternative in the 2050 TY, from the Unified Model. Multiply the volume with typical combined sewer concentration of 3.1 mg/L (EPA Alternative TMDL for Mystic).

$$Volume_{Alt\ CSO\ 2050\ TY}\ \frac{MG}{TY}\ x\ 3.1\frac{mg}{L}\ x\ 8.34\frac{lb}{gal} = P_{Load}, CSO\ Reduction\frac{lb}{TY}$$

b. Derive increase in new stormwater volume discharged to waterways in the 2050 TY, from the Unified Model that results from sewer separation scenarios. Multiply the volume with typical stormwater concentration of 0.27 mg/L (from EPA / National Stormwater Database).

$$Volume_{Alt\ CSO\ 2050\ TY}\frac{MG}{TY}\ x\ 0.27\frac{mg}{L}\ x\ 8.34\frac{lb}{gal} = P_{Load}, SW\ Addition\frac{lb}{TY}$$

3. Calculate the net change in P load accounting for both CSO reduction and stormwater increase: Calculate the percent reduction of total P load (from Baseline P load) for the given waterway.

$$(P_{Load}, Baseline - P_{Load}, CSO\ Reduction\ +\ P_{Load}, SW\ Addition) = Change\ in\ P\frac{lb}{TY}$$

$$\frac{Change\ in\ P\frac{lb}{TY}}{P_{Load}, Baseline\frac{lb}{TY}} = \%\ Net\ Change\ in\ P$$

4. Assign the alternative with a score from 0 to 5.

$$\%\ Net\ Change\ in\ P * 5 = Score$$

### 10.2.2 Schedule: Duration to CSO Reduction Benefit

**Table 10-3. Scoring Rubric for Schedule Criterion**

| Evaluation Criteria | Scoring Rubric | Example Factors Leading to a High Score | Example Factors Leading to a Lower Score |
|---|---|---|---|
| Schedule: Duration to CSO Reduction Benefit | Minimum Duration to Full CSO Benefit:<br>5 – < 5yrs<br>4 – 6 to 15 +/- yrs<br>3 – 16 to 25 +/- yrs<br>2 – 26 to 35 +/- yrs<br>1 – >35 yrs<br>+1 point for early/interim meaningful CSO benefit | Alternatives with project components that can be implemented quickly<br>Alternatives with phased implementation | Alternatives consisting of a single project with a long implementation period |

The goal of evaluating schedule was to prioritize alternatives that could be implemented more quickly. This evaluation criterion resulted from feedback received in engagement process. One of the watershed association's top priorities was achieving CSO reductions in a short timeframe. Alternatives that are comprised of multiple project elements are scored based on the full (longest) implementation duration and alternatives that have components that can get significant CSO reductions in the interim received additional points.

It should be noted that the implementation durations represent the fastest possible implementation schedule if the project component / alternative were a standalone construction project of high priority; however, actual implementation will require prioritizing individual project components / alternatives and sequencing construction across the region in a way that is feasible and affordable.

### 10.2.3 Construction Impacts

**Table 10-4. Scoring Rubric for Construction Impacts Criterion**

| Evaluation Criteria | Scoring Rubric | Example Factors Leading to a High Score | Example Factors Leading to a Lower Score |
|---|---|---|---|
| Construction Impacts | Average of two sub-criteria below | | |
| Impacts to Public Uses During Construction | 5 – Relatively limited interruption<br>3 – Relatively moderate interruption<br>1 – More extensive interruption | Construction that does not impact public uses | Construction activities or staging areas in parking or recreation areas<br>Significant street disruption (extent, duration, population density) |
| Neighborhood Impacts During Construction | 5 – Relatively limited impacts<br>3 – Relatively moderate impacts<br>1 – More extensive impacts | Construction away from residents and businesses | Sewer separation, which has a larger construction footprint with impacts very close to residences and businesses |

This criterion was based on the average of two sub-criteria: impacts to public uses during construction and neighborhood impacts during construction.

Impacts to public uses covers how each alternative impacts the access to and use of public facilities, including recreation, green space, parking, and traffic major arteries. It also considers the size of the populations impacted. The scoring was based on one dominant project element or was averaged between multiple project elements of similar scale.

Neighborhood impacts relate to noise, dust, vibration, lighting, and truck traffic that residential and/or commercial neighborhoods will experience during construction. This criterion qualitatively considers intensity and duration of the impacts, as well as the size of population impacted. The scoring was based on one dominant project element or was averaged between multiple project elements of similar scale.

### 10.2.4 Construction Complexity and Risk

**Table 10-5. Scoring Rubric for Construction Complexity and Risk Criterion**

| Evaluation Criteria | Scoring Rubric | Example Factors Leading to a High Score | Example Factors Leading to a Lower Score |
|---|---|---|---|
| Construction Complexity and Risk | Average of two sub-criteria below | | |
| Depth of Excavation | 5 – Shallowest excavation < 20-ft (e.g. pipes)<br>3 – Deeper excavation 20 – 50-ft (e.g. tank)<br>1 – Deepest Excavation > 50-ft (e.g. tunnel) | Shallower excavation, such as sewer separation | Deeper excavation, such as tunnels |
| Construction Complexity | 5 – Traditional construction / limited constraints<br>3 – Moderately complex sequencing/constraints<br>1 – Relatively complex sequencing/site constraints and/or potential impact to existing infrastructure | Small storage tank on a permittee-owned parcel | Linear construction through congested utility corridors<br>Truck exclusions on access roads<br>Insufficient staging area. |

Construction complexity and risk was evaluated as the average of the sub-scores of depth of excavation and construction complexity. Deeper excavation for an alternative increases risks of challenges and risks to safety. Construction complexity was scored based on the complexity of construction methods, sequencing, constraints, access, geological conditions, and subsurface utility conflicts.

### 10.2.5 Operation and Maintenance Considerations

**Table 10-6. Scoring Rubric for Operation and Maintenance Criterion**

| Evaluation Criteria | Scoring Rubric | Example Factors Leading to a High Score | Example Factors Leading to a Lower Score |
|---|---|---|---|
| Operation and Maintenance Considerations | 5 – Relatively minimal additional O&M activities/safety risks<br>3 – Moderate additional O&M activities/safety risks; typical access requirements<br>1 – Substantial additional O&M activities and/or challenging access/safety risks | Typical routine maintenance, such as gravity/passive conveyance<br>Fewer assets to maintain | Challenging access (e.g. confined space entries, deep access)<br>Use of chemicals<br>Frequent maintenance such as washing down combined sewer tanks after activation |

When scoring the different alternatives, operation and maintenance (O&M) considerations were evaluated with respect to familiarity with equipment and processes to be maintained, complexity of crew scheduling, and health and safety considerations.

### 10.2.6 Resiliency and Adaptability

**Table 10-7. Scoring Rubric Resiliency and Adaptability Criterion**

| Evaluation Criteria | Scoring Rubric | Example Factors Leading to a High Score | Example Factors Leading to a Lower Score |
|---|---|---|---|
| Resiliency and Adaptability | 5 – Can be readily modified/expanded to accommodate future conditions<br>3 – Modification/expansion is possible but economies of scale are limited<br>1 – Does not include provisions for future modification/expansion | Projects built with additional capacity<br>A CSO storage project that could be converted to stormwater storage following local sewer separation | Projects with capacity fully utilized in the design LOC |

Certain alternatives improved the region's ability to be resilient and adaptable to future conditions. This criterion evaluated an alternative's ability to accommodate future conditions, such as handling higher flows, providing redundancy, or being flexible to function differently in a future condition.

### 10.2.7 Renewal of Existing Infrastructure

**Table 10-8. Scoring Rubric for Renewal of Existing Infrastructure Criterion**

| Evaluation Criteria | Scoring Rubric | Example Factors Leading to a High Score | Example Factors Leading to a Lower Score |
|---|---|---|---|
| Renewal of Existing Infrastructure | 5 - Rehabilitates existing critical sewer infrastructure in poor condition<br>3 – Includes notable rehabilitation (larger assets, larger areas, and/or areas with poorer condition scores)<br>1 - Includes minimal rehabilitation (smaller assets and/or smaller areas) | Upsizing a 100-year old interceptor that will need to be rehabbed in the near future or lining pipes for infiltration removal and increasing C-factors for conveyance while also extending the life of the sewer | Tunnels, which capture CSO flows without otherwise improving the existing system, leaving outdated pipes/structures in place |

If implementation of an alternative results in renewing or replacing existing infrastructure, that was considered a benefit. This criterion qualitatively considers the extent of the renewal, the size, and the condition of the infrastructure that would be restored.

### 10.2.8 Flooding: Sewer/Storm Flood Risk

**Table 10-9. Scoring Rubric for Flooding Criterion**

| Evaluation Criteria | Scoring Rubric | Example Factors Leading to a High Score | Example Factors Leading to a Lower Score |
|---|---|---|---|
| Flooding: sewer/storm flood risk | Quantitative evaluation:<br>5 – 100% reduction in the number of flood risk manhole nodes with a reduced risk of flooding<br>0 – No improvement to flood risk<br>Score of 0-5 is scaled according to the percent reduction | Projects which draw down hydraulic gradeline | Projects which divert waters downstream of CSO regulator weirs, thus not improving level of service of the existing combined system |

Flooding was also evaluated as part of the scoring process. This examines how an alternative can improve combined sewer and stormwater drainage infrastructure capacity, resulting in quantifiable reduction in street flooding between baseline and the implementation of the project alternative, or at a minimum confirms there aren't negative impacts to flooding. Riverine flooding from the Alewife Brook is not part of this model because the unified model is a one-dimensional network model that is not able to represent or quantify overland flooding from the brook. See Section 7.5 for more information.

Reduction of flooding was calculated by the steps below:

1. Identify the number of baseline flood risk nodes: An area of potential impact was delineated for each waterway. Nodes that presented flood risk were identified (hydraulic grade line within 3 feet below ground surface or above ground surface).
2. Identify the number of baseline flood risk nodes that were improved: The hydraulic grade line of the baseline flood risk nodes to the hydraulic grade line for the alternative were compared. Nodes with reduced risk of flooding (>12 inches hydraulic grade line reduction) were identified.
3. Calculate the percentage of baseline flood risk nodes that have reduced risk of flooding due to the alternative.

$$\frac{Nodes\ with\ Improved\ Flood\ Risk}{Total\ Baseline\ Flood\ Risk\ Nodes} = \%\ Benefit$$

4. Assign the alternative with a score.

$$\%\ Benefit * 5 = Score$$

### 10.2.9 Community Co-Benefits and Long-Term Site Impacts

**Table 10-10. Scoring Rubric for Community Co-Benefits and Long-Term Site Impacts Criterion**

| Evaluation Criteria | Scoring Rubric | Example Factors Leading to a High Score | Example Factors Leading to a Lower Score |
|---|---|---|---|
| Community Co-benefits and Long-term Site Impacts | Average of two sub-criteria below | | |
| Community Co-benefits | 5 - Offers notable co-benefits in more categories, serving larger populations, and/or contributing to identified areas of need<br>3 - Offers notable co-benefits in one category, serving medium populations<br>1 - Offers some co-benefits reaching small populations<br>0 - no co-benefit opportunities | Green infrastructure, which replenishes groundwater; installations that are not fully subsurface may also increase green space.<br>Sewer separation in Cambridge, which includes streetscape corridor improvements | Tunnels, which have limited surface restoration.<br>Sewer separation in Somerville, which is somewhat independent of streetscape corridor improvements |
| Permanent Impacts to Public Uses | 5 - Relatively minimal permanent impact to existing public uses, negatively impacting small populations<br>3 - Relatively moderate permanent impact to existing public uses, negatively impacting medium populations<br>1 - Relatively extensive permanent impact to existing public uses, negatively impacting larger populations | Projects that are mostly or wholly subsurface | Permanent facilities in present day public spaces and parking lots |

Community co-benefits and long-term site impacts were scored as the average of the two sub-criteria: facilitate community co-benefits and permanent impacts to public uses. Facilitating community co-benefits represents an evaluation of co-benefits in the following categories, which were shaped from stakeholder input:

- Green space (gathering space, infiltration, heat reduction, habitat improvement, community health);
- Opportunities for streetscape corridor improvements (street trees, bike lanes, renewed sidewalks, traffic calming);
- Opportunities for utility renewal (other than sewer/drain);

- Groundwater replenishment; and
- Reduction of damage in flood-vulnerable areas.

Permanent impacts to public uses are similar to the temporary construction impacts, evaluating how each alternative affects access to and use of public facilities (including recreation, green space, parking, and traffic on major arteries). This sub-criterion takes into account the degree of impact and the size of the population affected. For instance, the presence of above-ground features, such as a new building, would not necessarily constitute permanent impacts, depending on how the site is used and how the building impacts that use.

### 10.2.10 Impacts to Non-Variance CSOs

**Table 10-11. Scoring Rubric for Impacts to Non-Variance CSOs Criterion**

| Evaluation Criteria | Scoring Rubric | Example Factors Leading to a High Score | Example Factors Leading to a Lower Score |
|---|---|---|---|
| Impacts to Non-Variance CSOs | Quantitative evaluation.<br>5 – 100% reduction in non-Variance CSO volume<br>0 – 0% reduction in non-Variance CSO volume<br>Score of 0-5 is scaled according to the percent reduction<br>Any increase in non-Variance CSO volume gets a score of zero and is documented as a project risk outside of scoring | Reduced non-Variance CSOs | Increased non-Variance CSOs. |

Each alternative was evaluated for how it impacts CSO volumes downstream of the waterways subject to the Variances, either to identify a downstream benefit, or simply to confirm that there are no negative downstream impacts as stewards to the adjacent waterways. Specifically, Prison Point and Somerville Marginal (during low tide) outfalls are below the dams on the Charles River and Mystic Rivers respectively. High scores were given to alternatives that reduce CSOs to these non-Variance outfalls.

This criterion did not apply to alternatives for the Alewife Brook because they had minimal impacts to waterways outside of the Variances.

The method of calculation for the Charles River and the Mystic River was as follows:

1. Calculate the baseline non-Variance CSO volumes: Derive CSO volumes to non-Variance CSOs in baseline 2050 TY for each waterway from the Unified Model. Specifically, MWR203 (Prison Point) was the non-Variance discharge location evaluated for the Charles River and MWR 205 (Somerville Marginal) was evaluated for the Mystic River.

2. Calculate the with-alternative non-Variance CSO volumes: Derive CSO volumes to non-Variance CSOs using the same outfalls, for each alternative.

3. Calculate the percentage of non-Variance CSO reduction due to the alternative.

$$\frac{(Baseline\ nonvariance\ CSO\ volume) - (Alterantive\ nonvariance\ CSO\ volume)}{Baseline\ nonvariance\ CSO\ volume} = \%\ Benefit$$

4. Assign the alternative with a score.

$$\%\ Benefit * 5 = Score$$

## 10.3 Alternatives Evaluation and Screening

This section presents the first screening step in the alternatives evaluation process. **Table 10-12** summarizes the 39 total alternatives under consideration, and Section 9 describes each of these alternatives in detail.

**Table 10-12. Summary of CSO Control Alternatives**

| LOC | Alewife Brook | Mystic River | Charles River |
|---|---|---|---|
| **0 CSOs in 2050 TY** | 1.AB Integrated<br>3 tanks (3 MG) + 264 ac. sewer separation | 1.MR Integrated<br>1 tank (4 MG) + 366 ac. sewer separation | 1.CR Integrated<br>2 tanks (3.1 MG) + 2-mile-long deep tunnel (17 ft diameter) + 2 storage conduits |
| | 2.AB Hybrid 1<br>2 tanks (2.9 MG) + 108 ac. sewer separation + 0.75-mile-long conveyance pipe + 0.5 mile-long microtunnel | 2.MR Hybrid 1<br>1 tank (7.4 MG) + 95 ac. sewer separation | 2.CR Hybrid 1<br>1 tank (2.5 MG) + 80 ac. sewer separation + 2-mile-long deep tunnel (17 ft diameter) |
| | 3.AB Hybrid 2<br>2 tanks (3 MG) + 8 ac. sewer separation + 0.75-mile-long conveyance pipe + 1 mile-long microtunnel | 3.MR Storage<br>1 tank (10.5 MG) | 3.CR Hybrid 2<br>2 tanks (12.7 MG) + 284 ac. sewer separation +0.75 mile-long Microtunnel + 2 storage conduits |
| | 4.AB Tunnel<br>1.5-mile-long deep tunnel (11 ft. diameter) | 4.MR Storage + GSI<br>1 tank (9.4 MG) + GSI (20 acres) | 4.CR Hybrid 3<br>2 tanks (12.6 MG) + 446 ac. sewer separation + 2 storage conduits |
| | 5.AB Tunnel + GSI<br>Same tunnel as 4.AB + GSI (36 acres) | | 5.CR Tunnel<br>4.5-mile-deep tunnel (12 ft diameter) + 2 storage conduits |
| | | | 6. CR Tunnel + GSI<br>Same tunnel as 5.CR + GSI (90 acres) + 2 storage conduits |
| **Limited CSOs in 2050 Typical Year** | 7.AB Hybrid 1<br>3 tanks (2.5 MG) + 108 ac. sewer separation + 0.75-mile-long conveyance pipe | 6a.MR Hybrid 1<br>1 tank (2.7 MG) + 95 ac. sewer separation | 8.CR Hybrid 1<br>1 tank (2.5 MG) + 268 ac. sewer separation + 1 storage conduit |
| | 8.AB Hybrid 2<br>3 tanks (2.5 MG) + 8 ac. sewer separation + 0.75-mile-long conveyance pipe + 0.5 mile-long microtunnel | 6b.MR Hybrid 2<br>1 tank (5 MG) | 9.CR Hybrid 2<br>1 tank (2.5 MG) + 80 ac. sewer separation + 0.75 mile-long Microtunnel + storage conduit |
| | | 6c.MR Hybrid 3<br>95 ac. sewer separation | |

**Table 10-12. Summary of CSO Control Alternatives**

| LOC | Alewife Brook | Mystic River | Charles River |
|---|---|---|---|
| **0 CSOs in 2050 5-year Storm** | 9.AB Tunnel<br>1.5-mile-long deep tunnel (22 ft. diameter) | 7.MR Storage<br>1 tank (10.5 MG) | 10.CR Tunnel<br>4.5-mile-long deep tunnel (24 ft diameter) +1-mile-long Microtunnel |
| | 10.AB Tunnel + GSI<br>Same tunnel as 9.AB + GSI (36 acres) | 8.MR Storage + GSI<br>1 tank (9.4 MG) + GSI (20 acres) | 11.CR Tunnel + GSI<br>Same tunnel as 10.CR + GSI (90 acres) + 1-mile-long Microtunnel (same tunnel as 10. CR) |
| | | 9.MR Hybrid 1<br>1 tank (7.4 MG) +95 ac. sewer separation | |
| **0 CSOs in 2050 25-year Storm** | 11.AB Tunnel<br>1.5-mile-long deep tunnel (32 ft. diameter) | 10.MR Storage<br>1 tank (16.7 MG) | 12.CR Tunnel<br>4.5-mile-long deep tunnel (32 ft diameter) + 1-mile-long Microtunnel + 1 storage conduit |
| | 12.AB Tunnel + GSI<br>Same tunnel as 11.AB + GSI (36 acres) | 11.MR Storage + GSI<br>1 tank (15 MG) + GSI (20 acres) | 13.CR Tunnel + GSI<br>Same tunnel as 12.CR + GSI (90 acres) + 1-mile-long Microtunnel + 1 storage conduit |
| | | 12.MR Hybrid 1<br>1 tank (14.2 MG) + 95 ac. sewer separation | |
| **Varies** | 6.AB Regional Sewer Separation<br>900 ac. sewer separation | 5.MR Regional Sewer Separation<br>690 ac. sewer separation | 7.CR Regional Sewer Separation<br>4,400 ac. sewer separation |

Most levels of CSO control had only two or three alternatives per waterbody, whereas there were significantly more alternatives to achieve 0 CSOs in the 2050 TY. Therefore, the process of comparing alternatives was twofold:

- Evaluation of alternatives to achieve 0 CSO in 2050 TY: With a large number of alternatives in this category, the initial alternatives evaluation focused on a robust scoring and weighting process to narrow the field. Regional Sewer Separation Alternatives 6.AB, 5.MR, and 7.CR were also included in this evaluation because they lack a distinct LOC but meet or come close to 0 CSOs in the 2050 TY. The results of this evaluation are presented in **Section 10.3.1**. **Section 10.3.2** provides a focused discussion on the evaluation of Regional Sewer Separation in each of the three waterbodies.
- Evaluation of alternatives for higher levels of CSO control: Due to the constraints in developing alternatives to achieve the higher levels of control, the type of projects making up the alternatives developed to the 2050 5- and 25-year storms are very similar. Performing a scored alternative evaluation will not elucidate much about the differences in performance of these alternatives compared to each other. Therefore, the Partners used the lessons learned from the first step to select preliminary preferred alternatives within other LOCs. **Section 10.3.3** presents the logic the Partners used to select a preliminary preferred alternative for each of the remaining LOCs.

**Figure 10-2** illustrates this process, where the 12-14 alternatives developed for each waterbody are consolidated into four preliminary preferred alternatives for comparison across LOCs.

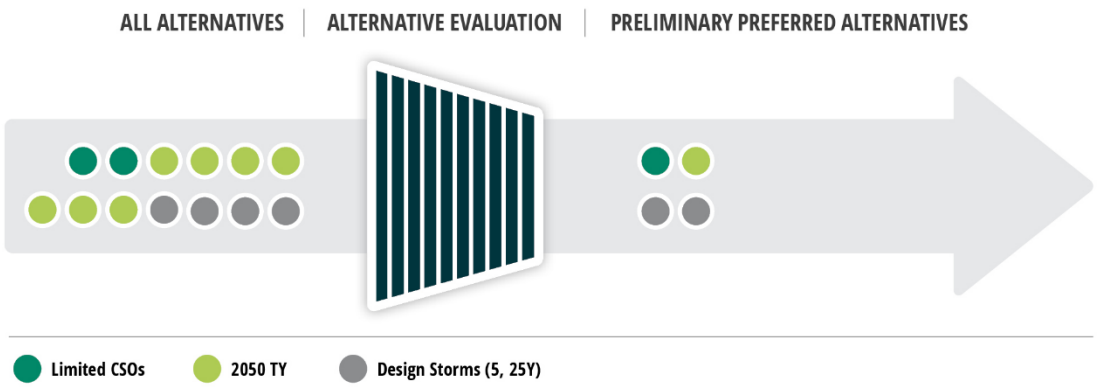



**Figure 10-2. Alternatives Evaluation and Screening Schematic (Conducted per Waterbody)**

### 10.3.1 Scoring and Weighting Process for 0 CSOs in 2050 TY Alternatives

The Partners scored each criterion based on the scoring rubric described in **Section 10.2**. The Partners and their consultants used the rubrics to individually score alternatives, and then came together to review and discuss scores, resulting in adjustments to ensure consistency across all the scored alternatives. While assigning qualitative scores to conceptual alternatives can be a subjective process, the Partners ensured that each score was reviewed and discussed by multiple parties so the results would be internally consistent. Raw scores are provided in Appendix F.

Recognizing that different stakeholders may prioritize the ten evaluation criteria differently, the Partners developed a set of weighting scenarios to reflect the different stakeholder priorities. For example, community members living in areas proposed for significant construction may favor projects that minimize construction impacts, while others do not see this as a priority. Nutrient loading is important to the watershed organizations that protect the water quality of the receiving waters as well as internal city staff who oversee nutrient reduction and stormwater programs. Cambridge, Somerville, and MWRA each have their own unique priorities that may result in differing focuses across the criteria as well.

In some weighting scenarios, some criteria were set to zero weight if they were not deemed important for that scenario (e.g., construction impacts were not seen as important in the “Water Quality and Co-Benefits” scenario, so that was set to 0%); some criteria were deemed more critical to varying degrees in each scenario (e.g., nutrient loading, schedule, and co-benefits always carried a non-zero weighting). The Partners developed eight weighting scenarios to represent stakeholders varied perspectives, ranging from equal weights to higher/reduced emphasis in certain areas. The weighting scenarios are shown in **Table 10-13**, with darker shades of blue signifying higher weights.

**Table 10-13. Weighting Scenarios**

| Weighting Scenario: / Criterion | 1: Flood / Resiliency | 2: Between Scenarios 1 & 3 | 3: Regional Construction Impacts and Water Quality | 4: Water Quality and Co-Benefits | 5: Water Quality, Co-Benefits, Schedule | 6: Equal Weights | 7: Equal Weights without Construction | 8: Water Quality and Schedule |
|---|---|---|---|---|---|---|---|---|
| Nutrient Loading | 20% | 20% | 20% | 30% | 30% | 10% | 13% | 50% |
| Schedule | 10% | 10% | 10% | 10% | 20% | 10% | 13% | 30% |
| Construction Impacts | 0% | 5% | 10% | 0% | 0% | 10% | 0% | 0% |
| Construction Complexity / Risk | 0% | 10% | 10% | 0% | 0% | 10% | 0% | 0% |
| O&M | 5% | 5% | 15% | 0% | 0% | 10% | 12% | 0% |
| Resiliency and Adaptability | 15% | 10% | 0% | 10% | 5% | 10% | 13% | 4% |
| Renewal of Ex. Infrastructure | 15% | 10% | 0% | 0% | 0% | 10% | 12% | 0% |
| Flooding | 20% | 15% | 0% | 10% | 10% | 10% | 13% | 0% |
| Co-Benefits | 15% | 15% | 15% | 20% | 30% | 10% | 12% | 4% |
| Impacts to Non-Variance CSOs | 0% | 0% | 20% | 20% | 5% | 10% | 12% | 12% |
| **Total** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** |

For each weighting scenario, weights were multiplied by scores for each of the ten criteria to obtain a weighted total score by alternative.

$$(Score_{Criterion\ 1} \times Weight\ \%_{Criterion\ 1}) + \ldots + (Score_{Criterion\ 10} \times Weight\ \%_{Criterion\ 10}) = Weighted\ Total\ Score$$

The objective of this first alternative evaluation was not to select a singular optimal alternative; however, it was to use the criteria and weighting to allow the Partners, the stakeholders, and the public to understand the benefits of each of the alternatives from various perspectives, and to see where there is consensus on which alternatives were more or less preferred. These insights helped the Partners to select preliminary preferred alternatives to carry forward into the level of control evaluation presented in **Section 10.4**.

#### 10.3.1.1 Alewife Brook Initial Screening (0 CSOs in 2050 Typical Year)

Initial scoring and weighting were performed for the Alewife Brook alternatives that target 0 CSOs in the 2050 TY. A weighted score was developed for each alternative under each weighting scenario, and the results are graphically represented in **Table 10-14**. Each row represents a unique weighting scenario, and the colors across each row represent the relative results for each alternative across the scenario. The highest score for any given weighting scenario is shown in green, and then the gradient moves towards lower results with the lowest score in red.

**Table 10-14. Initial Weighted Alternatives Screening (Alewife Brook, 0 CSOs in 2050 Typical Year)**

| Weighted Scenario | 1. AB - Integrated Alternative | 2. AB - Hybrid 1 Alternative | 3. AB - Hybrid 2 Alternative | 4. AB - Tunnel Alternative | 5. AB - Tunnel + GSI Alternative | 6.AB Sewer Separation |
|---|---|---|---|---|---|---|
| Estimated Capital Cost | $600M | $440M | $340M | $600M | $630M | $1700M |
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |




Alternative 3.AB Hybrid 2 received consistently the highest scores (illustrated in green in **Table 10-14**), regardless of the weighting scenario considered. Additionally, it had the lowest estimated capital cost. Therefore, Alternative 3.AB Hybrid 2 was the alternative that was advanced for comparison with other levels of CSO control, and the remaining alternatives were not considered further.

#### 10.3.1.2 Mystic River Initial Screening (0 CSOs in 2050 Typical Year)

Initial scoring and weighting were performed for the Mystic River alternatives that target 0 CSOs in the 2050 TY. A weighted score was developed for each alternative under each weighting scenario, and the results are graphically represented in **Table 10-15**. The highest score for any given weighting scenario is shown in green, and then the gradient moves towards lower results with the lowest score in red.

**Table 10-15. Initial Weighted Alternatives Screening (Mystic River, 0 CSOs in 2050 Typical Year)**

| Weighted Scenario | 1. MR - Integrated Alternative | 2. MR - Hybrid Alternative | 3. MR - Storage Alternative | 4.MR - Storage + GSI Alternative | 5.MR - Sewer Separation |
|---|---|---|---|---|---|
| Estimated Capital Costs | $570M | $260M | $200M | $200M | $810M |
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| 7 | | | | | |
| 8 | | | | | |




Alternatives 2.MR Hybrid 1 and 4.MR Storage + GSI received consistently high scores, regardless of the weighting scenario considered. Of these, Alternative 4.MR Storage + GSI relied primarily on storage for CSO control (with local GSI to offset the storage volume), whereas Alternative 2.MR Hybrid 1 had a smaller storage tank with a sizeable area of sewer separation (and related opportunities for GSI). The Partners recognize the importance of including sewer separation in the Plan where it can be done efficiently, and feedback received from stakeholders such as the watershed associations indicate that they also support the inclusion of sewer separation. Therefore, Alternative 2.MR Hybrid 1 was advanced for comparison with other levels of CSO control, even with a higher capital cost, and the remaining alternatives were not considered further.

#### 10.3.1.3 Charles River Initial Screening (0 CSOs in 2050 Typical Year)

Initial scoring and weighting was performed for the Charles River alternatives that target 0 CSOs in the 2050 TY. A weighted score was developed for each alternative under each weighting scenario, and the results are graphically represented in **Table 10-16**. The highest score for any given weighting scenario is shown in green, and then the gradient moves towards lower results with the lowest score in red.

**Table 10-16. Initial Weighted Alternatives Screening (Charles River, 0 CSOs in 2050 Typical Year)**

| Weighted Scenario | 1.CR - Integrated Alternative | 2.CR - Hybrid 1 Alternative | 3. CR - Hybrid 2 Alternative | 4.CR - Hybrid 3 Alternative | 5.CR - Tunnel Alternative | 6.CR - Tunnel + GSI Alternative | 7.CR - Sewer Separation |
|---|---|---|---|---|---|---|---|
| Estimated Capital Cost | $1100M | $1200M | $750M | $690M | $1400M | $1500M | $4500M |
| 1 | | | | | | | |
| 2 | | | | | | | |
| 3 | | | | | | | |
| 4 | | | | | | | |
| 5 | | | | | | | |
| 6 | | | | | | | |
| 7 | | | | | | | |
| 8 | | | | | | | |



More Preferred Less Preferred

Alternatives 3.CR Hybrid 2, 4.CR Hybrid 3, and 7.CR Regional Sewer Separation received consistently high scores, regardless of the weighting scenario. Alternative 7.CR had an estimated capital cost that was seven to eight times the other alternatives, and would take a significantly longer timeframe to implement, and thus was not prioritized.

Additionally, scoring for the criterion “Impacts to Non-Variance CSOs” was a factor in why Alternative 7.CR Regional Sewer Separation received high scores. Quantitative criteria used the entire range of 0 to 5, and Alternative 7.CR Regional Sewer Separation had the greatest benefit to Non-Variance CSOs (that is, reduction of CSO volume to the Boston Harbor) and therefore received a score of 5, while all other alternatives ranged from 0 to 1 – this difference led to a total score advantage. The dominance of this one criterion score was so great that, if eliminated from consideration, the resulting total scores for Alternative 7.CR Regional Sewer Separation dropped below Alternatives 3.CR Hybrid 2 and 4.CR Hybrid 3. The screening results without any consideration of Non-Variance CSOs are illustrated in **Table 10-17**.

**Table 10-17. Initial Weighted Alternatives Screening (Charles River, 0 CSOs in 2050 Typical Year, without Considering Non-Variance CSO Criterion)**

| Weighted Scenario | 1.CR - Integrated Alternative | 2.CR - Hybrid 1 Alternative | 3. CR - Hybrid 2 Alternative | 4.CR - Hybrid 3 Alternative | 5.CR - Tunnel Alternative | 6.CR - Tunnel + GSI Alterna-tive | 7.CR - Sewer Separation |
|---|---|---|---|---|---|---|---|
| Estimated Capital Cost | $1100M | $1200M | $750M | $690M | $1400M | $1500M | $4500M |
| 1 | | | | | | | |
| 2 | | | | | | | |
| 3 | | | | | | | |
| 4 | | | | | | | |
| 5 | | | | | | | |
| 6 | | | | | | | |
| 7 | | | | | | | |
| 8 | | | | | | | |




The Partners determined that this specific benefit below the Charles River Dam was not sufficient to advance Alternative 7.CR Regional Sewer Separation, especially when coupled with the high cost and long timeline for implementation.

Of the remaining alternatives, the main difference between Alternatives 3.CR Hybrid 2 and 4.CR Hybrid 3 was in how CSOs were controlled for MWR018 / 019 / 020. Alternative 3.CR Hybrid 2 had a smaller area of sewer separation coupled with a microtunnel, which would have significant impacts along the Esplanade during construction, whereas Alternative 4.CR Hybrid 3 relied primarily on sewer separation for those tributary areas and did not include storage. The Partners recognize the importance of including sewer separation in the Plan where it can be done efficiently, and the additional groundwater recharge benefit in the Back Bay cannot be underestimated. Therefore, Alternative 4.CR Hybrid 3 was advanced for comparison with other levels of CSO control, and the remaining alternatives were not considered further.

### 10.3.2 Evaluation of Regional Sewer Separation

Section 9.2.4 illustrated that systemwide sewer separation did not fit neatly into a single LOC. While most outfalls would not activate in the 2050 TY, some still would, and more outfalls were predicted to activate in the larger design storms. The CSO performance is similar when systemwide sewer separation is broken down to a regional scale (each waterbody), as represented by alternatives 6.AB, 5.MR, and 7.CR, all entitled “Regional Sewer Separation.” Thus, even though full sewer separation was evaluated as a representation of CSO Elimination (Section 7.1.2), it doesn’t fully eliminate CSOs systemwide, even in the 2050 TY. This is due to remaining I/I, including from the fully separated MWRA communities, as described in Section 9.2.4.

Lacking a distinct LOC, alternatives 6.AB, 5.MR, and 7.CR were included in the scoring and weighting process for alternatives achieving 0 CSOs in the 2050 TY, presented in **Section 10.3.1**. The reasons that these alternatives were not carried forward are:

- 6.AB did not rise to the top in the scoring process among the alternatives to eliminate CSOs to the Alewife Brook in the 2050 TY (see **Section 10.3.1.1**);

- 5.MR did not rise to the top in the scoring process among the alternatives to eliminate CSOs to the Mystic River in the 2050 TY (see **Section 10.3.1.2**); and
- 7.CR was in the top three high scores among the alternatives to eliminate CSOs to the Charles River in the 2050 TY. However, the following factors led the Partners to conclude that it was not preferred:
  - Alternative 7.CR would take 50 years or more to complete, as compared to the other high-scoring alternatives which were estimated to take 15-30 years (see Section 9.9.14);
  - The success of Alternative 7.CR in the scoring process was due in large part to the criterion "Impacts to Non-Variance CSOs" (reducing CSO volume to the Boston Harbor, indicating a limited benefit to the Charles River above the dam) and how scoring was performed across waterbodies (see **Section 10.3.1.3**);
  - Large-scale sewer separation is significantly complex and uncertain (see Section 9.2.4), including identifying treatment requirements, technologies, and land to treat new stormwater discharges and construct peak flow attenuation where needed; and
  - Alternative 7.CR had an estimated capital cost ($4.5 Billion) that was seven to eight times that of other high-scoring alternatives (see Section 9.9.14).

### 10.3.3 Preliminary Preferred Alternatives Across Levels of Control

The Partners screened alternatives across the other LOCs to identify one preferred alternative for each LOC for each waterbody. This way, a direct comparison of costs and benefits could be assessed for each waterbody in supporting an ultimate recommended plan.

The screening process presented in **Section 10.3.1** clarified key findings on the types of alternatives that are more or less preferred based on the evaluation criteria. Using this understanding, the Partners identified preferred alternatives in each LOC based on maximizing the co-benefits and minimizing the risks as portrayed in the criteria used for the 2050 TY evaluation. For the design storm LOCs, the Partners selected the alternative that included GSI over the alternative without GSI for further consideration. For alternatives achieving Limited CSOs in the 2050 TY, the preferred alternative in the Alewife Brook prioritized near-term solutions, while the preferred alternatives in the Mystic and Charles Rivers balanced incorporation of sewer separation with multi-project solutions.

**Table 10-18** highlights the four alternatives carried forward for the Alewife Brook. The same is shown for the Mystic River in **Table 10-19**, and the selected Charles River alternatives are presented in **Table 10-20.**

**Table 10-18. Preliminary Preferred Alternatives for Alewife Brook**

| Alternative Name | Level of Control | Estimated Cost and Duration | Alternative Description |
|---|---|---|---|
| 3.AB Hybrid 2 | 0 CSOs in 2050 TY | $340M, 13-18 years | 2 tanks (3 MG) + 8 acres of sewer separation + 0.75-mile-long conveyance pipe + 1 mile-long microtunnel |
| 8.AB Hybrid 2 | Limited CSOs in 2050 TY | $240M, 10-20 years | 3 tanks (2.5 MG) + 8 acres of sewer separation + 0.75-mile-long conveyance pipe + 0.5 mile-long microtunnel |
| 10.AB Tunnel + GSI | 2050 5-year Storm | $1.1B, 12-15 years | 22-ft diameter (20.6 MG) tunnel + GSI (36 acres) |
| 12.AB Tunnel + GSI | 2050 25-year Storm | $1.7B, 12-15 years | 32-ft diameter (41.6 MG) tunnel + GSI (36 acres) |

**Table 10-19. Preliminary Preferred Alternatives for Mystic River**

| Alternative Name | Level of Control | Estimated Cost and Duration | Alternative Description |
|---|---|---|---|
| 2.MR Hybrid 1 | 0 CSOs in 2050 TY | $260M, 5-7 years | 1 tank (7.4 MG) + 95 acres of sewer separation |
| 6a.MR Hybrid 1 | Limited CSOs in 2050 TY | $170M, 5-10 years | 1 tank (2.7 MG) + 95 acres of sewer separation |
| 9.MR Hybrid 1 | 2050 5-year Storm | $260M, 5-7 years | 1 tank (7.4 MG) +95 acres of sewer separation |
| 12.MR Hybrid 1 | 2050 25-year Storm | $340M, 5-10 years | 1 tank (14.2 MG) + 95 acres of sewer separation |

**Table 10-20. Preliminary Preferred Alternatives for Charles River**

| Alternative Name | Level of Control | Estimated Cost and Duration | Alternative Description |
|---|---|---|---|
| 4.CR Hybrid 3 | 0 CSOs in 2050 TY | $690M, 28-33 years | 2 tanks (12.6 MG) + 446 acres of sewer separation + 2 storage conduits |
| 8.CR Hybrid 1 | Limited CSOs in 2050 TY | $360M, 23-28 years | 1 tank (2.5 MG) + 268 acres of sewer separation + 1 storage conduit |
| 11.CR Tunnel + GSI | 2050 5-year Storm | $2B, 14-20 years | 24-ft diameter (71.9 MG) tunnel + GSI (90 acres) + 1-mile-long Microtunnel |
| 13.CR Tunnel + GSI | 2050 25-year Storm | $2.7B, 15-20 years | 32-ft diameter (132 MG) tunnel + GSI (90 acres) + 1-mile-long Microtunnel + 1 storage conduit |

## 10.4 Evaluation of Preferred Alternatives Across Levels of Control

The screening and evaluations presented so far have aimed to narrow the list of alternatives within each LOC to the most optimal alternatives based on the evaluation criteria presented in **Section 10.2**.

Next, the Partners sought to evaluate the remaining alternatives across levels of control. This evaluation focused on balancing considerations including regional system performance limitations, CSO control, cost, timeline to CSO reduction benefits, expected water quality improvements with further CSO control, implementation considerations, overall impacts such as neighborhood disruption, and temporary and permanent loss of recreational areas.

The Partners further broke out these considerations to evaluate on either a regional or local scale, as summarized in **Figure 10-3.** The regional considerations are presented in **Section 10.4.1**, and the local considerations that ultimately lead to a recommended alternative for each waterbody are presented in **Section 10.4.1.1**.




**Figure 10-3. Level of Control Evaluation**

### 10.4.1 Regional Considerations

This section presents the regional considerations in evaluating alternatives across levels of control, including:

- Collection System Capacity and Flooding: Building off the evaluations in Section 7.5, this considers where the collection system is beyond its conveyance capacity, leading to the same water quality and public health risk that CSOs pose.
- CSO Control (Volume Reduction & Recreation Benefits):
  - Using a long-term ten-year simulation period, this compares the CSO volume reductions and activation reductions associated with each alternative across the four LOCs. The Partners used the actual rainfall patterns from 2015-2024 to represent a ten-year simulation period and compared the benefits across all the alternatives in each waterbody.
  - Assessing impact of remaining modeled CSO activations on the number of days that recreational access would be restricted by CSO-driven water quality advisories.
  - Using water quality modeling results presented in Section 7 for baseline conditions with all sources vs baseline conditions with non-CSO sources only to help understand the impact of remaining non-CSO sources on attainment of water quality criteria.
- Costs: Based on the CSO control benefits presented above, this considers the cost to achieve each of these benefits in an attempt to identify an optimal point of CSO control for the associated costs.

These regional considerations highlighted important trends across the levels of control and formed one of the building blocks feeding into the waterbody specific (local) considerations presented in **Section 10.4.2**.

#### 10.4.1.1 Considerations on Collection System Capacity and Flooding

The Partners adopted design storm LOCs as proxies for effective CSO elimination because they define targets for CSO alternatives to achieve. Those same large design storms also reveal the upper limits of the conveyance capacity for the various collection systems in the region. Above that limit, the system does not perform as designed, resulting in sewer backups, SSOs, and other sources of contamination. These contamination sources may outweigh water quality benefits that could be realized by CSO control. Elsewhere in the MWRA collection system, the Dorchester Bay Storage Tunnel project performed a capacity analysis and identified that the present day (at the time) 25-year storm (5.4 inches in 24 hours) represented the upper limit of the collection system's conveyance capacity.

Section 7.5 demonstrated through modeling results that at these more intense future storm conditions (2050 5- and 25-year storms, representing 5.3 and 7.8 inches of rain in 24 hours, respectively), the existing drainage infrastructure capacity is already exceeded. This indicates that, even if the Partners control CSOs to these storm events, untreated stormwater and sanitary sewage would back up into the street and eventually travel overland or through storm drains into these receiving waters, thus creating the same water quality degradation that this Plan aims to mitigate.

The 2050 5-year storm is the most similar in size to the storm identified for the Dorchester Bay Storage Tunnel project (5.3 versus 5.4 inches of rain in 24 hours), and much of the system tributary to the Alewife Brook, Mystic River, and Charles River is beyond its capacity in this size storm. Manholes which are completely full to the ground surface, where more stormwater cannot get in during this storm, were previously shown in Section 7.5, are presented again in **Figure 10-4**. In a storm of this magnitude or larger, the system is subject to SSOs and flooding, potentially offsetting the benefits of any CSO control.

**Figure 10-5** illustrates the progressively increasing system capacity and flood risks from the largest storm in the 2050 TY to the largest design storm (2050 25-year storm) considered. Since the model is unable to represent Alewife Brook overtopping its banks outside of the Parkway and into streets and homes (as described in **Section 10.2.8**), this flood map includes a single representation of an area where flooding may occur when banks may overtop in large design storms.

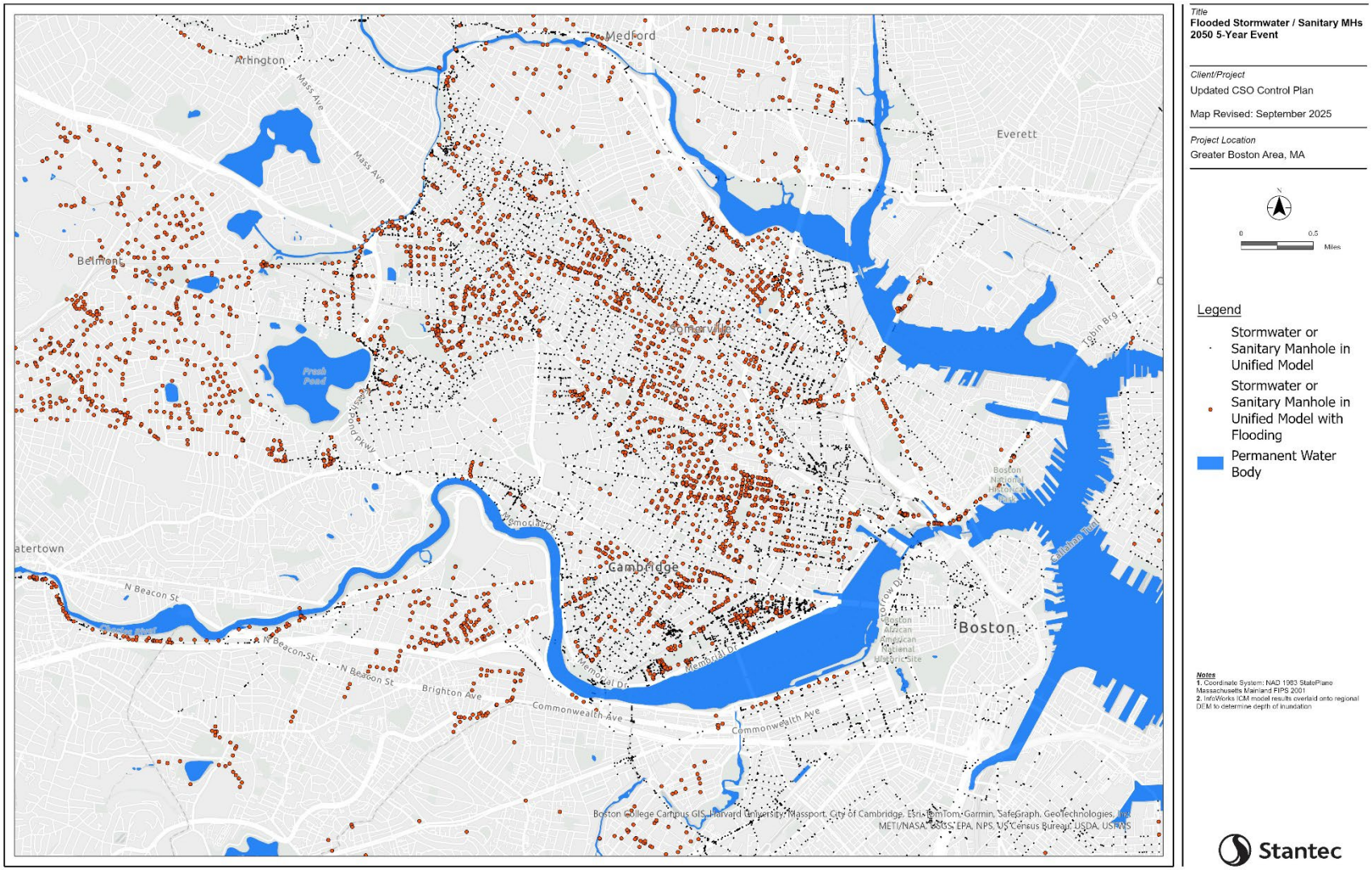



**Figure 10-4. System Performance in 2050 5-Year Storm: Manhole Flooding**

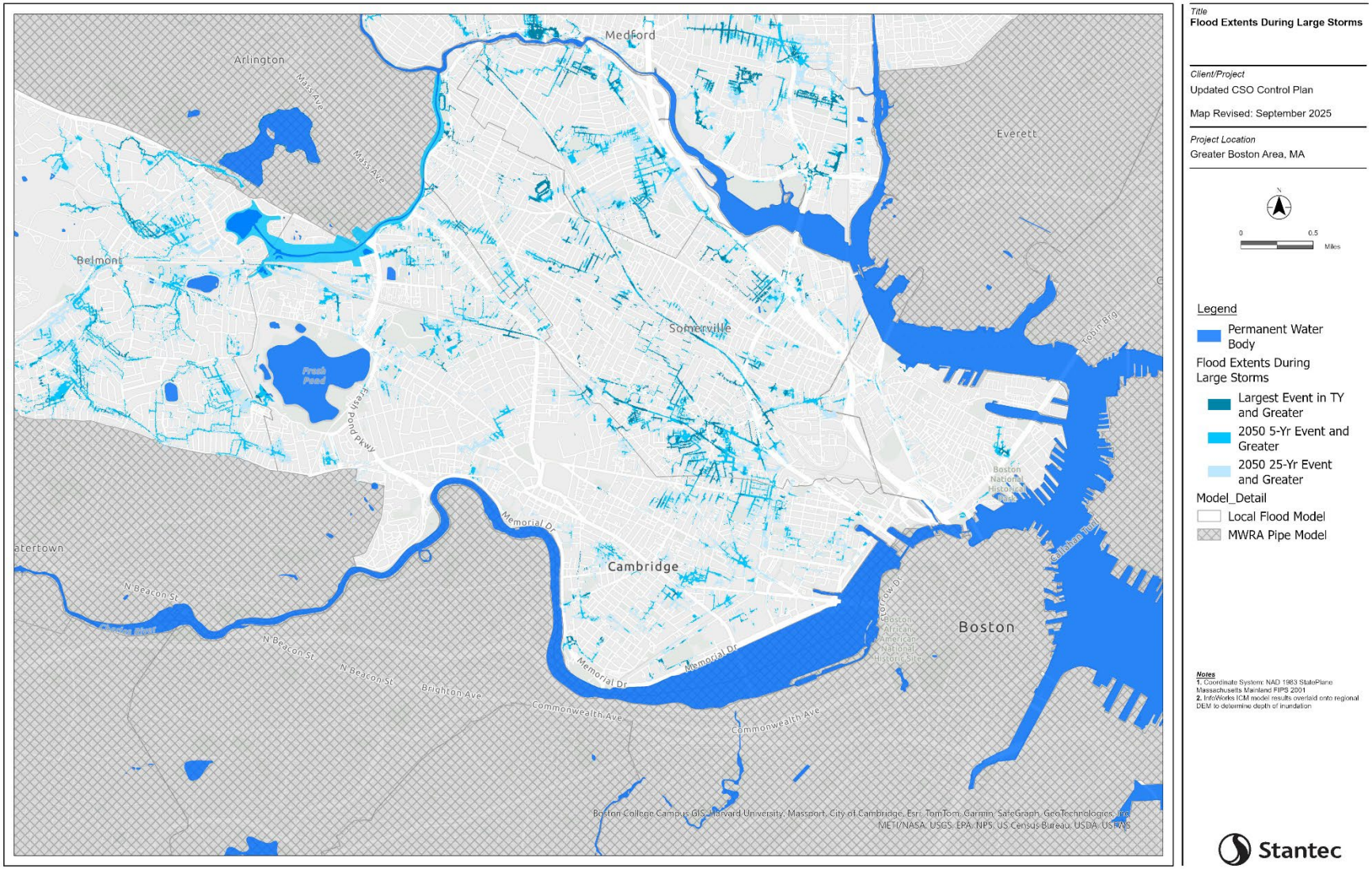



**Figure 10-5. Progressive Flood Extents During Large Storms**

This analysis did not preclude the Partners from developing and evaluating alternatives to meet these higher levels of control, but rather, sought to use system performance as one of the many criteria for considering an ultimate recommendation. The long-term simulation analysis performed in the following sections further emphasizes the limited benefits of the higher LOCs when compared to ten years of real rainfall patterns.

#### 10.4.1.2 CSO Control: Long Term CSO Volume Reductions

The Partners conducted a long-range, ten-year simulation for each of the remaining alternatives to more directly compare the benefits across each LOC. Since the recurrence period for a 2050 25-year storm is not easily comparable to the 2050 TY, and vice versa, this assessment aims to capture the benefits of each alternative over one period of performance.

The alternatives developed for each LOC vary widely in terms of what size storm(s) they are designed for, and what CSO volumes they were developed to mitigate within the system. **Table 10-21** presents a comparison of the Baseline Conditions regional CSO volumes for the largest storm in the 2050 TY, the 2050 5-year storm, and the 2050 25-year storm. The stark increase in both storm size and associated CSO volume moving from the 2050 TY to the larger design storms is clear. In the Alewife Brook, the largest CSO volume increases almost ten-fold (4.8 MG to 40.1 MG); in the Mystic River, the volumes almost triple (10.5 MG to 27.2 MG); in the Charles River, the volumes increase by over seven-times (16.6 MG to 120.6 MG). As large as these CSO volumes are in the large design storms, the volumes reported by the model only represent those flows exiting through the CSO regulators and outfalls, and do not account for combined sewage and stormwater on the street (sanitary sewer overflows) that exit the system in low lying areas and make their way to waterways – overland or through the storm drain systems.

**Table 10-21. Total Regional CSO Volume by Waterbody for Each LOC under Baseline Conditions**

| Waterbody | Largest Storm in 2050 TY(1) CSO Volume | 2050 5-Year LOC(2) CSO Volume | 2050 25-Year LOC(3) CSO Volume |
|---|---|---|---|
| Alewife Brook | 4.8 MG | 20.9 MG | 40.1 MG |
| Mystic River | 10.5 MG | 17.4 MG | 27.2 MG |
| Charles River | 16.6 MG | 65.6 MG | 120.6 MG |

**Notes:**

(1) Largest storm in the 2050 TY is 3.3 inches of rainfall in 21 hours

(2) 2050 5-year storm is 5.3 inches of rainfall in 24 hours

(3) 2050 25-year storm is 7.8 inches of rainfall in 24 hours

The Partners modeled performance for the preferred alternatives in each LOC over the ten-year period from 2015-2024 to better compare the alternatives across levels of control and analyze how the alternatives would perform across varying storm events. This period was selected because it was relatively recent, it included multiple large impactful storms, and metered and reported CSO events were available that could be used for comparison. Additionally, the last projects from the 2006 LTCP were finalized in 2015, so this period reflects a time after the completion of all 2006 LTCP projects. Some of the characteristics of this 2015-2024 period that make it a prudent evaluation horizon include:

- Two of the three wettest Julys on record in Boston occurred between 2015 and 2024. According to the National Weather Service, the wettest July ever recorded was in 1921, with 11.7 inches of rainfall. July 2023 ranks as the second wettest, with 10.43 inches of rainfall, followed closely by July 2021 in third place with 10.07 inches. July 2021 also set a record for the most days with measurable rain—19 out of 31. For comparison, the average July rainfall in the Boston area is currently approximately 3.3 inches. These extreme precipitation months in 2021 and 2023, resulted in large CSO volumes across all three watersheds and the region.

- Multiple years within the period had precipitation totals over 50 inches—well above the annual rainfall average in the Boston area of 44 inches (note, the 2050 TY has a rainfall total of 49.8 inches)
- Six storms had periods of rainfall intensity greater than a current 5-year return interval, and one storm had periods of rainfall intensity equivalent to a current 25-year return interval (high intensity events that tend to trigger CSOs).

The six storms with the high return intervals noted in the bullet above are shown in **Table 10-22.**

**Table 10-22. List of 2015-2024 Storms with 5-Year or Higher Return Periods**

| Date | Total Rainfall (inches) | Critical Period | | |
|---|---|---|---|---|
| | | Duration (hours) | Rainfall Depth (inches) | Current-Day Return Period[(1)] (years) |
| 9/29/2015 | 3.91 | 6 | 2.95 | 5 |
| | | 12 | 3.89 | >5 |
| | | 24 | 3.91 | >5 |
| 10/19/2016 | 1.88 | 0.5 | 1.29 | 5 |
| | | 2 | 1.67 | 5 |
| 8/7/2019 | 2.8 | 1 | 1.56 | 5 |
| | | 2 | 1.96 | >5 |
| | | 6 | 2.8 | 5 |
| 9/1/2021 | 4.43 | 6 | 3.22 | 10 |
| | | 12 | 4.25 | 10 |
| | | 24 | 4.43 | 5 |
| 7/1/2021 | 3.33 | 1 | 1.55 | 5 |
| | | 2 | 1.94 | >5 |
| | | 6 | 2.91 | 5 |
| 8/8/2023 | 2.85 | 0.25 | 0.82 | 5 |
| | | 0.5 | 1.3 | 10 |
| | | 1 | 1.97 | 25 |
| | | 2 | 2.69 | 25 |
| | | 6 | 2.76 | 5 |

**Notes:**
(1) Return period based on Atlas 14 (https://hdsc.nws.noaa.gov/pfds/)

As indicated in **Table 10-22**, the 10-year period included a range of robust storm events (for comparison, the 2050 TY had four storms with periods of rainfall intensity equivalent to a current 2-year recurrence interval). However, none of the storms in the 10-year period fully matched the characteristics of the 2050 5-year storm (5.3 inches in 24 hours) or the 2050 25-year storm (7.8 inches in 24 hours). As a result, the 10-year period does not provide differentiation in the performance of the alternatives sized for the 2050 5-year versus the 2050 25-year LOCs. Nevertheless, the analysis of the 10-year period does provide differentiation among the performance of the Limited CSOs in the 2050 TY, 0 CSOs in the 2050 TY, and the 2050 5-year LOCs. That the historical period does not include a 2050 25-year storm is not surprising and is consistent with how extraordinary such an event would be.

Some of the larger storms correspond to named climate events that hit the Northeast US (for example, the 09/1/2021 storm in **Table 10-22** corresponds to Hurricane Ida, which transitioned to a post-tropical cyclone as it moved north).

Since this Plan is forward looking, with 2050 storm events building the basis of analyses, there is a compounding effect of increases in CSOs due to climate confounding the benefits of each level of control. This analysis demonstrates the scale of CSO reductions anticipated within each level of control, which, unsurprisingly, scale up as the LOC becomes higher.

**Table 10-23** presents the predicted CSO reductions across each waterbody for the 10-year period for the remaining alternatives across the four LOCs.

**Table 10-23. Comparison of CSO Volumes and Activations from 2015-2024**

| Waterbody | Alternative Number | Level of Control | Activations (Count, Max) | Total CSO Volume (MG) | Percent CSO Activation Reduction (%) | Percent CSO Volume Reduction (%) |
|---|---|---|---|---|---|---|
| Alewife Brook | N/A | Historic; Reported Values | 109 | 170 | n/a | n/a |
| | 8.AB | Limited CSOs in 2050 TY | 21 | 68 | 82% | 60% |
| | 3.AB | 0 CSOs in 2050 TY | 9 | 41 | 91% | 76% |
| | 10.AB | 0 CSOs in 5-yr 2050 | 0 | 0 | 100% | 100% |
| | 12.AB | 0 CSOs in 25-yr 2050 | 0 | 0 | 100% | 100% |
| Mystic River | N/A | Historic; Reported Values | 102 | 238 | n/a | n/a |
| | 6a.MR | Limited CSOs in 2050 TY | 6 | 9 | 94% | 96% |
| | 2.MR | 0 CSOs in 2050 TY | 0 | 0 | 100% | 100% |
| | 9.MR | 0 CSOs in 5-yr 2050 | 0 | 0 | 100% | 100% |
| | 12.MR | 0 CSOs in 25-yr 2050 | 0 | 0 | 100% | 100% |
| Charles River | N/A | Historic; Reported Values | 56 | 389 | n/a | n/a |
| | 8.CR | Limited CSOs in 2050 TY | 24 | 241 | 50% | 38% |
| | 4.CR | 0 CSOs in 2050 TY | 10 | 100 | 80% | 74% |
| | 11.CR | 0 CSOs in 5-yr 2050 | 0 | 0 | 100% | 100% |
| | 13.CR | 0 CSOs in 25-yr 2050 | 0 | 0 | 100% | 100% |

As indicated in **Table 10-23**, all of the alternatives considered demonstrate significant reductions across this 2015-2024 period. Alternatives developed to the lowest LOC (i.e. Limited CSOs in 2050 TY) achieve volumetric reductions of 60% in the Alewife Brook, 96% in the Mystic River, and 38% in the Charles River over Reported. This corresponds to activation reductions of 82% in the Alewife Brook, 94% in the Mystic River, and 50% in the Charles River. These reductions, even realized for the lowest LOCs developed in this Plan, demonstrate the benefits of using future climate conditions for alternative development. Alternatives developed to achieve 0 CSOs in the 2050 TY and 2050 5-year and 25-year design storms add even higher levels of CSO reduction, up to 0 CSOs over the ten-year period.

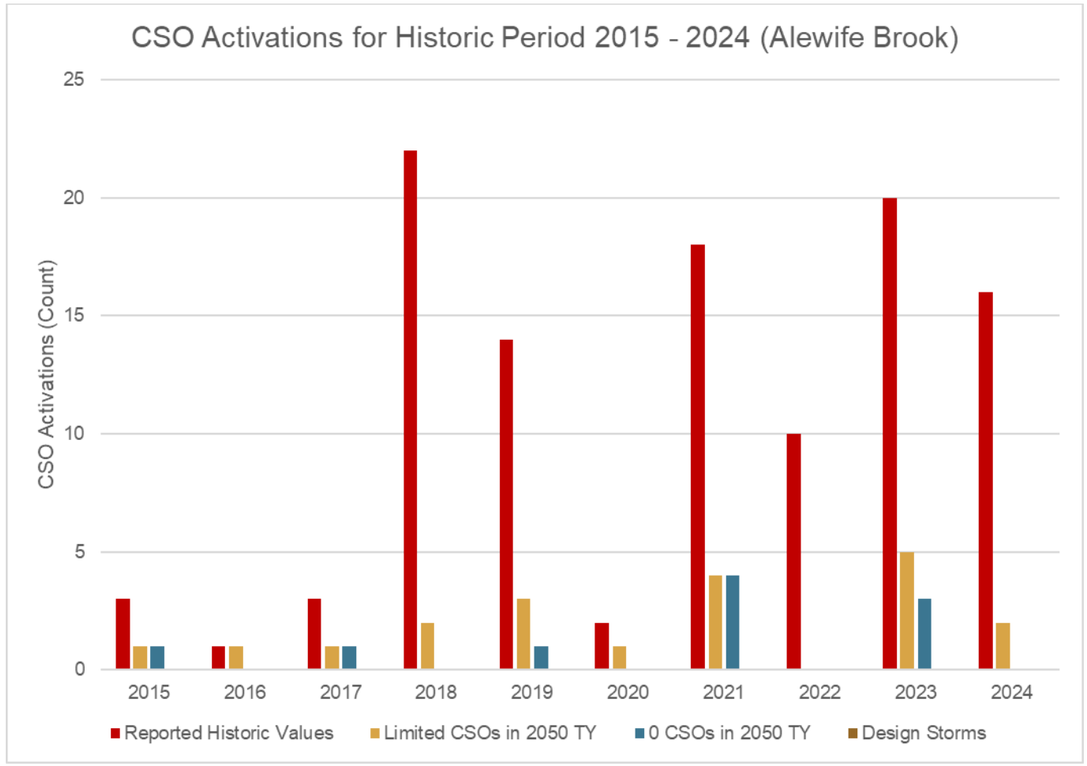
**Figure 10-6** through **Figure 10-8** show the reported historic CSO volumes and activations for each calendar year in the historic period for the 3 waterbodies, respectively. They also show simulations of CSO volumes and activations that are modeled to occur in the four preferred alternatives, each representing a LOC, with “Design Storms” representing the results for both 0 CSOs in 2050 5- and 25-year LOCs.

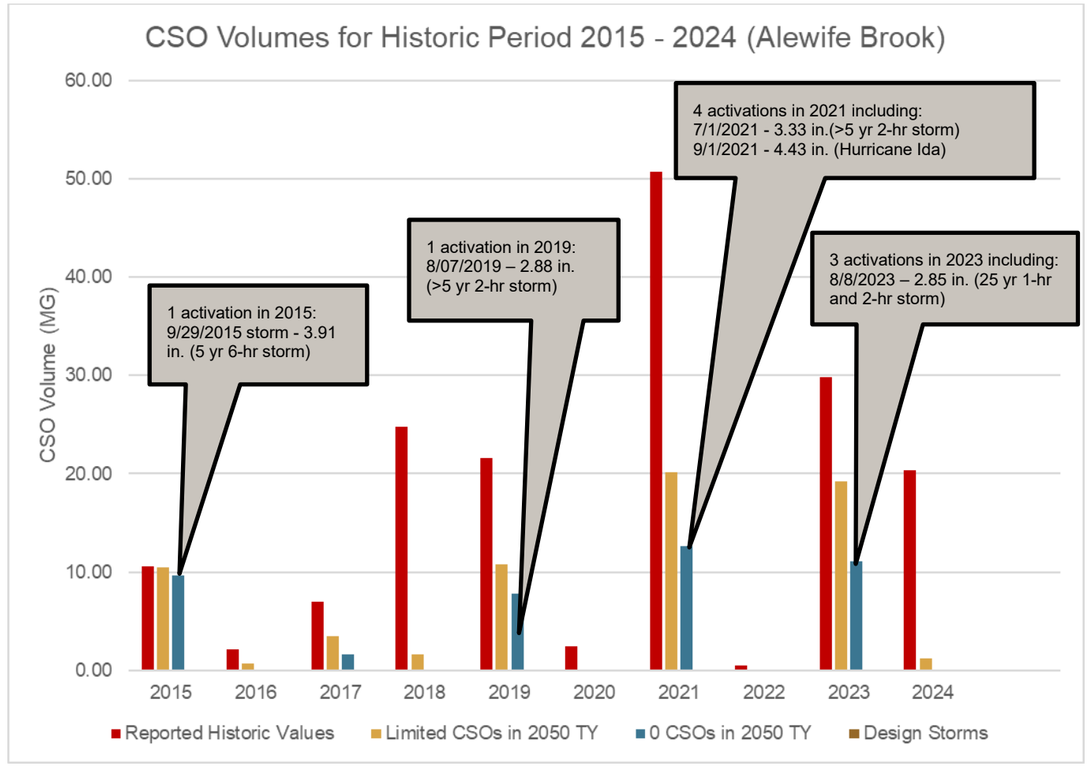
The reported historic CSO volumes and activations (red bars) in **Figure 10-6** through **Figure 10-8** illustrate how annual variation in rainfall can translate to significant variation in CSOs from year to year. Additionally, the systems along the three waterbodies are very different, so the same rainfall patterns yielded varying historic performance in each waterway. The year with the largest CSO volumes in the Alewife Brook and Charles River was 2021; however, the year with the largest CSO volume in the Mystic

River was 2018. There are also years with numerous CSO activations (for example, 2020 and 2022 in the Charles River) with very small associated volumes. These differences reflect the unique characteristics of each of the systems.

The other bars in these figures represent CSOs that would remain in the 2015-2024 period if the preferred alternatives for each LOC were built, and are discussed below:

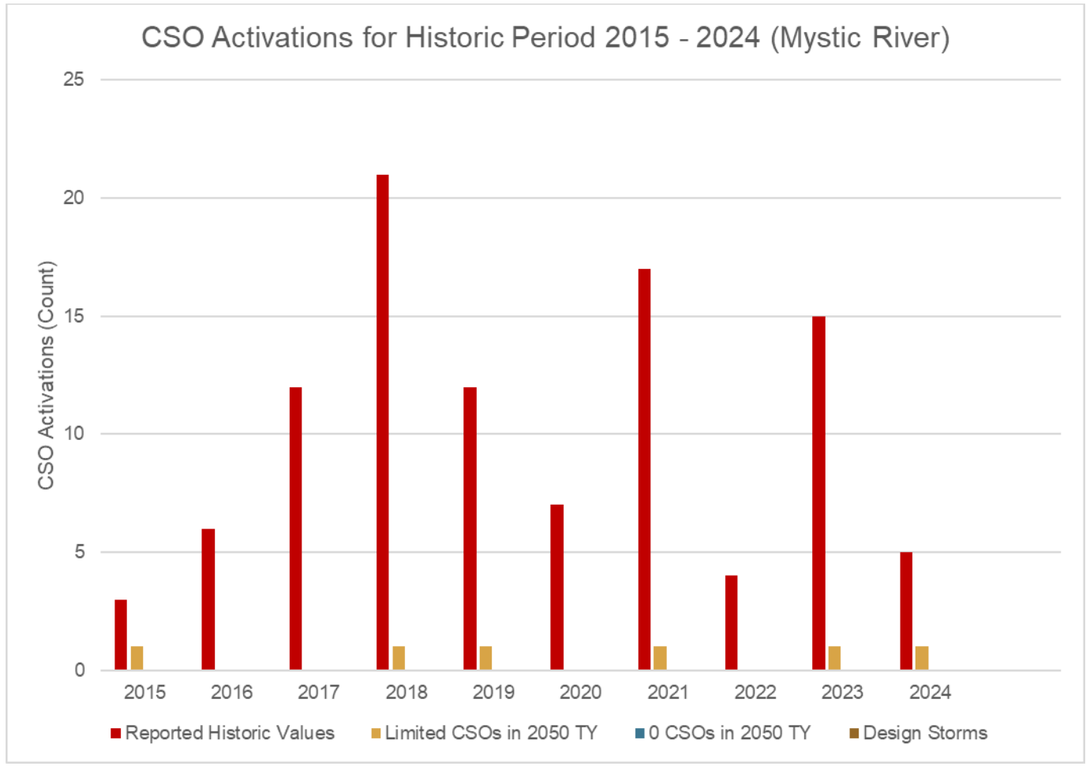
- Alternatives for the Design Storm LOCs (that is, 0 CSOs in the 2050 5- and 25-year storms): If in place, these alternatives would have eliminated CSOs in the 2015-2024 period. However, as discussed in **Section 10.4.1.1**, sewer and drainage systems are beyond their capacity in large storm events such as these, and the region would be subject to SSOs, basement backups, and flooding in neighborhoods. Combined sewer flooding can travel to waterways overland or through storm drain pipes, potentially offsetting the benefits of any CSO control.
- Alternative for 0 CSOs in the 2050 TY: If in place, these alternatives would have resulted in CSO activations in five or fewer of the ten years in each waterbody – an expected outcome given that a typical year is meant to represent generally average conditions. It is notable that within Alewife Brook, over 80% of the remaining CSO volume could be attributed to just four rain events over that 10-year period (9/30/2015, 8/7/2019, 9/2/2021 and 8/8/2023 – see **Table 10-22**). For the Charles River, over 70% of the remaining CSO volume could be attributed to those same four rain events over the 10-year period. CSOs in the Mystic River were eliminated with the alternative in the 2015-2024 period.
- Alternative for Limited CSOs in the 2050 TY: If in place, these alternatives would have resulted in more activations than the above scenarios, as expected.

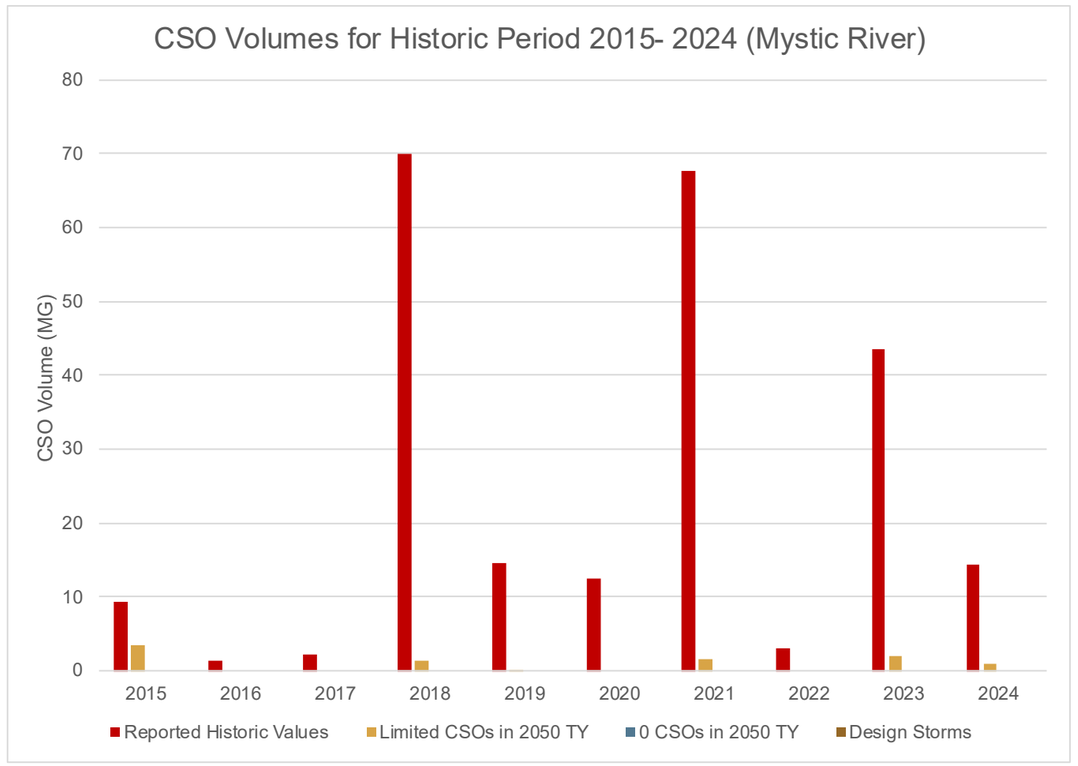



Note: No CSO activations (and no CSO volume) predicted during this 10-year period for the 5-year and 25-year levels of control (“design storms”).

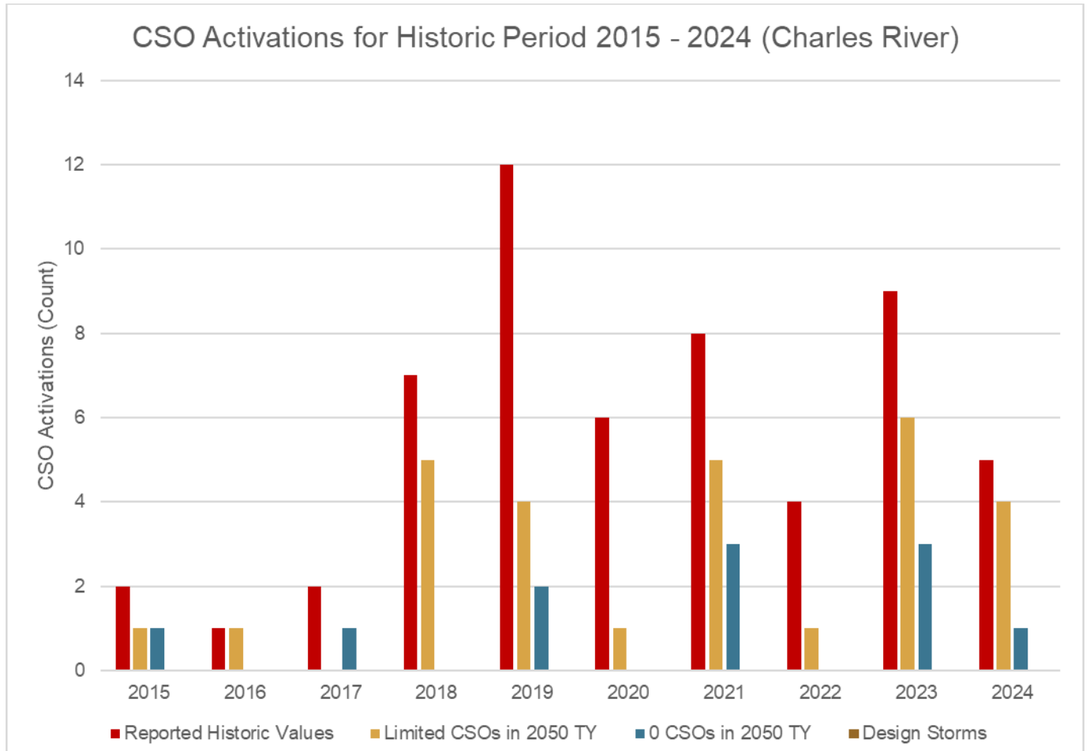
**Figure 10-6. Modeled Performance for 2015-2024 Period in Alewife Brook**

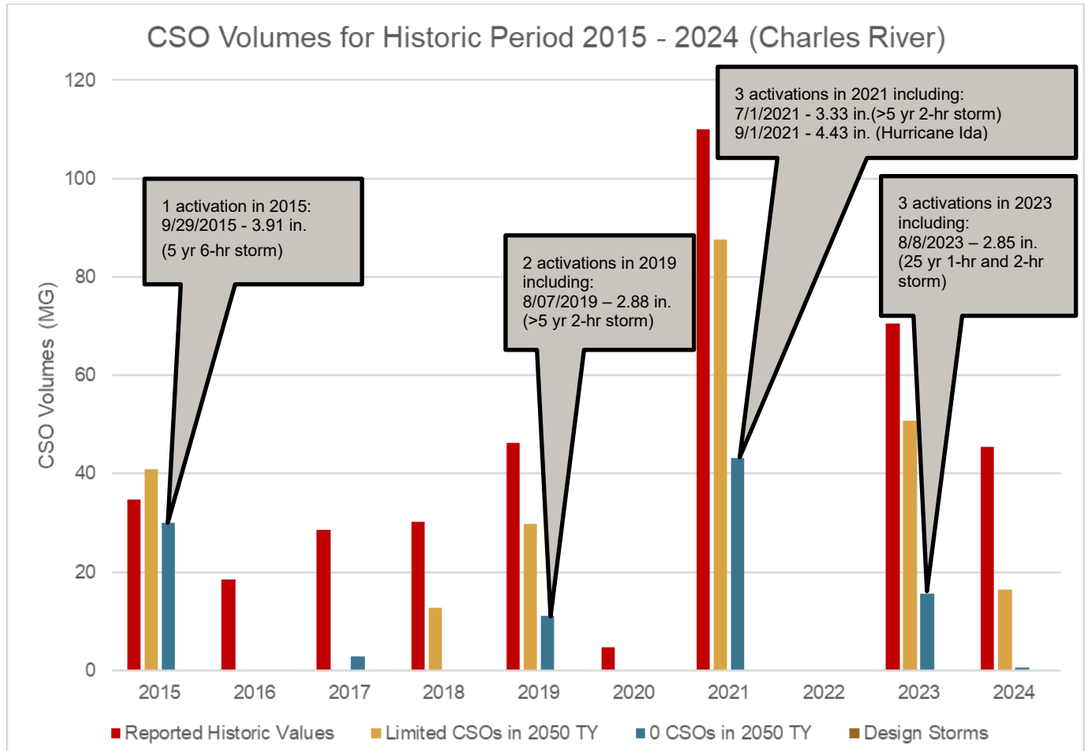



Note: No CSO activations (and no CSO volume) predicted during this 10-year period for 0 CSOs in the 2050 TY or the 5-year and 25-year levels of control (“design storms”).

**Figure 10-7. Modeled Performance for 2015-2024 Period in Mystic River**




Note: No CSO activations (and no CSO volume) predicted during this 10-year period for the 5-year and 25-year levels of control (“design storms”).

**Figure 10-8. Modeled Performance for 2015-2024 Period in Charles River**

Large rain events such as those shown in **Table 10-22** would cause significant decrease in water quality of the Alewife Brook, Mystic River, and Charles River due to CSO and non-CSO sources; Tables 7-6, 7-7, and 7-9 in Section 7 illustrated that even in a 2050 TY, more than 80% of *E. coli* comes from non-CSO sources in the Alewife Brook, and more than 99% in Mystic River and Charles River. Additionally, these percentages do not account for SSOs that may be conveyed to the waterways in very large rain events. And when these large storms occur, Section 7.6 describes that the duration of impact from CSOs is short, with *E. coli* mostly dissipating within three to six hours after the CSO – within the 48-hour period that MassDEP recommends no contact, and recreation in the waterbodies would not be expected.

#### 10.4.1.3 Water Quality and Recreation Benefits

CSOs pose public and human health risks in waterbodies that are designated for recreation due to the presence of bacteria in the CSO and stormwater discharges. After a CSO event, MassDEP recommends:

> *"that the public avoid contact with affected water bodies for at least 48 hours after a sewage discharge or overflow, and during rainstorms and for 48 hours after rainstorms end, due to increased health risks from bacteria or other pollutants associated with urban stormwater runoff and discharges of untreated or partially treated wastewater" (314 CMR 16.09(4)(b)).*

**Table 10-24** presents the concurrent activations reported for the ten-year period compared to the reported activations over that period for each LOC. This compares the number of historic activations against what would have happened in this time, were each alternative implemented. Since there are multiple CSO outfalls along some of these waterbodies, the total time of a CSO activation depends on the concurrence of activations across the outfalls. To better estimate the recreational access benefits associated with each LOC over this ten-year period, the Partners calculated the number of calendar days with unique CSO activations in each scenario and multiplied this by the two days (48 hours) of recreation access loss. These values are presented in **Table 10-24**. The column "Calendar Days with an Active CSO (Decade)" tallies up the unique days over the ten-year period; this is converted into an average annual count of CSO days in the column "Average Annual Days with an Active CSO." Lastly, the column "Average Annual Days with CSO Related Recreational Advisories" multiplies the number of days in the previous column by two to tally up the estimated average annual recreational impacts of each LOC. Note that these days without recreational access only consider when access is restricted due to CSO activations; there are other scenarios where recreational access is constrained either by bacteria from non-CSO sources or eutrophication from stormwater inputs and these are not captured here as they are not CSO-driven. For example, as noted in Section 7, water quality modeling results showed no change in the duration of exceedance of the MassDEP recommended *E. coli* single sample maximum criterion for baseline conditions with All Sources compared to baseline conditions with Non-CSO Sources Only in the 2050 TY.

**Table 10-24. 2015-2024 CSO Related Recreational Access Advisories by Number of Activations, Calendar Days and Duration of CSO Activations**

| Waterbody | Alternative Number | Level of Control / Scenario | Calendar Days with an Active CSO (Decade) | Average Annual Days with an Active CSO | Average Annual Days with CSO Related Recreational Advisories |
|---|---|---|---|---|---|
| Alewife Brook | N/A | Historic; Reported Values | 109 | 11 | 22 |
| | 8.AB | Limited CSO in 2050 TY | 19 | 2 | 4 |
| | 3.AB | 0 CSOs in 2050 TY | 9 | <1 | 2 |
| | 10.AB | 0 CSOs in 5-yr 2050 | 0 | 0 | 0 |
| | 12.AB | 0 CSOs in 25-yr 2050 | 0 | 0 | 0 |
| Upper Mystic River | N/A | Historic; Reported Values | 102 | 10 | 20 |
| | 6a.MR | Limited CSO in 2050 TY | 6 | <1 | 2 |
| | 2.MR | 0 CSOs in 2050 TY | 0 | 0 | 0 |
| | 9.MR | 0 CSOs in 5-yr 2050 | 0 | 0 | 0 |
| | 12.MR | 0 CSOs in 25-yr 2050 | 0 | 0 | 0 |
| Charles River | N/A | Historic; Reported Values | 56 | 6 | 12 |
| | 8.CR | Limited CSO in 2050 TY | 28 | 3 | 6 |
| | 4.CR | 0 CSOs in 2050 TY | 10 | 1 | 2 |
| | 11.CR | 0 CSOs in 5-yr 2050 | 0 | 0 | 0 |
| | 13.CR | 0 CSOs in 25-yr 2050 | 0 | 0 | 0 |

While the total CSO activation time is not a direct indicator of receiving water quality, it serves as a proxy for the incremental benefit that the different alternatives provide with respect to the loss of water use days due to CSO activations.

The Alewife Brook experienced 109 calendar days with an active CSO between 2015-2024. Comparatively, the Limited CSO in 2050 TY alternative would result in only 19 calendar days with an active CSO in this ten-year period. Increasing control from Limited to 0 CSOs in 2050 TY would reduce the days with an active CSO by another 10 calendar days in a decade. This corresponds to less than one day with CSOs in an average year, or less than two days of recreation access loss per year. Finally, increasing from the 0 CSOs in the 2050 TY to the 2050 5-year and 25-year LOC alternatives would reduce CSO activations to zero in this ten-year period.

The Mystic River experienced 102 calendar days with an active CSO between 2015-2024. The Limited CSO in 2050 TY alternative would result in only 6 calendar days with active CSOs in the decade, or less than one CSO day per average year. There are no modeled CSO activations in this ten-year period for the alternative achieving 0 CSOs in the 2050 TY or higher levels of control.

The Charles River experienced 56 calendar days with CSO activations from 2015-2024. Comparatively, the Limited CSO in 2050 TY alternative would result in 28 calendar days with an active CSO in this ten-year period. Increasing control from the Limited CSO to the 0 CSOs in 2050 TY would reduce this value to 10 days with an active CSO over the decade, which corresponds to about one per year. Finally, increasing to the 2050 5-year or 25-year LOC would reduce CSO activations to zero in this ten-year period.

Adopting the higher levels of control (5-year and 25-year LOC) carries a small potential incremental benefit for recreational access if other pollutant sources were eliminated. In most cases, **Table 10-24**

demonstrates that moving from 0 CSOs in the 2050 TY to the 2050 5-year storm only adds two days of recreational access per year. As stated above, these days of potential increased recreational access do not account for other the other pollution sources that may restrict access. Specifically, direct stormwater inputs into these waterways can and do have their own impacts on recreational access.

#### 10.4.1.4 Assessing Incremental Costs and Benefits of Enhanced CSO Reduction and Elimination

The benefits presented above (assessed over the 2015-2024 period) each carry an associated alternative cost. While the alternatives developed to the design storms realize higher CSO reductions and a marginal increase in recreational access, the additional cost for that additional benefit quickly scales to become very expensive.

**Table 10-25** illustrates these unitized costs in multiple ways:

(1) Cost per Activation Removed: calculates the unit cost for the removal of each activation in this period. This is calculated by dividing the total alternative cost by the reduction in activations seen over the ten-year period. As fewer activations remain, the cost to eliminate each one increases.

(2) Cost per MG (of CSO Volume) Reduced: presents the cost associated with each MG of CSO reduction over this period. This is calculated by dividing the total alternative cost by the CSO reduction seen over the ten-year period.

(3) Incremental Cost/MG Over Prior Alt: this value captures the additional cost to increase the scale of CSO control. This is calculated by dividing the difference in alternative cost by the difference in CSO volume reduction (i.e., for Alewife 0 CSOs in the 2050 5-year storm, this value is ($1,100M-$340M)/(41MG) to calculate the incremental cost associated with capturing the remaining 41 MG of overflow that would be achieved with the 5-year level of control alternative compared to the 0 CSOs in the 2050 TY alternative).

The alternative costs presented here are those developed in Section 9; the CSO volumes and activations are presented based on the ten-year simulation from 2015-2024 so that the benefits of each alternative are assessed on the same scale.

As indicated in **Table 10-25**, for Alewife Brook and the Charles River, the cost per gallon of CSO reduced jumps substantially from the 0 CSOs in the 2050 TY alternative to the 2050 5-year storm alternative. For Alewife Brook, the cost per gallon increases by a factor of 2.7, and for the Charles River, the cost per gallon increases by a factor of 2.1. The increase in incremental cost to go from the 0 CSOs in the 2050 TY to the 2050 5-year storm LOC is even more substantial. For Alewife Brook, the incremental cost per gallon to go from capturing 106 MG with the Limited CSOs in 2050 TY to capturing 129 MG with the 0 CSOs in the 2050 TY is $3.9M/MG. The incremental cost per gallon to go from capturing 129 MG to capturing 170 MG in the 2050 5-year storm alternative jumps to $18.5M/MG, a 4.7-fold increase. For the Charles River, the incremental cost per gallon to go from capturing 151 MG with the Limited CSOs in 2050 TY to capturing 288 MG with the 0 CSOs in the 2050 TY is $2.4M/MG. The incremental cost per gallon to go from capturing 288 MG to capturing 389 MG in the 2050 5-year storm alternative jumps to $13.1M/MG, a 5.5-fold increase. The cost per activation removed follows a similar trend.

For the Mystic River, as described in Section 9, the alternative to provide the 2050 5-year level of control is the same as the alternative to provide 0 CSOs in the 2050 TY, due to the influence of the tide on the SOM007A/MWR205A outfall. The cost/gallon analysis does not, therefore, provide differentiation between those alternatives.

## Table 10-25. Incremental Costs of Higher Levels of Control for 2015-2024 Period

| Waterbody | Alternative Number | Level of Control / Scenario | Alternative Cost | Activations (Count, Max) | Cost ($M) per Activation Removed | Total CSO Volume (MG) | Cost ($M) per MG Reduced[1] | Incremental Cost ($M)/MG over Prior Alt |
|---|---|---|---|---|---|---|---|---|
| Alewife Brook | N/A | Historic; Reported Values | n/a | 109 | n/a | 170 | n/a | n/a |
| | 8.AB | Less than 2050 TY | $250,000,000 | 19 | $2.8M | 64 | $2.4M | n/a |
| | 3.AB | 0 CSOs in 2050 TY | $340,000,000 | 9 | $3.4M | 41 | $2.6M | $3.9M |
| | 10.AB | 0 CSOs in 2050 5-year | $1,100,000,000 | 0 | $10.1M | 0 | $6.5M | $18.5M |
| | 12.AB | 0 CSOs in 2050 25-year | $1,700,000,000 | 0 | $15.6M | 0 | $10M | --[2] |
| Mystic River | N/A | Historic; Reported Values | n/a | 102 | n/a | 238 | n/a | n/a |
| | 6a.MR | Less than 2050 TY | $170,000,000 | 6 | $1.8M | 9 | $0.74M | n/a |
| | 2.MR | 0 CSOs in 2050 TY | $260,000,000 | 0 | $2.5M | 0 | $1.1M | $10M |
| | 9.MR | 0 CSOs in 2050 5-year | $260,000,000 | 0 | $2.5M | 0 | $1.1M | --[2] |
| | 12.MR | 0 CSOs in 2050 25-year | $340,000,000 | 0 | $3.3M | 0 | $1.4M | --[2] |
| Charles River | N/A | Historic; Reported Values | n/a | 56 | n/a | 389 | n/a | n/a |
| | 8.CR | Less than 2050 TY | $360,000,000 | 28 | $13M | 238 | $2.4M | n/a |
| | 4.CR | 0 CSOs in 2050 TY | $690,000,000 | 10 | $15M | 100 | $2.4M | $2.4M |
| | 11.CR | 0 CSOs in 2050 5-year | $2,000,000,000 | 0 | $36M | 0 | $5.1M | $13.1M |
| | 13.CR | 0 CSOs in 2050 25-year | $2,700,000,000 | 0 | $48M | 0 | $6.9M | --[2] |

**Notes**:

(1) Calculated by dividing “Alternative Cost” by “CSO Volume Reduction.” For example, Alt 8.AB “Cost per MG Reduced” is $250,000,000/106.
(2) Incremental cost/MG cannot be calculated because the change in volume reduced is zero.

#### 10.4.1.5 CSO Control Cost Knee of the Curve

The performance evaluation from 2015-2024 highlighted the significant benefits associated with the alternatives across all four LOCs, as well as the increases in recreational access predicted for each. In recommending a level of control for each waterbody, the regulators advised the Partners to evaluate where, along the spectrum of costs and benefits, would represent a most cost-effective solution. What level of investment represents the inflection point where increases in spending do not return significant additional benefits (i.e., the "knee of the curve")? The analysis presented in Sections **10.4.1.1** through **0** have illustrated the diminishing returns of the alternatives sized for the large design storms when analyzed against the 2015-2024 period. This section aims to take this analysis a step further and identify an optimal point of CSO control investment.

**Figure 10-9** compares the costs and CSO reduction volumes (for 2015-2024) across the four levels of control. The costs along the x-axis represent the total alternative costs across each of the three waterbodies for that level of control. The volume reductions along the y-axis present the "benefits" of the alternatives, represented as the average annual CSO reductions based on the analysis from 2015-2024. These volume reductions compare the CSOs that occurred during this period to the modeling results of this decade of storms if these alternatives were implemented. Here, the incremental benefit going from the Limited to 0 CSOs in 2050 TY LOC scales with the incremental cost. There are significant additional benefits for these additional costs. Moving to the design storms (2050 5-year and 2050 25-year), the rate of change between costs and benefits are no longer within the same order of magnitude. The incremental cost increase now far outpaces the CSO reductions.

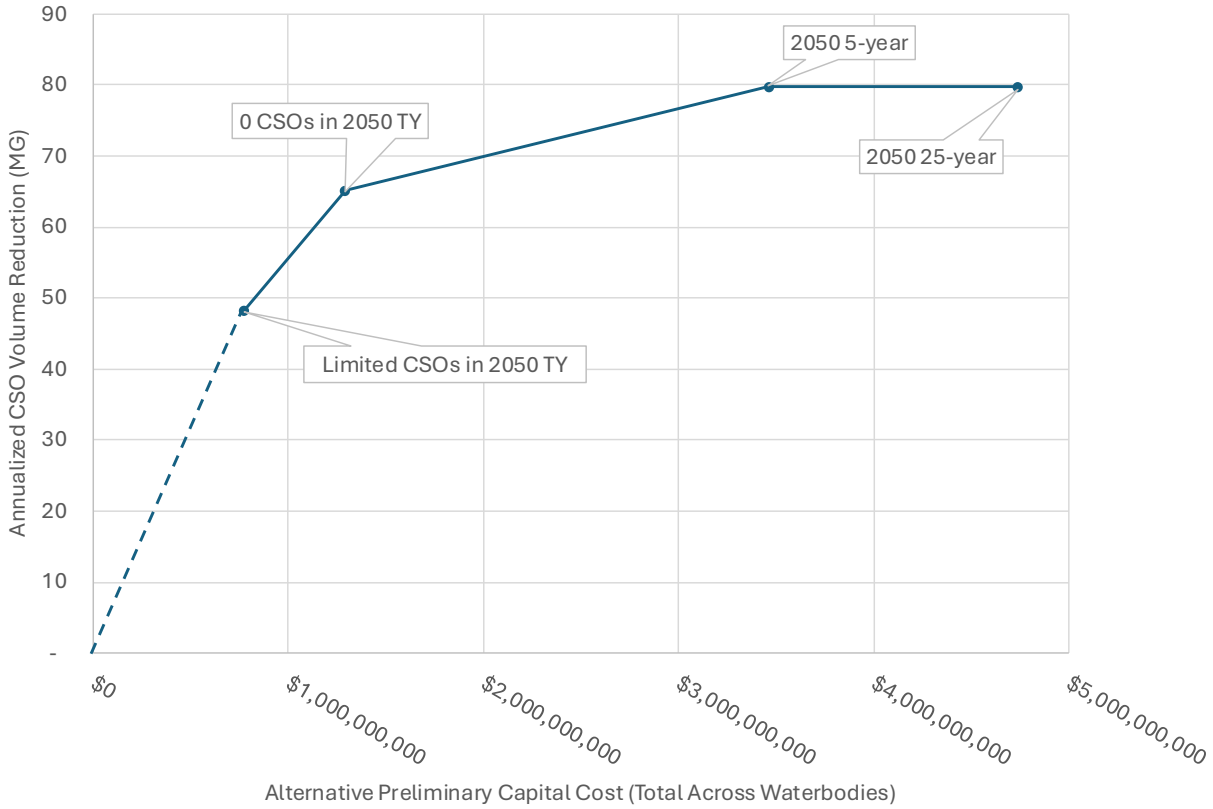



**Figure 10-9. Cost-Benefit for Levels of Control**

Since the alternatives under consideration in this Plan represent the next step in CSO control in this region, the Partners also compared these cost-benefit trends to the prior work completed in the MWRA LTCP. Meaning; with a baseline investment of over $1 billion in CSO control from the 2006 LTCP, if the investments proposed here were added to that prior investment, how would that impact the cost-benefit assessment?

The 2006 LTCP reported an escalated total spending value of about $1.3 billion[1], which resulted in a reduction of 638 million gallons of CSO (reduction from 1,039 MG during the 1997 Plan to 401 MG at the end of LTCP implementation as reported in Section 3). Note that the benefits for the 2006 LTCP are in terms of the 1992 TY volumes and the annualized reductions for the LOCs are based on the 2015-2024 period. These are all simulated reductions used as a proxy for benefits and comparable for this level of analysis. This is presented in **Table 10-26** and **Figure 10-10**.

**Table 10-26. CSO Reduction Investment Levels**

| | Waterbody | Limited CSOs in 2050 TY | 0 CSOs in 2050 TY | 2050 5-Year | 2050 25-Year |
|---|---|---|---|---|---|
| Costs | Alewife | $240,000,000 | $340,000,000 | $1,200,000,000 | $1,700,000,000 |
| | Mystic | $170,000,000 | $260,000,000 | $260,000,000 | $340,000,000 |
| | Charles | $360,000,000 | $690,000,000 | $2,000,000,000 | $2,700,000,000 |
| | **Total LOC** | **$770,000,000** | **$1,290,000,000** | **$3,460,000,000** | **$4,740,000,000** |
| Annual Volume Reduction(1) | Alewife | 10 | 13 | 17 | 17 |
| | Mystic | 23 | 24 | 24 | 24 |
| | Charles | 15 | 29 | 39 | 39 |
| | **Total LOC** | **48** | **66** | **80** | **80** |
| **Cost, including 2006 LTCP(2)** | | $2,070,000,000 | $2,590,000,000 | $4,760,000,000 | $6,040,000,000 |
| **Annual CSO Reduction Volume, including 2006 LTCP(3)** | | 686 | 704 | 718 | 718 |

**Notes:**
(1) Annual volume reduction calculated by dividing "CSO volume reduction" values presented in **Table 10-23** by 10 to get average annual reduction.
(2) Cost calculated by adding $1,300,000,000 for 2006 LTCP to Total LOC Cost
(3) Volume calculated by adding 638 MG for 2006 LTCP to Total LOC Volume Reduction

[1] Section 3 reported $941M spending by MWRA + $150M by other communities; escalated at 4% per year for 9 years.

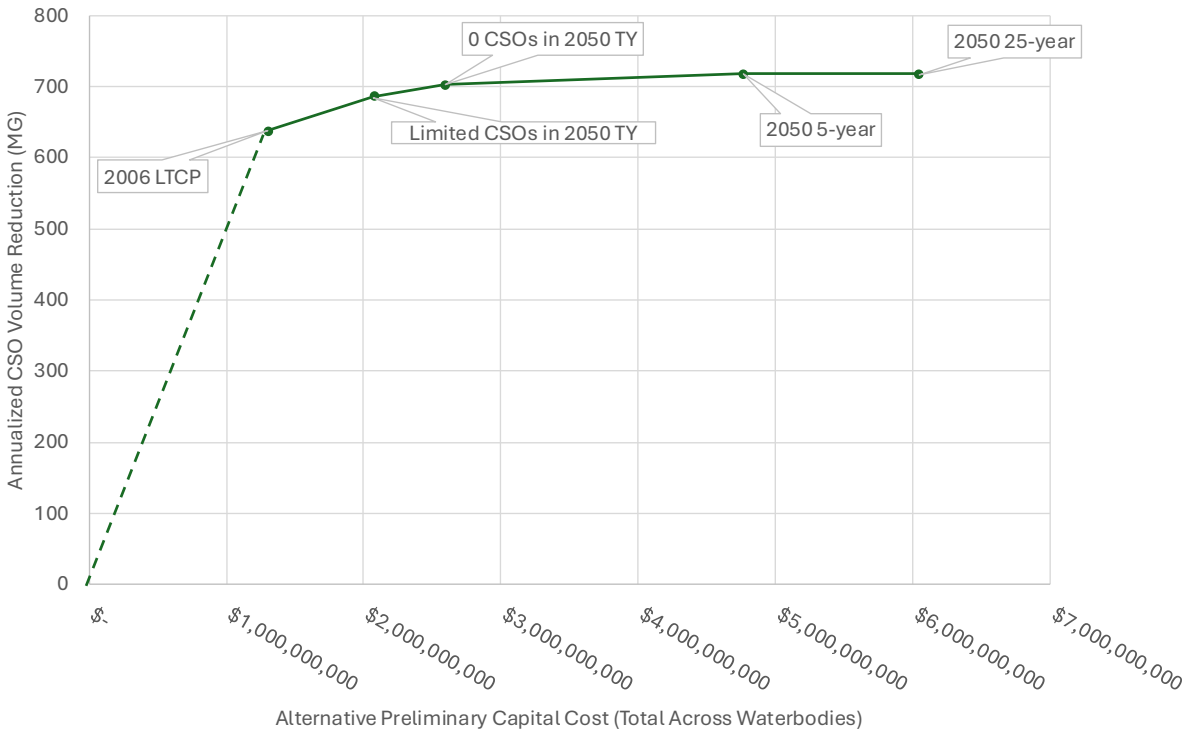



**Figure 10-10. Cost Benefit of CSO Control, Historic and Present**

When the prior costs associated with the MWRA LTCP are added to each LOC, the costs and marginal benefits associated with all four LOCs becomes clear. **Figure 10-10** shows that the most cost-effective CSO reductions were achieved with the work accomplished through the last LTCP. This is not surprising; however, viewing the proposed alternatives together with the prior work further contextualizes the magnitudes of additional investment being considered.

This illustrates how complicated the remaining CSO volumes are to eliminate. This is also borne out through the alternatives development process; technologies like sewer separation, which traditionally results in CSO elimination, does not manage to eliminate overflows in this system. Chasing CSO elimination is complex, costly, and difficult. While each LOC is costly, the relative increases in cost compared to CSO reduction benefits (change in the x- compared to y-axes in **Figure 10-9** and **Figure 10-10**) are more comparable for the Limited and 0 CSOs in 2050 LOCs. The stark jump from 0 CSOs in the 2050 TY to the 2050 5-year LOC (large jump to the right in the figure) illustrates a nominal benefit associated with a multifold cost increase. The step to the 2050 25-year LOC shows another significant step to the right, and there is no additional CSO benefit when assessed in this period.

The Partners are committed to continuing to reduce CSOs and recognize that there is no simple solution to this complex problem. The intent of this analysis is to assess these benefits across all LOCs on one consistent basis to support the overarching evaluation.

### 10.4.2 Local Considerations by Waterbody

Building off the regional considerations, this section discusses the specific alternatives and associated considerations in each of the waterbodies to ultimately recommend a Plan.

At this early stage in planning, there are several unknowns in the feasibility and ability to implement each alternative. This section articulates uncertainties that could significantly increase cost or duration to

implement, to a degree that cannot be known today. Additionally, this section demonstrates the scale of potential construction and operational impacts associated with increased levels of control. Key considerations include:

- Site Acquisition and Access:
  - Site Acquisition: In many cases, project components of an alternative will require physical space for assets. Site acquisition, including the ability or feasibility of obtaining the property needed for an alternative influenced the evaluation of an alternative. All three waterbodies are in very developed areas, so finding available land in the location needed and at the size needed is a challenge. While attempts are made to site projects on publicly owned land, sometimes the location is limited by hydraulics. This could involve acquiring property or easements from private landholders or other entities, for which negotiations can take time; landowners unwilling to cooperate could require alternative site evaluation and/or eminent domain.
  - Article 97: Some land proposed in alternatives includes land owned by the state that is protected by Article 97. The ability to acquire real property interests currently subject to Article 97 would require the involvement of the appropriate state departments, and/or require legislative action to permit. The magnitude of these kinds of impacts cannot be determined at this time but should be considered as a risk of being able to effectively advance a project.
- Implementation Considerations (Permitting Risks):
  - NPDES MS4 Permit: Sewer separation increases the volume of new stormwater runoff that discharges to receiving waterbodies. The NPDES MS4 Permit requires the management of pollutants like trash, chemicals, oils, nutrients and sediment in the discharge that can harm water quality. Existing final and draft state and federal regulatory requirements for stormwater treatment are complex and may limit the feasibility of some alternatives; this uncertainty also increases the likelihood of appeals for any permits issued. Furthermore, EPA and MassDEP have limited technologies approved for stormwater treatment, and none of them can achieve major or full reductions in the pollutants of concern. For example, there is no approved treatment technology that can remove 100% of the phosphorous from all new stormwater flows.
  - Work in or Near Waterways: Work in or near waterways require extensive permitting, with the potential for significant delays and/or permit conditions that add significant scope and cost. Some of the permits that may be required include the Wetland Protection Act, MassDEP Chapter 91, and US Army Corps of Engineers. When CAM004 was separated, the permitting and associated appeals process for the new wetland for flow attenuation took approximately 10 years, which exemplifies potential implementation delays and scope increases.
  - Local and Railroad Permitting: Permits for railroad crossings, local zoning, and other administrative processes may come into play depending on the alternative. This, in turn, also increases uncertainty in scope, cost, and timeline.
- Construction and O&M:
  - Construction: Several of the potential projects being evaluated are less complex, limited to a particular site, and can be accomplished in a few years; while others are very complex, impacting large areas, and would be constructed over many years. In addition, several involve construction below ground, some significantly deep, which poses a unique set of challenges. The construction considerations vary by CSO technology:
    - **Sewer Separation** typically involves excavations in streets to install pipelines to convey either the sewer or stormwater in a separate pipeline. Construction could impact many interconnected streets over potentially large areas. These would be multiyear project(s) that are typically phased to limit the impact area of a particular construction project. While overall construction would not be 24 hours a day, 7 days per week, both day & night work would occur depending on the location. These types of projects will include temporary lane/road

closures or detours. The new pipelines could be up to 84 inch diameter with new manholes and other chambers to properly separate and convey the flows. It may not be possible to install such large infrastructure in some roadways that already house many existing underground utilities and, where required, some existing utilities may need to be relocated and reconstructed to make room for the new pipelines, further adding complexity.

- **Storage Tanks** vary in size ranging from 0.5 to 16.7 MG. These would be multi-year construction projects that would primarily be done during daytime working hours; however, some night work would be expected. Most of the work would be confined to the project site with the exception of connection piping that may extend into nearby roadways where traffic impacts may occur. These tanks would be constructed below grade, some as deep as 70 feet. Based on system hydraulics, the largest tank sizes considered would need to be located in areas of known high groundwater and poor soil conditions (i.e., Magazine Beach and Assembly Square). The deeper tanks being considered may require special design features such as slurry walls, pile foundations and/or uplift resistance adding to construction complexity and cost.
- **Microtunneling** is a specialized construction method used to install new pipelines without large stretches of open cut excavations. These new pipelines would add new conveyance and/or storage capacity to an existing system. Typically, the new pipe alignments follow public land (roadways or other green space) and avoid private property and extending under structures. The microtunnel projects considered would include installation of new pipelines up to 9 foot diameter, which is a large pipe to install by any method and would require careful coordination to find a suitable alignment. This method requires shaft sites at each end of the new pipeline alignment, plus up to 5 connection or transition points. Construction at a particular shaft or connection point for microtunnel work can generally be accomplished in 1 to 2 years and requires a modest construction staging area (0.5 to 2 acres). However, since the new pipe alignments may follow roadways, these construction staging areas would be at least partially in roadways resulting in some traffic impacts. Most of the work would be done during the daytime with some night work and limited work being conducted at all hours.
- **Regional Tunnels** can provide large storage volumes. The potential projects being considered include 22 to 32 foot diameter, 1.4 to 4.5 mile long tunnels which could store approximately 21 to 123 MG of flow. If constructed, these tunnels would be some of the largest CSO tunnels constructed in the country. Modern tunneling is a very complex construction method involving the use of tunnel boring machines (TBMs). Significant coordination of the sequence of work occurring inside the tunnel and shafts, at the surface, and off site is required to ensure that the TBM operates at an efficient rate otherwise construction is slowed resulting in not only a longer construction duration but also significant cost increase. Regional tunnel projects would require large multi-acre construction staging areas (at least 2 to 5 acres depending on site use) and take about 8 years to complete the work. Tunnel mining would be non-stop, meaning construction would run at all hours for 1 to 2 years, depending on the tunnel diameter, length and actual tunnel mining rate. These types of projects also require constant truck hauling to and from the project site, sometimes at a magnitude of tens or even hundreds of trucks per day.

– Operations: Operation and maintenance of the new facilities that would be constructed as part of the alternatives being considered vary significantly. No new permanent above ground structures requiring routine operation and maintenance are anticipated for sewer separation options. However, for some of the microtunnel options, and all the tank and regional tunnel options, new pump stations and odor control facilities would be needed. In addition to the Cities of Cambridge and Somerville, the MWRA would be responsible to own, operate and maintain these new pump stations and odor control facilities. Other operational considerations include the downstream impacts of dewatering storage facilities (microtunnels, tanks, and tunnels) and the frequency of using these facilities (facilities will be mostly empty for most of the time). The storage facilities would be dewatered as soon as possible after each storm event, regardless of

the volume captured, in order to provide that capacity for the next storm event. In most storm events, these new facilities can likely be pumped out within a day or two without negatively impacting other areas of the MWRA sewerage transport system. However, it's estimated that in the 2050 5-year and 25-year storm events, dewatering would be slow and would need to be coordinated until other aspects of the system return to near normal flows. It could take approximately one week or more to dewater existing CSO storage facilities plus the new CSO storage tanks and tunnels given the large additional volume stored at these new facilities (approximately 100 to 190 MG, respectively) without causing a SSOs, exceeding the secondary treatment capacity at the DITP, or the recirculation of the captured flow back to the storage facility. Currently, the MWRA has the capacity to store approximately 25 MG of CSO flow.

While all projects come with inherent risks, the Partners aimed to identify where there are potential risks that could undermine the feasibility of a given alternative and therefore undermine the ability to achieve a level of control. There is no one-size-fits-all approach to balance these considerations. Through careful consideration of each of the unique alternatives in each waterbody, the Partners came to consensus on the draft recommended alternative and level of control for each waterbody.

#### 10.4.2.1 Determining the Draft Recommended Alternative for the Alewife Brook

**Table 10-27** presents the four alternatives carried forward into this stage of the analysis.

**Table 10-27. Preliminary Preferred Alternatives for the Alewife Brook**

| Alternative Name | Level of Control | Estimated Cost and Duration | Alternative Description |
|---|---|---|---|
| 3.AB Hybrid 2 | 0 CSOs in 2050 TY | $340M, 13-18 years | 2 tanks (3 MG) + 8 acres of sewer separation + 0.75-mile-long conveyance pipe + 1 mile-long microtunnel |
| 8.AB Hybrid 2 | Limited CSOs in 2050 TY | $240M, 10-20 years | 3 tanks (2.5 MG) + 8 acres of sewer separation + 0.75-mile-long conveyance pipe + 0.5 mile-long microtunnel |
| 10.AB Tunnel + GSI | 2050 5-year Storm | $1.1B, 12-15 years | 22-ft diameter (20.6 MG) tunnel + GSI (36 acres) |
| 12.AB Tunnel + GSI | 2050 25-year Storm | $1.7B, 12-15 years | 32-ft diameter (41.6 MG) tunnel + GSI (36 acres) |

Key considerations for determining the level of control for Alewife Brook focused on the timeline to CSO reduction benefit; construction considerations including duration of construction and traffic; site acquisition, including temporary and permanent impacts to public uses/parkland; operational impacts; and cost compared to the water quality benefit achieved.

As stated in previous Sections, the Variances required the Partners to examine solutions "up to and including elimination". This is consistent with every CSO LTCP researched by the Partners, in the US and abroad, which have uniformly recommended an LOC that results in limited discharges during the historic TY. Notwithstanding this precedent, throughout the outreach and engagement process described in Section 5, the Partners clearly heard from stakeholders and the regulators that even a single discharge during the TY would not constitute "elimination," and would thus require a change in designated use by MassDEP to Class B(CSO). The preponderance of feedback received during the formulation of the Draft Plan led the Partners to conclude that a change in designated use would not be supported. Consequently, the Partners decided to eliminate the alternatives for Limited CSOs in the 2050 TY from further consideration in all three waterbodies.

The Partners next considered tradeoffs between 0 CSOs in the 2050 TY and the 2050 design storms. Achieving CSO elimination in the 5- and 25-year storms are ambitious efforts that require large, regional solutions as described in detail in Section 9.

Duration to CSO Reduction Benefit

The singular tunnel solutions included in the 5- and 25-year storms offer no opportunity to achieve interim CSO reductions before the tunnel is constructed. This means that there would be no CSO reduction for at least 12-15 years if either of these alternatives are selected. The 0 CSOs in the 2050 TY alternative allows for earlier CSO reduction benefits through construction of smaller individual projects such as tanks.

Construction Considerations

Regional tunnels included in alternatives for the 5- and 25-year storms require larger land area during construction and longer construction durations. For example, an evaluation of potential projects on the Dilboy Field property show the temporary construction easement and permanent land area needed for the tunnels are approximately double that of the 0 CSOs in 2050 TY alternative.

The tunnels are significantly deeper than the infrastructure included the 0 CSOs in 2050 TY alternative and generate more truck traffic. For example, an evaluation of potential projects on the Dilboy Field property shows that truck traffic for 5- and 25-year alternatives averaged 100 trucks per day and 200 trucks per day respectively for about 12 months just to remove the excavated materials from the tunnels, compared to 20 trucks per day for 0 CSOs in the 2050 TY.

Operational Considerations

Operational considerations for all alternatives in the Alewife Brook include ongoing operation and maintenance associated with the dewatering pump stations and odor control facilities, which increase in complexity as the size and depth of infrastructure increases, as well as the impacts to the downstream collection system and DITP from dewatering activities. The storage facilities (microtunnels, tanks and tunnels) would be dewatered as soon as possible after each storm event, regardless of the volume captured, in order to provide that capacity for the next storm event. In most storm events, these new facilities can likely be pumped out within a day or two without negatively impacting other areas of the MWRA sewerage transport system. However, in the 2050 5-year and 25-year storm events, dewatering would take longer and would need to be coordinated until other aspects of the system return to near normal flows. Initial estimates indicated this could take approximately one week or more to dewater existing CSO storage facilities plus the new CSO storage tanks and tunnels given the large additional volume stored at these new facilities (approximately 100 to 190 MG, respectively) without causing a potential SSO, exceeding the secondary treatment capacity at the DITP, or the recirculation of the captured flow back to the storage facility. Currently, the MWRA has the capacity to store approximately 25 MG of CSO flow.

Moreover, the existing MWRA infrastructure systems in Cambridge, Somerville, and upstream and downstream are not suited to handle these large future storm events. This was illustrated previously in Section 7.5, and it means that even if the CSOs are eliminated in the 5- and 25-year storms, the system is at capacity, and inland flooding will be widespread during these storm events, essentially creating the same water quality and public health risks that this Plan aims to mitigate. Considering the robust benefits achieved for the 2050 TY LOC across the 2015-2024 horizon (76% reduction in CSO volume 91% reduction in CSO activations), the incremental added benefit of these alternatives for the 5- and 25-year LOC (100% reduction in CSO volume and activations in the period) is marginal.

The tunnels required in the 5- and 25-year storms would be highly underutilized in a typical year. These tunnels would be sized for larger volumes to accommodate their respective design storms, which statistically would occur once every 5 years or once every 25 years. The largest storm in a 2050 TY would fill only 22% of the 5-year tunnel, and 11% of the 25-year tunnel.

While the 0 CSOs in the 2050 TY alternative also requires permanent facilities, these facilities are smaller in footprint and require shallower depths for the pumping facilities, and the volume of the microtunnel is considerably less than the volume of the regional tunnels included in the 5- and 25-year storms.

Cost and Water Quality Considerations

The increase in cost between the 2050 TY and design storms represent a three-to-five times cost increase with minimal additional benefits for this investment. **Section 10.4.1.3** estimated that, using the 2015-2024 period, progressing from 0 CSOs in the 2050 TY to the 2050 5-year storm alternative yields an average annual recreational benefit of two additional days (**Table 10-24**).

**Since the 2050 TY is itself an ambitiously developed TY, and since the alternative developed to this LOC also has the added benefit of allowing for incremental CSO reductions during phased implementation, Alternative 3.AB Hybrid 2 was identified as the draft recommended alternative for the Alewife Brook.** More details of this alternative, and additional analyses of its performance, are presented in Section 12.

### 10.4.2.2 Determining the Draft Recommended Alternative for the Mystic River

**Table 10-28** presents the four alternatives carried forward into this stage of the analysis.

**Table 10-28. Preliminary Preferred Alternatives for the Mystic River**

| Alternative Name | Level of Control | Estimated Cost and Duration | Alternative Description |
|---|---|---|---|
| 2.MR Hybrid 1 | 0 CSOs in 2050 TY | $260M, 5-7 years | 1 tank (7.4 MG) + 95 acres of sewer separation |
| 6a.MR Hybrid 1 | Limited CSOs in 2050 TY | $170M, 5-10 years | 1 tank (2.7 MG) + 95 acres of sewer separation |
| 9.MR Hybrid 1 | 2050 5-year Storm | $260M, 5-7 years | 1 tank (7.4 MG) +95 acres of sewer separation |
| 12.MR Hybrid 1 | 2050 25-year Storm | $340M, 5-10 years | 1 tank (14.2 MG) + 95 acres of sewer separation |

The decision process for the Mystic River level of control followed similar principles as detailed in the Alewife Brook. The optimal tank site selected during the alternatives development process was at Assembly Square in Somerville, which is a privately owned site adjacent to the Mystic River with poor soils. This location, while the best option identified, still poses significant challenges that scale as the tank size grows. The conceptual tank size ranges from 2.7 MG to up to 15 MG, which translates into tank dimensions of up to 205 ft (W) x 235 ft (L) x 50 ft (D). The construction complexity, operability, and long-term maintenance for infrastructure of this size were important considerations that factored into this analysis. Some of the implementation concerns associated with tanks of this magnitude were discussed in Section 9.7.3.2.

A figure illustrating the type of space these sized tanks would take up is presented in **Figure 10-11**.

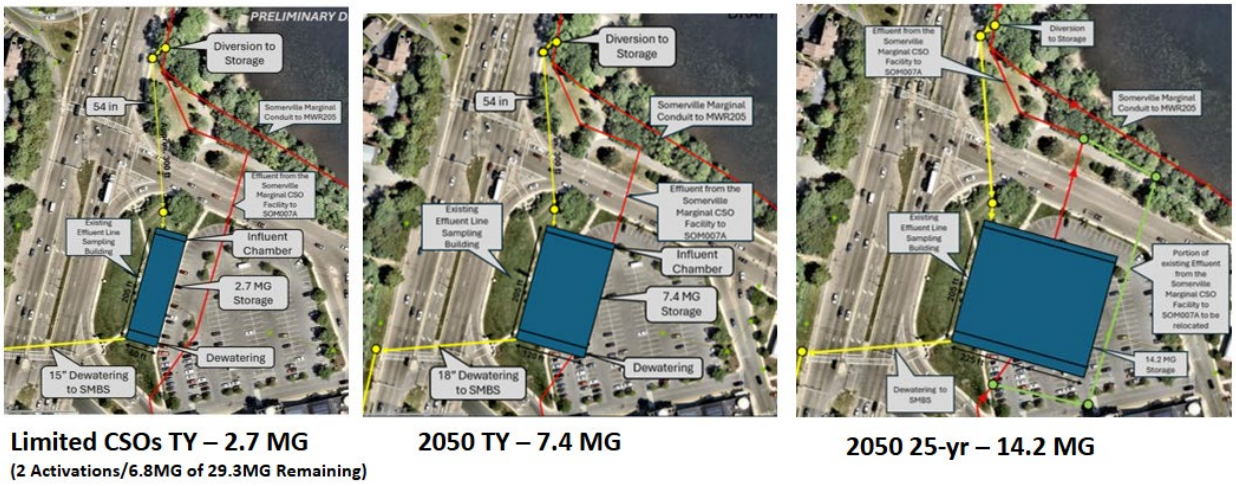



**Figure 10-11. Schematic of Tank Sizing**

The Partners considered these tradeoffs. With the conveyance system past its limit in the 2050 25-year storm, and the corresponding magnitude of the tank for limited additional benefits over the other LOCs in the 2015-2024 horizon, this LOC was removed from consideration. The Partners eliminated the Limited LOC alternative for the same reasons described in the Alewife Brook (**Section 10.4.2.1**). Due to the tidal influence at this outfall, the same alternative can achieve both 0 CSOs in the 2050 TY and elimination to the 2050 5-year storm under average tide conditions (see Section 9.6.1). **Therefore, the Partners recommend Alternative 2.MR Hybrid 1 as the draft recommended alternative. This alternative strikes a balance between constructability and water quality improvements. Additionally, the inclusion of sewer separation in this alternative facilitates an opportunity for interim CSO reductions.** More details of this alternative, and additional analyses of its performance, are presented in Section 12.

### 10.4.2.3 Determining the Draft Recommended Alternative for the Charles River

**Table 10-29** presents the alternatives carried forward into this stage of the analysis.

**Table 10-29. Preliminary Preferred Alternatives for the Charles River**

| Alternative Name | Level of Control | Estimated Cost and Duration | Alternative Description |
|---|---|---|---|
| 4.CR Hybrid 3 | 0 CSOs in 2050 TY | $690M, 28-33 years | 2 tanks (12.6 MG) + 446 acres of sewer separation + 2 storage conduits |
| 8.CR Hybrid 1 | Limited CSOs in 2050 TY | $360M, 23-28 years | 1 tank (2.5 MG) + 268 acres of sewer separation + 1 storage conduit |
| 11.CR Tunnel + GSI | 2050 5-year Storm | $2B, 14-20 years | 24-ft diameter (71.9 MG) tunnel + GSI (90 acres) + 1-mile-long Microtunnel |
| 13.CR Tunnel + GSI | 2050 25-year Storm | $2.7B, 15-20 years | 32-ft diameter (132 MG) tunnel + GSI (90 acres) + 1-mile-long Microtunnel + 1 storage conduit |

The configuration along the Charles River is complicated, involving 9 CSO outfalls, 8 of which are untreated, along with a treated CSO outfall from Cottage Farm (MWR201). As can be seen in **Table 10-29**, the preliminary preferred alternatives carried forward are widely varied with many multi-project solutions, and most have considerably longer implementation durations compared to the alternatives in

the Alewife Brook and Mystic River. These longer durations are largely driven by the scale of sewer separation included in these alternatives.

Key considerations for determining the level of control for the Charles River focused on the timeline to CSO reduction benefit; construction considerations including duration of construction and traffic; site acquisition, including temporary and permanent impacts to public uses/parkland; operational impacts; and cost compared to the water quality benefit achieved.

Duration to CSO Reduction Benefit

Similarly to the other watersheds, the alternatives developed for Limited and 0 CSOs in the 2050 TY can realize short term CSO reductions during the implementation schedule, whereas the alternatives for the large design storms rely on large singular tunnels, thus deferring all CSO reductions for at least 15-20 years.

Construction Considerations

As described in **Section 10.4.2**, regional tunnels included in alternatives for the 5- and 25-year storms require large land area during construction and longer construction durations. For example, an evaluation of potential projects at Magazine Beach shows that while the temporary construction easement is the same for the storage tank in the 0 CSOs in 2050 TY and tunnels, the construction duration is approximately two years longer for the tunnels. However, the permanent easement is smaller for the tunnels.

The tunnels are significantly deeper than the infrastructure included the 0 CSOs in 2050 TY alternative and generate more truck traffic, and also require 24-hour, 7 days a week construction during tunneling. For example, an evaluation of potential projects at Magazine Beach shows that truck traffic for the 5- and 25-year alternatives averaged 150 trucks per day and 250 trucks per day respectively for about 24 months just to remove the excavated materials from the tunnels, compared to 35 trucks per day during excavation of the tank for 0 CSOs in the 2050 TY. Access to this site would be from Memorial Drive which poses challenges given low clearances under bridges.

Similar considerations were evaluated for the Esplanade with increased truck traffic for the tunnel alternatives and challenging access to the area via Storrow Drive. While work is required in the Esplanade in alternatives for each level of control, the permanent facilities and impacts to public land are greater with the tunnel alternatives. The tunnels would each require a permanent dewatering pump station at Magazine Beach and odor control facilities in other parkland. The tunnels may require localized odor control at the drop shaft locations along the Esplanade as well.

Operational Considerations

The Charles River system experiences the same conveyance capacity limitations in large design storms as described previously. With widespread flooding in both the 5- and 25-year 2050 storms, the water quality benefits associated with the alternatives designed to meet those levels of control do not scale with the scaled cost. The alternatives sized to the design storms only adds an additional 2 days per year of recreational access (**Table 10-24**) for an increase in cost from $690M to $2B or $2.7B, respectively. Sewer backups, SSOs, and flooding associated with those large design storms will worsen public health and water quality at these storm events in proportions that are not outweighed by the benefits associated with these levels of control.

The tunnels required in the 5- and 25-year storms would also be highly underutilized in a typical year. These tunnels would be sized for larger volumes to accommodate their respective design storms, which statistically would occur once every 5 years or once every 25 years. The largest storm in a 2050 TY would fill only 22% of the 5-year tunnel, and 13% of the 25-year tunnel.

Operational considerations associated with permanent facilities and downstream impacts from dewatering microtunnels, storage tanks, and tunnels are similar in nature, but greater in magnitude, to those already described for Alewife Brook. Given the large amount of storage and size of the pump station associated with the 2050 5-year and 25-year levels of control for the Charles River regional tunnel alternatives,

multiple size pumps would be required. One pump would need to be sized much larger than the others to accommodate the wide volume range that could be stored and need to be efficiently pumped back to the sewerage system for transport to DITP for treatment after each storm event adding to the operational complexity of this facility. Corrective and preventative maintenance activities at storage facilities, including cleaning after each storm and equipment replacement, and operation and maintenance of the deep tunnel and pump station would require specialized equipment and training for staff to enter the deep tanks and pump stations to perform the maintenance activities.

Cost and Water Quality Considerations

Perhaps unique from other watersheds, the cost differences between Limited and 0 CSOs in the TY are vast. This represents a significant increased complexity in moving from a limited CSO scenario to elimination in the TY. This also corresponds to a significant increase in benefits between these two LOCs when assessed against the 2015-2024 period (38% CSO volume reduction for Limited vs. 74% CSO volume reduction for 0 CSOs in 2050 TY).

**The draft recommended alternative in the Charles River is 4.CR Hybrid 3, which achieves 0 CSOs in the 2050 TY.** More details of this alternative, and additional analyses of its performance, are presented in Section 12.

# 11. Financial Capability Assessment

The 2024 Variances require Cambridge, Somerville, and the MWRA to conduct an affordability analysis consistent with the EPA's 2024 CWA Financial Capability Assessment Guidance (herein referred to as the EPA Guidance), along with any other relevant information to assess financial capacity. As recognized in the EPA Guidance, financial capability assessments (FCAs) provide information to inform schedules to meet CSO control requirements.

This section of the Updated CSO Control Plan provides an overview of the EPA Guidance, a summary of limitations of an FCA as a measure of affordability, and a summary of the FCAs that were completed for Cambridge, Somerville, and MWRA. Reports that contain additional details for each FCA are provided as Appendices G, H, and I. The MWRA FCA only accounts for MWRA's projected CWA costs, while Cambridge and Somerville FCAs account for both MWRA municipal assessments and projected municipal CWA costs required to maintain and improve municipally owned and maintained infrastructure.

## 11.1 Overview of EPA Financial Capability Assessment Guidance

The objective of the CWA is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (33 U.S.C. § 1251). Municipal discharges that violate the CWA can pose significant threats to public health and the environment. When a community is out of compliance with the CWA, EPA's expectation is that the community will achieve compliance with the CWA as soon as practicable (USEPA, 2024).

The EPA has recognized the importance of taking a community's financial capabilities into consideration when developing implementation schedules for achieving compliance with the CWA standards and regulations. As a result, in 1997 the EPA issued the "Combined Sewer Overflows: Final Guidance for Financial Capability Assessment and Schedule Development" (USEPA, 1997).

Since it was issued, the original 1997 guidance has been updated and expanded to incorporate additional financial and affordability considerations and establish a framework to assist permittees with creating a more complete picture of their financial capability. In early 2023, the EPA released its updated CWA Financial Capability Assessment Guidance that built on previous iterations by implementing additional indicators and adding alternative approaches for conducting the FCA analysis. In March 2024, EPA reissued this guidance to incorporate a minor editorial correction.

The EPA Guidance includes two alternatives for conducting the analysis. Alternative 1 contains a two-phase approach for assessing a permittee's financial capability to implement current and proposed wastewater and stormwater treatment and CSO controls. The first phase calculates the financial impact of water pollution costs (wastewater and stormwater) on individual households to determine the Residential Indicator (RI), which examines the average cost of household water pollution costs relative to benchmarks of the service area median household income (MHI). The results of this preliminary screening analysis are assessed by placing the community in one of three categories:

- Low economic impact: average household CWA costs are less than 1% of MHI;
- Mid-range economic impact: average household CWA costs are between 1% and 2% of MHI; and
- High economic impact: average household CWA costs are greater than 2% of MHI.

The second phase of Alternative 1 evaluates the following six Financial Capability Indicators (FCIs) regarding a permittee's debt, socioeconomic, and financial conditions: bond rating, overall net debt as a percent of full market property value (FMPV), unemployment rate, median household income, property tax revenues as a percent of FMPV, and property tax revenue collection rate. The FCIs are compared to national benchmarks and are used to generate a score that is the average of the six FCI scores. Lower

FCI scores suggest weaker economic conditions, and thus the increased likelihood that additional water pollution control costs could cause a substantial economic impact. The results of the first and second phases are entered into an FCA Matrix, which determines an FCA score.

Alternative 1 also includes the following two steps: 1) development of a Lowest Quintile Poverty Indicator (LQPI) Score, and 2) a Financial Alternatives Analysis (FAA). The LQPI aids in assessing the severity and prevalence of poverty in a community's service area. The score provided by the FCA Matrix is combined with the score from the LQPI analysis in an Expanded FCA Matrix, which is used to inform the development of an appropriate CSO control implementation schedule.

An FAA documents whether a community has considered feasible steps to reduce costs and address impacts to low-income households, including use of variable rate structures, and applications for grants or subsidies from the Clean Water State Revolving Fund. Without the types of information developed in an FAA, it may be more difficult for EPA or MassDEP to assess possible financial impacts and whether those impacts might outweigh the environmental impacts of extended noncompliance, so the recommendations for compliance schedules for communities that have not performed an FAA are shorter than for those communities that have developed a comprehensive FAA.

Alternative 2 utilizes dynamic financial and rate models that evaluate the impacts of debt service on customer bills in addition to calculating an LQPI and performing an FAA.

## 11.2 Limitations of Financial Capability as a Measure of Affordability

The EPA Guidance is widely used to negotiate the length of an implementation schedule for a community's or utility's CWA requirements (e.g., construction schedule for implementation of a CSO control plan), but it is not an accurate tool for measuring water and sewer affordability for households. National organizations, including but not limited to the National Association of Clean Water Agencies (NACWA) and the National League of Cities (NLC), have consistently identified limitations in the FCA methodology that prevent it from reflecting the real financial burden on low-income residents, in particular.

The FCA's core metric, the RI, assumes communities are financially uniform. National analyses show MHI does not represent income distribution and therefore significantly understates the hardship faced by low-income residents. The NLC reports that reliance on MHI "places a particularly high burden on residents at the lower end of the economic scale" (NLC, 2023). The FCA also relies on broad communitywide indicators such as bond ratings, unemployment rates, tax capacity, and overall fiscal health. These measure a utility's municipality's ability to borrow, not residents' ability to pay. NACWA warns that such community level metrics "mask the actual impact on individual households," leaving low income and environmental justice communities to "unfairly bear the brunt of increasing clean water rates" (NACWA, 2023).

EPA states the FCA "is not a methodology for defining water affordability" and continues to treat poverty measures as supplemental inputs rather than primary determinants. EPA's approach still depends on MHI and nationwide averages, which overlook what families actually experience when facing rising water and sewer costs (USEPA, 2024). NACWA, the U.S. Conference of Mayors, and the NLC have all noted that use of the new version of the FCA does not evaluate actual impacts on the bills that a low-income household might pay. Instead, it uses community level metrics and compares those to national benchmarks as opposed to looking at what individual households will be asked to spend. The organizations note that this fundamental methodological flaw fails to adequately document that households comprised of lower income earners are paying proportionately more for the same water and wastewater services as a percentage of their income than the rest of the community. While standardizing a methodology might be an understandable objective of EPA, it ignores very real factors that must be considered in evaluating the impacts of additional costs on real people across the country.

The procedure established by EPA also does not account for the substantial differences in cost of living in different parts of the country that significantly affect the amount of money users have to allocate part of

their budget to paying for clean water costs. The cost of living reflects the actual burden on households in an area to pay for daily costs of housing, food, education, transportation, and healthcare. The cost of living varies substantially across the country and affects the ability of residents and businesses to pay for other necessities including utilities such as heat, water, and sewer. Households, particularly households in the lowest quintile, have limited ability to relocate to other parts of the country where cost of living may be lower.

As recognized by the EPA Guidance, additional considerations (such as local economic conditions, cost of living, and poverty severity) have been included in the FCAs conducted for Cambridge, Somerville, and MWRA to capture financial pressures on households that the core FCA metrics cannot fully represent. These additional inputs help identify disproportionate impacts on low income and vulnerable households and provide the nuanced information needed to justify reasonable and practicable implementation schedules and inform water quality standards decisions.

## 11.3 Cost Allocation by Partner for Financial Capability Assessment

The Partners collaboratively developed a provisional cost share structure for the sole purpose of evaluating financial capability. Actual cost splits of the final plan will be subject to future negotiation. The FCA was conducted for the following LOCs, as shown in **Table 11-1**:

- **Limited 2050 TY**: Limited CSOs in the 2050 Typical Year;
- **2050 TY**: 0 CSOs in 2050 Typical Year;
- **2050 5-YR**: 0 CSOs in the 2050 5-year storm;
- **2050 25-YR**: 0 CSOs in the 2050 25-year storm; and
- **Full Sewer Separation**: CSOs resulting from full sewer separation.

**Table 11-1. Updated CSO Control Plan FCA Costs by Level of Control**

| | FCA Costs by Partner (1) | | |
|---|---|---|---|
| Level of Control | MWRA (FY2024 Dollars) | Cambridge (FY2025 Dollars) | Somerville (FY2025 Dollars) |
| Baseline(2) | $2,359,039,913 | $815,970,467 | $628,371,504 |
| Limited 2050 TY | + $329,600,000 | + $266,600,000 | + $171,200,000 |
| **2050 TY (3)** | **+ $763,700,000** | **+ $257,000,000** | **+ $257,300,000** |
| 2050 5-YR | + $1,727,400,000 | + $1,071,100,000 | + $380,000,000 |
| 2050 25-YR | + $2,273,100,000 | + $1,829,500,000 | + $530,000,000 |
| Full Sewer Separation | + $1,853,700,000 | + $2,409,500,000 | + $2,640,000,000 |

**Notes:**

(1) Costs for each LOC are evaluated as additions to the baseline. Costs for MWRA include MWRA's capital cost allocation for the respective preliminary preferred alternatives (these costs would be distributed between MWRA's 43 wastewater communities, including Cambridge and Somerville). Costs for Cambridge and Somerville include their own capital cost allocations as well as MWRA costs that are distributed to them.

(2) Baseline includes current and future expenditures, which vary by Partner.

(3) Represents the draft recommended alternatives.

## 11.4 Summary of MWRA Financial Capability Assessment

### 11.4.1 Approach

The entire MWRA sewer service area, which is comprised of approximately 917,000 households across four counties and 43 municipalities[1], and includes a population of over two million people, was included in MWRA's FCA since the entire service area will pay for MWRA's share of the recommended CSO control alternative. A typical annual cost per household value was developed for use in the analysis that accounts for the residential share of current and projected CWA program costs. Projected costs account for MWRA's wastewater system improvement costs included in MWRA's Fiscal Year 2024 Capital Improvement Plan ($2.36 billion)[2] as well as the cost estimate for MWRA's share of the Draft Recommended Plan that is presented in Section 12, which achieves 0 CSOs in the 2050 TY across all three waterbodies ($763.7 million). The Draft Recommended Plan includes Alternative 3.AB Hybrid 2 for Alewife Brook, Alternative 2.MR Hybrid 1 for the Mystic River, and Alternative 4.CR Hybrid 3 for the Charles River. A preliminary FCA was also completed for the preliminary preferred alternatives across all the LOCs evaluated in the Updated CSO Control Plan, as summarized in **Table 11-2**. It is important to note this FCA does not account for additional projected municipal wastewater and stormwater costs, since this information was not available for all service area municipalities and is not included in MWRA's municipal assessments that are passed on to municipal customers (i.e., costs required to maintain and improve municipally owned and maintained infrastructure are in addition to MWRA municipal assessments). As a result, projected wastewater and stormwater costs are actually higher than the costs used for this FCA.

**Table 11-2. MWRA Updated CSO Control Plan – FCA Scenarios**

| Scenario | MWRA Costs (FY2024 Dollars)(1) |
|---|---|
| Baseline(2) | $2,359,039,913 |
| Limited 2050 TY | + $329,600,000 |
| **2050 TY(3)** | **+ $763,700,000** |
| 2050 5-YR | + $1,727,400,000 |
| 2050 25-YR | + $2,273,100,000 |
| Full Sewer Separation | + $1,853,700,000 |

**Notes:**
(1) Costs for each scenario are evaluated as additions to the baseline.
(2) Includes the $2.36 billion wastewater improvements costs included in MWRA's Fiscal Year 2024 Capital Improvement Plan.
(3) Represents the draft recommended alternatives.

Regional and municipal level scores were developed for each critical FCA metric (including RI, FCI, and LQPI) to enable results at a sewer service area wide level as well as understanding impacts to individual municipalities. To derive scores at the regional or service area level, the individual municipal scores were weighted by the population served within the municipality.

[1] The MWRA sewer service area is comprised of the following 43 municipalities: Arlington, Ashland, Bedford, Belmont, Boston, Braintree, Brookline, Burlington, Cambridge, Canton, Chelsea, Dedham, Everett, Framingham, Hingham, Holbrook, Lexington, Malden, Medford, Melrose, Milton, Natick, Needham, Newton, Norwood, Quincy, Randolph, Reading, Revere, Somerville, Stoneham, Stoughton, Wakefield, Walpole, Waltham, Watertown, Wellesley, Westwood, Weymouth, Wilmington, Winchester, Winthrop, and Woburn.

[2] MWRA's wastewater system improvement costs included in MWRA's Fiscal Year 2024 Capital Improvement Plan ($2.36 billion) includes projects to maintain and improve the existing wastewater system including projects to maintain DITP, rehabilitating pump stations, headworks facilities and CSO facilities, maintenance and improvements to conveyance systems, and continuing to provide financial assistance to communities for I/I reduction.

### 11.4.2 Findings

The FCA calculates that the MWRA service area, taken as a whole, demonstrates a "Low Impact" rating across the FCA indicators for the Draft Recommended Plan (i.e., 0 CSOs in the 2050 TY). The regional RI score of 0.87% falls below the EPA's 1% threshold for low economic impact, and the regional FCI score of 2.8 indicates strong financial capability. The regional LQPI score of 2.6 suggests that the majority of households are not expected to experience significant financial hardship due to increased CWA compliance costs. Regional results for each level of control are provided in **Table 11-3**.

**Table 11-3. CSO Control Scenario Summary**

| Alternative | Cost Summary | | Regional FCA Results | | | | |
|---|---|---|---|---|---|---|---|
| | CSO Control Cost (Millions) | Total Annual Cost Per Household | Residential Indicator | FCI Score | LQPI Score | Expanded FCA Matrix Results | EPA FCA Guidance Implementation Schedule |
| **Baseline**[3] | $0 | $1,003 | 0.82% | 2.8 | 2.8 | Low Impact | Normal Engineering / Construction Schedule |
| **Limited 2050 TY** | $329.6 | $1,025 | 0.84% | 2.8 | 2.8 | Low Impact | Normal Engineering / Construction Schedule |
| **2050 TY** | **$763.7** | **$1,053** | **0.87%** | **2.8** | **2.8** | **Low Impact** | **Normal Engineering / Construction Schedule** |
| **Full Sewer Separation** | $1,853.7 | $1,125 | 0.92% | 2.8 | 2.8 | Low Impact | Normal Engineering / Construction Schedule |
| **2050 5-YR** | $1,727.4 | $1,116 | 0.92% | 2.8 | 2.8 | Low Impact | Normal Engineering / Construction Schedule |
| **2050 25-YR** | $2,273.1 | $1,152 | 0.95% | 2.8 | 2.8 | Low Impact | Normal Engineering / Construction Schedule |

**Note:**
Results presented in table reflect use of 2023 ACS 5-year data.

However, the assessment also reveals several limitations in the EPA's FCA framework and emphasizes the importance of assessing impacts on individual municipalities and low-income households:

- Regional Aggregation Masks Local Vulnerabilities: While regional scores suggest low impact, several municipalities, most notably Chelsea, exhibit elevated levels of financial vulnerability (see **Table 11-4**). Chelsea's "High Impact" LQPI score and "High Impact" Expanded FCA Matrix result underscore the need for localized analysis and targeted mitigation strategies.
- MHI Limitations: The use of MHI as a central metric does not capture income variability or the disproportionate burden on low-income households, particularly in a service area as large as a regional sewer provider like MWRA. In Chelsea, for example, nearly 22% of households earn less than $25,000 annually, resulting in RI scores exceeding 4%, which is well above EPA's high-impact threshold.
- Constraints on MWRA's Financial Flexibility: As a wholesale provider, MWRA lacks control over municipal rate structures and cannot implement customer assistance programs directly. This limits its ability to mitigate financial impacts on vulnerable populations.
- Benchmark Applicability: The use of MHI as a central metric does not account for substantial differences in cost of living across the United States and reduces the value of comparing local data to national benchmarks. According to data from the Council for Community and Economic Research, Boston's cost of living is about 50% higher than the national average, making it one of the most

[3] Baseline CSO Control alternative represents existing cost/impact information if no CSO controls are implemented.

expensive cities in the country. The Economic Research Institute indicates the Boston metropolitan area reports an even higher cost of living (+78%) than the national average.

- Static Nature of the Assessment: The FCA evaluates current conditions without accounting for future economic shifts, inflation, or demographic changes, which could affect affordability over time.

**Table 11-4. MWRA Sewer Service Area Communities with Medium and High Impacts**

| Community | Expanded FCA Matrix Designation |
|---|---|
| Chelsea | High Impact (all alternatives) |
| Everett | Medium Impact (all alternatives) |
| Framingham | Medium Impact (all alternatives, except Baseline) |
| Quincy | Medium Impact (all alternatives) |
| Revere | Medium Impact (all alternatives) |

**Note:**
Results presented in table reflect use of 2023 ACS 5-year data.

Also, as noted above, this FCA does not account for other projected municipal wastewater and stormwater costs that municipalities may incur in addition to MWRA's Capital Improvement Plan costs and MWRA's share of the recommended CSO control alternative, since this information was not available for all service area municipalities. As a result, projected wastewater and stormwater costs are underrepresented, and the resulting typical cost per household and RI values used for the analysis do not capture these additional municipal costs. The FCAs for the cities of Cambridge and Somerville in the sections below highlight this limitation of regional EPA Guidance metrics.

This FCA highlights the importance of supplementing quantitative metrics with qualitative insights and localized data to support development of implementation schedules for CSO control that are both environmentally effective and socially equitable. In addition, special consideration needs to be given to communities within MWRA's service area with elevated financial stress to avoid exacerbating existing disparities and avoid undue hardship.

### 11.4.3 Supplemental Debt Service Analysis

As noted in **Section 11.1**, the FCA Alternative 2 methodology identified in the EPA Guidance utilizes dynamic financial and rate models that evaluate the impacts of debt service on customer bills in addition to calculating an LQPI and performing an FAA. While a complete FCA was not performed using Alternative 2. MWRA did use its Assessment Projection Model to identify potential impacts to future sewer assessments to its member communities and MWRA's debt service as a result of implementation of the various levels of control.

To model the future sewer assessment impacts, MWRA staff developed estimated design and construction costs and spending timelines for MWRA's share of the projects. The projected CSO alternative costs used are in today's dollars and do not reflect potential inflationary pressures in the future. Consistent with MWRA's standard practice, the costs for the unawarded work were inflated at 2.5% per year until the estimated year the funds would be spent. **Table 11-5** details the estimated future value of the potential MWRA share of CSO costs at three levels of control after 2.5% annual inflation assumption.

**Table 11-5. Potential MWRA Share of CSO Costs in Current and Future Dollars**

| Alternative | CSO Cost in 2026 dollars | Spending (2.5%/year) | CSO Costs in Future dollars |
|---|---|---|---|
| **2050 TY** | **$ 763,700,000** | **2028 - 2042** → | **$ 1,011,274,416** |
| **2050 5-YR** | $ 1,730,000,000 | 2028 - 2042 → | $ 2,297,632,930 |
| **2050 25-YR** | $ 2,270,000,000 | 2028 - 2042 → | $ 3,014,813,150 |

Since long-term bonds will be issued to fund the costs of the CSO program, MWRA staff utilized the projected spending to develop future borrowings. For each year of future spending, a simulated 30-year bond at a 5.0% interest rate was created. These different borrowing scenarios result in the annual debt service to be added to the Assessment Projection Model to determine future sewer assessments that will directly impact ratepayers. **Figure 11-1** details the projected annual debt service (principal and interest) costs by level of control.

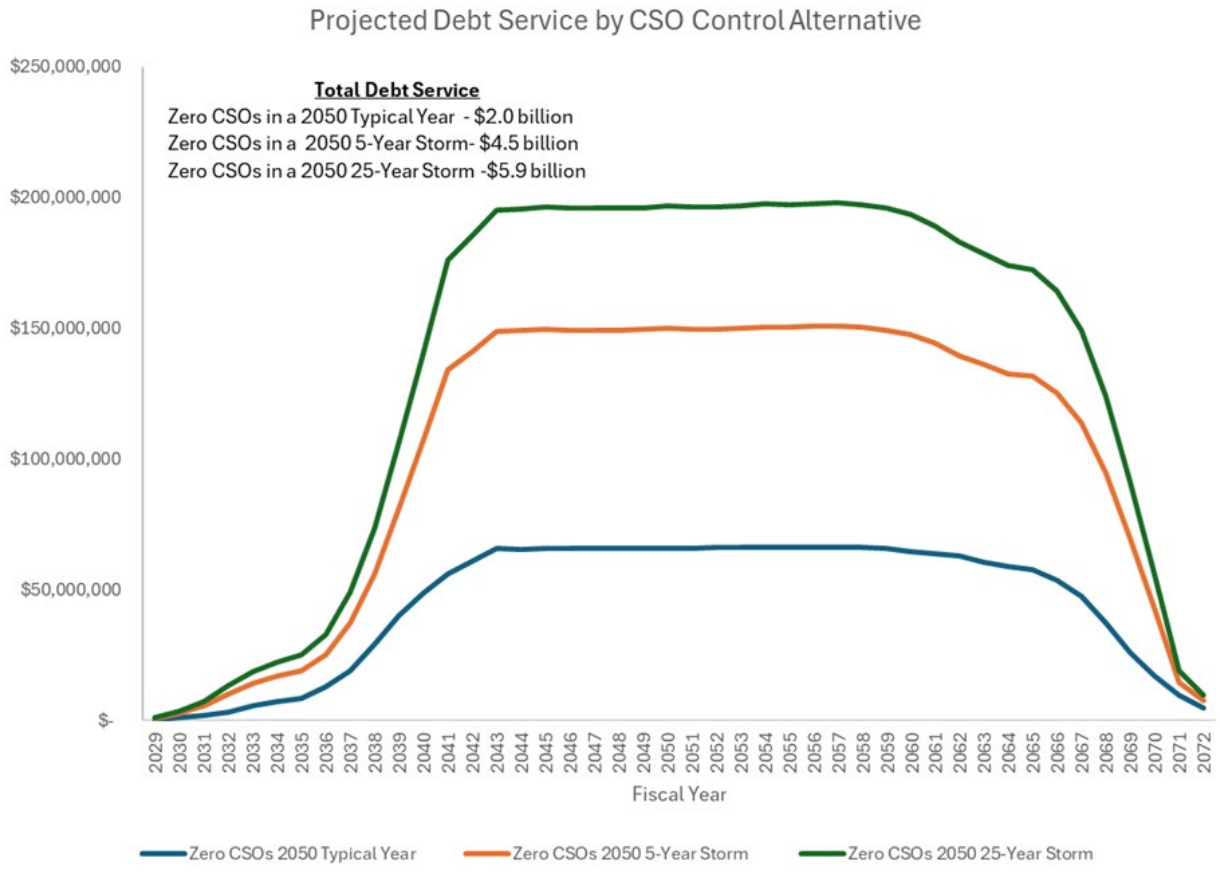



**Figure 11-1. Projected Debt Service by CSO Control Alternative**

The debt service shown In **Figure 11-1** results in between $1.9 billion and $5.9 billion in additional costs over and above the already planned capital spending between fiscal years 2029 and 2072. Annual debt service related to the CSO expenses peaks at $66.4 million, $150.9 million, and $198.0 million for

alternatives to achieve 0 CSOs in the 2050 TY, 2050 5-year, and 2050 25-year storms, respectively. The debt service from these borrowings was added to the Assessment Projection Model to project potential future rate impacts of the additional spending by level of control. In addition to the debt service cost, MWRA's Assessment Projection Model also performs calculations to make sure that MWRA will comply with the requirements of the Bond Resolution.

Like most revenue bond issuers, MWRA's issuance of debt is governed by a Bond Resolution which provides financial security to investors that allows them to invest in MWRA. Since bondholders are pledged all revenues remaining after the payment of operating expense, MWRA is required to raise $1.20 for every dollar in senior debt service expenses. This is known as a coverage requirement. The baseline projected spending does not result in the need for additional revenues to meet this coverage requirement, however the additional CSO related debt service does result in additional assessments to the sewer communities to allow for the issuance of this debt. The model currently projects that between 2029 and 2050, $143.6 million, $357.7 million, and $464.8 million in additional revenue would be required to support the bond issues to fund the CSO spending to achieve 0 CSOs in the 2050 TY, 2050 5-year, and 2050 25-year storms, respectively.

**Figure 11-2** details the results of the analysis of the impact of the additional CSO costs for the 43 communities that comprise the sewer system.

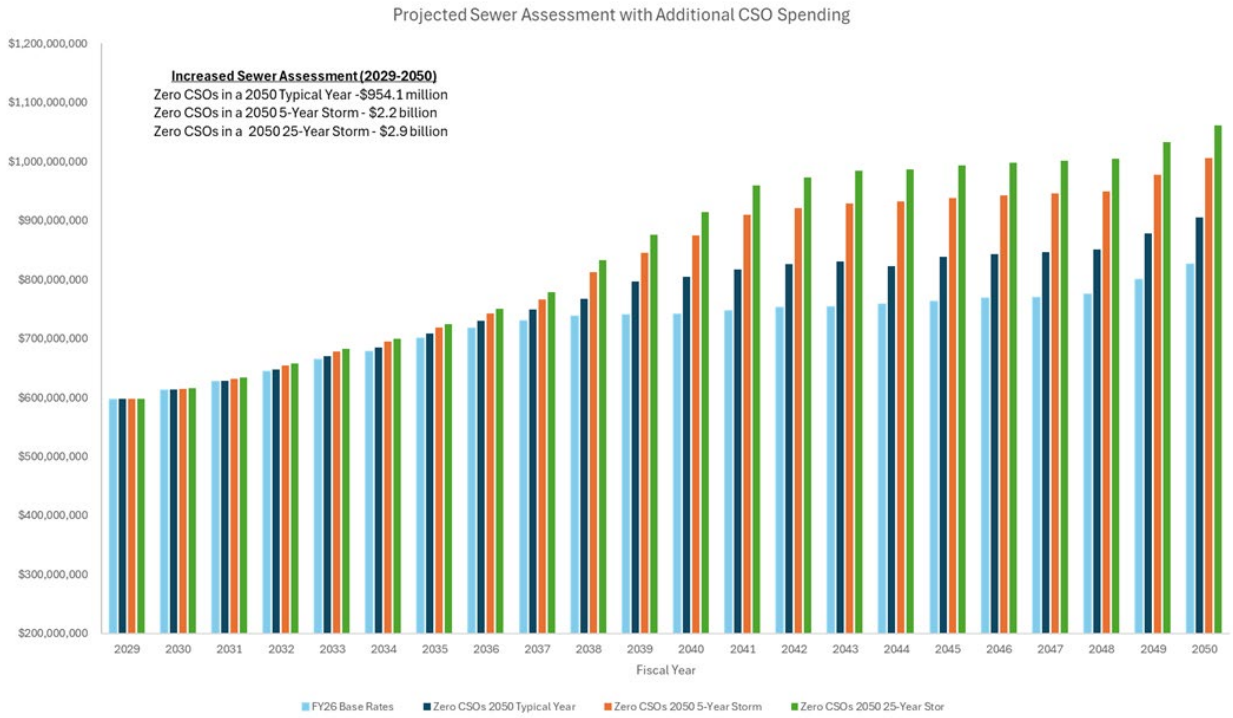



**Figure 11-2. Projected Sewer Assessment with Additional CSO Spending**

**Table 11-6** provides the total sewer assessment increase after the inclusion of the additional costs for CSO control projects between fiscal years 2029 and 2050.

**Table 11-6. Projected Sewer Assessment Increase After Inclusion of Additional Costs for CSO Control Projects**

| CSO Control Alternative | Fiscal Year 2029 Assessment | Time Horizon | Fiscal Year 2050 Assessment |
|---|---|---|---|
| **Baseline** | $ 597,055,642 | 2029 - 2050 → | $825,810,377 |
| **2050 TY** | **$ 597,444,765** | **2029 - 2050 →** | **$ 905,414,277** |
| **2050 5-YR** | $ 597,937,117 | 2029 - 2050 → | $ 1,005,400,851 |
| **2050 25-YR** | $ 598,212,260 | 2029 - 2050 → | $ 1,060,985,632 |

The proposed CSO spending increases sewer assessments between fiscal years 2029 and 2050 in total over the baseline projection by approximately $954.1 million, $2.2 billion, and $2.9 billion to fund projects to achieve 0 CSOs in the 2050 TY, 2050 5-year, and 2050 25-year storms, respectively.

The Assessment Projection Model also projects the future average annual household charges across the MWRA sewer system. **Figure 11-3** details the projected future sewer system household charges after the additional CSO spending.

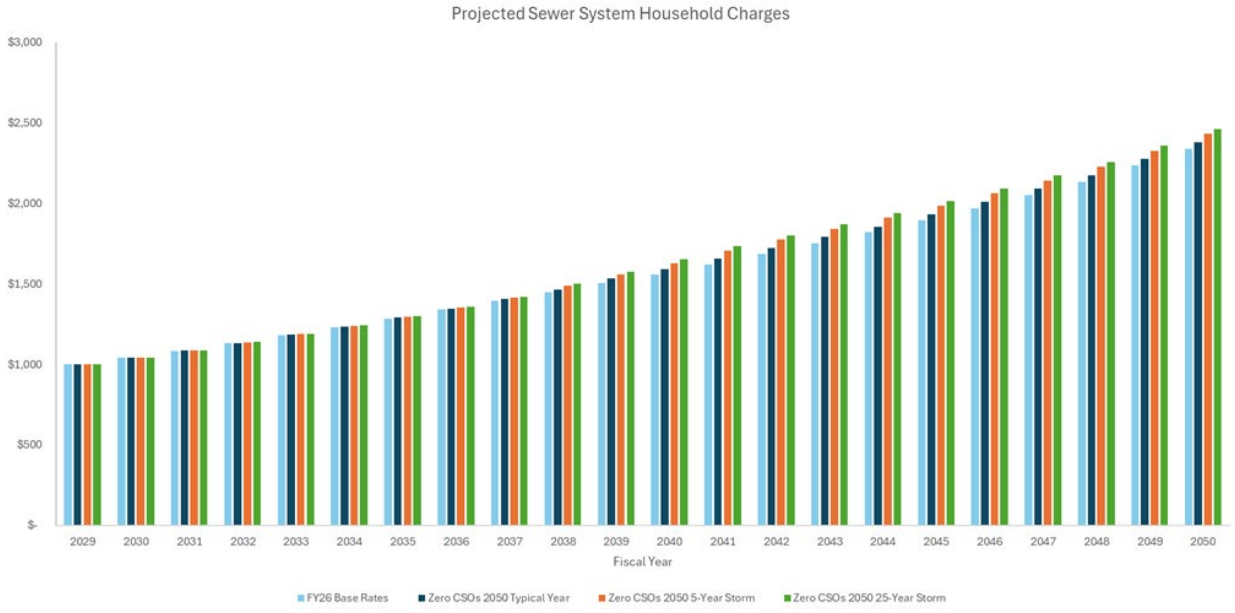



**Figure 11-3. Projected Sewer System Household Charges**

The sewer system annual household charges are currently anticipated to increase from $999 per year to $2,337 per year without the CSO spending between fiscal years 2029 and 2050. In 2050, based on the additional CSO spending, the household charges are projected to increase to $2,380, $2,433 and $2,462 per year for spending associated with level of control to achieve 0 CSOs in the 2050 TY, 2050 5-year, and 2050 25-year storms, respectively.

### 11.4.4 Additional Considerations

There are several important considerations to highlight when evaluating the affordability implications of the costs associated with anticipated CWA compliance on households within the MWRA service area. Even before additional CSO requirements, when utilizing the 2020-2024 American Community Survey (ACS) 5-year estimates data, the following five service area communities experience medium or high impacts under EPA's Expanded Financial Capability Assessment Matrix: Boston (Medium Impact), Chelsea (High Impact), Everett (Medium Impact), Quincy (Medium Impact), and Revere (Medium Impact). As shown in **Table 11-7**, these five communities represent approximately 41% of all households in the MWRA sewer service area—demonstrating that close to half of MWRA's service area population, including Environmental Justice communities like Chelsea, is already facing elevated financial pressures. This further increases to approximately 44% of all households when accounting for the more expensive CSO control alternatives, when a sixth community (Framingham) is designated as "Medium Impact."

**Table 11-7. Percentage of MWRA Sewer Service Area Households in Medium to High Impact Communities**

| Alternative | Residential Indicator Results for Service Area Communities | | | Expanded FCA Matrix Results for Service Area Communities | | | Percentage of Total Households |
|---|---|---|---|---|---|---|---|
| | Number of Communities with Low Impact | Number of Communities with Medium Impact | Number of Communities with High Impact | Number of Communities with Low Impact | Number of Communities with Medium Impact | Number of Communities with High Impact | Households in Medium to High Impact Communities |
| Baseline | 38 | 5 | 0 | 38 | 4 | 1 | 41.0% |
| Limited 2050 TY | 37 | 6 | 0 | 38 | 4 | 1 | 41.0% |
| 2050 TY | 35 | 8 | 0 | 38 | 4 | 1 | 41.0% |
| Full Sewer Separation | 30 | 13 | 0 | 37 | 5 | 1 | 43.8% |
| 2050 5-YR | 31 | 12 | 0 | 37 | 5 | 1 | 43.8% |
| 2050 25-YR | 28 | 15 | 0 | 37 | 5 | 1 | 43.8% |

**Note:**
Values presented in table reflect use of 2024 ACS 5-year data.

Note that the City of Boston's overall impact designation shifts from Medium Impact using the 2022 ACS 5-year data, to Low Impact using the 2023 ACS 5-year data (which was utilized for the overall FCA), and back to Medium Impact using the 2024 ACS 5-year data. These changes are driven in part by marginal year-to-year fluctuations in benchmarked indicators—most notably a 0.1 percent change in the City's unemployment rate relative to the national comparison threshold used under Alternative 1. Importantly, these threshold crossings do not represent a material change in the City's underlying economic conditions or financial capacity, but rather reflect the sensitivity of the FCA methodology to small statistical variations in census datasets.

This pattern illustrates an inherent limitation of EPA's FCA framework: its reliance on static, point-in-time data and discrete benchmark cutoffs. Because EPA's FCA framework evaluates current conditions without incorporating trend analysis, economic cycles, inflationary pressures, or anticipated demographic and labor-market changes, relatively minor data movements can yield different categorical outcomes in the Expanded FCA Matrix. EPA recognizes this limitation and emphasizes that FCA results should not be applied rigidly but instead interpreted holistically and supplemented with additional contextual information.

As noted earlier, research has shown that MHI does not represent income distribution and therefore significantly understates the hardship faced by low-income residents. Therefore, it is important to examine the lowest quintile income within the MWRA sewer service area, which constitutes the bottom 20% of households within each service area community. **Table 11-8** presents the same information as **Table**

**11-7**, but for the lowest quintile versus the community level. As **Table 11-8** shows, almost 52% of the lowest quintile households experience a Medium to High Impact under the Baseline, and the percentage increases to almost 56% for the Draft Recommended Plan (0 CSOs in the 2050 TY).

**Table 11-8. Percentage of MWRA Sewer Service Area Lowest Quintile Households with Medium to High Impact**

| Alternative | Residential Indicator Results for Service Area Communities | | | Expanded FCA Matrix Results for Service Area Communities | | | Percentage of Total Households |
|---|---|---|---|---|---|---|---|
| | Number of Communities with Low Impact | Number of Communities with Medium Impact | Number of Communities with High Impact | Number of Communities with Low Impact | Number of Communities with Medium Impact | Number of Communities with High Impact | Households in Medium to High Impact Communities |
| Baseline | 0 | 20 | 23 | 31 | 6 | 6 | 52% |
| Limited 2050 TY | 0 | 19 | 24 | 30 | 7 | 6 | 56% |
| 2050 TY | 0 | 19 | 24 | 30 | 7 | 6 | 56% |
| Full Sewer Separation | 0 | 17 | 26 | 29 | 8 | 6 | 57% |
| 2050 5-YR | 0 | 17 | 26 | 29 | 8 | 6 | 57% |
| 2050 25-YR | 0 | 16 | 27 | 29 | 8 | 6 | 57% |

**Note:**
Values presented in table reflect use of 2024 ACS 5-year data.

When looking only at the RI metric, even before additional CSO requirements (i.e., Baseline), about 72% of lowest quintile households in the MWRA service area experience a High Impact. This increases to about 76% for the Draft Recommended Plan (0 CSOs in the 2050 TY) and over 80% for the more expensive levels of control.

Also, the MWRA serves a region with exceptionally high costs of living, driven primarily by housing costs across Greater Boston and eastern Massachusetts. While many service area communities have median household incomes that compare favorably to state and national benchmarks, elevated housing and other fixed household expenses constrain the capacity of many customers (particularly renters and lower income households) to absorb increases in wastewater charges. These regional conditions are important context for interpreting standard affordability and financial capability indicators. Consistent with EPA's guidance encouraging consideration of community specific conditions and alternative financial metrics, Appendix E includes a section that examines regional cost-of-living pressures, providing important context for evaluating financial impacts and compliance schedule considerations across the MWRA service area.

In summary, the FCA results demonstrate that a substantial share of the MWRA service area—particularly low-income households and Environmental Justice communities—is already subject to medium-to-high financial stress, even before consideration of additional CSO obligations. The disproportionate impacts observed for lowest quintile households, combined with regional cost of living pressures and the documented sensitivity of FCA outcomes to minor data fluctuations, indicate that aggregate community indicators materially overstate the financial capacity of large portions of the service area. Consistent with EPA guidance, these conditions warrant a holistic interpretation of FCA results and support flexibility in implementation sequencing and schedule development.

## 11.5 Summary of Cambridge Financial Capability Assessment

### 11.5.1 Approach

The City of Cambridge's baseline financial condition is based on its current 10-year (2024 through 2033) wastewater capital improvement programs (CIPs), estimated long-term capital needs beyond 2036 as well as ongoing wastewater operations and maintenance (O&M) costs. This scenario is referred to as the Baseline. The Updated CSO Control Plan scenarios evaluated in this analysis include additional capital costs associated with the different levels of CSO control for the City of Cambridge based on the provisional cost share structure described in **Section 11.3**, as well as MWRA costs to be paid by the City of Cambridge (as shown in **Table 11-9**).

**Table 11-9. City of Cambridge Updated CSO Control Plan – FCA Scenarios**

| Scenario | Cambridge Costs (FY2025 Dollars)(1) |
|---|---|
| Baseline | $815,970,467 |
| Limited 2050 TY | + $266,600,000 |
| **2050 TY(2)** | **+ $257,000,000** |
| 2050 5-YR | + $1,071,100,000 |
| 2050 25-YR | + $1,829,500,000 |
| Full Sewer Separation | + $2,409,500,000 |

**Notes:**
(1) Costs for each scenario are evaluated as additions to the baseline.
(2) Represents the draft recommended alternatives.

The purpose of this section is to provide a summary FCA for the City of Cambridge's residential customers as evaluated under the EPA Guidance. The full FCA is included in Appendix G.

### 11.5.2 Findings

The Alternative 1 approach uses residential metrics like the RI and cost per household (CPH) and permittee financial capability indicators. This approach has limitations as it does not accurately reflect the burden on the ratepayers that are most economically vulnerable in a particular community due to its reliance on national averages. It also provides a snapshot in time without consideration of how financial health can vary over time for both ratepayers and the permittee.

Combining Phase 1 and 2 results for the City of Cambridge's CIP scenarios indicates the financial burden of the City of Cambridge's plans overall. **Table 11-10** and **Table 11-11** provide the Financial Capability Matrix and results pursuant to the EPA Guidance. The Phase 1 RI is determined to be in the "Mid-Range" category for the Baseline capital plan since the score is between 1 percent and 2 percent. Similarly, the Phase 1 RI is determined to be "Mid-Range" category for the Limited 2050 TY and 2050 TY capital plans and "High" for the Full Sewer Separation, 2050 5-YR and the 2050 25-YR. The average score of the Phase 2 Permittee Financial Capability Indicators (3.00) is above 2.50 for both scenarios. The Phase 2 Permittee Financial Capability Indicators results indicate the "Strong" category. The intersection of the Phase 1 and Phase 2 determinations shows that the overall assessment results place all Baseline, Limited 2050 TY, and 2050 TY capital plans in the "Low Impact" category and the Full Sewer Separation, 2050 5-YR and the 2050 25-YR in the "Medium Impact" category.

**Table 11-10. City of Cambridge Financial Capability Assessment Results – Baseline, Limited 2050 TY, and 2050 TY Capital Plans**

| Permittee Financial Capability Indicators Score (Socioeconomic, Debt, & Financial Indicators) | Residential Indicator (Cost per Household as % of MHI) | | |
|---|---|---|---|
| | Low (Below 1.0%) | Mid-Range (Between 1.0 and 2.0%) | High (Greater than 2.0%) |
| **Weak (Below 1.5)** | Medium Impact | High Impact | High Impact |
| **Mid-Range (Between 1.5 and 2.5)** | Low Impact | Medium Impact | High Impact |
| **Strong (Above 2.5)** | Low Impact | **Low Impact** | Medium Impact |
| | | = Results | |

**Table 11-11. City of Cambridge Financial Capability Assessment Results – Full Sewer Separation, 2050 5-YR, and 2050 25-YR Capital Plans**

| Permittee Financial Capability Indicators Score (Socioeconomic, Debt, & Financial Indicators) | Residential Indicator (Cost per Household as % of MHI) | | |
|---|---|---|---|
| | Low (Below 1.0%) | Mid-Range (Between 1.0 and 2.0%) | High (Greater than 2.0%) |
| **Weak (Below 1.5)** | Medium Impact | High Impact | High Impact |
| **Mid-Range (Between 1.5 and 2.5)** | Low Impact | Medium Impact | High Impact |
| **Strong (Above 2.5)** | Low Impact | Low Impact | **Medium Impact** |
| | | = Results | |

The LQPI combines the lowest quintile income element with five additional poverty indicators (PIs) to establish a numeric score for poverty prevalence within the community's service area, as compared to a national average. Equal weight is provided to the income element and the sum of the five PIs. Each of the factors in this analysis is evaluated based on the values of the community served relative to national statistics. Each of the LQPI criteria, with the exception of trends in household growth, are evaluated using a plus or minus 25% benchmark to national values, similar to the methodology used to calculate the FCI. Indicator values within 25% of national average are characterized as mid-range and scored two, while indicators outside of 25% of the national average are characterized as weak or strong and scored one or three respectively. The LQPI is then calculated as the weighted average score of the six indicators. LQPI above 2.5 is characterized as low impact, LQPI between 2.5 and 1.5 is a mid-range impact, and a LQPI below 1.5 is high impact. The City of Cambridge LQPI score is 2.90, resulting in a low impact.

Upon completion of the Initial LQPI analysis, the LQPI score and the FCA score were combined in the Expanded FCA Matrix to provide the final FCA result. The expanded FCA scores are shown in **Table 11-12** and **Table 11-13** and demonstrate an overall Low Impact for all capital plan scenarios.

**Table 11-12. City of Cambridge Expanded Financial Capability Assessment Matrix for the Baseline, Limited 2050 TY, and 2050 TY Capital Plans**

| Financial Capability Assessment Score | Lowest Quintile Poverty Indicator Score | | |
|---|---|---|---|
| | Low Impact (Above 2.5) | Mid-Range (Between 1.5 and 2.5) | High Impact ( Below 1.5) |
| **Low Impact** | **Low Impact** | Low Impact | Medium Impact |
| **Mid-Range** | Low Impact | Medium Impact | High Impact |
| **High Impact** | Medium Impact | High Impact | High Impact |
| | | = Results | |

**Table 11-13. City of Cambridge Expanded Financial Capability Assessment Matrix for Full Sewer Separation, 2050 5-Yr, and 2050 25-YR Capital Plans**

| Financial Capability Assessment Score | Lowest Quintile Poverty Indicator Score | | |
|---|---|---|---|
| | Low Impact (Above 2.5) | Mid-Range (Between 1.5 and 2.5) | High Impact (Below 1.5) |
| **Low Impact** | Low Impact | Low Impact | Medium Impact |
| **Mid-Range** | **Low Impact** | Medium Impact | High Impact |
| **High Impact** | Medium Impact | High Impact | High Impact |
| | | = Results | |

### 11.5.3 Additional Considerations

The Alternative 2 approach offers a more comprehensive analysis than the Alternative 1 approach. Under the Alternative 2 approach, permittees can incorporate financial and rate models and approaches to evaluate affordability burdens on different income levels.

Forecasts of affordability over time can be made through long-term financial planning. Rate increases used to analyze affordability over time were projected in a long-term financial plan developed for the City of Cambridge. While the wastewater system is not managed as a separate enterprise fund of the City of Cambridge, the financial plan was prepared as if the system was self-sustaining.

**Table 11-14** presents the average annual single family wastewater bill for each capital plan scenario. At the start of the forecast, the average annual single family wastewater bill is $1,233 (assumed usage of 6 CCF per month). By 2056, the annual bill is projected to be approximately $3,173 for the Baseline and up to $7,686 for the 2050 25-YR capital plan. This is almost a 157 percent increase in single family residential sewer bills for the Baseline plan and over a 523 percent increase for the 2050 25-YR plan.

**Table 11-14. Projection of Single Family Residential Annual Sewer Bills in the City of Cambridge**

| Alternatives | Current FY 2026 Annual Bill | Projected FY 2056 Annual Bill | Percent Change |
|---|---|---|---|
| **Baseline** | $1,233 | $3,173 | +157% |
| **Limited 2050 TY** | $1,233 | $3,308 | +168% |
| **2050 TY** | $1,233 | $3,341 | +171% |
| **2050 5-YR** | $1,233 | $5,308 | +330% |
| **2050 25-YR** | $1,233 | $7,686 | +523% |
| **Full Sewer Separation** | $1,233 | $5,831 | +372% |

The 2024 MHI is $131,963. The RI using the 2024 average wastewater bill is calculated to be 0.8%[4]. The table below (**Table 11-15**) depicts a 30-Year forecast of the RI for the Baseline and all the Updated CSO Control Plan scenarios. For the projection of MHI, an annual increase of the 30-year average change in CPI (2.5%) is assumed[5].

[4] The Residential Indicator (RI) in Alternative 1 Approach Phase 1 uses the Cost Per Household (CPH); whereas, the RI in Alternative 2 Approach uses average total residential bills
[5] Source: US Bureau of Labor Statistics: Consumer Price Index, All Urban Consumers - (CPI-U), U.S. city average, All items - CUUR0000SA0

**Table 11-15. City of Cambridge Projected Residential Indicator**

| | Baseline | Limited 2050 TY | 2050 TY | 2050 5-YR | 2050 25-YR | Full Sewer Separation |
|---|---|---|---|---|---|---|
| FY 2024 | 0.84% | 0.84% | 0.84% | 0.84% | 0.84% | 0.84% |
| FY 2025 | 0.86% | 0.86% | 0.86% | 0.86% | 0.86% | 0.86% |
| FY 2026 | 0.89% | 0.89% | 0.89% | 0.89% | 0.89% | 0.89% |
| FY 2027 | 0.93% | 0.95% | 0.95% | 1.00% | 1.04% | 1.01% |
| FY 2028 | 0.98% | 1.01% | 1.01% | 1.12% | 1.22% | 1.14% |
| FY 2029 | 1.03% | 1.07% | 1.07% | 1.26% | 1.43% | 1.29% |
| FY 2030 | 1.03% | 1.08% | 1.08% | 1.41% | 1.67% | 1.45% |
| FY 2031 | 1.04% | 1.10% | 1.10% | 1.58% | 1.87% | 1.55% |
| FY 2032 | 1.04% | 1.12% | 1.12% | 1.66% | 2.10% | 1.66% |
| FY 2033 | 1.04% | 1.13% | 1.12% | 1.75% | 2.26% | 1.79% |
| FY 2034 | 1.05% | 1.15% | 1.14% | 1.85% | 2.53% | 1.92% |
| FY 2035 | 1.05% | 1.17% | 1.14% | 1.95% | 2.72% | 2.06% |
| FY 2036 | 1.06% | 1.17% | 1.15% | 2.01% | 2.91% | 2.11% |
| FY 2037 | 1.07% | 1.18% | 1.15% | 2.00% | 2.90% | 2.16% |
| FY 2038 | 1.07% | 1.18% | 1.16% | 1.99% | 2.89% | 2.17% |
| FY 2039 | 1.08% | 1.19% | 1.17% | 1.98% | 2.87% | 2.18% |
| FY 2040 | 1.08% | 1.19% | 1.17% | 1.97% | 2.86% | 2.17% |
| FY 2041 | 1.09% | 1.20% | 1.18% | 1.96% | 2.84% | 2.16% |
| FY 2042 | 1.09% | 1.21% | 1.18% | 1.95% | 2.83% | 2.15% |
| FY 2043 | 1.10% | 1.21% | 1.19% | 1.95% | 2.82% | 2.14% |
| FY 2044 | 1.10% | 1.21% | 1.19% | 1.94% | 2.80% | 2.13% |
| FY 2045 | 1.11% | 1.20% | 1.20% | 1.93% | 2.79% | 2.12% |
| FY 2046 | 1.11% | 1.19% | 1.21% | 1.92% | 2.78% | 2.11% |
| FY 2047 | 1.12% | 1.19% | 1.20% | 1.91% | 2.76% | 2.10% |
| FY 2048 | 1.12% | 1.18% | 1.19% | 1.90% | 2.75% | 2.09% |
| FY 2049 | 1.13% | 1.18% | 1.19% | 1.89% | 2.74% | 2.08% |
| FY 2050 | 1.12% | 1.17% | 1.18% | 1.88% | 2.72% | 2.06% |
| FY 2051 | 1.12% | 1.17% | 1.18% | 1.87% | 2.71% | 2.05% |
| FY 2052 | 1.11% | 1.16% | 1.17% | 1.86% | 2.70% | 2.04% |
| FY 2053 | 1.11% | 1.15% | 1.17% | 1.85% | 2.68% | 2.03% |
| FY 2054 | 1.10% | 1.15% | 1.16% | 1.84% | 2.67% | 2.02% |
| FY 2055 | 1.10% | 1.14% | 1.15% | 1.83% | 2.66% | 2.02% |
| FY 2056 | 1.09% | 1.14% | 1.15% | 1.83% | 2.64% | 2.01% |

Over the course of the projection, the Baseline RI is low impact and increases until it reaches the medium threshold in FY 2029 where it remains around the medium impact threshold for the remainder of the forecast period. The Baseline RI peaks in FY 2049 at 1.13% and decreases for the remainder of the forecast. This gradual decrease in RI is due to the MHI increasing at a faster rate than the projected Baseline sewer bills. Debt service payments are expected to retire in the outer years and the rate increase required to maintain the revenue requirements of the wastewater system does not need to be as aggressive as the early in the projection for the Baseline.

The Limited 2050 TY is low impact in the beginning of the forecast and reaches medium impact in FY 2028 where it remains a medium impact for the duration of the forecast. It peaks in FY 2044 at 1.21% and gradually declines for the remainder of the forecast.

The 2050 TY follows a similar projection to the Limited 2050 TY and also reaches medium impact in FY 2028, but it reaches the peak later in the forecast in FY 2046 at 1.21%.

The 2050 5-YR reaches high impact in FY 2036 and then drops back down to medium impact starting in FY 2038.

The 2050 25-YR capital plan has the highest RI out of all of the scenarios. It reaches high impact in FY 2032 and remains high impact for the duration of the forecast. The 2050 25-YR has the most aggressive timeline of 15 years, so larger rate increases are required earlier in the forecast in order to remain in compliance with the minimum debt service coverage.

While the Full Sewer Separation capital plan has the largest capital needs, the duration is spread out over a longer period of time (30 years), so rate increases need not be as aggressive as the 2050 25-YR capital plan. As a result, the RI for the Full Sewer Separation is less than the 2050 25-YR and reaches a high impact later in the forecast in FY 2035.

EPA Guidance allows the City of Cambridge to present additional metrics that demonstrate the community's financial and demographic information. A detailed approach to evaluating affordability was previously developed by Stantec to properly account for income distribution, unique neighborhoods, and actual monthly wastewater bills for households in each census tract of the City of Cambridge's service area. This approach, called the weighted average residential index or WARi®, was applied to the City of Cambridge's customer base to evaluate affordability at a localized level. This census tract approach uses actual numbers of households and MHI for each census tract and scales the financial impact to the EPA Guidance CPH for a community's wastewater service for each census tract. This yields a more location-specific depiction of the financial impacts on individual communities.

The census tract WARi® results are shown in **Figure 11-4** for the following scenarios:

A. Baseline

B. Limited 2050 TY

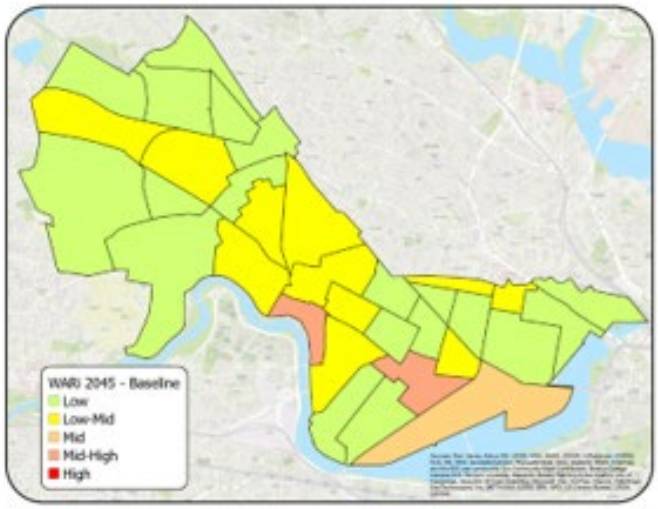
C. 2050 TY

D. 2050 5-YR

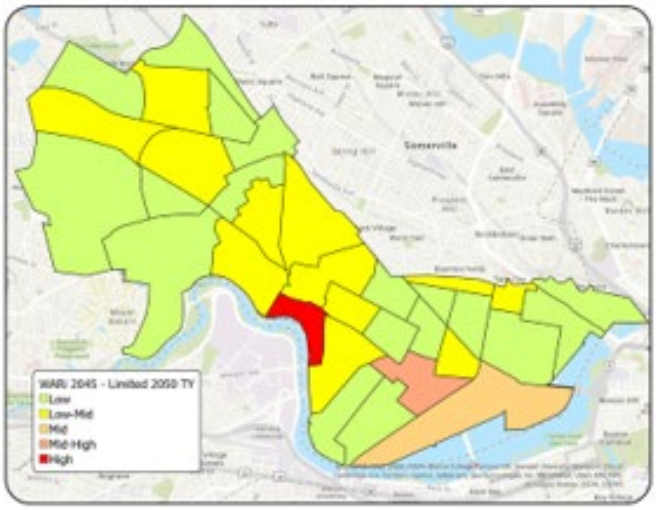
E. 2050 25-YR

F. Full Sewer Separation

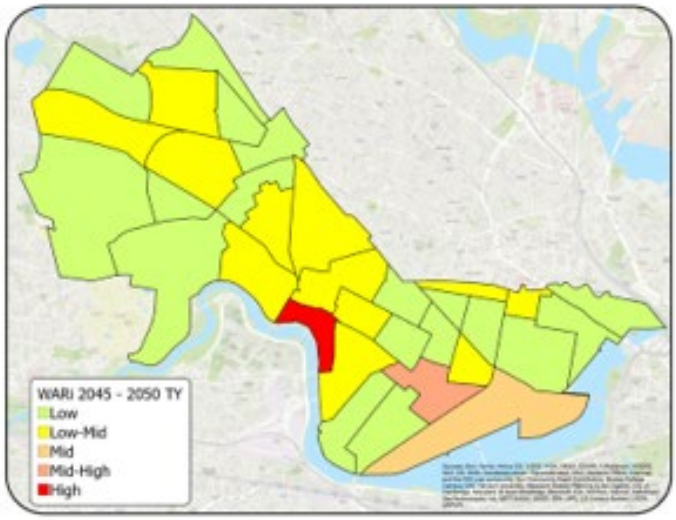
A


WARI 2045 - Baseline
Low
Low-Mid
Mid
Mid-High
High

B


WARI 2045 - Limited 2050 TY
Low
Low-Mid
Mid
Mid-High
High

C


WARI 2045 - 2050 TY
Low
Low-Mid
Mid
Mid-High
High

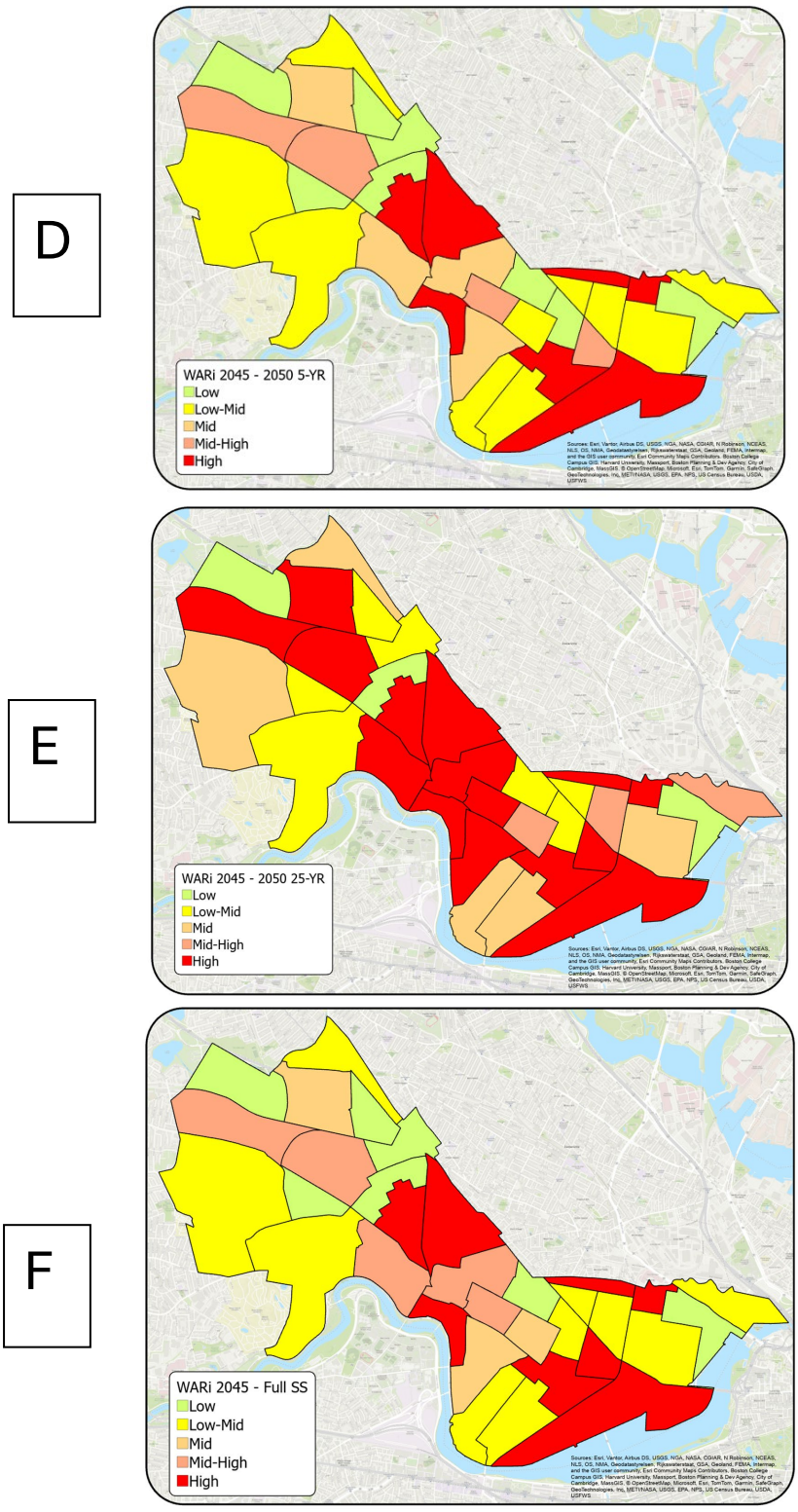



**Figure 11-4. City of Cambridge FY 2045 Wastewater & Census Tract WARi® Results for the FCA Scenarios**

As depicted in **Figure 11-4**, the impact on specific census tracts for the Baseline demonstrates an increased financial burden on actual bills throughout the extent of the CIP forecast. For the 2050 5-YR, 2050 25-YR, and the Full Sewer Separation, affordability concerns across census tracts become more widespread and unsustainable.

**Figure 11-5** shows the proportion of households with unaffordable bills (bills greater than 2% of the City MHI) for the Baseline capital plan and Updated CSO Control Plan scenarios. Based on the analysis, in 2025, less than one-fifth of the city households are expected to have unaffordable bills. By 2045, over one-fifth of the city households are forecasted to have high-burden bills for the Baseline. The 2050 TY scenario pushes the percentage of high-burden bills to one-fourth of the rate payers.




**Figure 11-5. Percent of City of Cambridge Households with Annual Wastewater Bills > 2% of MHI**

## 11.6 Summary of Somerville Financial Capability Assessment

### 11.6.1 Approach

The City of Somerville's baseline financial condition is based on its current 11-year (2025 through 2036) wastewater and stormwater system CIPs, estimated long-term capital needs beyond 2036 as well as ongoing wastewater and stormwater O&M costs. This scenario is referred to as the Baseline. The Updated CSO Control Plan scenarios evaluated in this analysis include additional capital costs associated with the different levels of CSO control for the City of Somerville based on the provisional cost share structure described in **Section 11.3**, as well as MWRA costs to be paid by the City of Somerville (as shown in **Table 11-16**).

**Table 11-16. City of Somerville Updated CSO Control Plan – FCA Scenarios**

| Scenario | Somerville Costs (FY2025 Dollars)(1) |
|---|---|
| Baseline | $628,371,504 |
| Limited 2050 TY | + $171,200,000 |
| **2050 TY(2)** | **+ $257,300,000** |
| 2050 5-YR | + $380,000,000 |
| 2050 25-YR | + $530,000,000 |
| Full Sewer Separation | + $2,640,000,000 |

**Note:**

(1) Costs for each scenario are evaluated as additions to the baseline.

(2) Represents the draft recommended alternatives.

The purpose of this section is to provide a summary FCA for the City of Somerville's residential customers as evaluated under the EPA Guidance. The full FCA is included in Appendix H.

### 11.6.2 Findings

The Alternative 1 approach uses residential metrics like the RI and CPH and permittee financial capability indicators. This approach has limitations as it does not accurately reflect the burden on the ratepayers that are most economically vulnerable in a particular community due to its reliance on national averages. It also provides a snapshot in time without consideration of how financial health can vary over time for both ratepayers and the permittee.

Combining the Phase I RI and the Phase 2 FCI for the City of Somerville's CIP scenarios indicates the financial burden of the City of Somerville's plans overall. **Table 11-17** and **Table 11-18** provide the Financial Capability Matrix and results pursuant to the EPA Guidance. The Phase 1 RI is determined to be in the "Mid-Range" category for the Baseline, Limited 2050 TY, 2050 TY, 2050 5-YR, and 2050 25-YR capital plans since the scores are between 1% and 2%. The Phase 1 RI is determined to be "High" category for the Full Sewer Separation capital plan. The average score of the Phase 2 Permittee Financial Capability Indicators (2.67) is above 2.5 for all scenarios. The Phase 2 Permittee Financial Capability Indicators results indicate the "Strong" category. The intersection of the Phase 1 and Phase 2 determinations shows that the overall assessment results place the Baseline, Limited 2050 TY, 2050 TY, 2050 5-YR, and 2050 25-YR capital plans in the "Low Impact" category and the Full Sewer Separation capital plan in the "Medium Impact" category, shown in **Table 11-18**.

**Table 11-17. City of Somerville Financial Capability Assessment Results – Baseline, Limited 2050 TY, 2050 TY, 2050 5-YR, and 2050 25-YR Capital Plans**

| Permittee Financial Capability Indicators Score (Socioeconomic, Debt, & Financial Indicators) | Residential Indicator (Cost per Household as % of MHI) | | |
|---|---|---|---|
| | Low (Below 1.0%) | Mid-Range (Between 1.0 and 2.0%) | High (Greater than 2.0%) |
| **Weak (Below 1.5)** | Medium Impact | High Impact | High Impact |
| **Mid-Range (Between 1.5 and 2.5)** | Low Impact | Medium Impact | High Impact |
| **Strong (Above 2.5)** | Low Impact | **Low Impact** | Medium Impact |
| | | = Results | |

**Table 11-18. City of Somerville Financial Capability Assessment Results – Full Sewer Separation Capital Plan**

| Permittee Financial Capability Indicators Score (Socioeconomic, Debt, & Financial Indicators) | Residential Indicator (Cost per Household as % of MHI) | | |
|---|---|---|---|
| | Low (Below 1.0%) | Mid-Range (Between 1.0 and 2.0%) | High (Greater than 2.0%) |
| **Weak (Below 1.5)** | Medium Impact | High Impact | High Impact |
| **Mid-Range (Between 1.5 and 2.5)** | Low Impact | Medium Impact | High Impact |
| **Strong (Above 2.5)** | Low Impact | Low Impact | **Medium Impact** |
| | | = Results | |

The LQPI combines the lowest quintile income element with five additional PIs to establish a numeric score for poverty prevalence within the community's service area, as compared to a national average. Equal weight is provided to the income element and the sum of the five PIs. Each of the factors in this analysis is evaluated based on the values of the community served relative to national statistics. Each of the LQPI criteria, with the exception of trends in household growth, are evaluated using a plus or minus 25% benchmark to national values, similar to the methodology used to calculate the FCI. Indicator values within 25% of national average are characterized as mid-range and scored two, while indicators outside of 25% of the national average are characterized as weak or strong and scored one or three respectively. The LQPI is then calculated as the weighted average score of the six indicators. LQPI above 2.5 is characterized as low impact, LQPI between 2.5 and 1.5 is a mid-range impact, and a LQPI below 1.5 is high impact. The City of Somerville LQPI score is 3.0, resulting in a low impact.

Upon completion of the Initial LQPI analysis, the LQPI score and the FCA score were combined in the Expanded FCA Matrix to provide the final FCA result. The expanded FCA scores are shown **Table 11-19** and **Table 11-20** and demonstrate a Low Impact for the Baseline, Limited 2050 TY, 2050 TY, 2050 5-YR, and 2050 25-YR capital plans and a Low Impact for the Full Sewer Separation capital plan.

**Table 11-19. City of Somerville Expanded Financial Capability Assessment Matrix for the Baseline, Limited 2050 TY, 2050 TY, 2050 5-YR, and 2050 25-YR Capital Plans**

| Financial Capability Assessment Score | Lowest Quintile Poverty Indicator Score | | |
|---|---|---|---|
| | Low Impact (Above 2.5) | Mid-Range (Between 1.5 and 2.5) | High Impact (Below 1.5) |
| **Low Impact** | **Low Impact** | Low Impact | Medium Impact |
| **Mid-Range** | Low Impact | Medium Impact | High Impact |
| **High Impact** | Medium Impact | High Impact | High Impact |
| | | = Results | |

**Table 11-20. City of Somerville Expanded Financial Capability Assessment Matrix for the Full Sewer Separation Capital Plan**

| Financial Capability Assessment Score | Lowest Quintile Poverty Indicator Score | | |
|---|---|---|---|
| | Low Impact (Above 2.5) | Mid-Range (Between 1.5 and 2.5) | High Impact (Below 1.5) |
| **Low Impact** | Low Impact | Low Impact | Medium Impact |
| **Mid-Range** | **Low Impact** | Medium Impact | High Impact |
| **High Impact** | Medium Impact | High Impact | High Impact |
| | | = Results | |

### 11.6.3 Additional Considerations

The Alternative 2 approach offers a more comprehensive analysis than the Alternative 1 approach. Under the Alternative 2 approach, permittees can incorporate financial and rate models and approaches to evaluate affordability burdens on different income levels.

Forecasts of affordability over time can be made through long-term financial planning. Rate increases used to analyze affordability over time were projected in a long-term financial plan consistent with the City of Somerville's practice of evaluating the sewer system needs on an annual basis. The sources and uses of funds are evaluated and deficits in sources of funds relative to uses yield annual rate revenue increases necessary to manage the utility and complete implementation of the City of Somerville's CIPs.

The current and projected average annual single family residential bills over the 30-year period are summarized for each alternative in **Table 11-21.**

**Table 11-21. City of Somerville Sewer Fund 30-Year Forecast of Single-Family Residential Bills**

| Alternatives | Current FY 2026 Annual Bill | Projected FY 2055 Annual Bill | Percent Change |
|---|---|---|---|
| **Baseline** | $852 | $2,094 | +146% |
| **Limited 2050 TY** | $852 | $2,367 | +178% |
| **2050 TY** | $852 | $2,600 | +205% |
| **2050 5-YR** | $852 | $2,976 | +249% |
| **2050 25-YR** | $852 | $3,109 | +265% |
| **Full Sewer Separation** | $852 | $7,409 | +770% |
| The City of Somerville's 2025 MHI is $138,253. The RI using the 2025 average wastewater bill is calculated to be 0.6%(1) Table 5-3 presents a 30-Year forecast of the RI for both the Baseline and all the Updated CSO Control Plan scenarios. For the projection of MHI, an annual increase of the 30-year average change in CPI (2.5%) is assumed.(2) | | | |

**Notes:**

(1) The Residential Indicator (RI) in Alternative 1 Approach Phase 1 uses the Cost Per Household (CPH); whereas, the RI in Alternative 2 Approach uses average total residential bills.

(2) Source: US Bureau of Labor Statistics: Consumer Price Index, All Urban Consumers - (CPI-U), U.S. city average, All items - CUUR0000SA0

The table below (**Table 11-22**) depicts a 30-Year forecast of the RI for the Baseline and all the Updated CSO Control Plan scenarios.

**Table 11-22. City of Somerville Projected Residential Indicator**

| | Baseline | Limited 2050 TY | 2050 TY | 2050 5-YR | 2050 25-YR | Full Sewer Separation |
|---|---|---|---|---|---|---|
| FY 2026 | 0.60% | 0.60% | 0.60% | 0.60% | 0.60% | 0.60% |
| FY 2027 | 0.66% | 0.69% | 0.69% | 0.69% | 0.69% | 0.70% |
| FY 2028 | 0.73% | 0.76% | 0.77% | 0.76% | 0.79% | 0.81% |
| FY 2029 | 0.80% | 0.84% | 0.87% | 0.84% | 0.91% | 0.95% |
| FY 2030 | 0.87% | 0.93% | 0.98% | 0.93% | 1.05% | 1.11% |
| FY 2031 | 0.90% | 0.99% | 1.04% | 0.97% | 1.17% | 1.31% |
| FY 2032 | 0.91% | 1.01% | 1.10% | 1.00% | 1.22% | 1.54% |
| FY 2033 | 0.91% | 1.03% | 1.12% | 1.04% | 1.27% | 1.65% |
| FY 2034 | 0.91% | 1.03% | 1.13% | 1.07% | 1.32% | 1.76% |
| FY 2035 | 0.90% | 1.02% | 1.12% | 1.11% | 1.32% | 1.88% |
| FY 2036 | 0.90% | 1.01% | 1.11% | 1.14% | 1.33% | 2.01% |
| FY 2037 | 0.89% | 1.01% | 1.11% | 1.18% | 1.33% | 2.08% |
| FY 2038 | 0.89% | 1.00% | 1.10% | 1.21% | 1.34% | 2.15% |
| FY 2039 | 0.88% | 1.00% | 1.09% | 1.25% | 1.34% | 2.22% |
| FY 2040 | 0.88% | 0.99% | 1.09% | 1.29% | 1.35% | 2.29% |
| FY 2041 | 0.87% | 0.98% | 1.08% | 1.27% | 1.33% | 2.36% |
| FY 2042 | 0.87% | 0.98% | 1.07% | 1.25% | 1.31% | 2.42% |
| FY 2043 | 0.86% | 0.97% | 1.07% | 1.23% | 1.29% | 2.43% |
| FY 2044 | 0.85% | 0.97% | 1.06% | 1.21% | 1.27% | 2.44% |
| FY 2045 | 0.84% | 0.95% | 1.04% | 1.19% | 1.25% | 2.45% |
| FY 2046 | 0.83% | 0.94% | 1.03% | 1.18% | 1.23% | 2.46% |
| FY 2047 | 0.82% | 0.92% | 1.01% | 1.16% | 1.21% | 2.47% |
| FY 2048 | 0.80% | 0.91% | 1.00% | 1.14% | 1.19% | 2.48% |
| FY 2049 | 0.79% | 0.89% | 0.98% | 1.12% | 1.17% | 2.49% |
| FY 2050 | 0.78% | 0.88% | 0.97% | 1.11% | 1.16% | 2.50% |
| FY 2051 | 0.77% | 0.87% | 0.95% | 1.09% | 1.14% | 2.51% |
| FY 2052 | 0.76% | 0.85% | 0.94% | 1.07% | 1.12% | 2.52% |
| FY 2053 | 0.74% | 0.84% | 0.92% | 1.06% | 1.10% | 2.53% |
| FY 2054 | 0.73% | 0.83% | 0.91% | 1.04% | 1.09% | 2.54% |
| FY 2055 | 0.72% | 0.82% | 0.90% | 1.03% | 1.07% | 2.55% |

Over the course of the projection, the Baseline RI is low impact. It peaks in FY 2033 at 0.91% and then decreases for the remainder of the forecast. This gradual decrease in RI is due to the Median Household Income increasing at a faster rate than the projected Baseline sewer bills. Debt service payments are expected to retire in the outer years and the rate increase required to maintain the revenue requirements of the wastewater system does not need to be as aggressive as the early in the projection for the Baseline.

For the Limited 2050 TY alternative, in FY 2032, the RI reaches the medium impact, peaks in FY 2034 at 1.03%, and then remains a medium impact until FY 2038 where it drops back down to low impact for the rest of the forecast.

The 2050 TY alternative RI follows a similar projection as the Limited 2050 TY alternative, but the RI remains medium impact for a longer duration from FY 2031 to FY 2047 and it peaks in FY 2034 at 1.13%.

This is because the 2050 TY alternative has more aggressive rate increases earlier in the projection that allows for lower rate increases later in the projection.

The 2050 5-YR alternative RI remains medium impact for the duration of the forecast and it peaks in FY 2040 at 1.29%.

Similarly to the 2050 5-YR, the 2050 25-YR alternative also RI remains medium impact for the duration of the forecast. However, every year the RI is higher for the 2050 25-YR, and it peaks in FY 2040 at 1.35%.

The Full Sewer Separation alternative has the highest RI out of all the scenarios. It is medium impact for FY2030 – 2035 and then is high impact from FY 2036 through the rest of the projection. The RI is always increasing for the Full Sewer Separation alternative because the sewer bills are increasing at a faster rate than the MHI. The Full Sewer Separation alternative adds almost an additional $2.6 billion (in 2025 dollars) in capital projects over 28 years.

## 11.7 References

National Association of Clean Water Agencies (NACWA). 2023. New EPA Guidance Will Continue to Unfairly Burden Low Income Households When Paying Water and Sewer Bills. Available online: https://www.nacwa.org/news-publications/news-detail/2023/02/01/new-epa-guidance-will-continue-to-unfairly-burden-low-income-households-when-paying-water-and-sewer-bills. Accessed March 16, 2026.

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United States Environmental Protection Agency (USEPA). 1997. Combined Sewer Overflows Guidance for Financial Capability Assessment and Schedule Development.

USEPA. 2024. *Clean Water Act Financial Capability Assessment Guidance, March 2024 Revision*.* https://www.epa.gov/system/files/documents/2023-01/cwa-financial-capability-assessment-guidance.pdf

# 12. Draft Recommended Plan

This section presents descriptions of the alternatives selected for the Draft Recommended Plan for Alewife Brook, the Upper Mystic River and the Charles River. The alternatives for each waterbody were selected based on the evaluation process presented in Section 10 and are all configured to achieve 0 CSOs in the 2050 TY. This level of CSO control, developed for a future typical year, represents a first-of-its-kind CSO Control Plan in the nation. The descriptions of the alternatives below include project components, costs, water quality impacts, implementation considerations, and implementation timeframes. Project component dimensions, volumes, and locations are preliminary and subject to change based on geotechnical investigations and other design factors that will be developed during the planning and design phases; however, the Partners are committed to achieving 0 CSOs in the 2050 TY.

## 12.1 Draft Recommended Plan for Alewife Brook

The Draft Recommended Plan for Alewife Brook corresponds to Alternative 3.AB Hybrid 2, which includes the following individual projects:

1) Sewer separation of approximately 8 acres tributary to outfall CAM001;
2) A 2.3 MG microtunneled storage conduit to store the CSO from outfalls CAM401B and SOM001A;
3) A combination of a CSO storage tank (between 1.5 MG and 2.1 MG), potential additional conveyance to the MWRA interceptors, and raising the existing regulator weir for outfall CAM401A; and
4) A 1.5 MG storage tank at outfall MWR003.

In combination, these projects would eliminate CSO activations to Alewife Brook in the 2050 TY. Under this alternative, no action is recommended at CAM002, as the outfall does not activate in the 2050 TY. A schematic layout of the components of this alternative is presented in **Figure 12-1.**

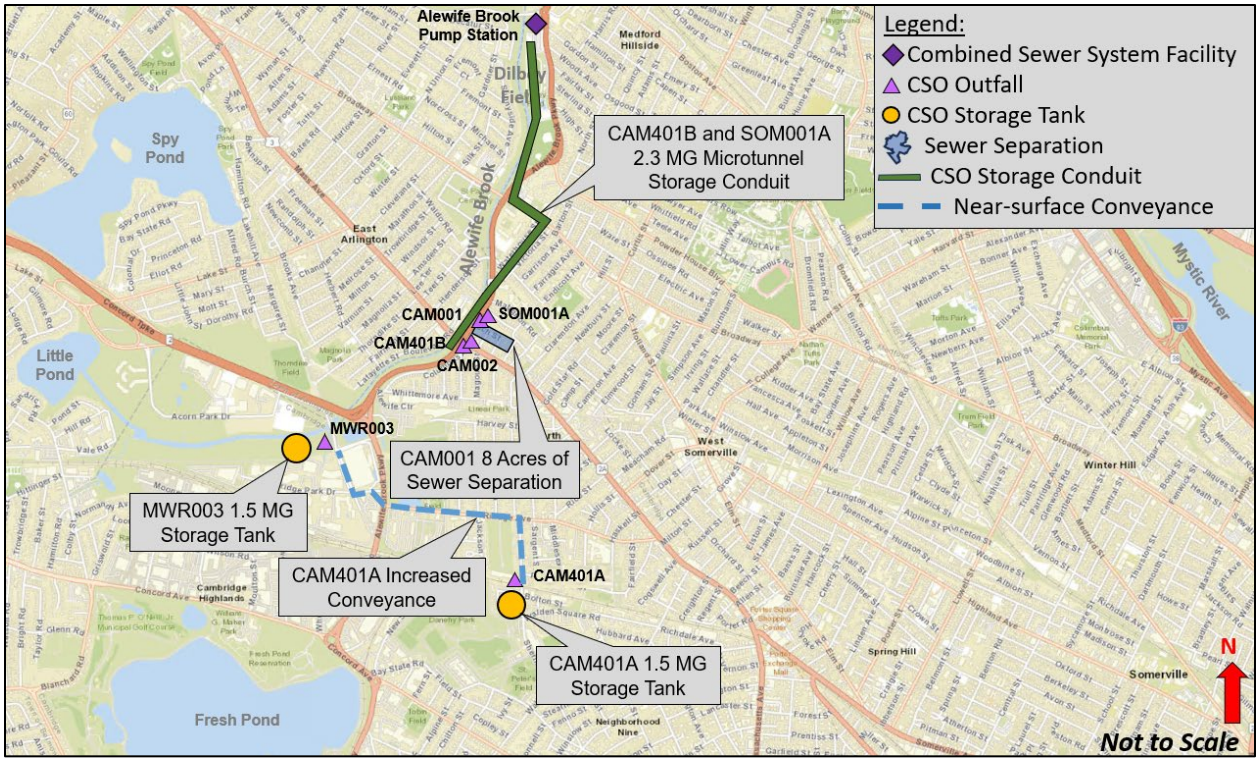



**Figure 12-1. Alternative 3.AB Hybrid 2 (0 CSOs in 2050 TY)**

### 12.1.1 Description

The individual components of Alternative 3.AB Hybrid 2 are described below.

#### CAM001 Sewer Separation

The project for outfall CAM001 consists of separating the combined sewer catchment tributary to this outfall, which is approximately 8 acres. Sanitary flow would be conveyed through the existing CAM001 underflow to the MWRA's ABBS. New stormwater pipes would be routed to the CAM001 outfall structure, which could be converted to a stormwater outfall. In order for the separation to work with the existing sanitary piping, the connection from the Tannery Brook Drain (SOM001A system) on Clarendon Avenue would be disconnected and flow would stay in the Tannery Brook Drain. The separation work would require flow attenuation and treatment for the additional stormwater flows. Sites for the stormwater attenuation and treatment have not been identified. The City of Cambridge is committed to incorporating local GSI wherever practical to complement infrastructure projects, including this one, to be evaluated during design; the City is also committed to pursuing a budget line item of $500,000/year for GSI implementation starting in FY27, which could fund such components that may be identified for this project. **Figure 12-2** presents a conceptual layout for the CAM001 Sewer Separation.

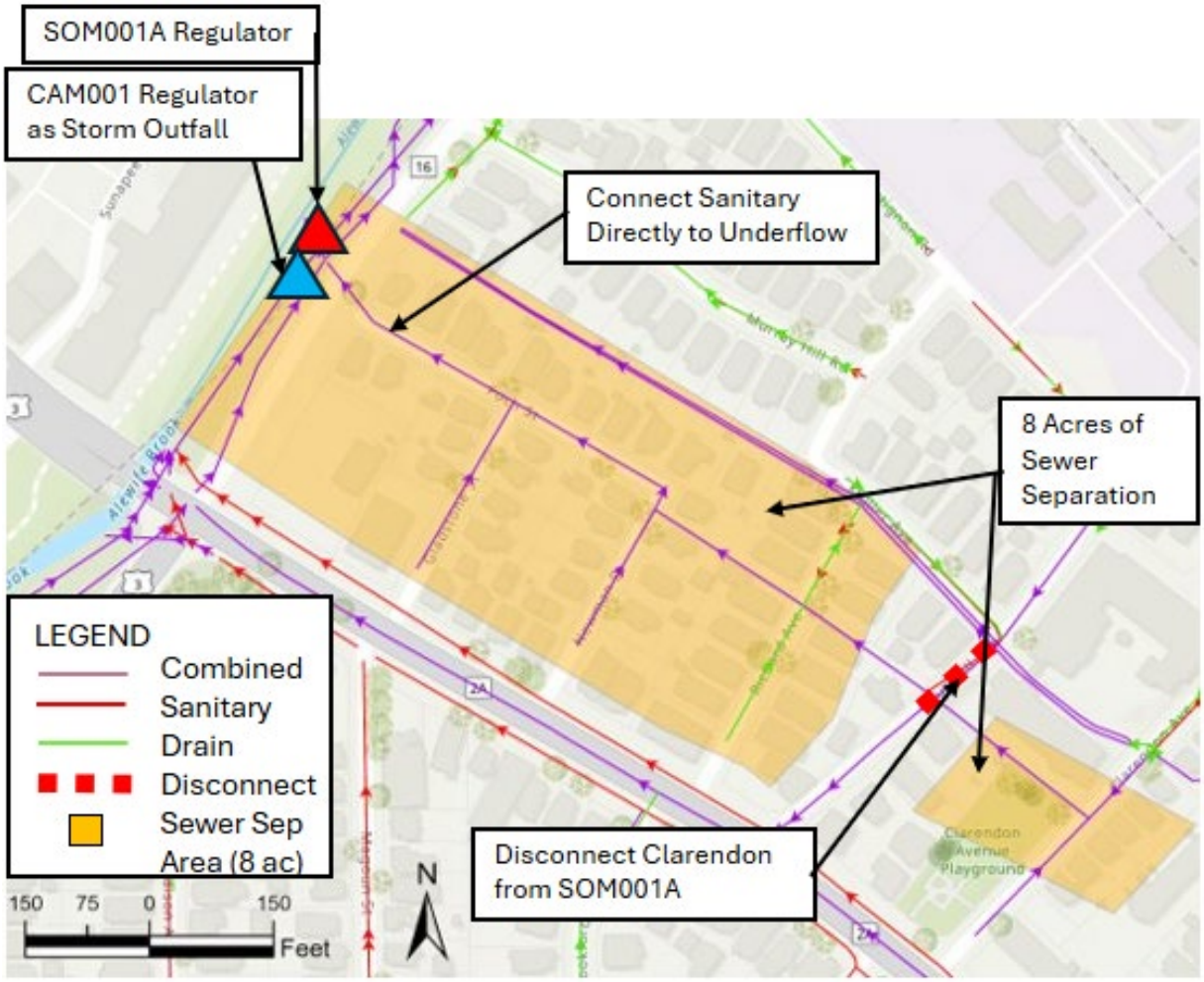



**Figure 12-2. Conceptual Layout for CAM001 Sewer Separation**

### CAM401A Storage Tank and Conveyance

The project components for this outfall include a combination of storage and increased conveyance capacity, shown conceptually in **Figure 12-3.** An underground combined sewer storage tank will be built in a City of Cambridge-owned parking lot on Sherman Street. The existing CAM401A regulator weir would be raised by approximately 1.5 feet, in turn raising the upstream water level and allowing flows to divert to a new tank on the Sherman Street property. The volume of the storage tank would depend on conveyance capacity between the CAM401A regulator and the MWRA interceptor – no additional conveyance would require a storage volume of 2.1 MG, but that volume could be reduced with additional conveyance capacity while still eliminating CSOs in the 2050 TY and supporting future plans for localized sewer separation. For example, the existing 48-inch conveyance along Sherman Street and Rindge Avenue (approximately 4,400 linear feet between the existing CAM401A regulator and the connection to the ABBS) could be augmented with a 30-inch auxiliary sewer or upsized to 60-inches, either of which would allow the storage volume at Sherman Street to be reduced to 1.5 MG while still meeting CSO control goals. Project design will be coordinated with MWRA if it impacts CSO activations and/or volumes at MWR003.

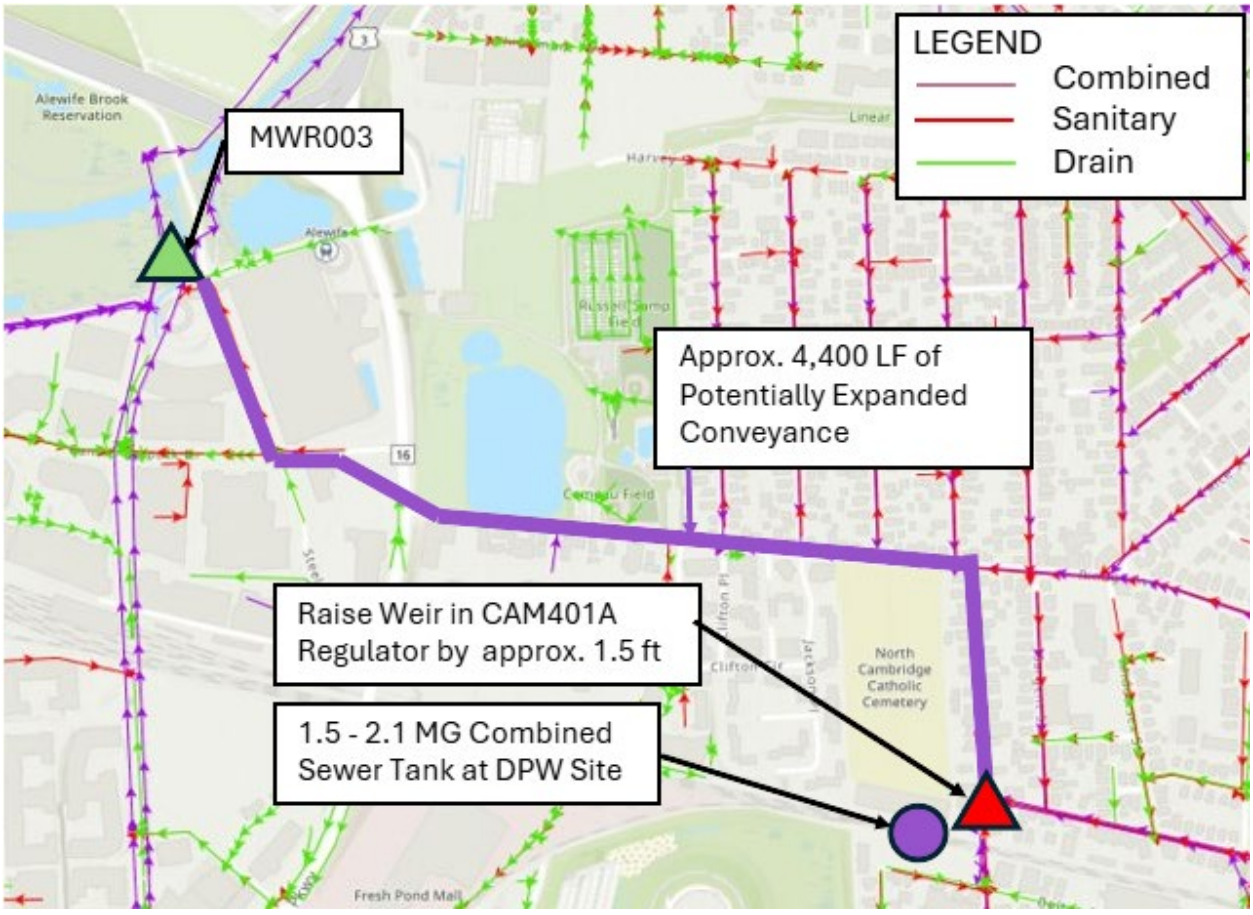



**Figure 12-3. CAM401A CSO Storage Tank and Potential Conveyance**

### CAM401B/SOM001A Storage Conduit

The project for CAM401B and SOM001A consists of a microtunneled storage conduit to capture overflow from these outfalls. The microtunnel would be designed to store approximately 2.3 MG of combined sewer with an expected 9-foot internal diameter and approximate length of 5,400 feet. Diversion structures on the CAM401B outfall and at the SOM001A regulator would be constructed to divert flow into the storage conduit via drop connections. **Figure 12-4** presents a conceptual layout of the microtunnel.

Based on the preliminary route, a total of four pipe jacking shafts and three retrieval shafts may be required. The final route and shaft locations could change and would be defined after further planning and design. A permanent aboveground structure at the downstream end of the storage conduit in the Dilboy Field parking lot would provide maintenance access and house a dewatering pump facility as well as electrical and odor control equipment.




**Figure 12-4. Conceptual Layout for CAM401B and SOM001A Microtunnel**

**Figure 12-5** presents a potential site plan which includes the approximate extent of temporary and permanent construction impacts as well as the approximate locations of a microtunnel jacking shaft at the Dilboy Field parking lot.

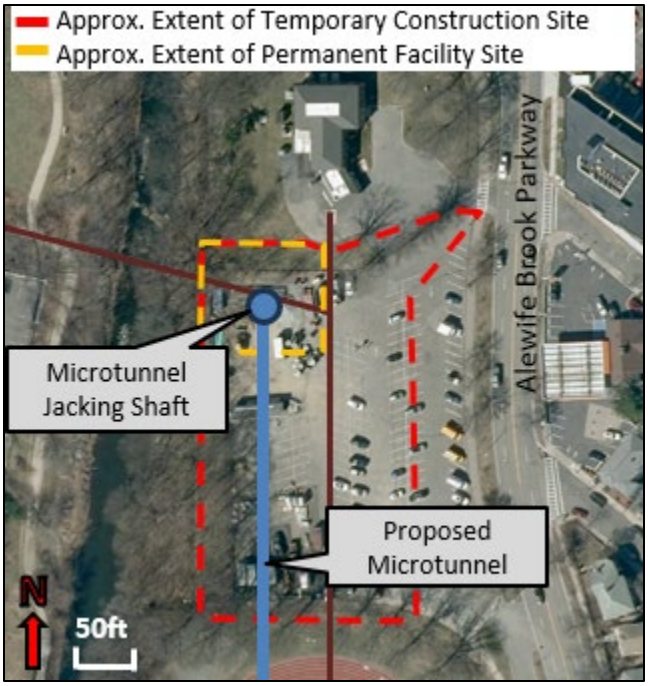



**Figure 12-5. CAM401B and SOM001A Microtunnel Potential Impacts to Dilboy Field Parking Lot**

### MWR003 Storage Tank

The project at outfall MWR003 would consist of a 1.5 MG below ground storage tank to capture overflows from this outfall. The storage volume was estimated based on a model run which includes the combination of the projects included in Alternative 3.AB Hybrid 2. The exterior dimensions of the 1.5 MG storage tank would be approximately 230 feet long by 90 feet wide with an approximate excavation depth of 32 feet. The approximate facility exterior dimensions include the tank and other facility components such as influent screening and flow distribution channels. The dimensions of the storage tank are preliminary and subject to change based on geotechnical investigations and other design factors.

**Figure 12-6** presents a conceptual layout for a 1.5 MG storage tank. The figure shows the approximate location of a diversion structure that would be constructed along the outfall pipe as well as the approximate size of the storage tank. The site shown in **Figure 12-6** is in DCR-owned property adjacent to the outfall. Alternative sites within the same general area, including sites on currently MBTA-owned property, could potentially be evaluated as part of subsequent facilities planning and design. A diversion structure would be constructed along the existing MWR003 outfall to divert wet weather flow to the storage facility. After storm flows subside, the stored flow could be pumped back to the ABC. If the capacity of the storage tank is exceeded in a larger storm, excess flow would be discharged to the existing MWR003 outfall via the new diversion structure weir. While the tank structure would be below ground, a permanent above-ground structure would provide maintenance access and house electrical and odor control equipment.

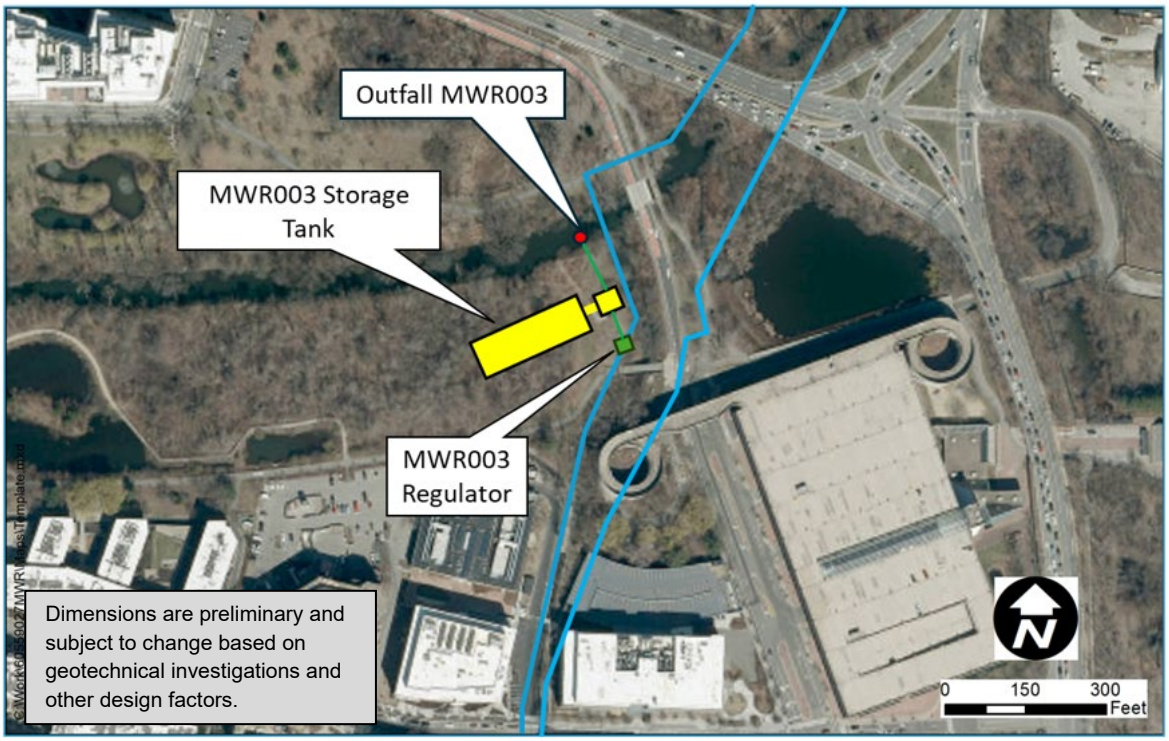



**Figure 12-6. Conceptual Layout for MWR003 Storage Tank**

### 12.1.2 Cost

**Table 12-1** presents the estimated capital cost for the Draft Recommended Plan for the Alewife Brook.

**Table 12-1. Estimated Capital Cost for Draft Recommended Plan for Alewife Brook**

| Alewife Brook Outfall | CSO Control Technology Description | Preliminary Capital Cost(1) ($million) |
|---|---|---|
| CAM001 | ~8 acres sewer separation | $15 M |
| CAM002 | No action(2) | N/A(3) |
| CAM401A | ~1.5 MG storage tank + conveyance | $98 M |
| MWR003 | 1.5 MG storage tank | $52 M |
| CAM401B SOM001A | ~2.3 MG microtunnel to store CAM401B and SOM001A | $170 M |
| **T**otal | - | **$340 M** |

**Notes:**

(1) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.

(2) CSO is not predicted to activate in the 2050 TY, therefore no project is required to achieve 0 CSOs in the 2050 TY.

(3) N/A: not applicable.

### 12.1.3 Performance

The Draft Recommended Plan for the Alewife Brook was developed to achieve 0 CSOs in the 2050 TY. The impacts of the Draft Recommended Plan on TMDLs and water quality are presented below.

#### Performance Relative to TMDLs

As described in Section 2.1.4, Alewife Brook is included in the M*ystic River Watershed Alternative TMDL Development for Phosphorus Management – Final Report* and the *Final Pathogen TMDL for the Boston Harbor, Weymouth-Weir, and Mystic Watersheds*. The Draft Recommended Plan for Alewife Brook would result in no net increase in phosphorus loading. Some project components, like sewer separation in CAM001, may result in an increase in phosphorus load due to increased stormwater flows; others, like the storage tanks and microtunnel, would reduce phosphorus loads. The Draft Recommended Plan would also provide a higher level of CSO control than was assumed as the basis for the bacterial waste load allocation from CSO. The Draft Recommended Plan therefore would not preclude attainment of either TMDL.

#### Water Quality Impacts of Draft Recommended Plan for Alewife Brook

The Alewife Brook/Upper Mystic River 1-dimensional water quality model described in Sections 6 and 7 was run for the 2050 TY to assess the predicted impact of the Draft Recommended Plan on bacteria concentrations in Alewife Brook. Because the model includes both Alewife Brook and the Upper Mystic River, the assessment was based on implementation of the Draft Recommended Plans for both Alewife Brook and the Upper Mystic River. Model output was generated in the form of *E. coli* and *Enterococcus* counts at 15-minute intervals at each defined segment along the linear 1-dimensional model. The model output was processed to assess the impacts of remaining bacteria loadings to the Alewife Brook/Upper Mystic River in terms of:

- Single sample maximum criteria;
- 30-day geometric mean criteria;
- 30-day STV criteria;

- Maximum bacteria concentrations; and
- Change in bacteria concentration over time.

The single sample maximum was assessed at MassDEP's recommendation, and the 30-day geometric mean and 30-day STV criteria are part of the SWQS in 314 CMR 4.05 (presented in Section 2.1.2). The figures presented below show the findings for *E. coli*. Similar figures for *Enterococcus* are included in Appendix J.

## Attainment of *E. coli* Single Sample Maximum Criterion

As noted in Section 7, the water quality criteria for Class B waters expressed in 314 CMR 4.05 do not include a single sample maximum, but based on guidance from MassDEP the Updated CSO Control Plan includes an assessment of attainment with a single sample maximum value based on the 90th percentile STV for *E. coli* and *Enterococcus*.

**Figure 12-7** presents longitudinal plots of the number of hours in the 2050 TY that the maximum *E. coli* concentration would be above the single sample maximum criterion (410#/100mL) for Baseline Conditions and for the Draft Recommended Plan. These plots include all modeled sources of bacteria, and the Draft Recommended Plan plot reflects no CSO bacteria loads consistent with the Plan performance of zero CSO discharges in the 2050 TY. The Y-axis also shows the values as a percentage of the total hours in the 2050 TY (366 days x 24 hours/day = 8,784 total hours; the 2050 TY is a leap year).

As indicated in **Figure 12-7**, the Draft Recommended Plan is predicted to result in a slight decrease in the hours of exceedance of the single sample maximum criterion for *E. coli* in the portions of Alewife Brook along and downstream of the CSO locations in the 2050 TY. The remaining hours of exceedance under the Draft Recommended Plan would be driven by non-CSO sources.

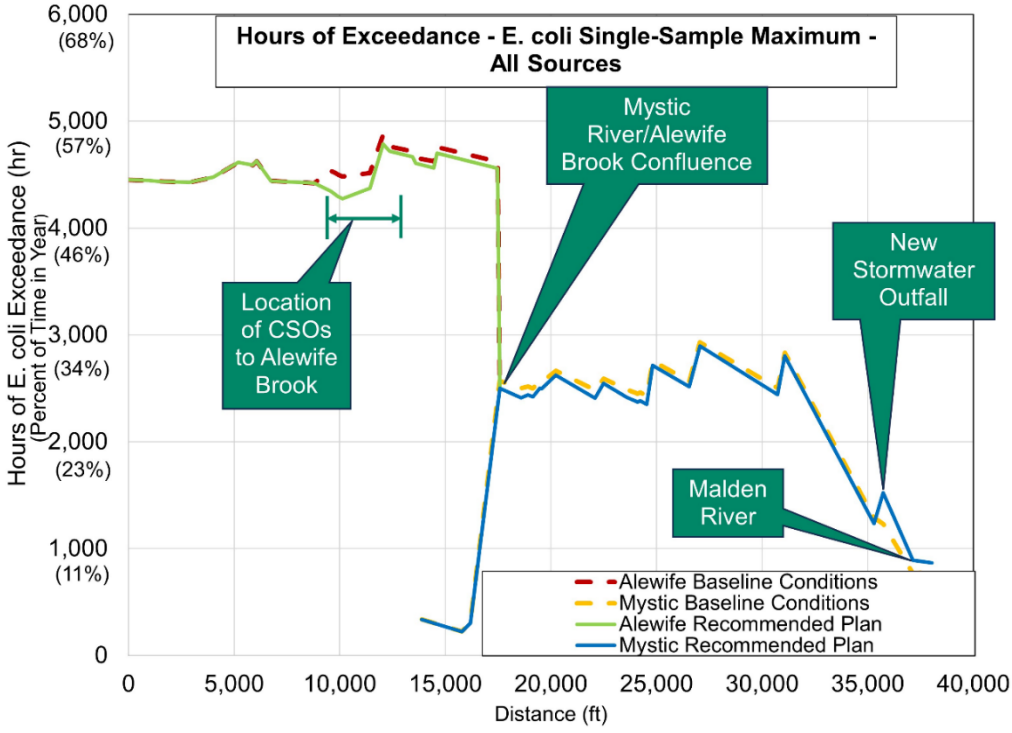



**Figure 12-7. Alewife Brook Hours of Exceedance of *E. coli* Single Sample Maximum Criterion, 2050 Typical Year Baseline Conditions vs. Draft Recommended Plan, All Sources**

## Attainment of *E. coli* 30-Day Geometric Mean and 90th Percentile STV Criteria

**Figures 7-11, 7-12, 7-15**, and **7-16** in Section 7 showed that under Baseline Conditions, the *E. coli* 30-day geometric mean and STV criteria were predicted to be exceeded 100 percent of the time in Alewife Brook in the 2050 TY for both the All Sources and the Non-CSO Sources conditions. With the Draft Recommended Plan, the attainment with the 30-day geometric mean and STV criteria is not predicted to change in Alewife Brook, due to the continued impact of the non-CSO sources. Plots of the 30-day geometric mean and STV criteria attainment for the Draft Recommended Plan are included in Appendix J.

## Maximum *E. coli* Concentrations

**Figure 12-8** presents plots of the maximum *E. coli* concentrations at each model segment in Alewife Brook and the Upper Mystic River for Baseline Conditions and for the Draft Recommended Plan, for the All Sources condition in the 2050 TY. As indicated in **Figure 12-8**, the Draft Recommended Plan is predicted to substantially reduce the peak *E. coli* concentrations in Alewife Brook due to the elimination of CSO discharges to Alewife Brook in the 2050 TY. However, the peak *E. coli* concentrations for the Draft Recommended Plan would still be substantially higher than the MassDEP-recommended single sample maximum criterion of 410 #/100mL, due mostly to the remaining stormwater loadings.

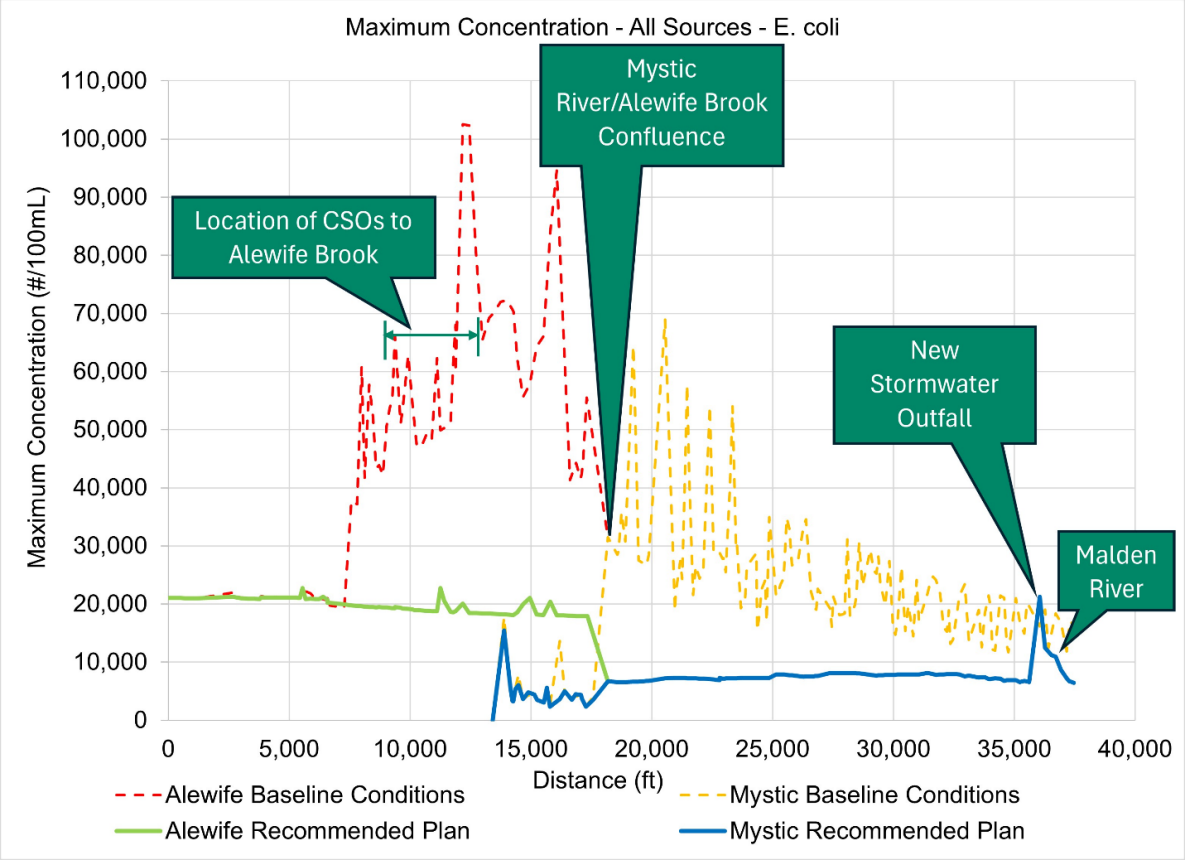



**Figure 12-8. Alewife Brook Maximum *E. coli* Concentrations, 2050 Typical Year Baseline Conditions vs. Draft Recommended Plan, All Sources**

### *E. coli* Concentrations Over Time Following Storm Event

**Figure 12-9** presents longitudinal plots of *E. coli* concentrations at the peak of the December 17 storm from the 2050 TY and at intervals of 6, 12, 24, and 48 hours following the peak, for All Sources. Plots are presented for Baseline Conditions and the Draft Recommended Plan. The December 17 storm generated the largest CSO volume to the Alewife Brook and the Upper Mystic River in the 2050 TY. As indicated in **Figure 12-9**, the Draft Recommended Plan would eliminate the concentration spikes associated with the CSOs that are seen in Alewife Brook at the peak of the storm and at the 3-hour mark under Baseline Conditions. By 6 hours after the peak of the storm, the impact of the CSOs under Baseline Conditions has passed, and minimal difference is predicted between the Baseline Conditions and the Draft Recommended Plan *E. coli* concentrations in Alewife Brook. The remaining elevated *E. coli* concentrations in Alewife Brook would be mostly attributed to stormwater.

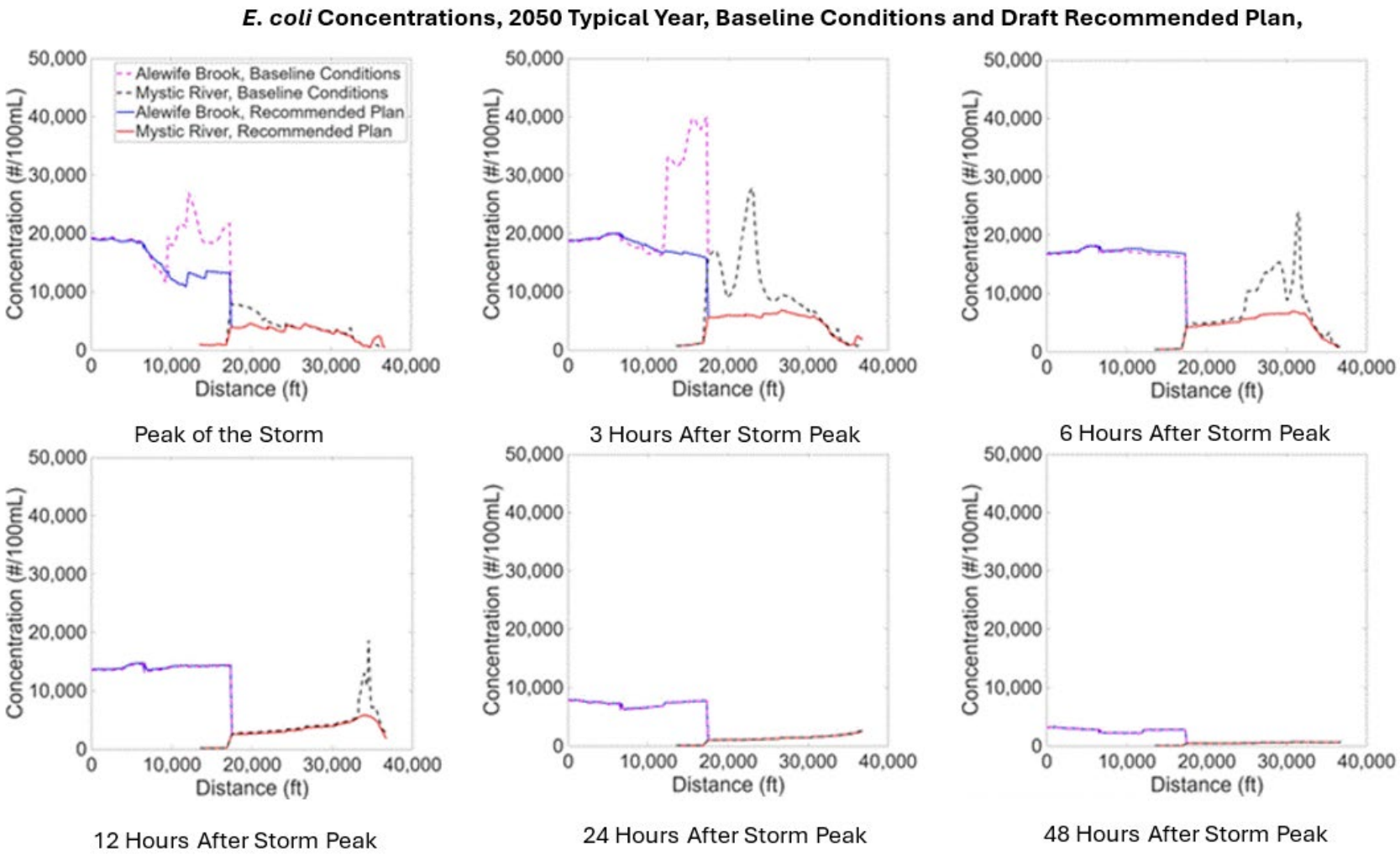



**Figure 12-9. Alewife Brook *E. coli* Concentrations Over Time During and After the December 17 Storm from the 2050 Typical Year, Baseline Conditions vs. Draft Recommended Plan, All Sources**

### Summary of the Draft Recommended Plan Water Quality Assessment for Alewife Brook

Key points from the water quality modeling assessment of the Draft Recommended Plan in the 2050 TY for Alewife Brook are summarized as follows:

- The Draft Recommended Plan is predicted to substantially reduce the relatively short-term spikes in *E. coli* concentrations in Alewife Brook associated with CSOs in the 2050 TY, but peak concentrations are predicted to remain well above the MassDEP-recommended single sample maximum criterion of 410 #/100mL due primarily to remaining stormwater loads.
- The Draft Recommended Plan is not predicted to substantially change the hours of exceedance of the MassDEP-recommended single sample maximum criterion of 410 #/100mL, or of the 30-day geometric mean or STV criteria in Alewife Brook in the 2050 TY due primarily to remaining stormwater loads.
- For storm events greater than those included in the 2050 TY, CSO volumes and durations will be reduced compared to baseline conditions and peak bacterial concentrations from this remaining CSO are predicted to be short term. Bacteria concentrations contributed by other sources are predicted to remain above the single sample maximum criteria after the concentrations from CSO have subsided.

## 12.2 Draft Recommended Plan for Upper Mystic River

The Draft Recommended Plan for the Upper Mystic River corresponds to Alternative 2.MR Hybrid 1 which includes the following individual projects:

1. 95 acres of sewer separation upstream of outfall SOM007A/MWR205A in Somerville; and
2. A 7.4 MG storage tank capturing the treated flow from the MWRA Somerville Marginal CSO Facility that would otherwise overflow to outfall SOM007A/MWR205A.

In combination, these projects would eliminate CSO activations to the Upper Mystic River in the 2050 TY. A schematic layout of the components of this alternative is presented in **Figure 12-10.**

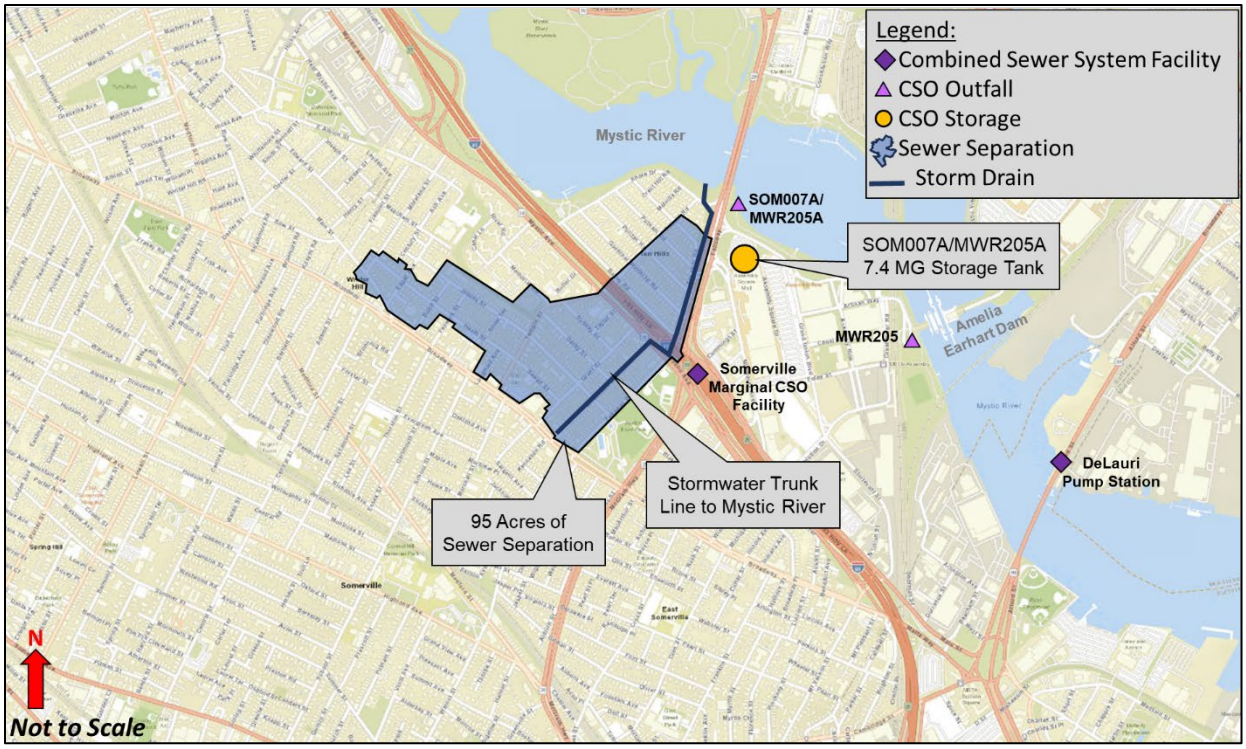



**Figure 12-10. Alternative 2.MR Hybrid 1 (0 CSOs in 2050 TY)**

### 12.2.2 Description

The individual components of Alternative 2.MR Hybrid 1 are described below.

#### Sewer Separation

This project consists of separating 95 acres of the combined sewer catchment tributary to outfall SOM007A/MWR205A. This area would be limited to the east side of the Ten Hills neighborhood as well as areas north of Broadway between Mystic Avenue and Fellsway West. New sanitary and/or stormwater pipes would be installed in each street currently served by combined sewers in the tributary area, and a new stormwater outfall would discharge stormwater to the Upper Mystic River. A proposed drain would be routed from Broadway along Wheatland Street and Fellsway West before discharging into the Mystic River. The separation work would require treatment for the now separate stormwater flows. Sites for stormwater treatment have not been identified. The separation work includes green stormwater infrastructure to the maximum extent practicable.

**Figure 12-11** presents a conceptual layout for the sewer separation project.




**Figure 12-11. Conceptual Layout of 95 Acres of Sewer Separation**

### Storage Tank

This project consists of a 7.4 MG below ground storage tank to capture flows from outfall SOM007A/MWR205A. Section 9.6.1 provides additional detail on the operation of the Somerville Marginal CSO Facility and the storage tank. The storage volume was estimated based on a model run which includes the 95 acres of sewer separation described above. The exterior dimensions of the 7.4 MG storage tank would be approximately 205 feet long by 120 feet wide with an approximate excavation depth of 70 feet. The approximate facility exterior dimensions include the tank and other facility components such as influent screening and flow distribution channels. Dimensions are preliminary and subject to change based on geotechnical investigations and other design factors.

**Figure 12-12** presents a conceptual layout for the storage tank. The storage tank could be constructed underground and located in the parking lot at the intersection of Grand Union Boulevard and Fellsway West in Assembly Square. A diversion structure would be constructed along the existing conduit between the SOM007A/MWR205A regulator and the outfall to divert wet weather flow to the storage facility. After storm flows subside, the stored flow would be pumped back to the SMBS. If the capacity of the storage tank is exceeded in a larger storm, excess flow would be discharged through the existing outfall via the new diversion structure weir. While the tank would be underground, a permanent above-ground structure would be required for maintenance access and to house electrical and odor control equipment.

The project would also include constructing a 4.5-foot diameter pipe to convey flow approximately 565 feet to the storage tank and constructing a 2-foot diameter dewatering pipe approximately 1,700 feet to the SMBS.

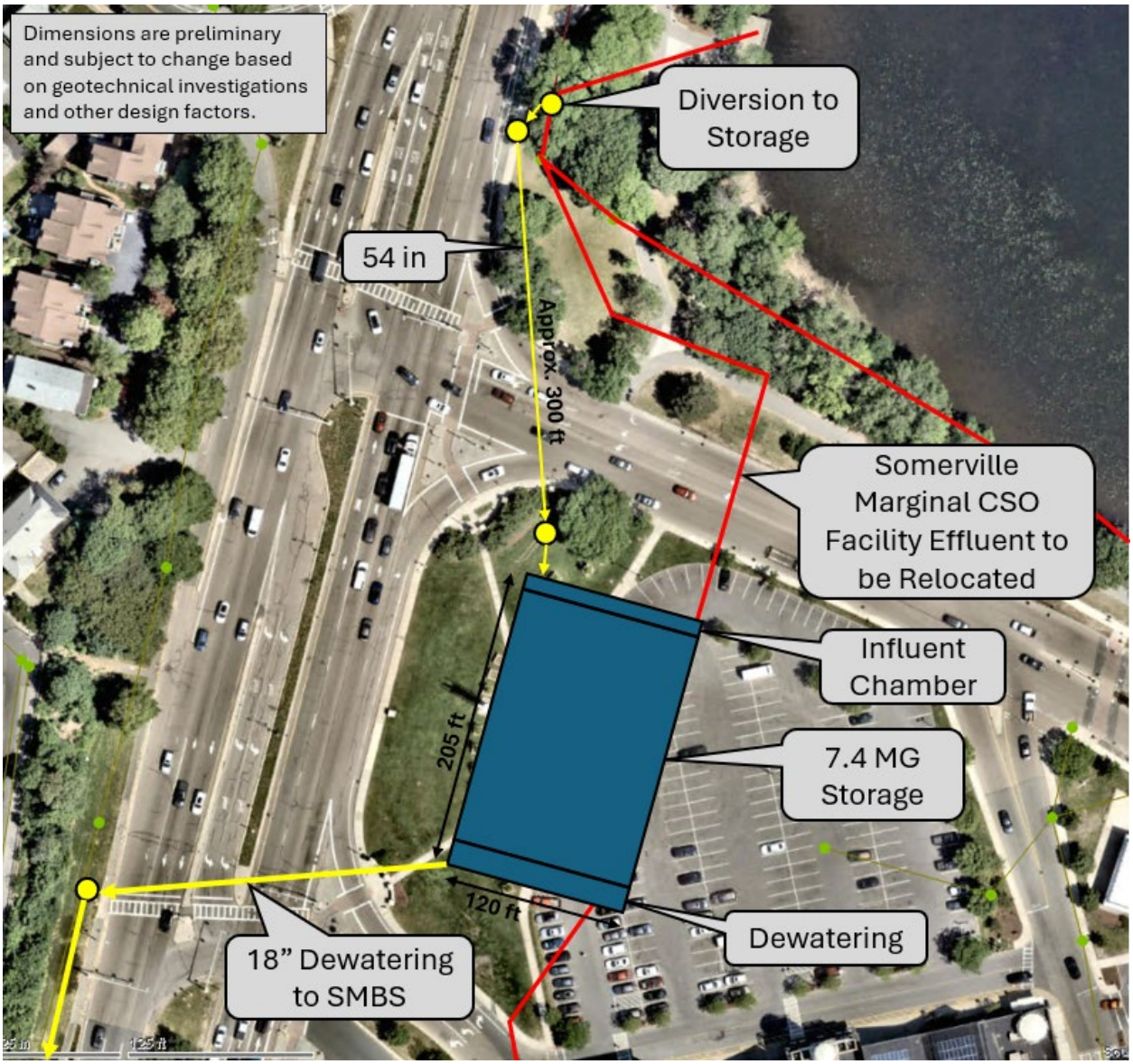



**Figure 12-12. SOM007A/MWR205A Storage Tank Conceptual Layout**

### 12.2.4 Cost

**Table 12-2** presents the estimated capital cost for the Draft Recommended Plan for the Upper Mystic River.

**Table 12-2. Estimated Capital Cost for Draft Recommended Plan for the Upper Mystic River**

| Upper Mystic River Outfall | Alternative Description | Preliminary Capital Cost(1) ($million) |
|---|---|---|
| SOM007A/MWR205A | 95 acres sewer separation | $97 M |
| | 7.4 MG storage | $160 M |
| **Total** | | **$260 M** |

**Note:**
(1) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.

### 12.2.5 Performance

#### Performance Relative to TMDLs

As described in Section 2.1.4, the Upper Mystic River is included in *the Mystic River Watershed Alternative TMDL for Phosphorus Management – Final Report* and the *Final Pathogen TMDL for the Boston Harbor, Weymouth-Weir, and Mystic Watersheds*. The Draft Recommended Plan for the Upper Mystic River would result in no net increase in phosphorus loading. Some project components, like the sewer separation, may result in an increase in phosphorus loading due to increase stormwater flows; others, like the storage tank, would reduce phosphorus loads. The Draft Recommended Plan would also provide a higher level of CSO control than was assumed as the basis for the bacterial waste load allocation from CSO. The Draft Recommended Plan therefore would not preclude attainment of either TMDL.

#### Water Quality Impacts of Draft Recommended Plan for Upper Mystic River

The Alewife Brook/Upper Mystic River 1-dimensional water quality model described in Sections 6 and 7 was run for the 2050 TY to assess the predicted impact of the Draft Recommended Plan on bacteria concentrations in the Upper Mystic River. Because the model includes both Alewife Brook and the Upper Mystic River, the assessment was based on implementation of the Draft Recommended Plans for both Alewife Brook and the Upper Mystic River. Model output was generated in the form of *E. coli* and Enterococcus counts at 15-minute intervals at each defined segment along the linear 1-dimensional model. The model output was processed to assess the impacts of remaining bacteria loadings to the Alewife Brook/Upper Mystic River in terms of:

- Single sample maximum criteria;
- 30-day geometric mean criteria;
- 30-day STV criteria;
- Maximum bacteria concentrations; and
- Change in bacteria concentration over time.

The single sample maximum was assessed at MassDEP's recommendation, and the 30-day geometric mean and 30-day STV criteria are part of the SWQS in 314 CMR 4.05 (presented in Section 2.1.2). The figures presented below show the findings for *E. coli*. Similar figures for *Enterococcus* are included in Appendix J.

## Attainment of *E. coli* Single Sample Maximum Criterion

As noted in Section 7, the water quality criteria for Class B waters expressed in 314 CMR 4.05 do not include a single sample maximum, but based on guidance from MassDEP the Updated CSO Control Plan includes an assessment of attainment with a single sample maximum value based on the 90th percentile STV for *E. coli* and *Enterococcus*.

**Figure 12-13** presents longitudinal plots of the number of hours in the 2050 TY that the maximum *E. coli* concentration would be above the single sample maximum criterion (410 #/100mL) for Baseline Conditions and for the Draft Recommended Plan. These plots include all modeled sources of bacteria, and the Draft Recommended Plan plot reflects no CSO bacteria loads consistent with the Plan performance of zero CSO discharges in the 2050 TY. The Y-axis also shows the values as a percentage of the total hours in the 2050 TY (366 days x 24 hours/day = 8,784 total hours; the 2050 TY is a leap year).

As indicated in **Figure 12-13**, the Draft Recommended Plan is predicted to result in a slight decrease in the hours of exceedance of the single sample maximum criterion for *E. coli* in the portions of the Upper Mystic River immediately downstream of the confluence with Alewife Brook in the 2050 TY. The hours of exceedance are predicted to increase slightly where the new storm drain outfall associated with the 95 acres of sewer separation in Somerville is anticipated to discharge ("New Stormwater Outfall" in **Figure 12-13**). The remaining hours of exceedance under the Draft Recommended Plan would be driven by non-CSO sources.

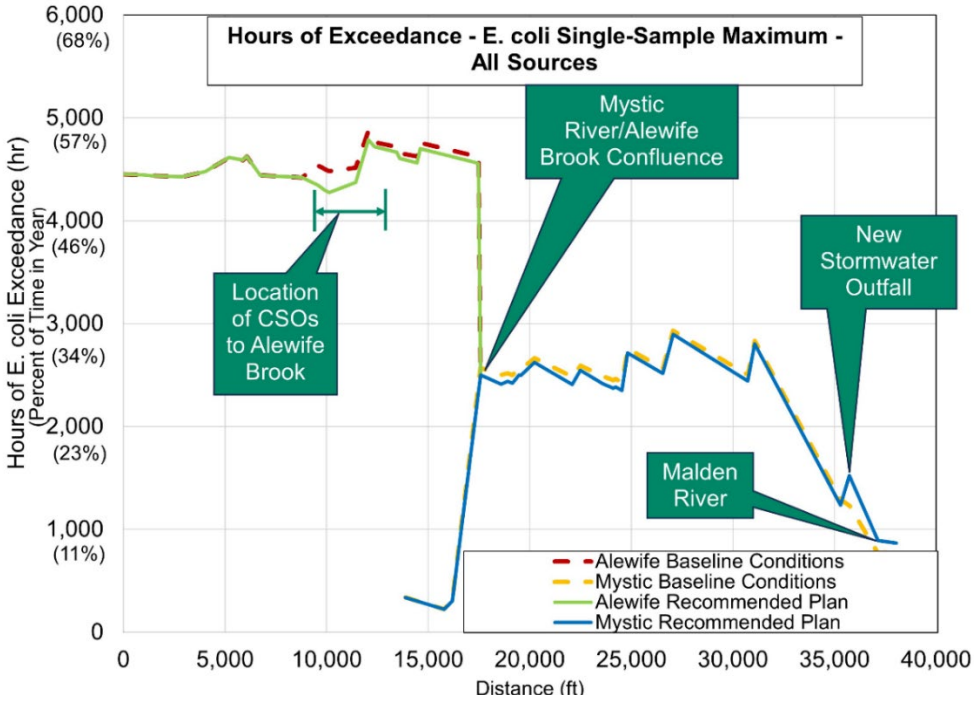



**Figure 12-13. Upper Mystic River Hours of Exceedance of *E. coli* Single Sample Maximum Criterion, 2050 Typical Year Baseline Conditions vs. Draft Recommended Plan, All Sources**

## Attainment of *E. coli* 30-Day Geometric Mean and 90th Percentile STV Criteria

**Figures 7-11** and **7-12** in Section 7 showed that in the Upper Mystic River below the confluence with Alewife Brook, the duration of exceedance of the 30-day geometric mean criterion for *E. coli* under

Baseline Conditions fluctuates between about 30 and 60% of the year, then drops to near zero percent at the downstream end. The shape of the curve did not change between the All Sources and Non-CSO Sources conditions. For the Draft Recommended Plan, the curve similarly did not substantially change.

**Figures 7-15** and **7-16** in Section 7 showed that in the Upper Mystic River below the confluence with Alewife Brook, the 30-day STV criterion for *E. coli* under Baseline Conditions is exceeded for the entire year until a point approximately 15,000 feet downstream of Alewife Brook. From that point, the hours of exceedance dropped to just under 50% of the year at the downstream end. The shape of the curve did not change between the All Sources and Non-CSO Sources conditions. For the Draft Recommended Plan, the curve did not substantially change, except for a slight spike in exceedance aligned with the location of the new sewer separation storm drain outfall in the downstream reach of the river.

Plots of the 30-day geometric mean and STV criteria attainment for the Draft Recommended Plan are included in Appendix J.

## Maximum *E. coli* Concentrations

**Figure 12-14** presents plots of the maximum *E. coli* concentrations at each model segment in the Upper Mystic River for Baseline Conditions and for the Draft Recommended Plan, for the All Sources condition in the 2050 TY. As indicated in **Figure 12-14**, the Draft Recommended Plan is predicted to substantially reduce the peak *E. coli* concentrations in the Upper Mystic River due to the elimination of CSO discharges to both the Alewife Brook and Mystic River in the 2050 TY. The impact of eliminating treated CSO discharges form SOM007A/MWR205A is not discernable in the plots of maximum *E. coli* concentration, however, since the treated discharge concentrations were already below the MassDEP-recommended single sample maximum criterion of 410 #/100mL. A small spike in the maximum concentration under the Draft Recommended Plan appears in the location of the new sewer separation storm drain outfall in the downstream reach of the river. The small spike was of approximately the same magnitude as the peak Baseline Conditions concentration in that location.

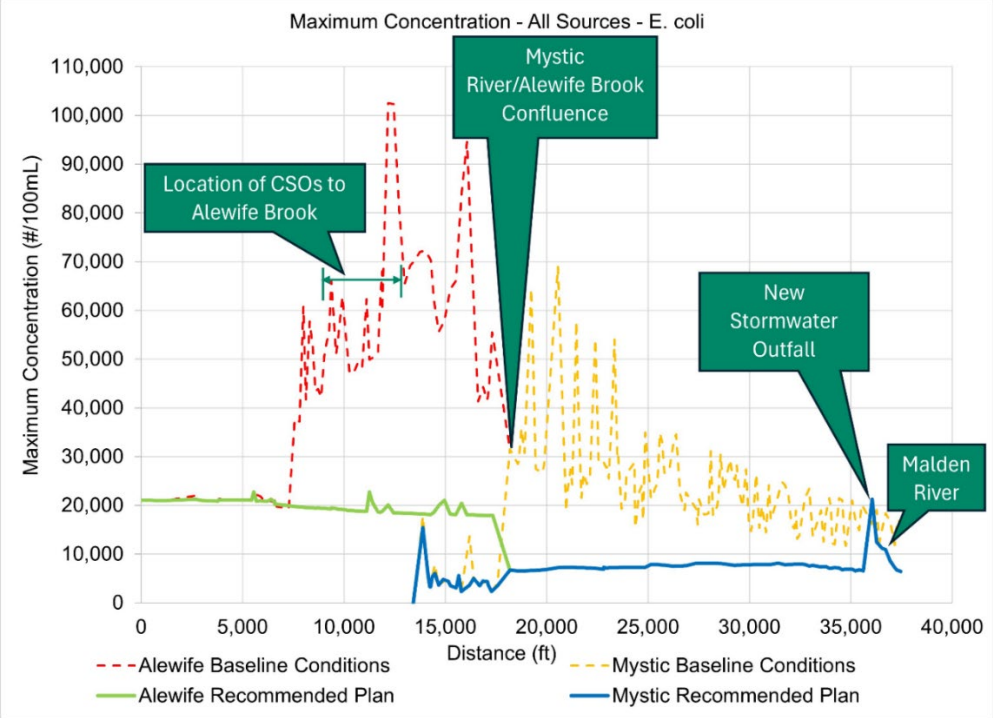



**Figure 12-14. Maximum *E. coli* Concentrations, 2050 Typical Year Baseline Conditions vs. Draft Recommended Plan, All Sources**

### *E. coli* Concentrations Over Time Following Storm Event

**Figure 12-15** presents longitudinal plots of *E. coli* concentrations at the peak of the December 17 storm from the 2050 TY and at intervals of 6, 12, 24, and 48 hours following the peak, for All Sources. Plots are presented for Baseline Conditions and the Draft Recommended Plan. The December 17 storm generated the largest CSO volume to the Alewife Brook and the Upper Mystic River in the 2050 TY. As indicated in **Figure 12-15**, the Draft Recommended Plan would eliminate the concentration spikes associated with the Alewife Brook CSOs that are seen in the Upper Mystic River at the peak of the storm through the 12-hour mark under Baseline Conditions. By 24 hours after the peak of the storm, the impact of the Alewife CSOs under Baseline Conditions has passed, and minimal difference is predicted between the Baseline Conditions and the Draft Recommended Plan *E. coli* concentrations in the Upper Mystic River. The remaining elevated *E. coli* concentrations in the Upper Mystic River would be mostly attributed to stormwater.

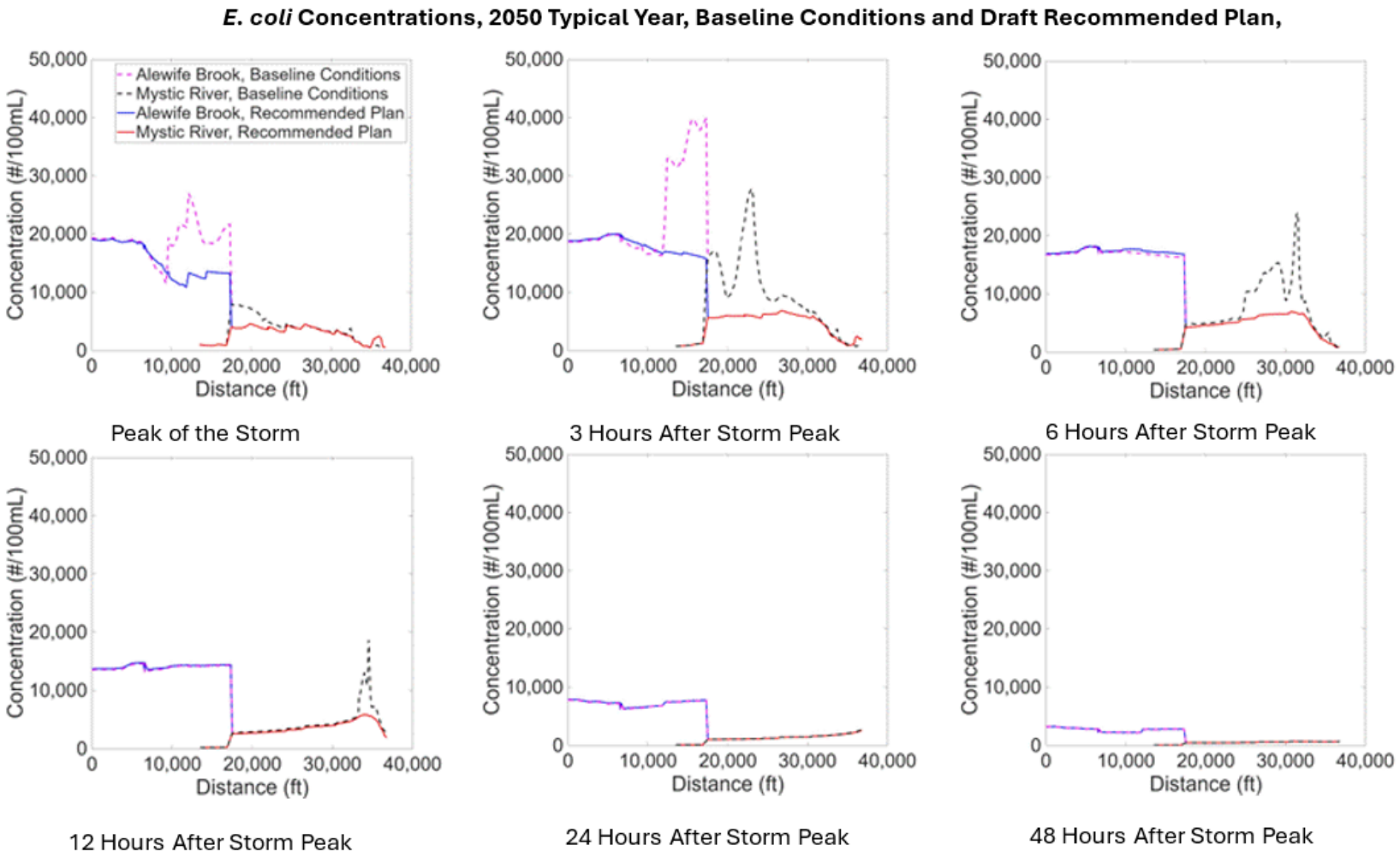



**Figure 12-15. Upper Mystic River *E. coli* Concentrations Over Time During and After the December 17 Storm from the 2050 Typical Year, Baseline Conditions vs. Draft Recommended Plan, All Sources**

### Summary of the Draft Recommended Plan Water Quality Assessment for the Upper Mystic River

Key points from the water quality modeling assessment of the Draft Recommended Plan in the 2050 TY for the Upper Mystic River are summarized as follows:

- The Draft Recommended Plan is predicted to substantially reduce the relatively short-term spikes in *E. coli* concentrations in the Upper Mystic River associated with Alewife Brook CSOs in the 2050 TY, but peak concentrations are predicted to remain above the MassDEP-recommended single sample maximum criterion of 410 #/100mL due primarily to remaining stormwater loads. A small spike in the maximum concentration under the Draft Recommended Plan appears in the location of the new sewer separation storm drain outfall in the downstream reach of the river. The small spike was of approximately the same magnitude as the peak Baseline Conditions concentration in that location.
- The Draft Recommended Plan is not predicted to substantially change the hours of exceedance of the MassDEP-recommended single sample maximum criterion of 410 #/100mL, or of the 30-day geometric mean or STV criteria in the Upper Mystic River in the 2050 TY due primarily to remaining stormwater loads. A small spike in the hours of exceedance of the MassDEP-recommended single sample maximum criterion and the 30-day STV criterion under the Draft Recommended Plan appears in the location of the new sewer separation storm drain outfall in the downstream reach of the river.
- For storm events greater than those included in the 2050 TY, CSO volumes and durations will be reduced compared to baseline conditions and peak bacterial concentrations from this remaining CSO are predicted to be short term. Bacteria concentrations contributed by other sources are predicted to remain above the single sample maximum criteria after the concentrations from CSO have subsided.

## 12.3 Draft Recommended Plan for Charles River

The Draft Recommended Plan for the Charles River corresponds to Alternative 4.CR Hybrid 3 which includes the following individual projects:

1) A 2.5 MG stormwater storage tank and flow restriction upstream of outfall CAM005 in Cambridge;
2) A 10.1 MG storage tank to capture flows from the Cottage Farm CSO Facility in Cambridge;
3) Separation of approximately 366 acres of runoff area tributary to the Boston Marginal Conduit and outfalls MWR018/019/020 in Boston;
4) A 0.16 MG storage conduit to capture overflow from regulator RE046-100 and a 0.08 MG storage conduit to capture overflow from regulator RE046-381 upstream of outfall MWR023 in Boston; and
5) 80 acres of sewer separation upstream of outfall CAM017 in Cambridge.

In combination, these projects would eliminate the untreated and treated CSO activations to the Charles River in the 2050 TY. Under this alternative, no action is recommended at outfalls CAM007 or MWR010, as these outfalls do not activate in the 2050 TY.

A schematic layout of the components of this alternative is presented in **Figure 12-16**.

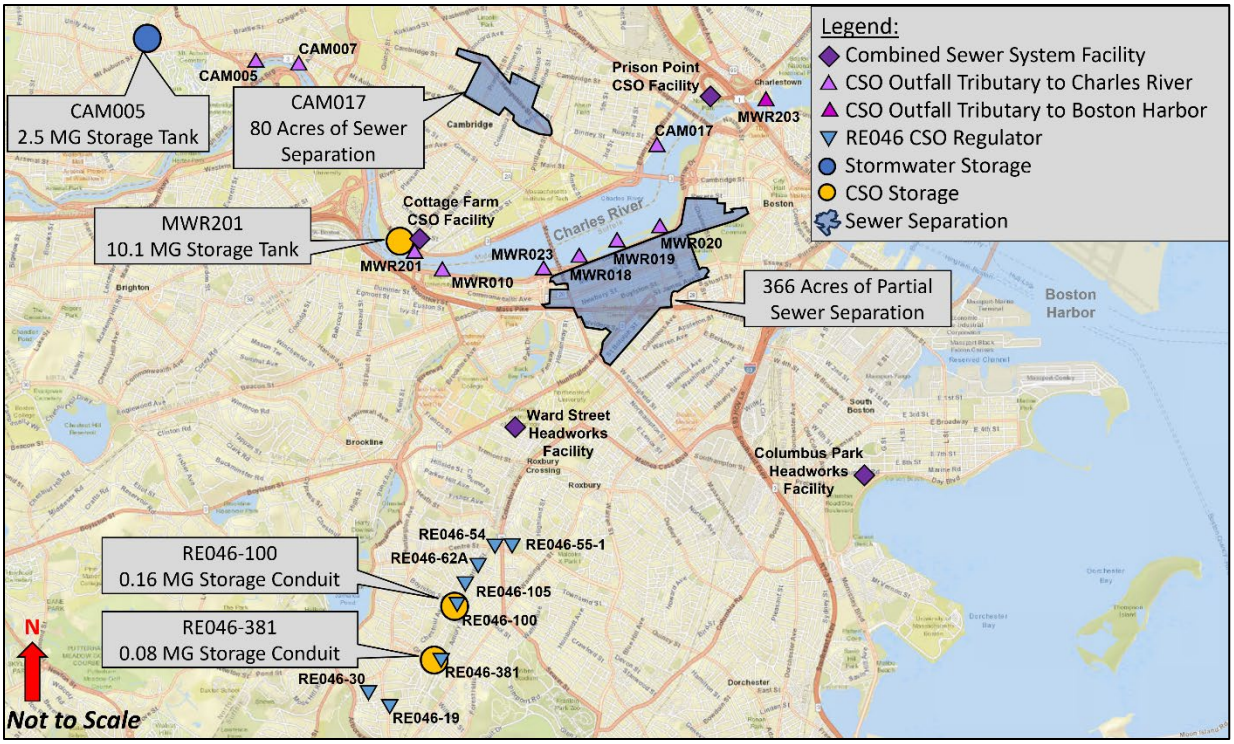



**Figure 12-16. Alternative 4.CR Hybrid 3 Summary (0 CSOs in 2050 TY)**

### 12.3.2 Description

The individual components of Alternative 4.CR Hybrid 3 are described below.

#### CAM005 Stormwater Storage Tank

The project at CAM005 consists of a stormwater storage tank to capture separate stormwater that currently flows into the combined sewer system upstream of outfall CAM005. Preliminary modeling indicates that approximately 2.5 MG of stormwater storage would reduce CSO activation frequency and volume at outfall CAM005 to zero in the 2050 TY and would also reduce surface flooding, although the volume is subject to refinement in the process of design.

As described in Section 9.8.1, this project would limit stormwater flows from the existing separated Aberdeen area into the combined sewer near the intersection of Mount Auburn Street and Aberdeen Avenue. The existing 42-inch diameter storm drain connection would be significantly downsized to limit the peak flow rate into the combined sewer. The peak stormwater flows would be diverted to a below-ground storage tank likely in a parking lot in the vicinity of the Collins Branch Library. A dewatering pump station would return flows to the combined system after flows recede, thus providing stormwater treatment for the separated area. **Figure 12-17** presents a conceptual layout.

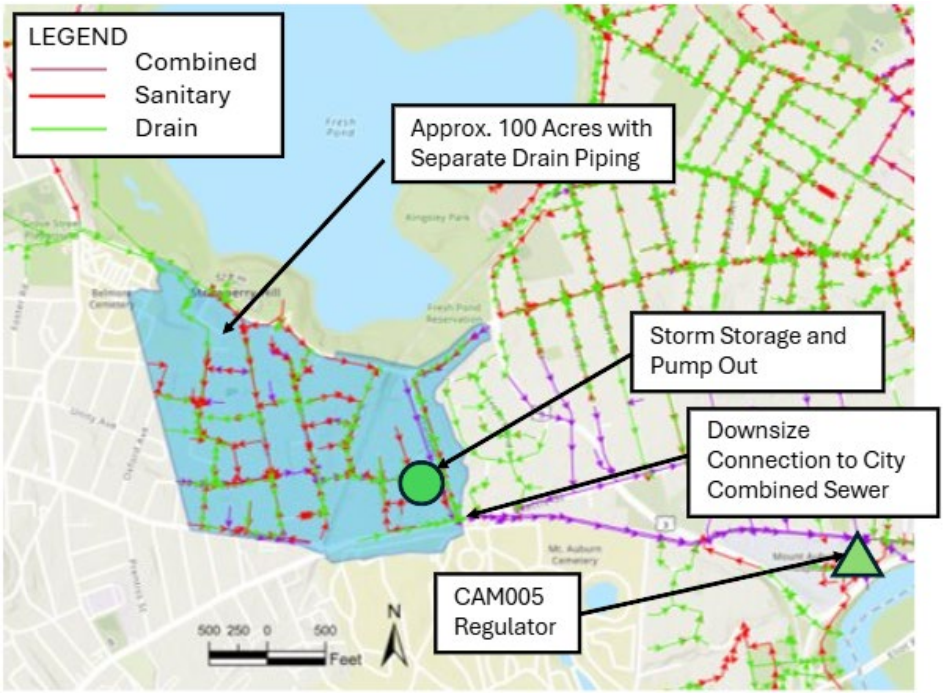



**Figure 12-17. Separated Area and Stormwater Storage Upstream of CAM005**

The stormwater storage tank would involve excavation, ideally located in one of the existing parking lots in the vicinity. The City of Cambridge is committed to incorporating local GSI wherever practical to complement infrastructure projects, including this one, to be evaluated during design; the City is also committed to pursuing a budget line item of $500,000/year for GSI implementation starting in FY27, which could fund such components that may be identified for this project.

### MWR201 (Cottage Farm CSO Facility) Storage Tank

The project at outfall MWR201 consists of a 10.1 MG storage tank to capture flow diverted to the Cottage Farm CSO Facility. The storage tank would be constructed below ground at a site located in Magazine Beach Park adjacent to the existing Cottage Farm CSO Facility.

The storage volume was estimated based on a model run which includes the combination of projects in Alternative 4.CR Hybrid 3. The exterior dimensions of the 10.1 MG storage tank would be approximately 300 feet long by 150 feet wide with an approximate excavation depth of 65 feet. The approximate facility exterior dimensions include the tank and other facility components such as influent screening and flow distribution channels. Dimensions of the storage tank are preliminary and subject to change based on geotechnical investigations and other design factors. The project would also include constructing an 8.5-foot diameter pipe to convey flow approximately 500 feet to the storage tank and constructing a 2-foot diameter dewatering pipe approximately 700 feet to the South Charles Relief Sewer.

**Figure 12-18** presents a conceptual layout for the storage tank. The figure shows the approximate location of a gravity pipe to storage, a dewatering pump station connection, existing infrastructure, and the approximate size of the storage tank. Flow could be diverted to the storage tank from the existing Cottage Farm CSO Facility sedimentation tank influent channel, downstream of the existing influent pumps. If the new storage tank fills to its capacity, remaining influent flow at the existing Cottage Farm facility would continue to the existing sedimentation tanks, then discharge to the Charles River when the existing tanks were full. After storm flows subside, dewatering pumps in the new storage facility would pump the stored flow back to the MWRA interceptor system adjacent to the Cottage Farm facility. While the tank structure would be below ground, a permanent above-ground structure would provide maintenance access and house electrical and odor control equipment.

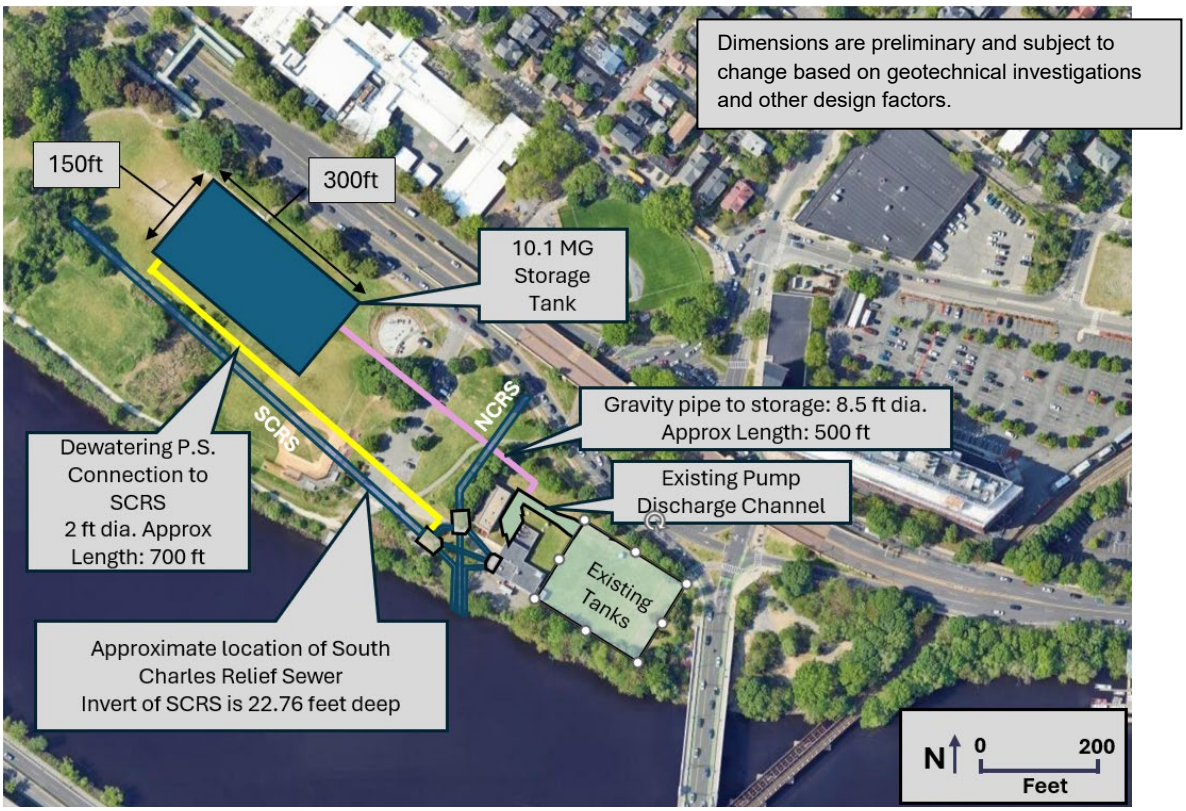



**Figure 12-18. Conceptual Layout for MWR201 Storage Tank**

### MWR018/019/020 Sewer Separation

The project for outfalls MWR018/019/020 consists of separating a 224-acre combined sewer catchment area and relocating 142 acres of already-separated stormwater tributary to outfalls MWR018/019/020. This project is predicted to reduce CSO activation frequency and volume to zero in the 2050 TY at these outfalls. **Figure 12-19** presents the approximate project area for outfalls MWR018/019/020.

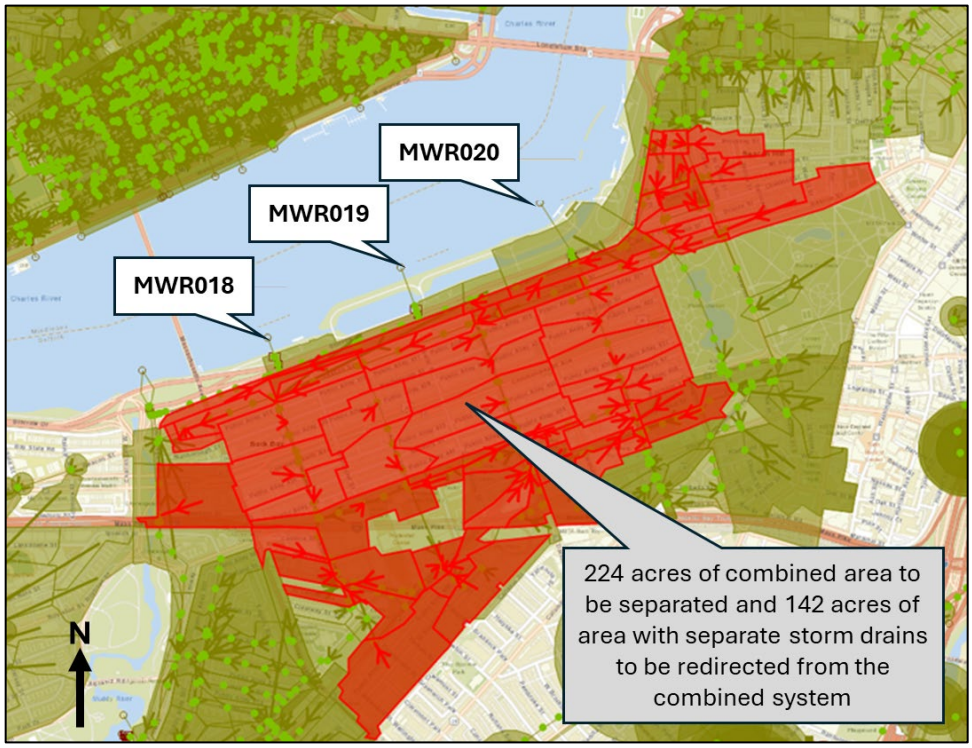



**Figure 12-19. Area to be Separated Tributary to Outfalls MWR018/019/020**

To separate these areas, it is anticipated that new storm drain trunk sewers would be needed to convey the separated stormwater to the vicinity of Back Street on the south side of Storrow Drive. Multi-barrel microtunneled stormwater pipes would then be needed to convey the separated stormwater under the Boston Marginal Conduit and Storrow Drive, tying into the existing MWR018/019/020 outfalls to the Charles River. **Figure 12-20** presents a potential configuration of the new storm drain trunk sewers and the multi-barrel microtunneled stormwater pipes with additional detail provided near MWR018 as an example. It is anticipated that the configurations of MWR019 and MWR020 would be similar. The existing separate storm drains within the 142 acres of already-separated stormwater areas would likely be tied into new storm drains constructed as part of the separation of downstream combined sewer areas. Based on discussions with the BWSC, GSI would be installed in areas to be separated to help recharge local groundwater with captured stormwater runoff. Stormwater pump stations may be needed in certain parts of the area to be separated.

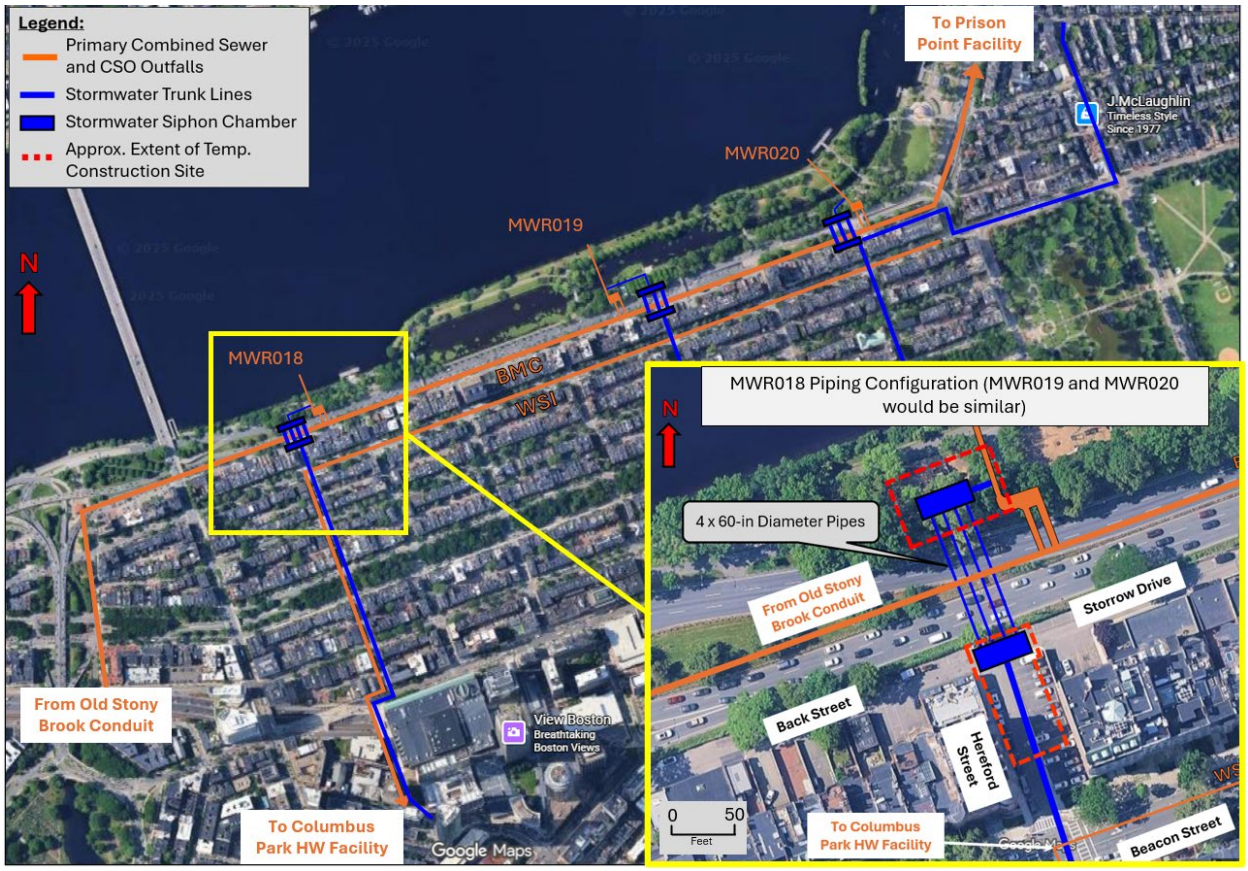



**Figure 12-20. Potential Configuration of New Storm Drain Pipes and Multi-barrel Stormwater Siphons to Convey Separate Stormwater for Sewer Separation in the Area Tributary to Outfalls MWR018/019/020**

This sewer separation work is proposed to include small-diameter connections between the new storm drains and the Boston Marginal Conduit to recapture stormwater from smaller storms that would not cause CSOs to activate. The benefit of this approach is that stormwater pollutant loadings from smaller storms, and the start of larger storms, would still be captured for treatment at DITP, thereby helping to mitigate the impact of the increased stormwater discharge volumes associated with sewer separation. This approach has been successfully implemented in the Cambridgeport neighborhood of Cambridge, upstream of the Cottage Farm facility.

### MWR023 Storage at Upstream Regulators

The project at outfall MWR023 consists of two storge conduits: a 0.16 MG storage conduit to capture overflows from regulator RE046-100 and a 0.08 MG storage conduit to capture the overflows from regulator RE046-381. As described in Section 9.8.6, these storage conduits are predicted to reduce CSO activation frequency and volume at outfall MWR023 to zero in the 2050 TY. The dimensions of the storage conduits presented below, including whether they would be circular pipes or rectangular box sections, are preliminary and subject to change based on geotechnical investigations and other design factors.

**Figure 12-21** presents a conceptual layout for the 0.16 MG storage conduit that would capture the overflow volume from regulator RE046-100. A 9 x 9-foot box conduit extending 300 feet would be an example of a configuration that could provide the required volume of storage. The final configuration would be developed as part of additional planning and design. A dewatering pump facility would be provided at the low end of the storage conduit. Stored flows would likely be dewatered to the Southwest Corridor Interceptor for conveyance to Ward Street Headworks. The storage conduit would be below-ground within the public right-of-way along Lamartine Street. The dewatering pump station and odor control facility would likely require small, above-ground structures located off the street. If the capacity of the storage conduit is exceeded in a larger storm, excess flow would be discharged to the existing MWR023 outfall via the new diversion structure weir.

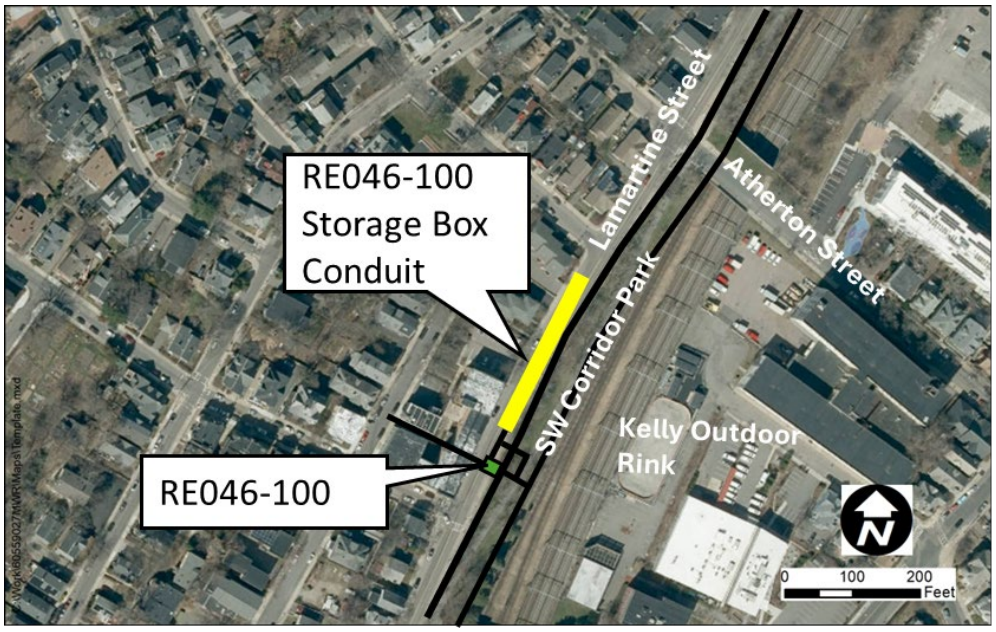



**Figure 12-21. Conceptual Layout for RE046-100 (MWR023) 0.16 MG Storage Conduit**

**Figure 12-22** presents a conceptual layout for the 0.08 MG storage conduit that would capture the overflow volume from regulator RE046-381. A 6 x 6-foot box conduit extending for 320 feet would be an example of a configuration that could provide the required volume of storage. The final configuration would be developed as part of additional planning and design. A dewatering pump facility would be provided at the low end of the storage conduit. Stored flows would likely be dewatered to the Southwest Corridor Interceptor for conveyance to Ward Street Headworks. The storage conduit would be below ground on land owned by the MBTA adjacent to the DCR-owned Johnson Park. The dewatering pump station and odor control facility would likely require small, above-ground structures. In addition, truck access would be required for system maintenance including tank cleaning activities following storm

events. If the capacity of the storage conduit is exceeded in a larger storm, excess flow would be discharged to the existing MWR023 outfall via the new diversion structure weir.

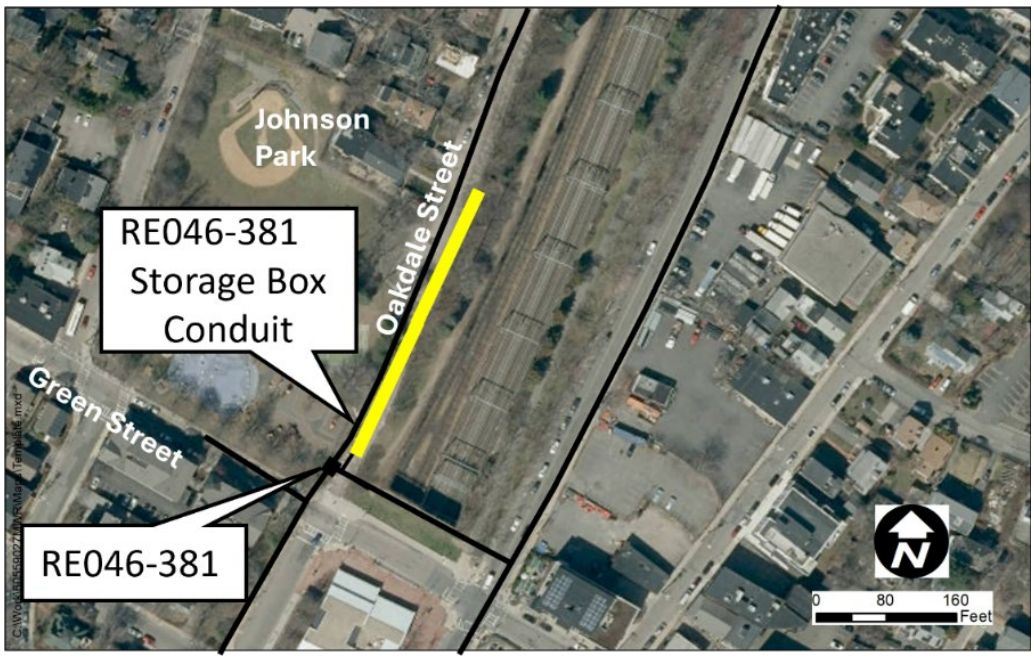



**Figure 12-22. Conceptual Layout for RE046-381 (MWR023) 0.08 MG Storage Conduit**

### CAM017 Sewer Separation

The project for CAM017 consists of separating a portion of the combined sewer catchment area tributary to this outfall to reduce CSOs at outfall CAM017 to zero in the 2050 TY. Preliminary modeling indicates that separating approximately 80 acres of the tributary area that drains to Hampshire Street could achieve this goal, but the exact area is subject to refinement during design. Ideally, separated stormwater would be connected to the Broadway drain after the Broadway Drain Extension project is complete. The separation work would require treatment for the additional stormwater flows. Sites for the stormwater treatment have not yet been identified. The City of Cambridge is committed to incorporating local GSI wherever practical to complement infrastructure projects, including this one, to be evaluated during design; the City is also committed to pursuing a budget line item of $500,000/year for GSI implementation starting in FY27, which could fund such components that may be identified for this project. **Figure 12-23** presents the potential 80-acre area upstream of outfall CAM017 to be separated.

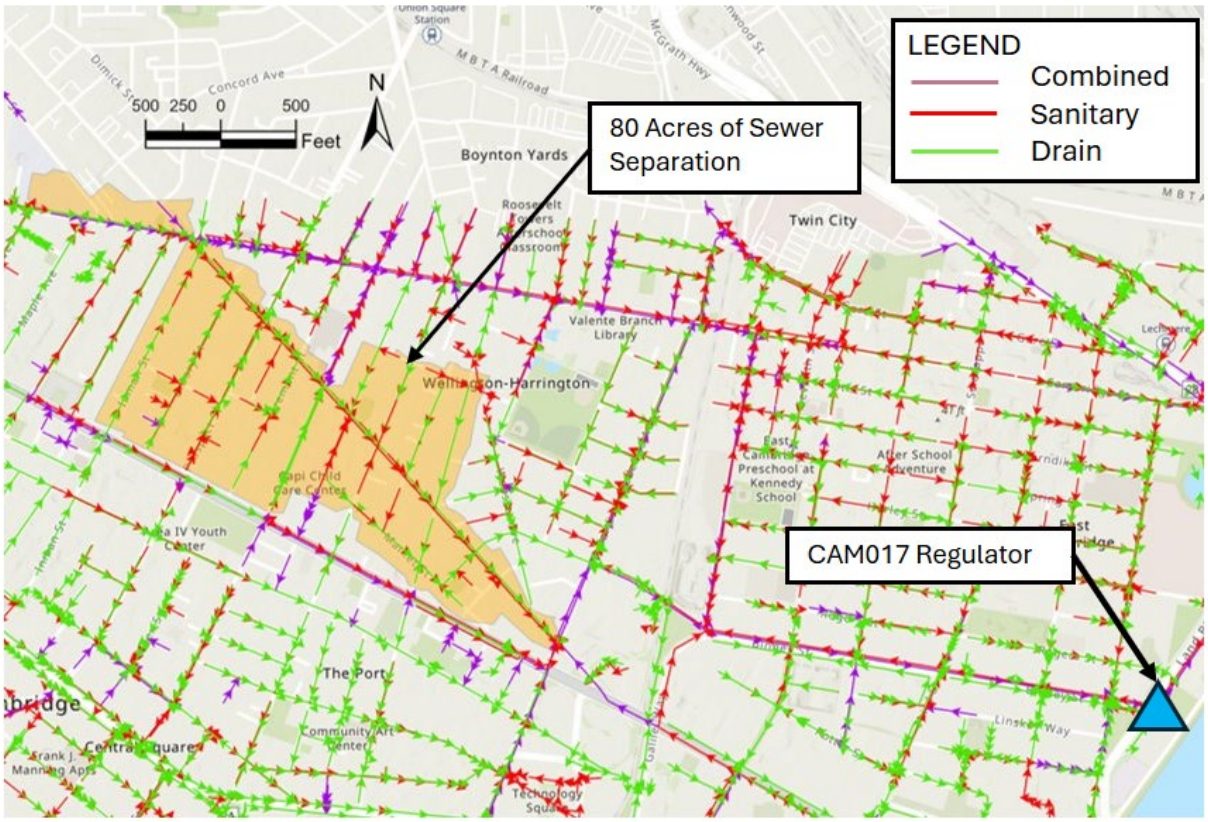



**Figure 12-23. Conceptual Layout for Approximately 80 Acres of Sewer Separation at CAM017**

### 12.3.4 Cost

**Table 12-3** presents the estimated capital cost for the Draft Recommended Plan for the Charles River.

**Table 12-3. Estimated Capital Cost for Draft Recommended Plan for Charles River**

| Charles River Outfall | Alternative Description | Preliminary Capital Cost[1] ($Millions) |
|---|---|---|
| CAM005 | 2.5 MG stormwater storage with underflow restrictions | $83 M |
| CAM007 | No action[2] | N/A[3] |
| MWR201 (Cottage Farm - Treated) | 10.1 MG storage tank | $190 M |
| MWR010 | No action | N/A |
| MWR018 | 366 acres sewer separation | $320 M |
| MWR019 | | |
| MWR020 | | |
| CAM017 | 80 acres sewer separation | $77 M |
| RE046-100 (MWR023) | 0.16 MG storage conduit | $11 M |
| RE046-381 (MWR023) | 0.08 MG storage conduit | $7.6 M |
| **Total** | **-** | **$690 M** |

**Notes:**
(1) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.
(2) CSO is not predicted to activate in the 2050 TY, therefore no project is required to achieve 0 CSOs in the 2050 TY.
(3) N/A: not applicable.

### 12.3.5 Performance

The Draft Recommended Plan for the Charles River was developed to achieve 0 CSOs in the 2050 TY. The impacts of the Draft Recommended Plan on TMDLs and water quality are presented below.

#### Performance Relative to Charles River TMDLs

As described in Section 2.1.4, the reach of the Charles River addressed in this Updated CSO Control Plan is included in the *Final Total Maximum Daily Load for Nutrients in the Lower Charles River Basin* and the *Massachusetts and the Final Pathogen TMDL for the Charles River Watershed*. The Draft Recommended Plan for the Charles River would result in no net increase in phosphorus loading. Some project components, like sewer separation, may result in an increase in phosphorus loads due to increased stormwater flows; others, like the storage tanks and conduits, would reduce phosphorus loads. The Draft Recommended Plan would also provide a higher level of CSO control than was assumed as the basis for the bacterial waste load allocation from CSO. The Draft Recommended Plan therefore would not preclude attainment of either TMDL.

### Water Quality Impacts of Draft Recommended Plan for the Charles River

The Charles River 2-dimensional water quality model described in Sections 6 and 7 was run for the 2050 TY to assess the predicted impact of the Draft Recommended Plan on bacteria concentrations in the Charles River. Model output was generated in the form of *E. coli* and *Enterococcus* counts at 1-hour intervals at each of the 4,400 grid cells in the model. The model output was processed to assess the impacts of remaining bacteria loadings to the Charles River in terms of:

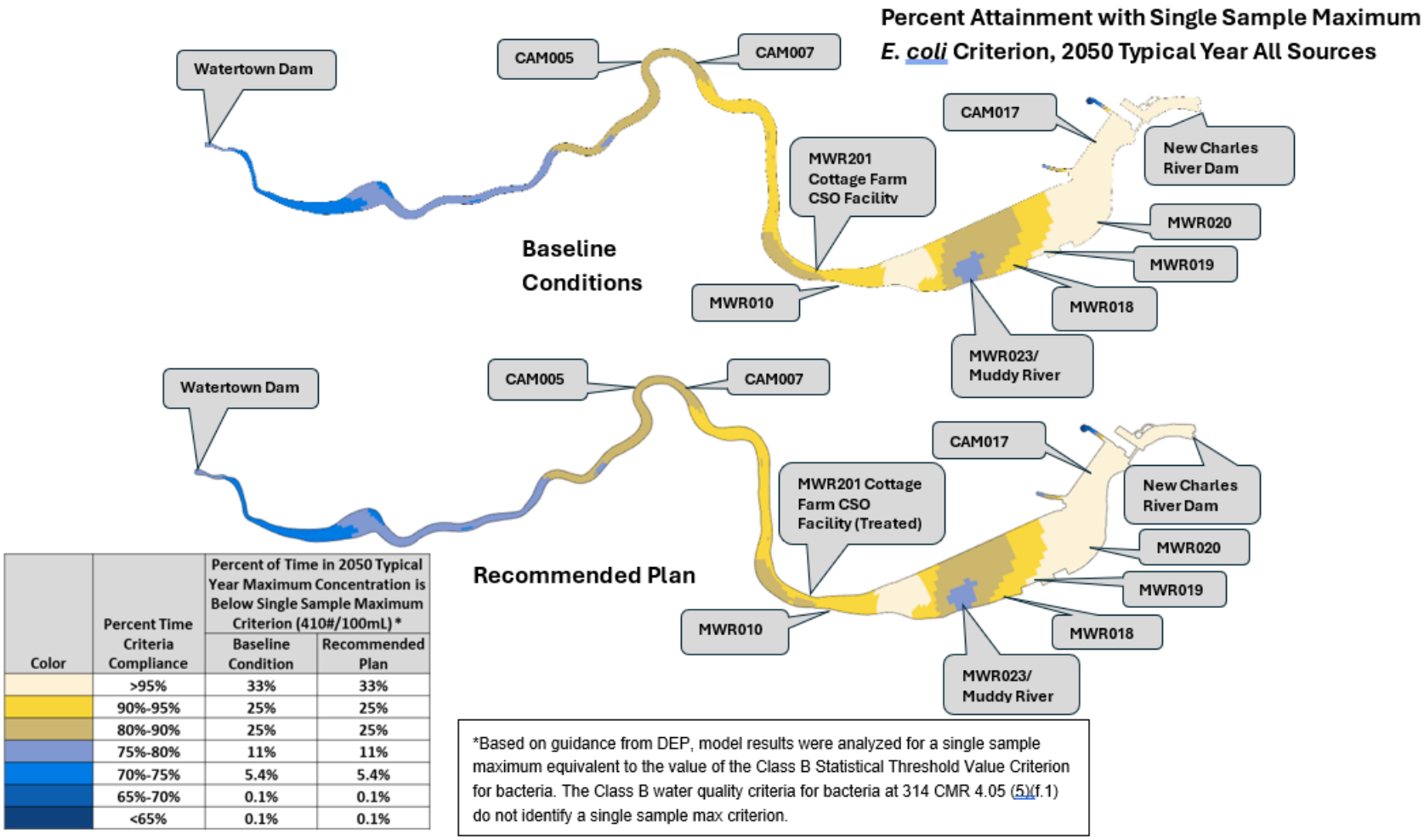
- Single sample maximum criteria;
- 30-day geometric mean criteria;
- 30-day STV criteria;
- Maximum bacteria concentrations; and
- Change in bacteria concentration over time.

The single sample maximum was assessed at MassDEP's recommendation, and the 30-day geometric mean and 30-day STV criteria are part of the SWQS in 314 CMR 4.05 (presented in Section 2.1.2). The figures presented below show the findings for *E. coli*. Similar figures for *Enterococcus* are included in Appendix J.

#### Attainment of Single Sample Maximum Criteria

As described above for the Alewife Brook and Upper Mystic River, based on direction from MassDEP, the Charles River water quality model was used to assess attainment with single sample maximum criteria equal to the existing 30-day STV criteria of 410 #/100mL for *E. coli* and 130 #/100mL for *Enterococcus.*

**Figure 12-24** presents contour maps of the percent of time in the 2050 TY that the maximum E. coli concentration is predicted to be below the single sample maximum criterion (410 #/100mL) for Baseline Conditions and for the Draft Recommended Plan under the All Sources scenario.




| Color | Percent Time Criteria Compliance | Percent of Time in 2050 Typical Year Maximum Concentration is Below Single Sample Maximum Criterion (410#/100mL) * | |
|---|---|---|---|
| | | Baseline Condition | Recommended Plan |
| | >95% | 33% | 33% |
| | 90%-95% | 25% | 25% |
| | 80%-90% | 25% | 25% |
| | 75%-80% | 11% | 11% |
| | 70%-75% | 5.4% | 5.4% |
| | 65%-70% | 0.1% | 0.1% |
| | <65% | 0.1% | 0.1% |

*Based on guidance from DEP, model results were analyzed for a single sample maximum equivalent to the value of the Class B Statistical Threshold Value Criterion for bacteria. The Class B water quality criteria for bacteria at 314 CMR 4.05 (5)(f.1) do not identify a single sample max criterion.

**Figure 12-24. Charles River Percent Annual Attainment of Single Sample Maximum Criterion for *E. coli*, 2050 Typical Year Baseline Conditions vs. Draft Recommended Plan, All Sources**

As indicated in **Figure 12-24**, the plots for Baseline Conditions and the Draft Recommended Plan are essentially identical. The elimination of treated and untreated discharges from the Charles River in the 2050 TY is not predicted to affect the magnitude or spatial distribution of exceedances of the single sample maximum criterion in the 2050 TY due to the impact of stormwater and upstream sources. Areas of consistently lower attainment are just downstream of the Watertown Dam, and the area adjacent to the Muddy River confluence and MWR023 outfall. The lower attainment downstream of the Watertown Dam is driven by the bacteria loads coming over the dam from upstream, while the lower attainment adjacent to the MWR023 outfall/Muddy River is driven primarily by the base flow and stormwater loadings from those sources.

### Attainment of *E. coli* 30-Day Geometric Mean and STV Criteria

**Figures 7-25, and 7-26** in Section 7 showed that under Baseline Conditions, plots of the exceedances of the *E. coli* 30-day geometric mean and STV criteria for All Sources and Non-CSO Sources were identical, indicating that the CSOs under Baseline Conditions had no impact on the magnitude or extent of exceedances of these criteria in the 2050 TY. The plots for the Draft Recommended Plan are similarly identical to the Baseline Conditions plots. With the Draft Recommended Plan, the magnitude and spatial extent of exceedances of the 30-day geometric mean and STV criteria remain driven by the non-CSO sources. Plots of the 30-day geometric mean and STV criteria attainment for the Draft Recommended Plan are included in Appendix J.

### Maximum *E. coli* Concentrations

**Figure 12-25** presents contour maps of the maximum *E. coli* concentrations in the 2050 TY for Baseline Conditions and for the Draft Recommended Plan under the All Sources scenario. As indicated in **Figure 12-25**, the magnitude and spatial distribution of the maximum *E. coli* concentrations for the two cases are generally similar, but differences can be discerned adjacent to outfall CAM017 and along the shoreline between outfall MWR019 and outfall MWR023/Muddy River where the maximum concentrations are lower. Under the Draft Recommended Plan, the maximum *E. coli* concentrations continue to be driven by the non-CSO sources.

As another way to visualize the impact of the Draft Recommended Plan on peak *E. coli* concentrations, **Figure 12-26** and **Figure 12-27** present plots of *E. coli* concentration versus time at two specific locations in the Charles River for Baseline Conditions and the Recommended Plan, for a period covering the storm that generated the largest CSO volume to the Charles River in the 2050 TY (the December 17$^{th}$ storm). The location in **Figure 12-26** corresponds to a model cell adjacent to the MWR023/Muddy River discharge, and the location in **Figure 12-27** corresponds to the end of the MWR020 outfall.

As indicated in **Figure 12-26**, the Draft Recommended Plan was predicted to slightly reduce the peak concentrations occurring on December 17 and December 18 near outfall MWR023 and the Muddy River outlet. The concentration peaks that occurred on December 14 and December 20 were associated with rain events that did not trigger CSO activations under the Baseline Conditions, so the Draft Recommended Plan did not affect those peaks.

As indicated in **Figure 12-27**, the Draft Recommended Plan was predicted to reduce the short-duration concentration spike on December 17 near outfall MWR020. The Draft Recommended Plan had minimal impact on the more prolonged and lower magnitude peak on December 19.

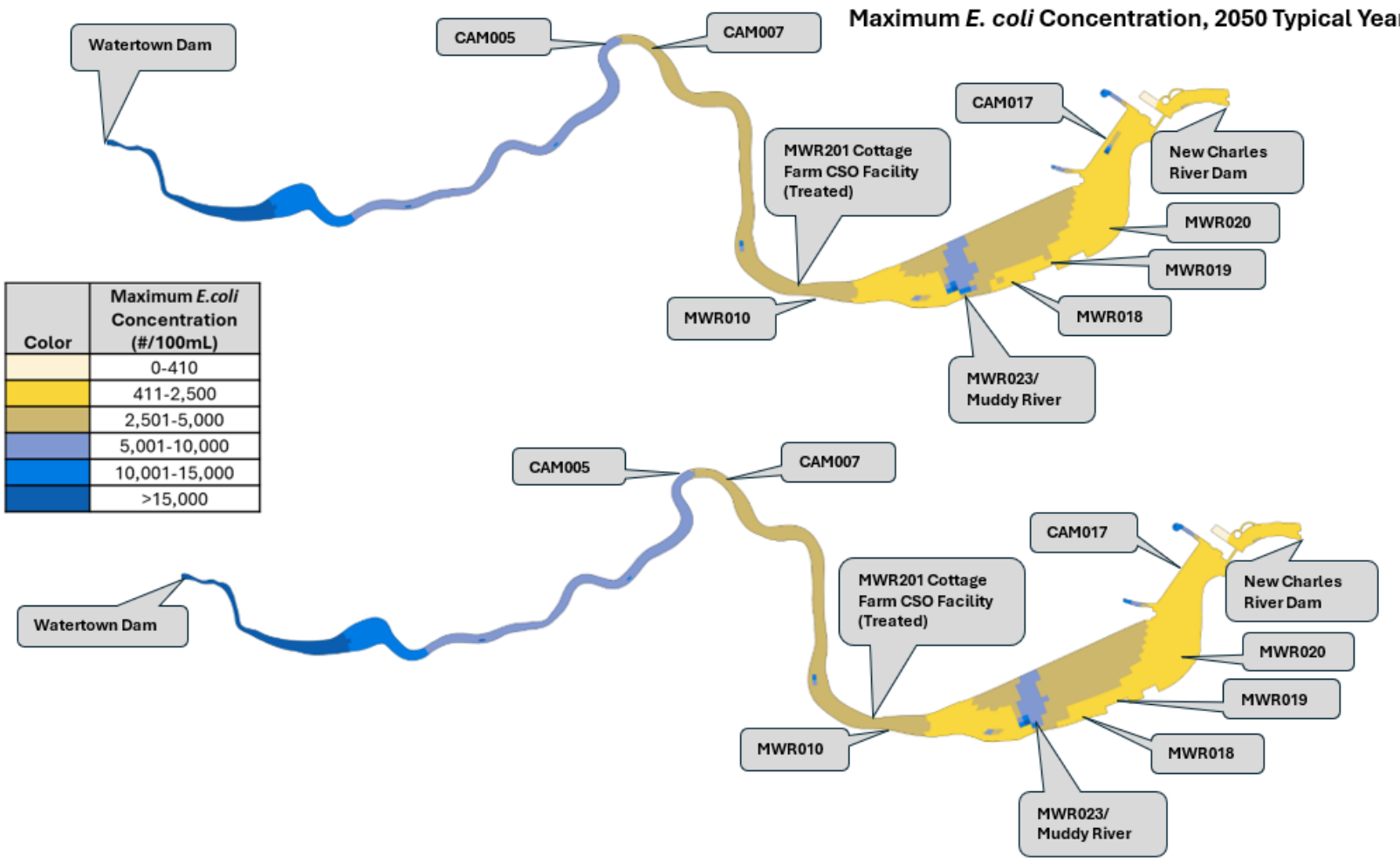



**Figure 12-25. Charles River Maximum *E. coli* Concentrations in 2050 Typical Year Baseline Conditions vs. Draft Recommended Plan, All Sources**

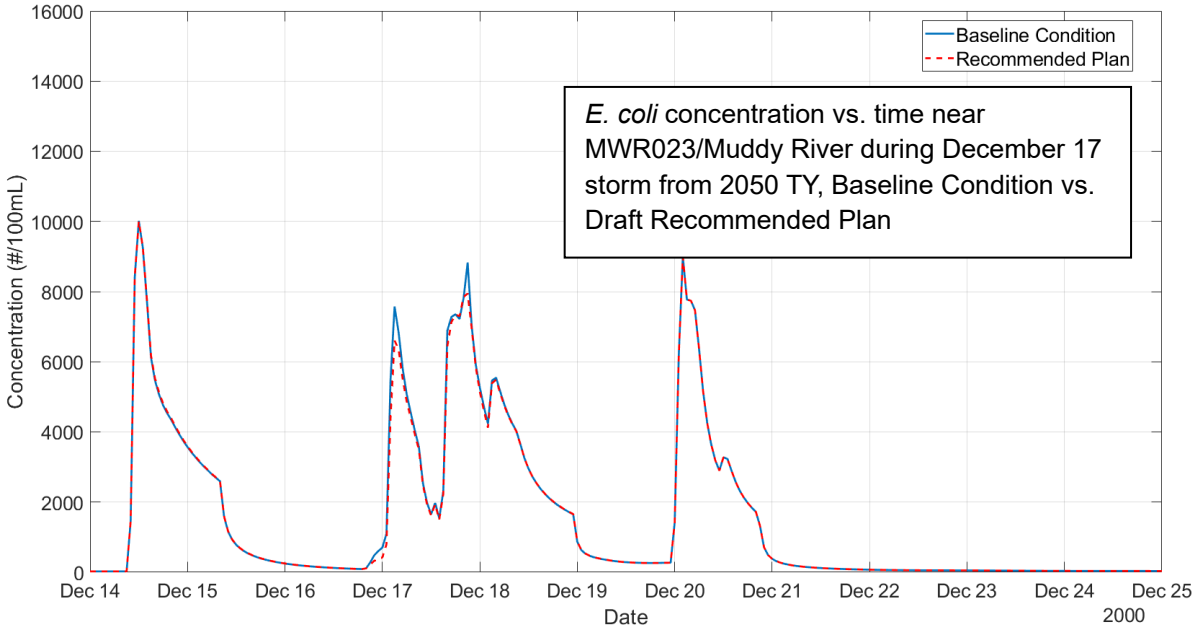



**Figure 12-26. *E. coli* Concentration vs. Time Near MWR023, Baseline Condition and Draft Recommended Plan, All Sources**

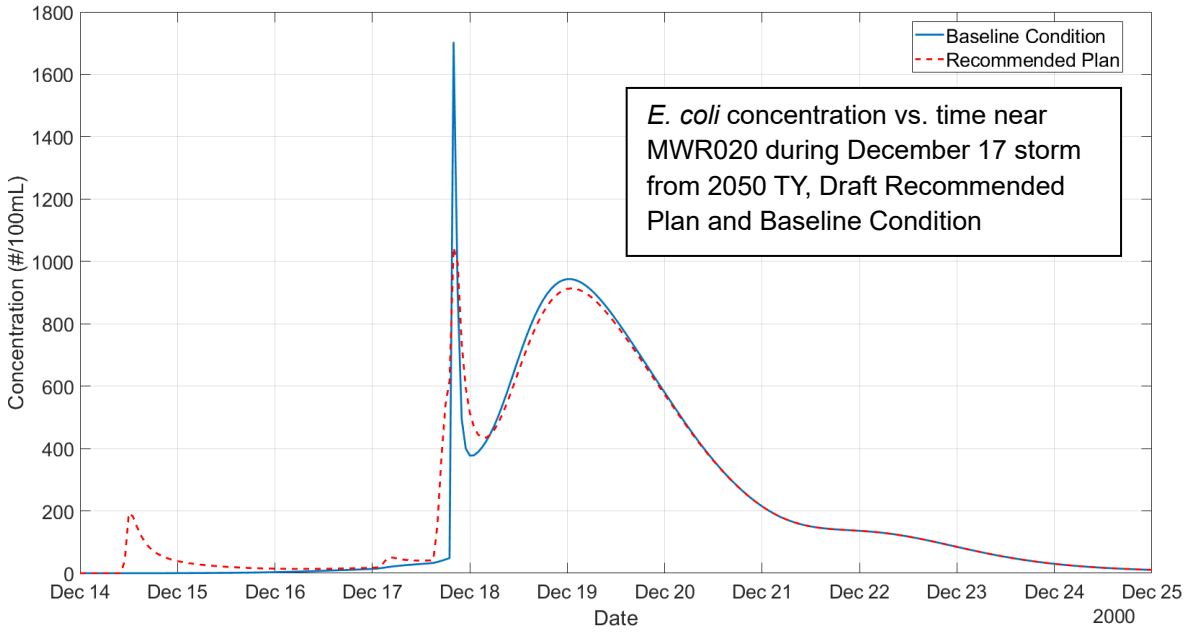



**Figure 12-27. *E. coli* Concentration vs. Time Near MWR020, All Sources, Baseline Condition and Draft Recommended Plan**

### *E. coli* Concentrations Over Time Following Storm Event

**Figure 12-28** presents a series of contour plots color coded by the *E. coli* concentrations at the peak of the December 17 storm from the 2050 TY and at intervals of 6, 12, 24, 48, and 72 hours following the peak, for the Draft Recommended Plan, All Sources. The December 17 storm generated the largest CSO volume to the Charles River in the 2050 TY.

Due to the format of these plots, it is somewhat cumbersome to compare to the Baseline Condition plots presented in **Figure 7-29** in Section 7. The plots are generally similar, but a locus of higher concentration at the peak of the storm adjacent to outfall CAM017 seen in the Baseline Conditions plot does not appear in the Draft Recommended Plan plot due to the draft recommended sewer separation project upstream of outfall CAM017. Similarly, the concentration plots slightly differ along the shoreline between outfalls MWR018 and MWR020 between the peak of the storm and hour 12 due to the draft recommended sewer separation project upstream of those outfalls. After hour 12, the plots are nearly identical. This is consistent with analysis performed in Section 7 (**Figure 7-30**) that evaluated the bacterial concentrations during the December 17th storm from CSO only. These figures showed that bacteria from CSOs only under baseline conditions would drop below the water quality criteria within 6 hours of the peak concentrations in the December 17th event.

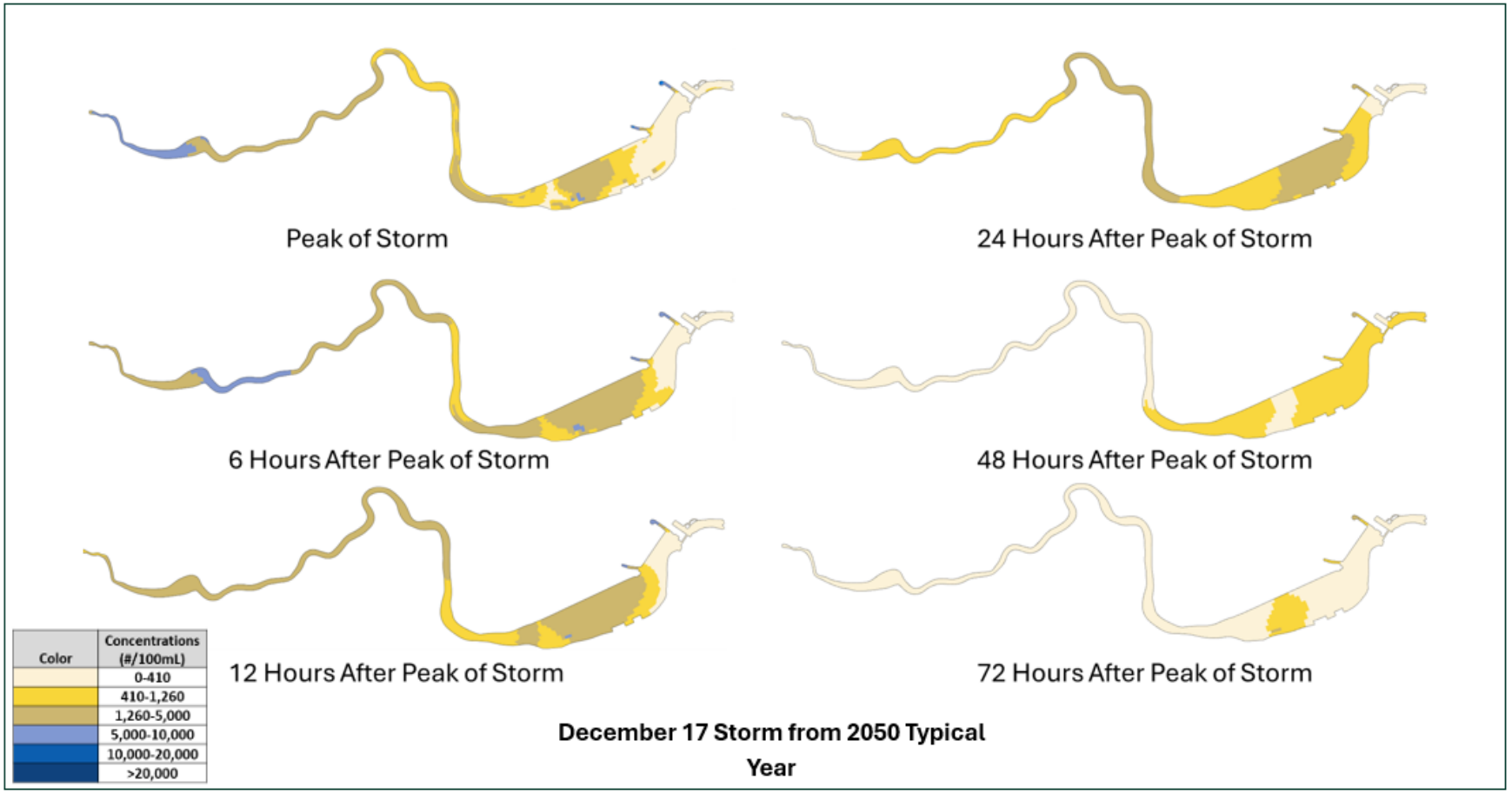



**Figure 12-28. Charles River *E. coli* Concentrations Over Time During and After the December 17 Storm from the 2050 Typical Year, Draft Recommended Plan, All Sources**

### Summary of the Draft Recommended Plan Water Quality Assessment for the Charles River

Key points from the water quality modeling assessment of the Draft Recommended Plan in the 2050 TY for the Charles River are summarized as follows:

- The Draft Recommended Plan is predicted to provide some reduction in localized peak *E. coli* concentrations in the Charles River associated with the elimination of the untreated CSOs in the 2050 TY. The highest peak concentrations without CSOs are predicted to remain in the areas downstream of the Watertown Dam and adjacent to the MWR023/Muddy River (tributary to the Charles River) discharge. Upstream sources continue to drive the peak *E. coli* concentrations below the Watertown Dam, and stormwater continues to drive the peak *E. coli* concentrations at the MWR023/Muddy River discharge[1].
- The Draft Recommended Plan is not predicted to substantially change the hours of exceedance of the MassDEP-recommended single sample maximum *E. coli* criterion of 410 #/100mL, or of the 30-day geometric mean or STV criteria in the Charles River in the 2050 TY due primarily to remaining stormwater and upstream loads.
- For storm events greater than those included in the 2050 TY, CSO volumes and durations will be reduced compared to baseline conditions and peak bacterial concentrations from this remaining CSO are predicted to be short term. Bacteria concentrations contributed by other sources are predicted to remain above the single sample maximum criteria after the concentrations from CSO have subsided.

## 12.4 Implementation Considerations

**Table 12-4** identifies the potential challenges to implementing the components of the Draft Recommended Plan for each of the projects organized by receiving water and outfall. This summarizes information presented in Section 9 and 10 on construction impacts, permanent impacts, and site acquisition/land ownership.

The table includes a summary of the construction period impacts and challenges including truck access, site constraints, depth of construction, permitting; and loss of public use; long term impacts including permanent above ground structures and maintenance activities; and Site Acquisition including Article 97 requirements. For each project, the Partners also consulted EJ Viewer (see Section 5) to understand the impacts of these projects to EJ communities. Using the EJ Viewer, the Partners identified if projects are located within the boundaries of an EJ population census block group. These communities may be impacted by the construction activities (short-term traffic/parking disruptions, noise, dust, etc.), and where there may be permanent impacts, they may be impacted by long-term maintenance and access.

[1] The Draft Recommended Plan would eliminate the CSO component from the BOS046 regulators in the discharge to the Muddy River from Boston Gatehouse No. 1 and would also eliminate overflows from the Old Stony Brook Conduit to the Muddy River via Boston Gatehouse No. 2 in the 2050 TY.

## Table 12-4. Implementation Considerations for Draft Recommended Plan

| Receiving Water | Outfall | Draft Recommended Plan by Outfall (2050 TY Level of Control) | Construction Period Impacts/ Challenges | Long-Term Impacts | Site Acquisition/Land Ownership | EJ Population Census Block Group(s) at the Project Location Based on the EJ Viewer |
|---|---|---|---|---|---|---|
| Alewife Brook | CAM001 | 8 acres sewer separation | • Construction will take place in densely populated residential area, including on private property. Residents and businesses in the area may experience construction disruptions.<br>• Outfall/regulator work on DCR/Article 97 land<br>• Access to portions of the Alewife Reservation | | • Sites for stormwater treatment and/or flow attenuation | • Minority |
| | CAM002 | No action because outfall does not activate in the 2050 TY | | | | |
| | CAM401A | Conveyance + 1.5 MG storage tank | • Public acceptance of CSO storage facility at the proposed location in the city-owned lot in a residential neighborhood, adjacent to a school<br>• Anticipated space and utility constraints for new 60-inch combined sewer along Sherman Street and Rindge Avenue<br>• Traffic impacts along Sherman Street and Rindge Avenue | • Long-term maintenance access to storage facility<br>• Potential odor complaints | • Site is owned by the City of Cambridge | • Minority<br>• Minority/Income/English Language Isolation |
| | CAM401B | 2.3 MG microtunnel to store CAM401B and SOM001A | • Constructing microtunneling shafts and diversion structures in Alewife Reservation will affect access to portions of the Reservation<br>• Truck access to sites along Alewife Brook Parkway<br>• Access to portions of the Alewife Reservation<br>• Loss of parking lot space at Dilboy Stadium during construction | • Long-term maintenance access to storage facility<br>• Permanent loss of parking space at Dilboy Stadium to accommodate the foot print of the dewatering pump station and odor control as well as space for maintenance access | • Microtunneling shafts and diversion structures in Alewife Reservation will require Article 97 legislation to authorize a change of use on sites under DCR control | • Minority,<br>• Minority and Income<br>• Minority and English Isolation |
| | MWR003 | 1.5 MG storage tank | • Construction of large tank with deep excavation in the Alewife Reservation, adjacent to wetlands and Alewife Brook<br>• Extensive permitting, management of groundwater, and excavation support will be required<br>• Current access to the MWR003 regulator is via a path off of the Fitchburg Cutoff Bikepath<br>• Site access for construction vehicles | • Above ground structures for dewatering and odor control facilities<br>• Truck access for long-term operation and maintenance | • DCR Owned Site would require Article 97 Legislation<br>• The compensatory open space would need to be of similar land type and size, within a similar geographic location and EJ designation. Payment in lieu of acquiring compensatory open space would be required if sufficient compensatory land could not be identified | • Minority |
| | SOM001A | Refer to CAM401B above. | | | | |
| Mystic River | MWR205A/ SOM007A | 95 acres ewer separation | • Sewer separation of 95 acres will take years to complete, and residents in the area may experience construction fatigue and disruptions during prolonged periods of time<br>• Construction of the proposed storm drain trunk across Mystic Avenue underneath the I-93 overpass will require detailed evaluation of geotechnical conditions and structural supports for the highway infrastructure<br>• Anticipated utility conflicts along the Mystic Avenue, Temple Street, and Fellsway West corridors | | • Easement negotiation with MassDOT for the crossing of Mystic Avenue and I-93 overpass with the proposed storm drain<br>• New storm outfall to the Mystic River on DCR owned site would require an easement | • Minority |

| Receiving Water | Outfall | Draft Recommended Plan by Outfall (2050 TY Level of Control) | Construction Period Impacts/ Challenges | Long-Term Impacts | Site Acquisition/Land Ownership | EJ Population Census Block Group(s) at the Project Location Based on the EJ Viewer |
|---|---|---|---|---|---|---|
| | | | • Site access for construction vehicles<br>• Traffic impacts<br>• Outfall work on DCR/Article 97 land | | | |
| | | 7.4 MG storage tank | • Construction of large tank with deep excavation adjacent to the Mystic River will require extensive management of groundwater and excavation support<br>• Construction impacts to the parking lot at the intersection of Grand Union Boulevard and the Fellsway West in Assembly Square<br>• Site access for construction vehicles<br>• Traffic impacts | • Permanent above ground structures will remain for the dewatering pump station and odor control facility which will require regulator maintenance | • The privately-owned site for the storage facility will need to be acquired<br>• Implementation on parkland would require Article 97 legislation to authorize a change of use of the site | • Minority |
| Charles River | CAM005 | 2.5 MG storage with underflow restrictions | • Construction of the large tank with deep excavation adjacent to the residences will require extensive management of groundwater and excavation support<br>• Truck traffic during construction will need to be managed to minimize impacts to residents and those using local roads and parking lot and adjacent neighborhoods | • Long-term maintenance access to storage facility<br>• Loss of parking from permanent facilities | • The privately-owned site for the storage facility will require property acquisition or obtaining an easement | • Minority |
| | CAM007 | No action because outfall does not activate in the 2050 TY | | | | |
| | MWR201 (Cottage Farm - Treated) | 10.1 MG storage tank | • Construction of the large tank with deep excavation adjacent to the Charles River will require extensive management of groundwater and excavation support<br>• Most of Magazine Beach Park will not be accessible to the public during the construction.<br>• Truck traffic during construction will need to be managed to minimize impacts to Memorial Drive and adjacent neighborhoods<br>• Tank construction within Magazine Beach Park will require coordination with Eversource who are working to install a major electrical duct bank through the park. Deep excavation adjacent to Charles River in Magazine Beach Park | • Permanent above ground structures will remain for the dewatering pump station and odor control facility which will require access for regular maintenance | • Construction on Magazine Beach Park would require Article 97 legislation to authorize the change of use of the site | • Minority |
| | MWR010 | No action because outfall does not activate in the 2050 TY | | | | |
| | MWR018<br>MWR019<br>MWR020 | 366 acres partial sewer separation | • Construction of large storm drains in Back Bay will likely encounter space constraints and utility conflicts, and create traffic impacts<br>• Construction will take place in densely populated residential and commercial areas over a long period. Residents and businesses in the area may experience construction fatigue and disruptions during prolonged periods of time<br>• Construction of large storm drains in Back Bay and microtunnels under BMC/Storrow Drive;<br>• Microtunneling and chamber construction will impact public use of the Charles River Esplanade, and may require removal of trees to perform the work.<br>• Sites have not been identified for stormwater treatment, stormwater pumping, or GSI | | • Construction under the BMC may require Article 97 legislation to authorize the change of use of the microtunnel shaft sites along the Esplanade<br>• Sites for stormwater treatment or pumping have not been identified | • Minority,<br>• Minority and Income<br>Minority, Income and English Isolation |

| Receiving Water | Outfall | Draft Recommended Plan by Outfall (2050 TY Level of Control) | Construction Period Impacts/ Challenges | Long-Term Impacts | Site Acquisition/Land Ownership | EJ Population Census Block Group(s) at the Project Location Based on the EJ Viewer |
|---|---|---|---|---|---|---|
| | CAM017 | 80 acres sewer separation | • Construction will take place in densely populated residential and commercial areas over a long period. Residents and businesses in the area may experience construction fatigue and disruptions during prolonged periods of time | | • Sites for stormwater treatment have not yet been identified | • Minority |
| | RE046-100 (MWR023) | 0.16 MG storage conduit | • Construction in a densely populated area with limited space<br>• Constructed in a public right of way adjacent to SW Corridor Park owned by MBTA<br>• Construction impacts to park<br>• Construction of the RE046-100 storage conduit will likely require lane closures along Lamartine Street, affecting traffic and local residents and businesses | • A small above ground structure will remain at the site permanently<br>• Long-term maintenance access to the storage facility will be needed | • An off-street site will need to be identified for a small above-ground structure | • Minority<br>• Minority and Income<br>• Minority, Income and English Isolation |
| | RE046-381 (MWR023) | 0.08 MG storage conduit | • Construction in a densely populated area with limited space<br>• Site access for construction vehicles<br>• Traffic impacts<br>• Construction impacts to park | • A small above ground structure will remain at the site permanently<br>• Long-term maintenance access to the storage facility will be needed | • The RE046-381 storage conduit would be constructed on land owned by MBTA adjacent to Johnson Park owned by DCR<br>• Some impacts to park during construction may require Article 97 legislation to authorize the change of use of the site | • Minority<br>• Minority and Income<br>• Minority, Income and English Isolation |

## 12.5 Implementation Timeframe

Overall implementation timeframes were developed for the Draft Recommended Plans for Alewife Brook, the Upper Mystic River and the Charles River. These timeframes were based on consideration of estimates of the duration for implementation of the individual projects that are included in the Draft Recommended Plans, and preliminary consideration of project sequencing constraints. Two key unknowns that could affect the duration of implementation for individual projects include site acquisition and permitting. Site acquisition is commonly initiated during a facilities planning phase to be completed before the design, while permitting typically requires advancement of the design but is intended to be completed during the project design phase. Specific challenges to be encountered with site acquisition and permitting, and the potential impacts on project schedules, are not typically known until the processes are started.

The specific sequencing of projects within the overall timeframe of the Draft Recommended Plan for each of the receiving waters has not yet been established. A number of factors need to be considered in establishing the sequencing of projects, including:

- Which Partner is responsible for project design and construction. At this time, the Partners are continuing to coordinate on establishing which Partner will be responsible for the design and construction of projects which will capture CSOs owned by multiple Partners.
- Which projects are expected to provide the greatest CSO reduction benefit in the shortest amount of time.
- The impact of projects on other hydraulically-connected projects. Projects may need to be sequenced to avoid short-term adverse impacts (e.g. the MWR003 storage tank needs to be constructed before the CAM401A hydraulic relief project to avoid a short-term increase in CSO at outfall MWR003).
- The potential for overlapping construction impacts resulting from projects being performed near one another (roadway grid lock, residential construction fatigue, etc.).
- The capacity of regional construction contractors to undertake simultaneous projects including items such as staffing, equipment availability, and ability to obtain bonds of high value.
- The financial capacity of the Partners to fund simultaneous projects and the staffing resources of the Partners to manage simultaneous projects.

Design for these projects is not expected to begin until after MassDEP and EPA approval of the Final Updated CSO Control Plan, with the exception of the following projects:

- CAM401A Storage Tank: Cambridge has begun design on this project, which would address the most frequently active CSO to Alewife Brook.
- SOM007A/MWR205A 95 acres of Sewer Separation: Somerville is already at the 60% design level for the 95 acres of sewer separation upstream of the Somerville Marginal CSO facility. This project alone is predicted to result in a 42% reduction in the annual treated CSO discharge to the Upper Mystic River, and some reduction may be achievable before the entire 95-acre area is separated. Construction of this project could begin upon completion of design, with City Council appropriation for construction and approval of associated rate increases.

**Table 12-5** presents the anticipated implementation timelines for each receiving water and an assessment of projects that may provide an early benefit.

**Table 12-5. Draft Recommended Plan Alternative Duration for Each Receiving Water**

| Receiving Water | Alternative Duration (years) | Opportunities for Early CSO Benefits |
|---|---|---|
| Alewife Brook | 18 | Construction of the CAM401A storage tank is planned to be built first providing early benefit. Full benefit will be achieved after conveyance is built. |
| Upper Mystic River | 20 | Potential early benefit as portions of the 95 acres of sewer separation are completed |
| Charles River | 25 | Potential early benefits after construction of microtunneling and major stormwater trunk lines are completed, enabling stormwater conveyance to the Charles River. For example, if one set of stormwater conveyance pipes including the microtunneled portion under Storrow Drive was completed, then the area tributary to that system could be separated, resulting in some CSO reduction before the full 366 acres is completed. |

**Note:**

(1) Alternative Duration is a preliminary estimate of the duration to design and construct all components of the alternative from the initiation of the alternative and does not account for delays that may be encountered (e.g. permitting and land acquisition). Timing and sequencing of individual projects is subject to debt financing, affordability, market forces (e.g. availability of construction crews), and other factors.

The schedule constraints imposed by the factors affecting the sequencing of projects could potentially affect the overall project duration. However, the Partners look forward to stakeholder comments and suggestions on the sequencing of projects, to be further refined, and a revised implementation schedule will be included in the final Updated CSO Control Plan.

## 12.6 Summary of Recommended Plan Projects

The components of the Draft Recommended Plan for Alewife Brook, Upper Mystic River, and the Charles River are summarized by outfall in **Table 12-6**. Estimated project costs are presented for each component, and the project costs are summed by waterbody and for all three waterbodies. These projects are predicted to result in zero treated or untreated discharges to Alewife Brook, Upper Mystic River, and the Charles River in the 2050 TY.

## Table 12-6. Summary of Draft Recommended Plan Components and Costs

| Outfall | Draft Recommended Plan by Outfall (2050 TY Level of Control) | Preliminary Capital Cost[1] ($Millions) |
|---|---|---|
| **Alewife Brook** | | |
| CAM001 | 8 acres of sewer separation upstream of outfall CAM001 in Cambridge | $15 M |
| CAM002 | No action because outfall does not activate in the 2050 TY | N/A[1] |
| CAM401A | 1.5 MG storage tank and additional conveyance to the MWRA interceptors for outfall CAM401A | $98 M |
| CAM401B | 5,400 linear foot, 9-foot diameter microtunneled storage conduit (2.3 MG capacity) to store the CSO from outfalls CAM401B and SOM001A | $170 M |
| MWR003 | 1.5 MG storage tank at outfall MWR003 | $52 M |
| SOM001A | Refer to CAM401B | Refer to CAM401B |
| **Subtotal Alewife Brook** | | **$340 M** |
| **Upper Mystic River** | | |
| SOM007A/ MWR205A | 95 acres of sewer separation upstream of outfall SOM007A/MWR205A in Somerville | $97 M |
| | 7.4 MG storage tank capturing the treated overflow from outfall SOM007A/MWR205A. | $160 M |
| **Subtotal Upper Mystic River** | | **$260 M** |
| **Charles River** | | |
| CAM005 | 2.5 MG stormwater storage tank and flow restriction upstream of outfall CAM005 in Cambridge | $83 M |
| CAM007 | No action; outfall does not activate in the 2050 TY | N/A[2] |
| MWR201 (Cottage Farm) | 10.1 MG storage tank to capture flows from the Cottage Farm CSO Facility in Cambridge | $190 M |
| MWR010 | No action; outfall does not activate in the 2050 TY | N/A |
| MWR018 | Separation of approximately 366 acres of runoff area tributary to the Boston Marginal Conduit and outfalls MWR018/019/020 in Boston | $320 M |
| MWR019 | | |
| MWR020 | | |
| MWR023 | 0.16 MG storage conduit to capture overflow from regulator RE046-100 upstream of outfall MWR023 in Boston | $11 M |
| | 0.08 MG storage conduit to capture overflow from regulator RE046-381 upstream of outfall MWR023 in Boston | $7.6 M |
| CAM017 | 80 acres of sewer separation upstream of outfall CAM017 in Cambridge | $77 M |
| **Subtotal Charles River** | | **$690 M** |
| **Grand Total, Alewife Brook, Upper Mystic River and Charles River** | | **$1,290 M** |

**Note:**

(1) Preliminary Capital Cost is described in Section 9.3. Costs for individual outfall projects are rounded to two significant figures; total alternative costs were rounded up to two significant figures and therefore may not match the sum.

# 13. Use Attainability Supporting Data and Information

Variance Condition F Item 5 in the 2024 Variances requires that "A Draft Updated CSO Control Plan, including a Recommended Plan, shall be submitted to MassDEP and EPA … including any documentation needed to support issuance of a Variance, or for changing the classification of any CSO-impacted receiving waters with Use Attainability Analyses" Further, MassDEP explained that this documentation should be submitted with the Draft Updated CSO Control Plan.

The intent of this section is to summarize key information from the previous sections and add supplemental information that may be helpful to MassDEP in developing a UAA.

The requirements for a UAA derive from the CWA section 101(a)(2), which set a national goal of fishable, swimmable waters "wherever attainable." Through their water quality standards, States establish "designated uses" for each water body or segment that consider the use and value of State waters for various beneficial purposes (e.g., public water supplies, recreation, navigation). EPA regulations provide for a structured, scientific assessment called "use attainability analysis" that defines six physical, chemical, biological, and economic factors that could justify "removing" a designated use associated with a particular water body or segment. State regulations provide that during the limited time period of a water quality variance, such as the variance granted to the Partners for CSO discharges to their receiving waters, the variance applicant must submit data that will allow the MassDEP to determine whether it may remove a national goal use that is not an existing use, or designate a segment as partial use.

As stated in Massachusetts' 1997 CSO Guidance, "the UAA is prepared by the Department (MassDEP), submitted to EPA and must be approved prior to any further action to reclassify a segment."

The EPA (Use Attainability Analysis and the Use Revision Process | US EPA) provides step-by-step guidance to help states, authorized tribes, and territories establish or revise designated uses by addressing the steps and questions they should consider while conducting a Use Attainability Analysis (UAA). The guidance notes that "In general, a UAA is required when revising designated uses related to protecting aquatic life, wildlife, and recreation in and on the water specified in Clean Water Act (CWA) section 101(a)(2)... 40 CFR 131.10 details when a UAA is required and the specific requirements for establishing and revising designated uses."

The EPA guidance suggests the following documentation be provided for a UAA (locations where this information is provided in Section 13 are indicated in parentheses):

A. Document the existing uses and data used to determine the existing uses. **(Sections 13.2.2, 13.3.2. 13.4.2)**

B. Explain how the state evaluated the attainability of the designated use. **(Section 13.1.32)**

C. Document the stressors which limit the ability of the designated use. **(Sections 13.2.3, 13.3.3. 13.4.3)**

D. Name the feasible activities and/or controls that would address the stressors impacting the attainability of the designated use and the extent to which they would address the stressors (recommended plan). **(Sections 13.2.4, 13.3.4. 13.4.4)**

E. Explain why the feasible activities and/or controls would not lead to attainment of the designated use. **(Sections 13.2.4, 13.3.4. 13.4.4)**

F. Identify and demonstrate which factor listed in 40 CFR 131.10(g) precludes attainment of the designated use. **(Sections 13.2.5, 13.3.5. 13.4.5)**

G. Explain how the state determined the highest attainable use. **(Sections 13.2.4, 13.3.4. 13.4.4)**

Expanding upon Item F above, as stated in 40 CFR 131.10(g):

*"States may designate a use, or remove a use that is not an existing use, if the State conducts a use attainability analysis as specified in paragraph (j) of this section that demonstrates attaining the use is not feasible because of one of the six factors in this paragraph. If a State adopts a new or revised water quality standard based on a required use attainability analysis, the State shall also adopt the highest attainable use, as defined in § 131.3(m).*

1. *Naturally occurring pollutants prevent the attainment of the use; or*
2. *Natural, ephemeral, intermittent, or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating State water conservation requirements to enable uses to be met; or*
3. *Human-caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or*
4. *Dams, diversions, or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in a way that would result in the attainment of the use; or*
5. *Physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, pool, riffles, and the like, unrelated to water quality preclude the attainment of aquatic life protection uses; or*
6. *Controls more stringent than those required by sections 301(b) and 306 of the (Clean Water) Act would result in substantial and widespread economic and social impact."*

The Massachusetts water quality standards regulations contain similar language regarding the factors that would justify changing a waterbody use at 314 CMR 4.03(4)(a).

The preceding sections of this Updated CSO Control Plan provide detailed information on water quality conditions in the Alewife Brook, Upper Mystic River, and Charles River, and the relative contributions of various sources to non-attainment of water quality criteria. Also provided are the evaluations of alternatives to further reduce CSOs to these waterbodies, and a proposed recommended plan that would contribute to the highest attainable use. **The intent of this section is to summarize key information from the previous sections and add supplemental information that may be helpful to MassDEP in developing a UAA.** This section will also include, as required in the Variances, water quality information and documentation to inform MassDEP's future decision making related to SWQS.

This section is organized as follows:

- **Section 13.1**: Water Quality Standards that Currently Apply to CSO-Impacted Waters and Methodology for Assessing Attainment
- **Section 13.2**: Information in Support of a UAA for Alewife Brook, including:
  - **Section 13.2.1** Description;
  - **Section 13.2.2** Existing Uses;
  - **Section 13.2.3** Stressors Limiting Attainment of Water Quality Standards;

  - **Section 13.2.4** Recommended Plan; and
  - **Section 13.2.5** Factors that Could Support a Change in Water Quality Status.
- **Sections 13.3** and **13.4**: Information in Support of a UAA for Upper Mystic River and the Charles River, respectively, organized similar to **Section 13.2**; and
- **Section 13.5**: References.

## 13.1 Applicable Water Quality Standards and Methodology for Assessing Attainment

### 13.1.1 Applicable Water Quality Standards

Surface water quality standards in the state of Massachusetts include two components: designated uses, and water quality criteria intended to support those uses. As described in Section 2, the Alewife Brook, the Upper Mystic River, and the Charles River are all currently under water quality variances for CSO discharges from MWRA and the Cities of Cambridge and Somerville. A variance is a temporary modification of the surface water quality standards, granted by MassDEP "for a specified period of time for a particular discharger and for specific pollutants so that it can be determined through a Use Attainability Analysis whether uses can be attained" (314 CMR 4.03(4)(c)). The water quality standards that have been temporarily modified for the Alewife Brook, Upper Mystic River, and the Charles River were associated with "Class B" inland waters that are "designated as a habitat for fish, other aquatic life, and wildlife, including for their reproduction, migration, growth and other critical functions, and for primary and secondary contact recreation" (314 CMR 4.05(3)(b)). For these three waterbodies, the Class B designation includes a "CSO" qualifier, indicating that the waters have been "identified as impacted by the discharge of combined sewer overflows; however, a long term control plan has not been approved or fully implemented for the CSO discharges" (314 CMR 4.06(1)(d)(10)).

No bathing beaches are identified in the Massachusetts Department of Public Health Beaches Dashboard (Interactive Beach Water Quality Dashboard | Mass.gov) along the Alewife Brook, Upper Mystic River, or in the Charles River downstream of the Watertown Dam. As discussed later in this section, informal swimming and wading has been observed at the upstream end of the Upper Mystic River and periodic swimming events have been organized for the Charles River.

Accordingly, the water quality criteria for Class B waters that would be applicable to the Alewife Brook, Upper Mystic River, and the Charles River absent the variances are presented in Table 2-1. The "CSO" qualifier attached to these waterbodies triggers the "reduced interval" requirements at 314 CMR 4.05(5)(f)(3)(a)(ii), which specify the criteria shown in **Table 13-1** to be calculated "over a 30-day or smaller interval".

**Table 13-1. Existing Class B Bacterial Surface Water Quality Criteria**

| Indicator Bacteria[1] | Geometric Mean (#/100mL)[2] | Statistical Threshold Value (90th Percentile) (#/100mL) [2][3] |
|---|---|---|
| *E. coli* | ≤126 | ≤410 |
| *Enterococcus* | ≤35 | ≤130 |

**Notes:**

(1) Criteria from 314 CMR 4.05(5)(f)(1)(c).

(2) For inland waterbodies with "CSO" qualifier per 314CMR4.06(1)(d)(10), the criteria "shall be calculated … over a 30-day or smaller interval" per 314 CMR 4.05(5)(f)(3)(a)(ii).

(3) No more than 10% of all samples collected within [the specified interval] shall exceed the statistical threshold value for this indicator.

As described above in Section 7, the water quality criteria for bacteria defined in 314 CMR 4.05 do not include a single sample maximum. However, MassDEP recommended that the Updated CSO Control Plan include an assessment of attainment with a single sample maximum value based on the 90th percentile STV for *E. coli* and *Enterococcus* (See Section 7 for further discussion). Based on the direction from MassDEP, the water quality assessments for the Alewife Brook, Upper Mystic River, and the Charles River included attainment with a single sample maximum criterion of 410 #/100mL for *E. coli* and 130 #/100mL for *Enterococcus*.

### 13.1.2 Consideration of Sensitive Uses

As described in Section 2, the CSO Control Policy identifies the requirements for preparing a CSO LTCP. Among other requirements, the CSO Control Policy states that "EPA expects a permittee's long-term CSO control plan to give the highest priority to controlling overflows to sensitive areas." (Policy at II.C.3). The policy goes on to identify sensitive uses to include:

- Outstanding National Resource Waters;
- National Marine Sanctuaries;
- Waters with threatened or endangered species or their habitats;
- Waters with primary contact recreation;
- Public drinking water intakes or their designated protection areas; and
- Shellfish beds.

Available data sources were reviewed to assess whether the sensitive uses listed in the CSO Policy were applicable to either the Alewife Brook, Upper Mystic River, or Charles River. The findings of this assessment are described in the following subsections.

#### Outstanding National Resource Waters

In Massachusetts, "Outstanding Resource Waters (ORW)" are defined as water bodies that are "those waters that are designated for protection as Outstanding Resource Waters under 314 CMR 4.04(3). Outstanding Resource Waters are assigned at the discretion of the Department (MassDEP), as appropriate" (314 CMR 4.06(1)(d)(2)). ORW include, but are not limited to:

- Public Water Supplies (314 CMR 4.06(1)(d)(1);
- Wetlands bordering Class A Outstanding Resource Waters, vernal pools, and all wetlands bordering other Class B, SB or SA Outstanding Resource Waters, to the boundary of the defined area (314 CMR 4.06(1)(d)(2); and
- Active and inactive reservoirs approved by the Department's (MassDEP's) Drinking Water Program after December 29, 2006 as a source of public water supply (314 CMR 4.06(1)(d)(2).

Based on the map included in the MassGIS website for Outstanding Resource Waters (Outstanding Resource Waters | MassGIS Data Hub), no ORW were identified in the Charles River below the Watertown Dam, Alewife Brook, or the Upper Mystic River.

#### National Marine Sanctuaries

The National Marine Sanctuary System is governed by the National Oceanic and Atmospheric Administration (NOAA) and includes 18 underwater parks spanning over 629,000 square miles of ocean and Great Lakes waters. From the NOAA website, the nearest National Marine Sanctuary to the Alewife Brook, Upper Mystic River, and Charles River is the Stellwagen Bank National Marine Sanctuary, located in the Atlantic Ocean from Cape Ann to north of Cape Cod Bay (NOAA Office of National Marine

Sanctuaries). Thus, the Alewife Brook, Upper Mystic River, and Charles River are not part of the National Marine Sanctuary System.

### Waters with Threatened or Endangered Species or Their Habitats

Information available from the Natural Heritage and Endangered Species Program (NHESP), the United States Fishery and Wildlife Service (USFWS), and the NOAA Section 7 Mapper related to the presence of threatened or endangered species or their habitats in the Alewife Brook, Upper Mystic River, and Charles River, is summarized in **Table 13-2**. As indicated in **Table 13-2**, all three waterbodies were identified as diadromous fish migratory habitat. A small area along Alewife Brook upstream of outfall MWR003 was identified as "Priority Habitat of Rare Species". The USFWS website identified the potential for certain species as noted in **Table 13-2** to be found in the specified areas but did not identify the presence of "critical habitat". The NOAA Section 7 mapper did not identify endangered species in the Alewife Brook, Upper Mystic River, and Charles River.

**Table 13-2. Information on Threatened and/or Endangered Species Habitats within the Charles River, Alewife Brook and Upper Mystic River**

| Waterbody | Information Source | | |
|---|---|---|---|
| | NHESP | USFWS(1) | NOAA Section 7 Mapper |
| **Alewife Brook** | Diadromous Fish Migratory Habitat.<br>MassGIS Data: Diadromous Fish \| Mass.gov<br>Priority Habitat of Rare Species. (2)<br>MassMapper - search, display, query and download MassGIS geospatial data | Proposed Endangered: Tricolored bat.<br>Proposed Threatened: Monarch Butterfly<br>No critical habitat.<br>IPaC: Explore Location resources | No threatened or endangered species listed in the NOAA Section 7 Mapper are located within Alewife Brook.<br>ESA Section 7 Mapper |
| **Upper Mystic River** | Diadromous Fish Migratory Habitat.<br>MassGIS Data: Diadromous Fish \| Mass.gov | Endangered: Roseate tern.<br>Proposed Endangered: Tricolored bat.<br>Proposed Threatened: Monarch Butterfly<br>No critical habitat.<br>IPaC: ExIPplore Location resources | No threatened or endangered species listed in the NOAA Section 7 Mapper are located within the Upper Mystic River.<br>ESA Section 7 Mapper |
| **Charles River** | Diadromous fish migratory habitat.<br>MassGIS Data: Diadromous Fish \| Mass.gov | Endangered: Northern long-eared bat, Roseate tern.<br>Proposed Endangered: Tricolored bat.<br>Proposed Threatened: Monarch Butterfly<br>No critical habitat.<br>IPaC: Explore Location resources | No threatened or endangered species listed in the NOAA Section 7 Mapper are located within the Charles River between the Watertown Dam and the New Charles River Dam.<br>ESA Section 7 Mapper |

**Notes:**

(1) USFWS only provides the potential for species listed to be found in the specified area. A survey by a USFWS-approved biologist would need to be conducted to confirm the presence of the listed species.

(2) The name of the rare species for which priority habitat was identified is not listed on NHESP website. The particular species associated with any identified priority habitat is not offered publicly, in order to protect the species. An informational request would need to be filed with Mass Wildlife to access this information.

### Waters with Primary Contact Recreation

Prior to the issuance of the Variances, the Alewife Brook, and Upper Mystic River, and Charles River were all classified as Class B waters, with primary contact recreation defined as a designated use. The Variances allow limited CSO discharges from the permitted MWRA, Cambridge and Somerville CSOs to these waterbodies. During wet weather events where the limited CSO discharges are authorized, Class B water quality criteria may not be met.

The EPA *Water Quality Standards Handbook Chapter 2: Designation of Uses* states that "Primary contact recreation usually includes swimming, water-skiing, skin-diving, surfing, and other activities likely to result in immersion" (EPA 2012). The Massachusetts Department of Public Health Interactive Beach Water Quality Dashboard[1] does not identify bathing beaches along the Alewife Brook, Upper Mystic River, or Charles River. As discussed later in this section, informal swimming and wading has been observed at the upstream end of the Upper Mystic River and periodic swimming events have been organized for the Charles River.

### Public Drinking Water Intakes or Their Designated Protection Areas

According to the MassGIS public water supply data map, neither the Charles River below the Watertown Dam, Alewife Brook nor the Upper Mystic River are designated as public water supply or protected areas (MassGIS Data: Public Water Supplies | Mass.gov).

#### Shellfish beds

Shellfish beds are designated as habitats that can potentially be used as shellfish growing areas. The Designated Shellfish Growing Areas (DSGA) are defined by the Massachusetts Department of Fish and Game Division of Marine Fisheries. Based on the GIS data map provided in the MassGIS database, no DSGAs are identified in the Charles River below the Watertown Dam, Alewife Brook or the Upper Mystic River (MassGIS Data: Designated Shellfish Growing Areas | Mass.gov).

### Summary of Consideration of Sensitive Uses

**Table 13-3, Table 13-4, and Table 13-5**. summarize the status of the sensitive use categories for the Alewife Brook, Upper Mystic River, and Charles River, respectively.

[1] Interactive Beach Water Quality Dashboard | Mass.gov

## Table 13-3. Alewife Brook Sensitive Use Assessment

| Sensitive Area Classification or Designation | Presence/Status of Classification | Source(s)/Justifications |
|---|---|---|
| Outstanding National Resource Water | No | Alewife Brook is not classified as an Outstanding Resource Water (ORW) according to MassGIS data. Outstanding Resource Waters \| MassGIS Data Hub |
| National Marine Sanctuaries | No | Alewife Brook is not located within a National Marine Sanctuary. Stellwagen Bank National Marine Sanctuary |
| Waters with Threatened or Endangered Species and their Habitat | Yes | NHESP, USFWS, NOAA Section 7 Mapper |
| Waters with Primary Contact Recreation | Yes(1) | Designated Uses for Class B waters are listed under 314 CMR 4.05(3)(b) |
| Public Water Supply Intake or Protected Area | No | Alewife Brook is not used as a water supply source MassGIS Data: Public Water Supplies \| Mass.gov |
| Shellfish Bed | No | No designated shellfish beds are located along Alewife Brook. MassGIS Data: Designated Shellfish Growing Areas \| Mass.gov |

**Note:**
(1) These waters were Class B but are currently covered under the Alewife Brook/Upper Mystic River Variance, which allows excursions from Class B criteria due to CSO discharges from MWRA and the Cities of Cambridge and Somerville where limited CSO discharges are authorized.

## Table 13-4. Upper Mystic River Sensitive Use Assessment

| Sensitive Area Classification or Designation | Presence/Status of Classification | Source(s)/Justifications |
|---|---|---|
| Outstanding National Resource Water | No | The Upper Mystic River is not classified as an Outstanding Resource Water (ORW) according to MassGIS data. Outstanding Resource Waters \| MassGIS Data Hub |
| National Marine Sanctuaries | No | The Upper Mystic River is not located within a National Marine Sanctuary. Stellwagen Bank National Marine Sanctuary |
| Waters with Threatened or Endangered Species and their Habitat | Yes | NHESP, USFWS, NOAA Section 7 Mapper |
| Waters with Primary Contact Recreation | Yes(1) | Designated uses for Class B waters are listed under 314 CMR 4.05(3)(b) |
| Public Water Supply Intake or protected area | No | The Upper Mystic River is not used as a water supply source. MassGIS Data: Public Water Supplies \| Mass.gov |
| Shellfish Bed | No | No designated shellfish beds are located on the Upper Mystic River. MassGIS Data: Designated Shellfish Growing Areas \| Mass.gov |

**Note:**
(1) These waters were Class B but are currently covered under the Alewife Brook/Upper Mystic River Variance, which allows excursions from Class B criteria due to CSO discharges from MWRA and the City of Somerville where limited CSO discharges are authorized.

**Table 13-5. Charles River Sensitive Use Assessment**

| Sensitive Area Classification or Designation | Applicability of Classification | Source(s)/Justifications |
|---|---|---|
| Outstanding National Resource Water | No | The Charles River is not classified as an Outstanding Resource Water (ORW) according to MassGIS data. Outstanding Resource Waters \| MassGIS Data Hub |
| National Marine Sanctuaries | No | The Charles River is not located within a National Marine Sanctuary. NOAA Office of National Marine Sanctuaries |
| Waters with Threatened or Endangered Species and their Habitat | Yes | NHESP, USFWS, NOAA Section 7 Mapper |
| Waters with Primary Contact Recreation | Yes(1) | Designated uses for Class B waters are listed under 314 CMR 4.05(3)(b). |
| Public Water Supply Intake or Protected Area | No | The Charles River is not used as a water supply source. MassGIS Data: Public Water Supplies \| Mass.gov |
| Shellfish Bed | No | No designated shellfish beds are located on the Charles River. MassGIS Data: Designated Shellfish Growing Areas \| Mass.gov |

**Note:**
(1) These waters were Class B but are currently covered under the Charles River Variance, which allows excursions from Class B criteria due to CSO discharges from MWRA and City of Cambridge CSOs where limited CSO discharges are authorized.

### 13.1.3 Methodology to Evaluate the Attainment of the Designated Use/Water Quality Criterion

As described in Sections 6 and 7, water quality models were the primary tools used to assess attainment with numerical water quality criteria for bacteria for the Alewife Brook, Upper Mystic River and Charles River. The Alewife Brook/Upper Mystic River model is a one-dimensional model based on the InfoWorks ICM software. The model includes a hydrodynamic part, which calculates water levels and cross-section-averaged velocities, and a water quality part, which calculates cross-section-averaged *E. coli* and *Enterococcus* counts. The model extends from the Amelia Earhart Dam to the Lower Mystic Lake and covers Alewife Brook in its entirety (**Figure 13-1**).

The Charles River model is a horizontally two-dimensional model based on the Delft3D software. The model includes a hydrodynamic part, which calculates water levels and depth-averaged velocities, and a water quality part, which calculates depth-averaged *E. coli* and *Enterococcus* counts. The model extends from the New Charles River Dam and locks to the Watertown Dam (**Figure 13-1**).

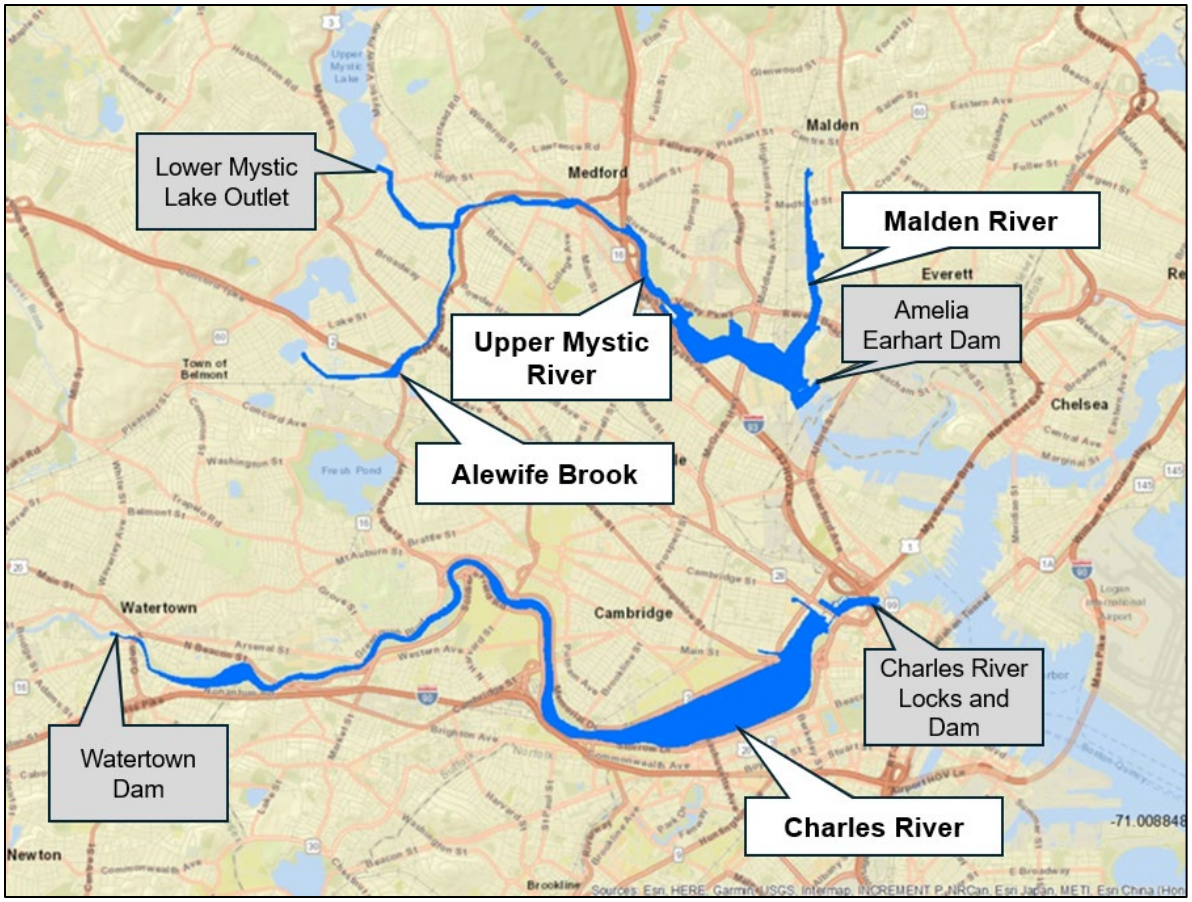



**Figure 13-1. Extent of the Charles River and Alewife Brook/Upper Mystic River Models**

The sources of flows and bacteria loads into Alewife Brook, the Upper Mystic River and the Charles River as represented in the models included the following:

- Stormwater;
- Untreated and treated CSO;
- Dry weather base flow (infiltration flow from storm drains or groundwater flow directly to a waterbody; could also include flow from illicit sanitary connections to storm drains); and
- Boundary conditions (flow into the study area from upstream).

These models were originally developed and calibrated in support of MWRA's Final CSO Post Construction Monitoring Program and Performance Assessment Report submitted to MassDEP and EPA in 2021. The models were then updated to support this Updated CSO Control Plan.

The baseline water quality assessments for the Alewife Brook/Upper Mystic River and the Charles River were based on a continuous simulation of the 2050 TY rainfall, with the system conditions as represented by the Baseline System Conditions version of the Unified Model as described in Section 7. Output from the baseline assessments include tabulations of the volumes and bacterial loadings from the various bacteria sources for the 2050 TY, and graphical representations of the model output.

The model output was assessed for attainment with single sample maximum, 30-day geometric mean, and 30-day STV criteria. The following additional assessments of water quality impacts were conducted:

- Model output plots were developed showing the maximum predicted concentrations in the waterbodies for All Sources, Non-CSO Sources, and CSO Sources Only.
- Model output plots were developed showing the change in predicted concentrations in the waterbodies over time following a storm event, for the All Sources condition.

The sections below summarize information that MassDEP could potentially use in support of UAAs for Alewife Brook, the Upper Mystic River and the Charles River, including descriptions of the waterbodies, existing uses, stressors limiting attainment of water quality standards, the proposed recommended plan, and applicable factors that would support a potential change in water quality status.

## 13.2 Alewife Brook

### 13.2.1 Description

The Alewife Brook is a relatively narrow, shallow stream that runs along the boundary between the town of Arlington and the cities of Cambridge and Somerville. The upstream end of Alewife Brook terminates at the outlet headwall for the Wheeler Street drain behind the Alewife MBTA station. This drain receives CSO from CAM401A, as well as separate stormwater. CAM401A is the most upstream CSO that discharges to Alewife Brook. The Little River feeds into Alewife Brook a short distance downstream of the Wheeler Street/CAM401A headwall. MWR003 discharges to the Little River just upstream of Alewife Brook. Alewife Brook discharges into the Upper Mystic River just downstream of the Mystic Valley Parkway bridge over Alewife Brook.

Historically, Alewife Brook was a meandering, tidally influenced stream that connected to Fresh Pond and a large marshy area known as the Great Swamp. In the 1800's, a variety of industries began to be established along Alewife Brook, including tanneries, slaughterhouses, and glue factories. Brickmaking became an important industry extending into the early 1900's, with many clay pits dug to support the industry. These uses, in conjunction with expanded farming, led to the draining of large portions of the original Great Swamp. In the early 1900's, construction of the Craddock Dam in Medford mostly isolated Alewife Brook from tidal influences. Between 1909 and 1912, the formerly meandering Alewife Brook was straightened and channelized (MDC 2003).

The land immediately adjacent to both sides of Alewife Brook and the Little River is part of the Alewife Reservation, under the jurisdiction of the Massachusetts Department of Conservation and Recreation (DCR). The Alewife Greenway Bike Path runs parallel to Alewife Brook through the reservation. The Minuteman Bikeway terminates at the reservation near the Alewife MBTA station, and transitions to the Fitchburg Cutoff Path and the Alewife Linear Path.

### 13.2.2 Existing Uses

From general observation, passive recreation along the bike paths that run parallel to Alewife Brook appears to be the most common use on or along the banks of Alewife Brook. The bike paths are heavily used in all seasons and under a range of weather conditions. The pathways through the constructed wetland adjacent to the Little River are also very popular. The athletic fields, tennis and basketball courts and DCR-owned, Somerville operated pool at and adjacent to Dilboy Field support a variety of land-based recreational uses. The occasional kayaker may venture up Alewife Brook, but parts of the brook can be obstructed by deadfalls, branches, and low bridges, making headway difficult.

Fishing has not been a commonly observed activity along Alewife Brook. As described in the 2003 MDC Alewife Reservation & Alewife Brook Master Plan:

> *"Most of the native fish species that once would have lived and bred in the Alewife waters are no longer found in the system. Fish such as brook trout, brown bullhead, and white perch have been replaced by nonnative species such as largemouth bass and common carp, the dominant fish at Alewife…*
>
> *Small numbers of alewife and blue-back herring still manage to migrate up Alewife Brook and Little River to spawn in Little Pond and Wellington Brook. Where siltation has reduced stream depth to less than 12 inches, water temperature tends to be too high for many native fish species…Common carp, which tend to fare better under these warm, shallow, and low-water-quality conditions, appear to consume most of the aquatic vegetation that does manage to grow in the stream channels"* (MDC 2003).

The Massachusetts Department of Public Health Bureau of Climate and Environmental Health Freshwater Fish Consumption Advisory List[2] identifies a limitation for consumption of carp from Alewife Brook and the Little River due to PCBs.

The conditions in Alewife Brook do not support swimming and/or wading. In addition to chronically high bacteria counts, the generally shallow water depths would preclude swimming, and the concrete channelization and mucky sediments discourage wading.

### 13.2.3 Stressors Limiting Attainment of Water Quality Standards

Multiple stressors affect attainment of water quality criteria and designated uses for Alewife Brook. Physical modifications to Alewife Brook and its hydrology constructed over 100 years ago has hampered its ability to support primary contact recreation and fish propagation. In addition, the construction of downstream dams altered the hydrology and habitat of the once tidal stream. As noted above, the brook is generally too shallow for swimming, and the channelization and bottom muck discourage wading. Canoeing and kayaking is possible, but difficult due to navigation hazards. The relatively warm, shallow waters of Alewife Brook and the concrete channelized bank create a challenging habitat for fish, favoring highly tolerant species such as carp. Legacy contamination from previous industries, in particular PCBs, has resulted in fish advisories for carp in Alewife Brook. The sediments have also been listed for lead, copper and chronic toxicity.

The altered hydrology and physical configuration have also contributed to periodic flooding of Alewife Brook during large rain events. The overbank flooding can affect use of the bike paths along Alewife Brook, and the floodwaters would likely have high bacteria counts due to CSO, stormwater, and other sources of bacteria.

As noted in Section 2, the Massachusetts 303(d) List[3] includes Alewife Brook under "Category 5 – Waters requiring a TMDL". The Alewife Brook impairments are identified in the Integrated List for Alewife Brook (MassDEP 2023) (Refer to Table 2-3 in Section 2). The listed impairments have been organized into the following general categories, although they may fall under more than one category:

- **Nutrients/eutrophication-related:** dissolved oxygen, total phosphorus, transparency/clarity;
- **Aesthetic**: debris, odor, scum/foam, trash flocculant masses;
- **Residual toxic chemical-related**: PCBs in fish tissue, sediment bioassay [chronic toxicity freshwater] copper in sediment, lead in sediment, oil and grease, chloride;

[2] Massachusetts Department of Public Health

[3] https://www.mass.gov/doc/final-massachusetts-integrated-list-of-waters-for-the-clean-water-act-2022-reporting-cycle/download

- **Invasive species:** water chestnut; and
- **Bacteriological:** *Enterococcus, E. coli*.

The water quality model for Alewife Brook allows for the evaluation of *E. coli* and *Enterococcus* concentrations in Alewife Brook but does not address the other pollutants or stressors identified on the 303(d) List.

As described in Section 6, bacteria concentrations were applied to the various flow sources to Alewife Brook to create the time-varying bacterial mass loading inputs to the water quality model. The stormwater and baseflow bacteria concentrations, and the sanitary and non-sanitary components of CSO used to compute the time-varying CSO concentrations for the Alewife Brook CSOs are presented in **Table 13-6** (information in this table appeared in Table 6-5 in Section 6).

**Table 13-7** presents the flow-weighted sanitary fraction and the flow-weighted average counts of *E. coli* and *Enterococcus* in each of the CSO discharges to Alewife Brook and the Upper Mystic River for the 2050 TY (information in this table appeared in Table 6-6 in Section 6). Section 7 presents information on modeled bacteria loadings to Alewife Brook under Baseline Conditions for the 2050 TY, as well as the modeled impact of those loadings on bacteria concentrations in Alewife Brook. Tables and Figures from Section 7 demonstrating water quality impacts during wet weather for Alewife Brook are presented below.

**Table 13-6. Water Quality Model Parameters – Alewife Brook**

| Bacteria | Stormwater Counts (#/100 mL) | Dry Weather Baseflow Counts (#/100 mL) | CSO Sanitary Fraction Counts (#/100 mL) | CSO non-Sanitary Fraction Counts (#/100 mL) |
|---|---|---|---|---|
| *E. coli* | 25,000 | 134 | 2,500,000 | 14,000 |
| *Enterococcus* | 6,700 | 45 | 1,000,000 | 6,700 |

**Table 13-7. Alewife Brook CSO Predicted Sanitary Fractions and Flow-weighted Counts for the 2050 Typical Year**

| Location | Flow-weighted Sanitary Fraction (%)(1) | 2050 Typical Year Baseline Conditions Flow-weighted Counts (#/100 mL) | |
|---|---|---|---|
| | | *E. coli* | *Enterococcus* |
| MWR003 | 4.3 | 130,493 | 49,038 |
| CAM401A | 0.1 | 27,225 | 7,593 |
| CAM401B | 10.5 | 284,032 | 110,658 |
| CAM002 | N/A(2) | N/A | N/A |
| CAM001 | 36.5 | 927,207 | 368,786 |
| SOM001A | 1.5 | 62,470 | 21,738 |

**Notes:**

(1) For each untreated CSO outfall, the sanitary fraction shown is the flow weighted average in the discharge pipe over the periods when the outfalls were discharging flow.

(2) N/A = Not applicable; outfall did not discharge CSO during the 2050 TY.

### Baseline Conditions Volumes and Loadings

**Table 13-8** presents a summary of the 2050 TY Baseline Conditions volumes and *E. coli* loads to Alewife Brook (this table appeared as Table 7-6 in Section 7). As indicated in **Table 13-8**, the single largest source of volume to Alewife Brook is the continuous dry weather flow, with stormwater the next largest source. **CSOs contribute less than 1% of the total annual volume. In terms of *E. coli* loading, separate stormwater is the predominant source at just under 80%.** The sanitary component of CSO contributes 10% of the total annual load, and the stormwater component of CSO contributes another 8%.

**Table 13-8. Alewife Brook 2050 Typical Year Baseline Conditions Volumes and *E. coli* Loads**

| | Alewife Brook 2050 Typical Year Baseline Conditions | | | |
|---|---|---|---|---|
| | *Volume* | | *E. coli* | |
| *Source* | Volume (MG) | Percent of Total | Loading (counts x $10^{12}$) | Percent of Total |
| Untreated CSO(1) | 21 | 0.9% | Sanitary Component: 25<br>Stormwater Component: 20 | 10%<br>8% |
| Treated CSO(2) | N/A | N/A | N/A | N/A |
| Stormwater | 216 | 9% | 204 | 78% |
| Dry Weather(3) | 2,269 | 91% | 12 | 4% |
| Boundary(4) | N/A | N/A | N/A | N/A |
| **Total** | **2,506** | **100%** | **260** | **100%** |

**Notes:**
(1) Untreated CSO includes a sanitary sewage component and a stormwater component.
(2) No treated CSOs discharge to Alewife Brook.
(3) Dry weather sources include continuous dry weather flows from tributary brooks and storm drains.
(4) Upstream flows into Alewife Brook were categorized as stormwater in the model, and a unique "boundary" flow was not defined.

### Baseline Conditions Attainment of Single Sample Maximum Criterion

Based on direction from MassDEP, the Alewife Brook/Upper Mystic River water quality model was used to assess attainment with single sample maximum criteria equal to the existing 30-day STV criteria of 410 #/100mL for *E. coli* and 130 #/100mL for *Enterococcus*.

The single sample maximum criteria were assessed using two approaches. The first approach computed percent attainment based on the proportion of modeled time in which bacterial concentrations at every defined segment along the linear model remained below the single sample maximum criterion. This approach presents a conservative assessment of the condition of the river, as the model segments where exceedances occur shift in time, and the extent of exceedance may be only a fraction of the total river length.

To address the spatial variability of bacteria concentrations, a second approach included creating longitudinal plots of hours of criteria exceedance along Alewife Brook and the Upper Mystic River for the individual model segments. With these plots, the percent of time that each individual river segment meets the single sample maximum criteria could be assessed. Because the timing of concentrations varies for each segment, the percent attainment for each individual segment would generally be higher than the percent attainment of the river as a whole computed using the first approach.

**Table 13-9** summarizes the percent attainment of the single sample maximum criteria for both *E. coli* and *Enterococcus* for the 2050 TY, using the first approach described above (this table appeared as Table 7-8 in Section 7). As indicated in **Table 13-9**, for both *E. coli* and *Enterococcus*, **no differences were**

**predicted in the percent attainment for All Sources compared to Non-CSO Sources for Alewife Brook. Thus, elimination of CSO would not change this assessment of attainment.** Attainment with Stormwater Only was only a few percentage points higher than All Sources. With CSOs Only, annual attainment was 99% for Alewife Brook.

**Table 13-9. Alewife Brook Percent Annual Attainment of the Single Sample Maximum Criteria for the 2050 Typical Year**

| Percentage Time Entire Modeled Alewife Brook Meets the Single Sample Maximum Criteria(1) – 2050 Typical Year Baseline Conditions | | | | | | | |
|---|---|---|---|---|---|---|---|
| *E. coli* (410 #/100mL) | | | | *Enterococcus* (130 #/100mL) | | | |
| All Sources | Non-CSO Sources | CSO Only | Stormwater Only | All Sources | Non-CSO Sources | CSO Only | Stormwater Only |
| 41% | 41% | 99% | 43% | 42% | 42% | 99% | 45% |

**Notes:**

(1) Based on guidance from MassDEP, model results were analyzed for a single sample maximum equivalent to the value of the Class B STV Criterion for bacteria.

**Figure 13-2** shows the Alewife Brook and Upper Mystic River with stationing values at major landmarks. This is presented to orient the reader to the locations and distances indicated in the subsequent plots.




**Figure 13-2. Alewife Brook and Mystic River Landmarks and Distances**

**Figure 13-3** presents a longitudinal plot of the number of hours in the 2050 TY that the maximum *E. coli* concentration is above the MassDEP-recommended single sample maximum criterion (410 #/100mL) under the All-Sources scenario. The Y-axis also shows the values as a percentage of the total hours in the 2050 TY (8,784 total hours). This figure provides a more nuanced assessment of the spatial distribution of attainment of the single sample maximum criterion. As indicated in **Figure 13-3**, the single sample maximum criterion for *E. coli* is exceeded in Alewife Brook for approximately half of the total hours in the 2050 TY.

**Figure 13-4** is a similar plot for the Non-CSO Sources condition. In comparing **Figure 13-3** and **Figure 13-4**, it is apparent that eliminating the CSO loads would not affect the spatial distribution of the duration of exceedance of the *E. coli* single-sample maximum criterion.

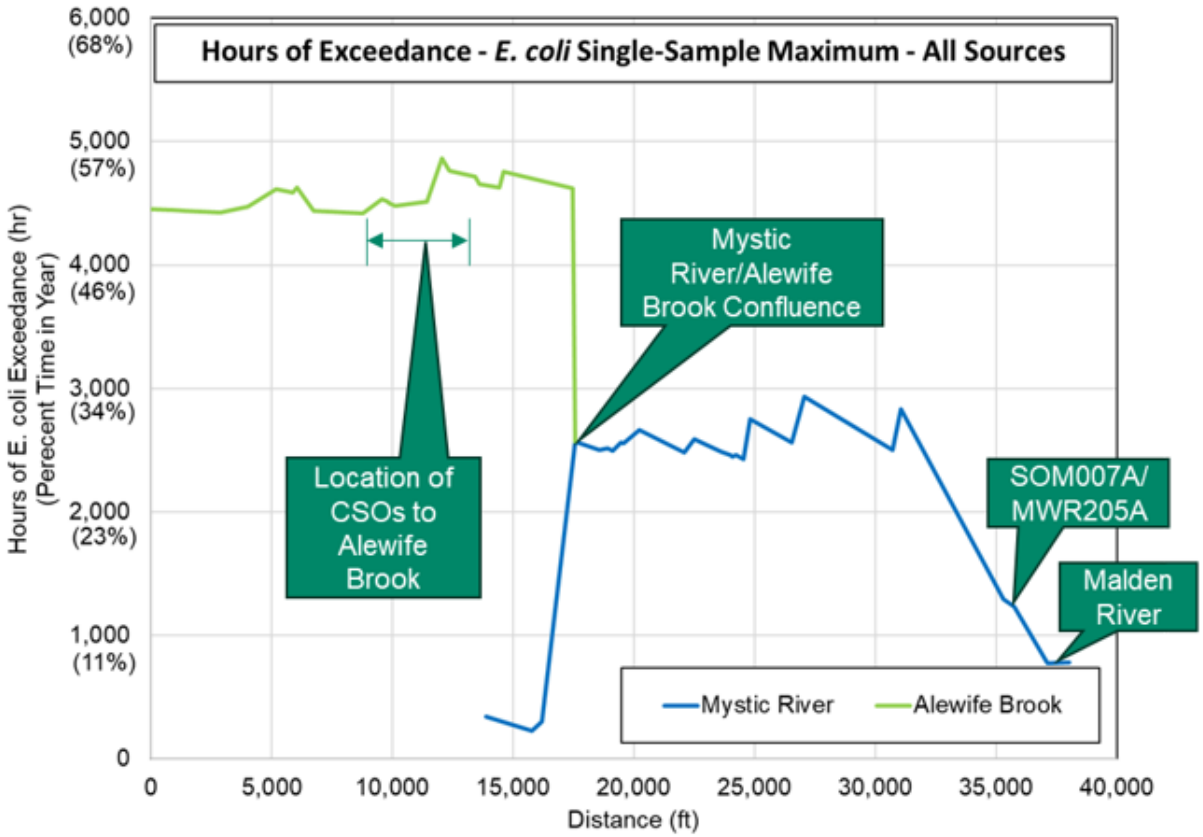



**Figure 13-3. Alewife Brook/Upper Mystic River Hours of Exceedance of *E. coli* Single Sample Maximum Criterion, 2050 Typical Year Baseline Conditions All-Sources**

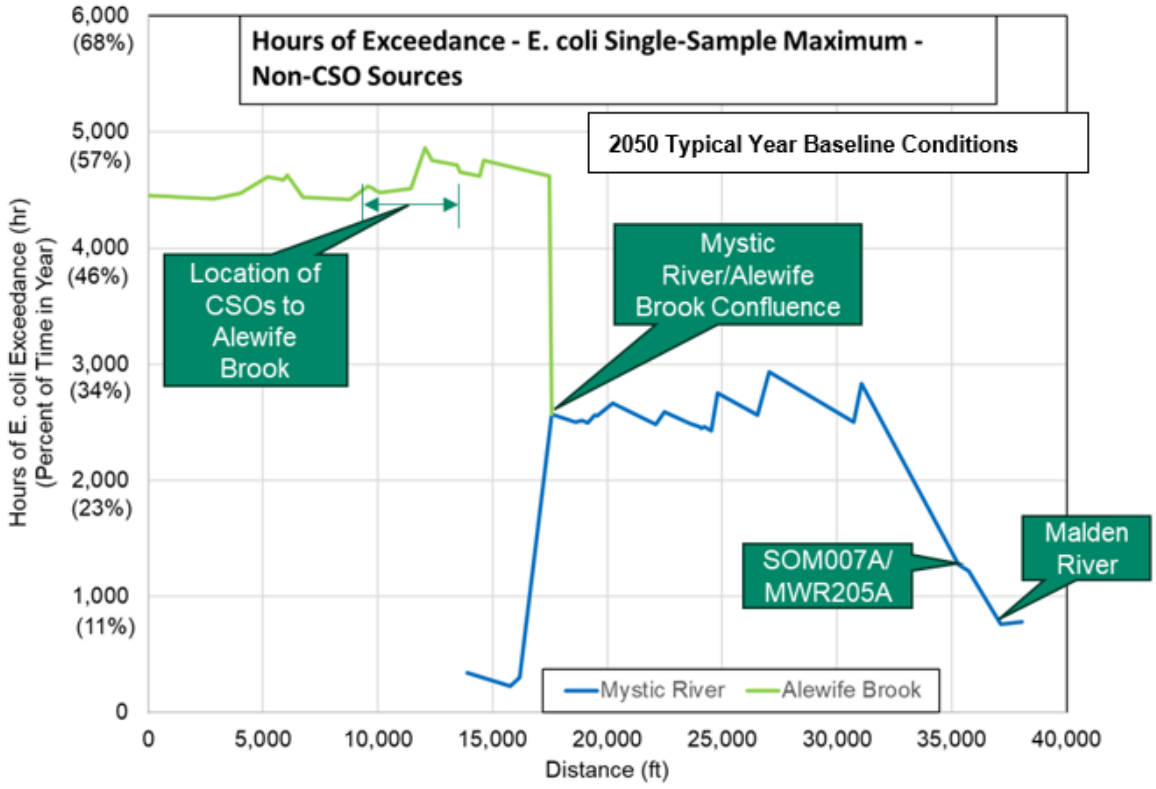



**Figure 13-4. Alewife Brook/Upper Mystic River Hours of Exceedance of *E. coli* Single Sample Maximum Criterion, 2050 Typical Year Baseline Conditions Non-CSO Sources**

**Figure 13-5** presents the duration of exceedance of the *E. coli* single-sample maximum criterion for the condition of CSO loads, only. Note that the Y-axis scales on **Figure 13-2** and **Figure 13-5** are different. As indicated in **Figure 13-5**, with only CSO loadings, the maximum duration of exceedance of the criterion in Alewife Brook would be approximately 50 hours.

Based on **Figure 13-2** to **Figure 13-5**, controlling the non-CSO sources of *E. coli* to Alewife Brook would be necessary to substantially reduce the hours of exceedance of the single sample maximum criterion in those waterbodies.

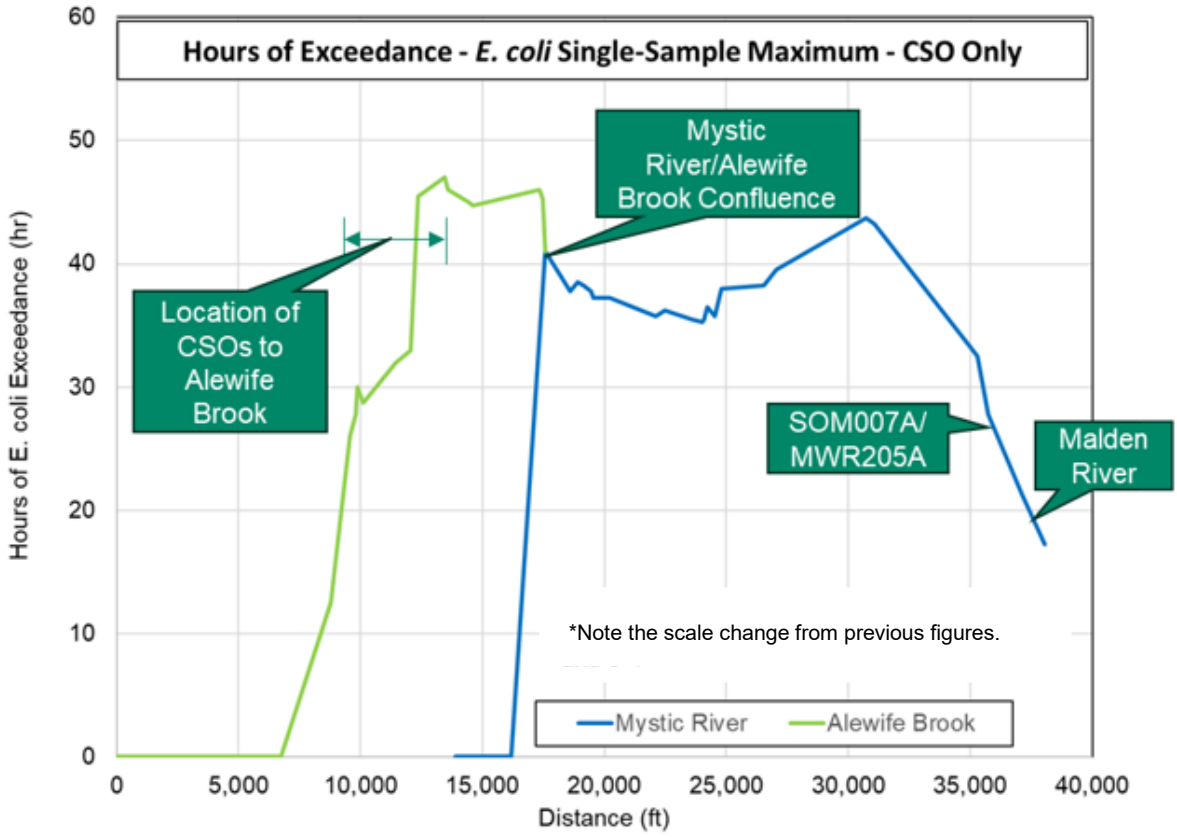



**Figure 13-5. Alewife Brook/Upper Mystic River Hours of Exceedance of *E. coli* Single Sample Maximum Criterion, 2050 Typical Year Baseline Conditions CSO Only**

### Baseline Conditions Attainment of 30-Day Geometric Mean and STV Criteria

**Figure 13-6** and **Figure 13-7** present plots of the percent of the time over the 2050 TY that each modeled segment was in compliance with the 30-day *E. coli* geometric mean criterion, for two simulation scenarios: All-Sources, and Non-CSO Sources Only.

As indicated in these figures, in Alewife Brook, the 30-day geometric mean criterion for *E. coli* is exceeded for the entire 8,784-hour duration of the 2050 TY for All Sources and for Non-CSO Sources only. The plots are essentially identical, indicating that CSOs have no impact on attainment of the 30-day geometric mean criterion for *E. coli*.

**Figure 13-8** and **Figure 13-9** present of plots of the percent of the time over the 2050 TY that each modeled segment was in compliance with the 30-day *E. coli* STV criterion, for two simulation scenarios: All-Sources, and Non-CSO Sources.

As indicated in **Figure 13-8** and **Figure 13-9**, in Alewife Brook, the 30-day STV criterion for *E. coli* is exceeded for the entire 8,784-hour duration of the 2050 Typical Year for All Sources and for Non-CSO Sources only. The plots are essentially identical, indicating that CSOs have no impact on attainment of the 30-day STV criterion for *E. coli*.

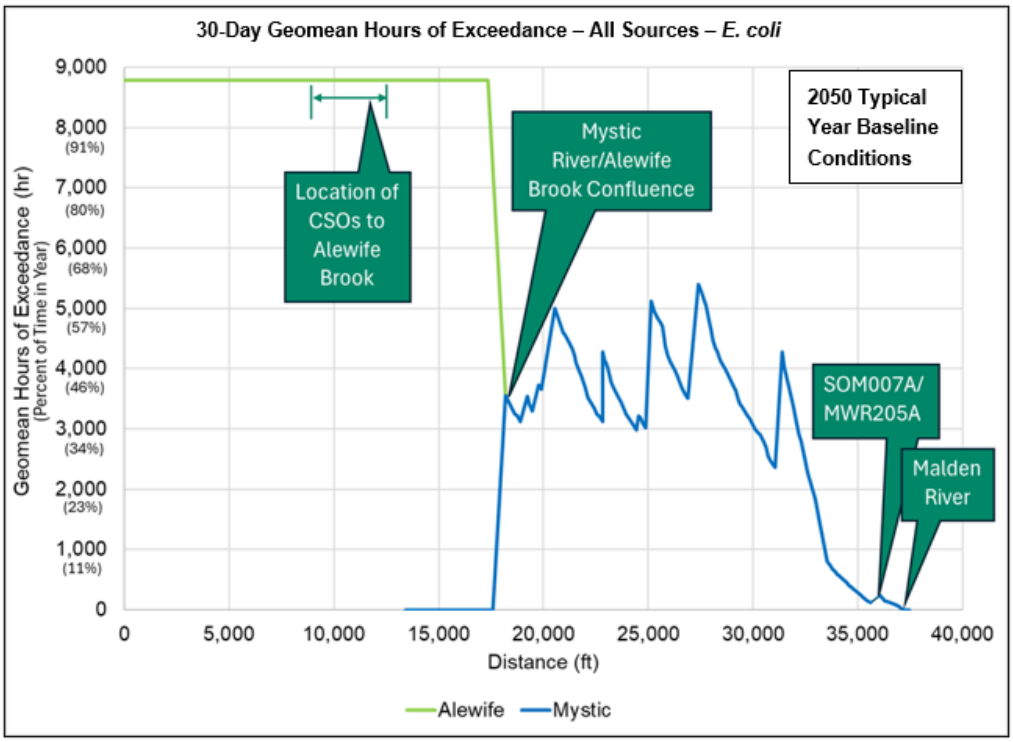



**Figure 13-6. Hours of Exceedance of E. coli 30-Day Geometric Mean Criterion, 2050 Typical Year Baseline Conditions, All Sources**

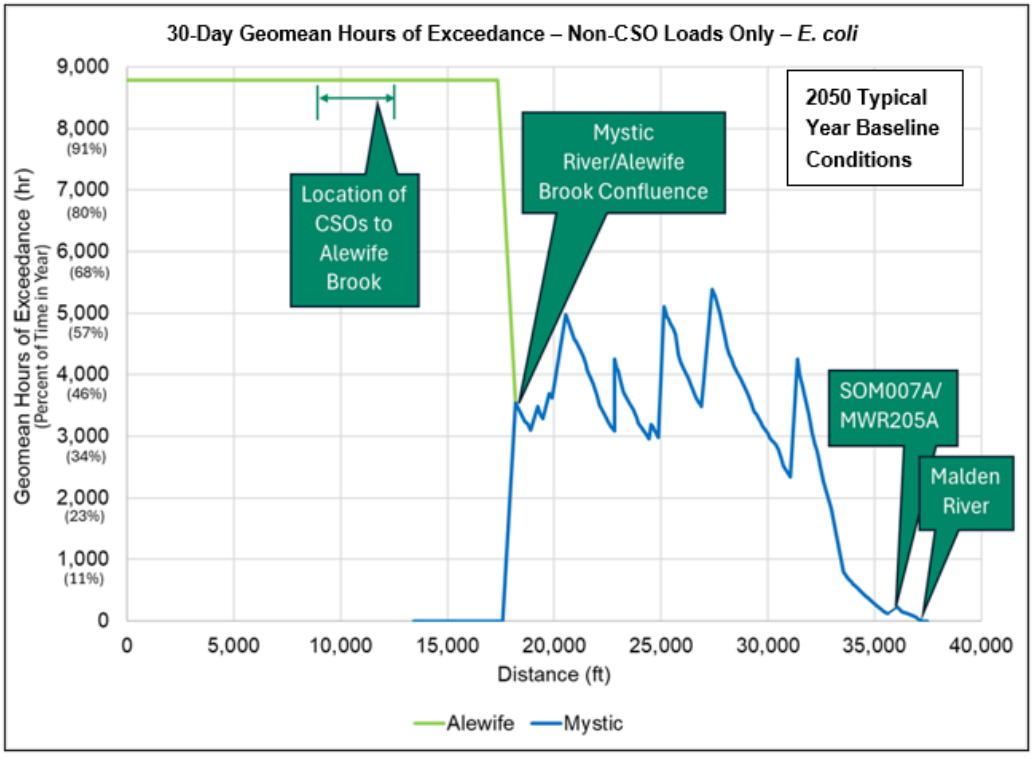



**Figure 13-7. Hours of Exceedance of *E. coli* 30-Day Geometric Mean Criterion, 2050 Typical Year Baseline Conditions, Non-CSO Sources**

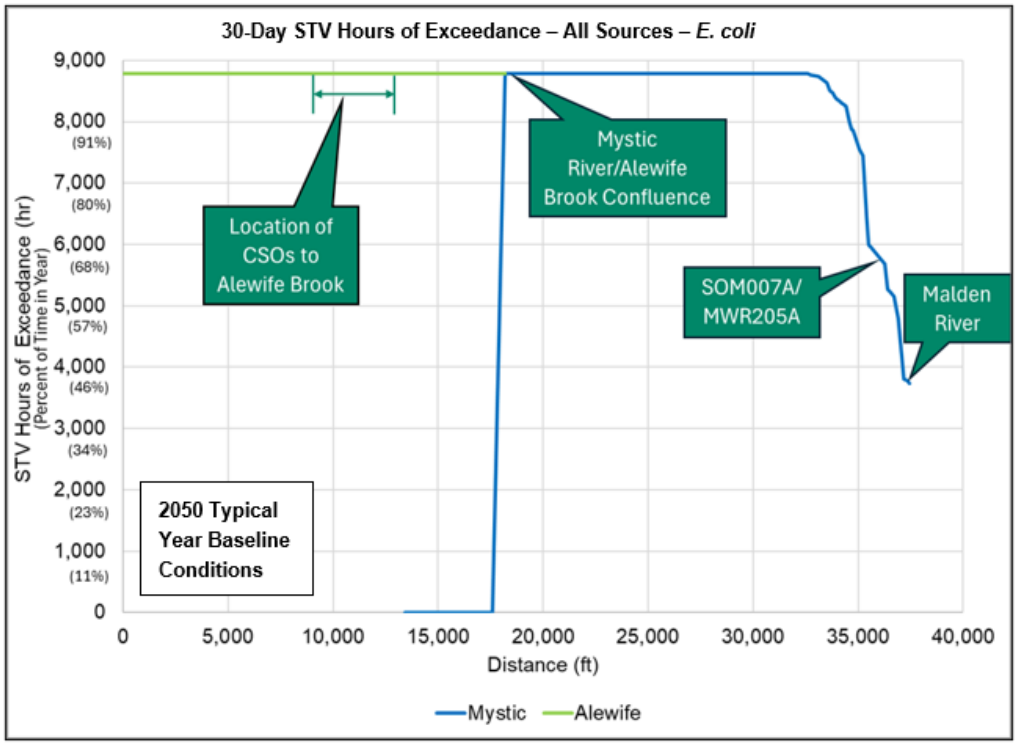



**Figure 13-8. Hours of Exceedance of *E. coli* 30-Day STV Criterion, 2050 Typical Year Baseline Conditions, All Sources**

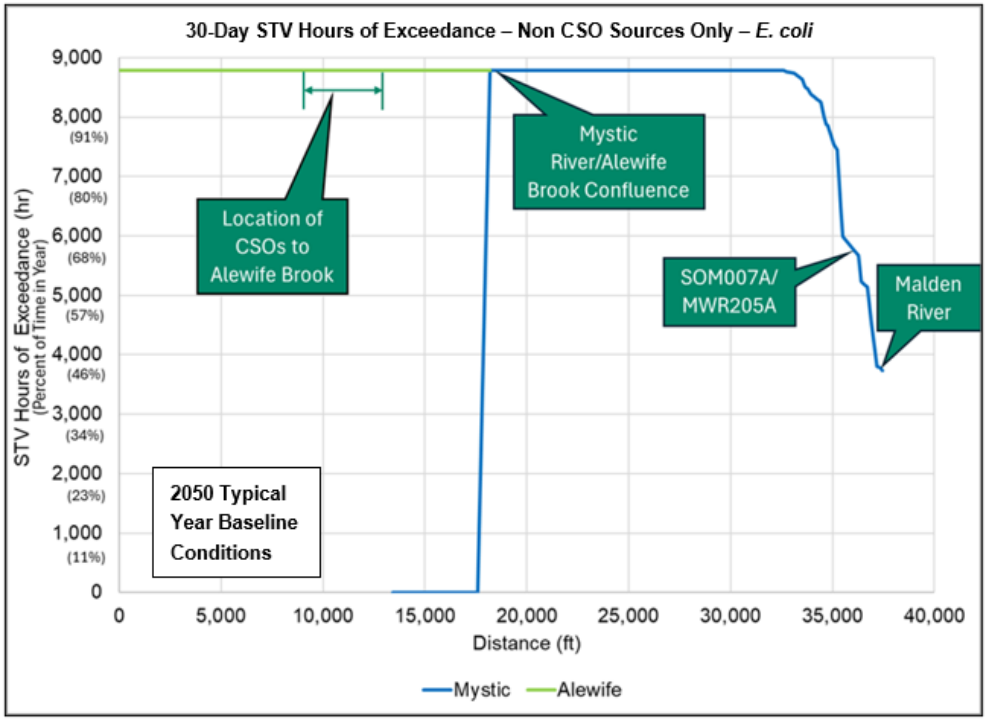



**Figure 13-9. Hours of Exceedance of *E. coli* 30-Day STV Criterion, 2050 Typical Year Baseline Conditions, Non-CSO Sources**

### Baseline Conditions Assessment of Maximum *E. coli* Concentrations and Duration of Impact

While the preceding sections demonstrated the relatively limited impact of CSOs on attainment of water quality criteria over the 2050 TY, those assessments do not reflect the short-term impacts of CSOs on water quality during the periods of time when the CSOs are discharging. One approach to assessing those short-term impacts is by plotting the maximum concentrations at each model segment in Alewife Brook under conditions of All Sources versus Non-CSO Sources Only (**Figure 13-10**; this figure appeared as Figure 7-19 in Section 7). As indicated in **Figure 13-10**, elimination of CSO loads in the 2050 TY would result in substantial reductions in the peak *E. coli* concentrations in Alewife Brook. The peak *E. coli* concentrations for the Non-CSO Sources condition would, however, still be substantially higher than the MassDEP-recommended single sample maximum criterion of 410 #/100mL, due mostly to the remaining stormwater loadings.

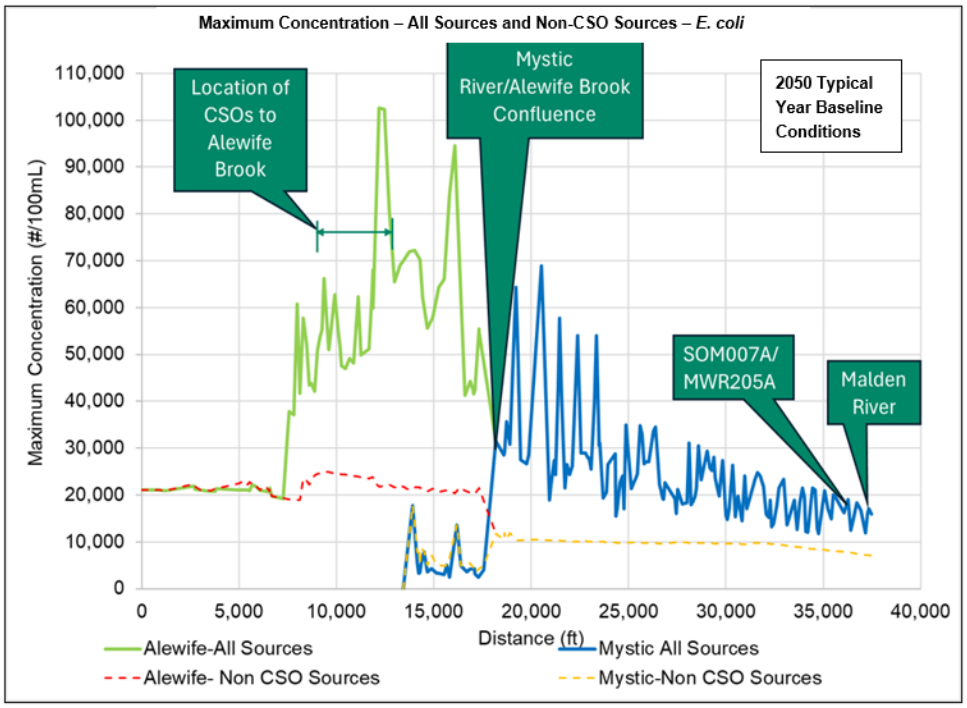



**Figure 13-10. Maximum *E. coli* Concentrations, 2050 Typical Year Baseline Conditions, All Sources vs. Non-CSO Sources**

As another means of representing the magnitude, duration, and spatial extent of impacts of wet weather bacteria loads on water quality in Alewife Brook, a series of plots were developed that present *E. coli* concentrations during and after the storm in the 2050 TY that generated the largest CSO volume to Alewife (the December 17 storm).

**Figure 13-11** presents longitudinal plots of *E. coli* concentrations at the peak of the December 17 storm from the 2050 TY, and at intervals of 3, 6, 12, 24, and 48 hours following the peak (this figure appeared as Figure 7-20 in Section 7).

As indicated in **Figure 13-11**, for the time intervals assessed, the highest *E. coli* concentrations in Alewife Brook occur at 3 hours after the peak of the storm. This result is likely a function of the timing of the peak CSO discharges relative to the peak rainfall. The 3-hour timestep also did not catch the maximum concentrations indicated above in **Figure 13-10**, which likely occurred between the peak rainfall and the 3-hour point. At 6 hours after the peak of the storm, the high concentrations from the CSOs in Alewife Brook have moved downstream, and the remaining elevated *E. coli* concentrations in Alewife Brook would be primarily attributable to stormwater loadings.

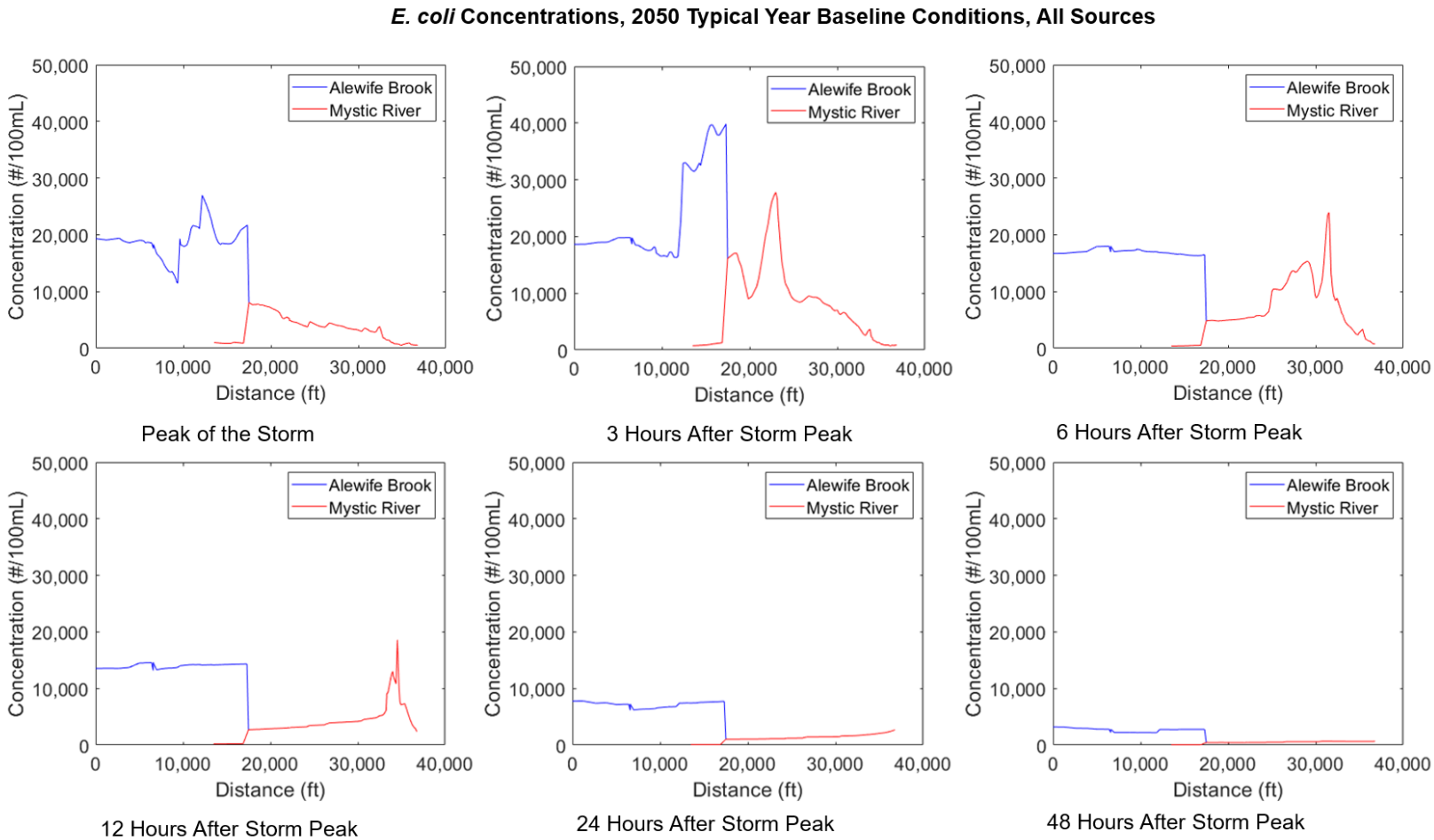



**Figure 13-11. Alewife Brook/Upper Mystic River E. coli Concentrations Over Time During and After the December 17 Storm from the 2050 Typical Year, Baseline Conditions, All Sources**

As described in Section 7, CSOs exert an influence on the peak bacteria concentrations in storms where CSOs activate, but the peak *E. coli* concentrations associated with the CSOs have a relatively short duration in Alewife Brook (see **Figure 13-11**). The duration that the concentrations of *E. coli* in Alewife Brook remain above the 410 #/100mL single sample maximum criterion recommended by MassDEP **is driven by the stormwater loadings**. **Removal of the CSO sources was predicted to substantially reduce the peak *E. coli* concentrations in Alewife Brook, but the duration that those concentrations would remain substantially above the 410 #/100mL single sample maximum criterion would not materially change**.

### Summary of Baseline Water Quality

In summary, the 303(d) List identified a wide range of impairments to Alewife Brook and as described in the section above certain physical aspects of the brook such as its shallow, channelized condition also contribute to limitations in the uses. In terms of impairments related to bacteria, CSOs contribute to the peak wet weather *E. coli* and *Enterococcus* concentrations in Alewife Brook but other sources, primarily storm water also contribute to non-attainment of the *E. coli* and *Enterococcus* water quality criteria. Removal of CSOs from Alewife Brook would reduce peak bacteria concentrations in Alewife Brook during events where the CSOs would otherwise activate but would **not improve the duration of attainment of the *E. coli* and *Enterococcus* water quality criteria due to remaining impacts from stormwater, nor materially change the level of attainment of uses of the waterbody**.

## 13.2.4 Recommended Plan

As described in Section 12, the recommended alternative for Alewife Brook is Alternative 3.AB Hybrid 2, which includes the following individual projects:

- 8 acres of sewer separation at outfall CAM001;
- A 5,400 linear foot, 9-foot diameter microtunneled storage conduit (2.3 MG capacity) to store the CSO from outfalls CAM401B and SOM001A;
- A 1.5 MG storage tank and additional conveyance to the MWRA interceptors for outfall CAM401A; and
- A 1.5 MG storage tank at outfall MWR003.

In combination, these projects would eliminate CSO activations to Alewife Brook in the 2050 TY. Under this alternative, no action is recommended at CAM002, as the outfall does not activate in the 2050 TY. The estimated capital cost of this alternative as presented in Sections 9 and 11 was $340M (2024 dollars, no escalation).

The estimated capital cost to reach the next highest level of control evaluated, capture of the CSO volumes from the 2050 5-year, 24-hour storm, was $1,100M (10.AB 5-Year Tunnel + GSI: 1.5-mile-long, 22-foot diameter storage tunnel + 36 acres of GSI). The additional $760M cost for the 5-year tunnel alternative would result in no change in water quality or uses during the 2050 TY. The benefit would likely be seen in reduced short-term peak bacterial concentrations during storms larger than the largest storm in the 2050 TY. Hydrologic and hydraulic modeling also predicts the potential for SSOs and coincident flooding that would result in indirect discharge of sanitary flow to the Alewife Brook that is not effectively captured in the water quality modeling. Based on modeling of storms in the 2050 TY, it is not anticipated that the duration of exceedance of the MassDEP-recommended single-sample maximum *E. coli* criterion of 410 #/100mL would change with the 5-year alternative due to the remaining impacts from the non-CSO bacteria sources. The physical impediments to achieving primary contact recreation in Alewife Brook as described above would also remain. As a result, as a practical matter, it is not likely that the supported uses of Alewife Brook would appreciably change during those large storm events that would be captured by the 5-year alternative compared to the level of control provided by the recommended plan. The recommended plan, which would reduce CSO activations to zero in the 2050 TY, should be considered

as part of MassDEP's UAA determination(s), along with existing and foreseeable reductions to other pollutant sources.

### 13.2.5 Factors that Could Support a Change in Water Quality Status

The applicable factors for consideration that could support a change in water quality status for Alewife Brook could potentially include one or both of the following:

- Factor 3: Human-caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or
- Factor 6: Controls more stringent than those required by sections 301(b) and 306 of the (Clean Water) Act would result in substantial and widespread economic and social impact."

#### Discussion of Factor 3

As described above, the designated uses for Class B waters include are "habitat for fish, other aquatic life, and wildlife, including for their reproduction, migration, growth and other critical functions, and for primary and secondary contact recreation" (314 CMR 4.05(3)(b)). MassDEP could consider that both human-caused conditions and sources of pollution prevent full attainment of these uses in Alewife Brook.

As also described above, over the course of the past 100 years, the hydrology and morphology of Alewife Brook have been significantly altered (by humans) from their original states. These changes have resulted in changes to the native fish populations and have resulted in creation of a challenging environment where only the most stress-tolerant fish such as carp can thrive. Full elimination of CSOs to Alewife Brook would not alter the warm, shallow, sluggish current typically seen during dry weather or the habitat-limiting impacts of the straightened concrete channels.

Some potential remedies to these physical constraints were identified in the 2003 MDC Master Plan, including dredging of Alewife Brook and adjoining ponds, and restoring the stream bank. Much work has been done since 2003 on the bike paths and habitat restoration above the banks of Alewife Brook, and in 2024 DCR conducted a cleanup of debris and deadfalls in Alewife Brook between the Route 2 bridge and the Broadway bridge. However, **significant dredging or restoration of the concrete sections of the stream bank has not taken place**. This work is not within the jurisdiction of the MWRA or the cities of Cambridge and Somerville to address and therefore could not be remedied by the Partners' CSO programs.

With regard to human-caused sources of pollution, the information on baseline water quality presented in Section 7 clearly demonstrates that even with the elimination of CSOs, the water quality criteria supporting primary contact recreation would not be met during wet weather, **primarily as a result of pollutant loadings from stormwater**. As indicated in **Table 13-6** above, the water quality model for Alewife Brook/Upper Mystic River was calibrated with average stormwater *E. coli* concentrations of 25,000 #/100mL (50,000 #/100mL upstream of water quality sampling station 083 in the Mystic River).

In support of the original water quality model calibration conducted by MWRA, stormwater samples were taken at a total of 14 storm drains in Cambridge, Somerville, Medford and Arlington that discharged to either Alewife Brook, the Upper Mystic River, or the Charles River, over the course of six storms (not all locations were sampled for all storms). The overall arithmetic mean concentration of all samples was 13,394 #/100mL. To better match measured concentrations from samples taken in Alewife Brook during wet weather events when CSOs did not discharge, the modeled concentration for stormwater had to be increased above the average value from the samples, but the value of 25,000 #/100mL was well within one standard deviation from the mean.

In reviewing the stormwater data collected, 82% of the samples taken in wet weather had *E. coli* concentrations greater than the MassDEP-recommended single-sample maximum criterion of 410 #/100mL. Two sample locations had all samples less than 410 #/100mL for a single storm event. Thus,

at most of the locations, most of the samples had values greater than 410 #/100mL. **To get from an overall average of 13,394 to 410 #/100mL would require an average 97% reduction in *E. coli* concentration in stormwater discharges**.

A 2002 study conducted by the USGS on the efficacy of structural stormwater controls and street sweeping focused on the Lower Charles River found that the upper bound of bacteria load removal from weekly street sweeping in combination with the upper quartile of load removal by structural controls was approximately 17%, with the lower bound of 7.5%. The range of structural controls included typical GSI/stormwater Best Management Practices such as biofiltration/bioretention, infiltration/filtration, and detention/retention (USGS, 2002). Based on those findings, an average load reduction of 97% would not reasonably be achievable through street sweeping and structural stormwater controls. Furthermore, small-scale stormwater controls implemented by individual communities are unlikely to intercept all stormwater runoff required to achieve the high average percent reduction required.

It is likely that at least some of the high bacteria concentrations captured in the sampling program are due in part to **illicit sanitary connections**. Communities along the Alewife Brook are required to continue to make progress in removing illicit connections through the administration of the NPDES MS4 Permit. EPA has estimated that about 340,000 gallons per day of sewage have been removed from Massachusetts waterbodies over the course of the 2016 NPDES MS4 Permit[4]. EPA requires that communities discharging to waterbodies with bacteria and pathogen impairments prioritize areas discharging to those impaired waters, and these efforts have and will continue to improve water quality entering the Alewife Brook and other impaired waterways. **Other on-going work by the communities in stormwater management will also likely lead to incremental improvements in stormwater quality over the years. However, the complete scope of work, cost, feasibility, and impacts needed to consistently reduce all stormwater concentrations into Alewife Brook to a level that would allow full attainment of the single sample maximum criterion cannot be defined at this time.**

### Discussion of Factor 6

As described in Section 11 and noted above in **Section 13.2.4**, implementing projects to achieve a higher level of control than the Recommended Plan would result in substantial increases in the implementation cost, and therefore, would result in substantial and widespread economic impact. Section 11 and Appendices G, H, and I provide further details on the economic impact of providing higher levels of control. The City Cambridge would have a residential indicator in the “high impact” category for levels of control higher than the recommended plan. While the overall Financial Capability Assessment results indicate a “medium impact” for Cambridge, there are a substantial number of ratepayers that would be faced with sewer bills greater than 2% of their household income. In Cambridge, more than 1 out 3 residents would be “high impact” under the higher LOCs. The City of Chelsea, with a medium household income roughly half of Cambridge and Somerville, is in the “high impact” category for the Recommended Plan already. The economic impact would be substantially greater under higher levels of control and widespread across the City.

The FCA calculates that the MWRA service area, taken as a whole, demonstrates a “Low Impact” rating across the FCA indicators for the Recommended Plan. However, evaluating the MWRA communities individually reveals a different picture. It is important to note this FCA does not account for additional projected municipal wastewater and stormwater costs, since this information was not available for all service area municipalities and is not included in MWRA’s municipal assessments that are passed on to municipal customers (i.e., costs required to maintain and improve municipally owned and maintained infrastructure are in addition to MWRA municipal assessments). As a result, projected wastewater costs are actually higher than the costs used for this FCA.

Even before additional CSO requirements, when utilizing the 2020-2024 American Community Survey (ACS) 5-year estimates data, the following five service area communities experience medium or high impacts under EPA’s Expanded Financial Capability Assessment Matrix: Boston (Medium Impact),

[4] https://www.epa.gov/system/files/documents/2025-11/fact-sheet-2024-ma-draft-ms4-gp.pdf

Chelsea (High Impact), Everett (Medium Impact), Quincy (Medium Impact), and Revere (Medium Impact). These five communities, which include substantial Environmental Justice populations, represent approximately 41% of all households in the MWRA sewer service area—demonstrating that close to half of MWRA's service area population, including Environmental Justice communities like Chelsea, is already facing elevated financial pressures. This further increases to approximately 44% of all households when accounting for the more expensive CSO control alternatives, when a sixth community (Framingham) is designated as "Medium Impact."

Note that the City of Boston's overall impact designation shifts from Medium Impact using the 2022 ACS 5-year data, to Low Impact using the 2023 ACS 5-year data (which was utilized for the overall FCA), and back to Medium Impact using the 2024 ACS 5-year data. These changes are driven in part by marginal year-to-year fluctuations in benchmarked indicators—most notably a 0.1 percent change in the City's unemployment rate relative to the national comparison threshold used under Alternative 1. Importantly, these threshold crossings do not represent a material change in the City's underlying economic conditions or financial capacity, but rather reflect the sensitivity of the FCA methodology to small statistical variations in census datasets.

As included in the FCA Guidance, it is important to examine the lowest quintile income within the MWRA sewer service area, which constitutes the bottom 20% of households within each service area community. **Table 13-10** presents number of communities that show a medium or high impact based on their lowest quintile households for both the RI and the Expanded FCA Matrix. As **Table 13-10** shows, when looking at the Expanded FCA Matrix Results, six of the communities experience a High Impact and an additional 6 communities experience a medium impact under the Baseline. The number of communities with a high impact remains at 6 with the Draft Recommended Plan (0 CSOs in the 2050 TY), but the number of communities with medium impacts increases to 7 for the Draft Recommended Plan and increased to 8 with higher levels of control.

**Table 13-10 MWRA Sewer Service Area Lowest Quintile Households with Medium to High Impact**

| Alternative | Residential Indicator Results for Service Area Communities | | | Expanded FCA Matrix Results for Service Area Communities | | |
|---|---|---|---|---|---|---|
| | Number of Communities with Low Impact | Number of Communities with Medium Impact | Number of Communities with High Impact | Number of Communities with Low Impact | Number of Communities with Medium Impact | Number of Communities with High Impact |
| Baseline | 0 | 20 | 23 | 31 | 6 | 6 |
| Limited 2050 TY | 0 | 19 | 24 | 30 | 7 | 6 |
| 2050 TY | 0 | 19 | 24 | 30 | 7 | 6 |
| Full Sewer Separation | 0 | 17 | 26 | 29 | 8 | 6 |
| 2050 5-YR | 0 | 17 | 26 | 29 | 8 | 6 |
| 2050 25-YR | 0 | 16 | 27 | 29 | 8 | 6 |

When looking only at the RI metric, even before additional CSO requirements (i.e., Baseline), about 23 communities in the MWRA service area experience a High Impact. This increases to 24 communities for the Draft Recommended Plan (0 CSOs in the 2050 TY) and 26 communities for the more expensive levels of control.

The MWRA serves a region with exceptionally high costs of living, driven primarily by housing costs across Greater Boston and eastern Massachusetts. While many service area communities have median household incomes that compare favorably to state and national benchmarks, elevated housing and other fixed household expenses constrain the capacity of many customers (particularly renters and lower income households) to absorb increases in wastewater charges. These regional conditions are important

context for interpreting standard affordability and financial capability indicators. Consistent with EPA's guidance encouraging consideration of community specific conditions and alternative financial metrics, Appendix I includes a section that examines regional cost-of-living pressures, providing important context for evaluating financial impacts and compliance schedule considerations across the MWRA service area.

In summary, the FCA results demonstrate that a substantial share of the MWRA service area—particularly low-income households and Environmental Justice communities—is already subject to medium-to-high financial stress, even before consideration of additional CSO obligations. The disproportionate impacts observed for lowest quintile households, combined with regional cost of living pressures and the documented sensitivity of FCA outcomes to minor data fluctuations, indicate that aggregate community indicators materially overstate the financial capacity of large portions of the service area. Consistent with EPA guidance, these conditions warrant a holistic interpretation of FCA results.

## 13.3 Upper Mystic River

### 13.3.1 Description

The Upper Mystic River begins at the outlet from the Lower Mystic Lake and runs along the boundary between the town of Arlington and the city of Medford to approximately the convergence with Alewife Brook. From that location, the river follows the boundary between the cities of Somerville and Medford until a point opposite the Whole Foods Market. Downstream of Whole Foods, the river runs entirely within the city of Medford for approximately 2.5 miles, at which point the western shore returns to the city of Somerville by the 10 Hills neighborhood. Approximately 4,900 feet further downstream, the eastern shoreline transitions to the city of Everett at the confluence with the Malden River, just upstream of the Amelia Earhart Dam. Between the outlet from the Lower Mystic Lake to approximately the I-93 bridge, the river is generally about 100 feet wide. Downstream of the I-93 bridge, the river widens to about 200 feet. The river widens out even further, to over 1,000 feet, downstream of the Route 16/Mystic Valley Parkway bridge.

**Figure 13-12** shows a map of the full Mystic River Watershed, which has an area of roughly 76 square miles.

Historically, the Upper Mystic River was a meandering, tidally influenced river. In the early 1900's, construction of the Craddock Dam in Medford mostly isolated the Upper Mystic River above that point from tidal influences (MDC 2003). In the mid-1960s, the construction of Interstate 93 and the Amelia Earhart Dam substantially changed the nature of the river. The Interstate 93 work included the straightening of meanders and the filling of marshes along the Upper Mystic River. The Amelia Earhart Dam isolated the upstream river from tidal influences, allowing for regulation of the upstream water level and changing the upstream water from brackish to freshwater. The dam was also originally intended to prevent harbor pollution from moving upstream with the tides (DCR 2009).

As described in the 2009 Mystic River Master Plan,

> *A significant portion of riverfront land is designated as public open space and is in public ownership. The Mystic River Reservation was one of the original five reservations delineated by the Metropolitan Park Commission in 1893. The Commission acquired 80 acres of land along the Mystic River in 1895 and by the end of 1899, "the Commissioners reported that practically the entire banks of the Mystic River in Medford had been taken for the use of the public, and that the last takings which lay in Arlington and Somerville would be complete in 1901."* (DCR 2009)

A number of public parks, recreational fields, bike paths and walking paths are located along the banks of the Upper Mystic River.

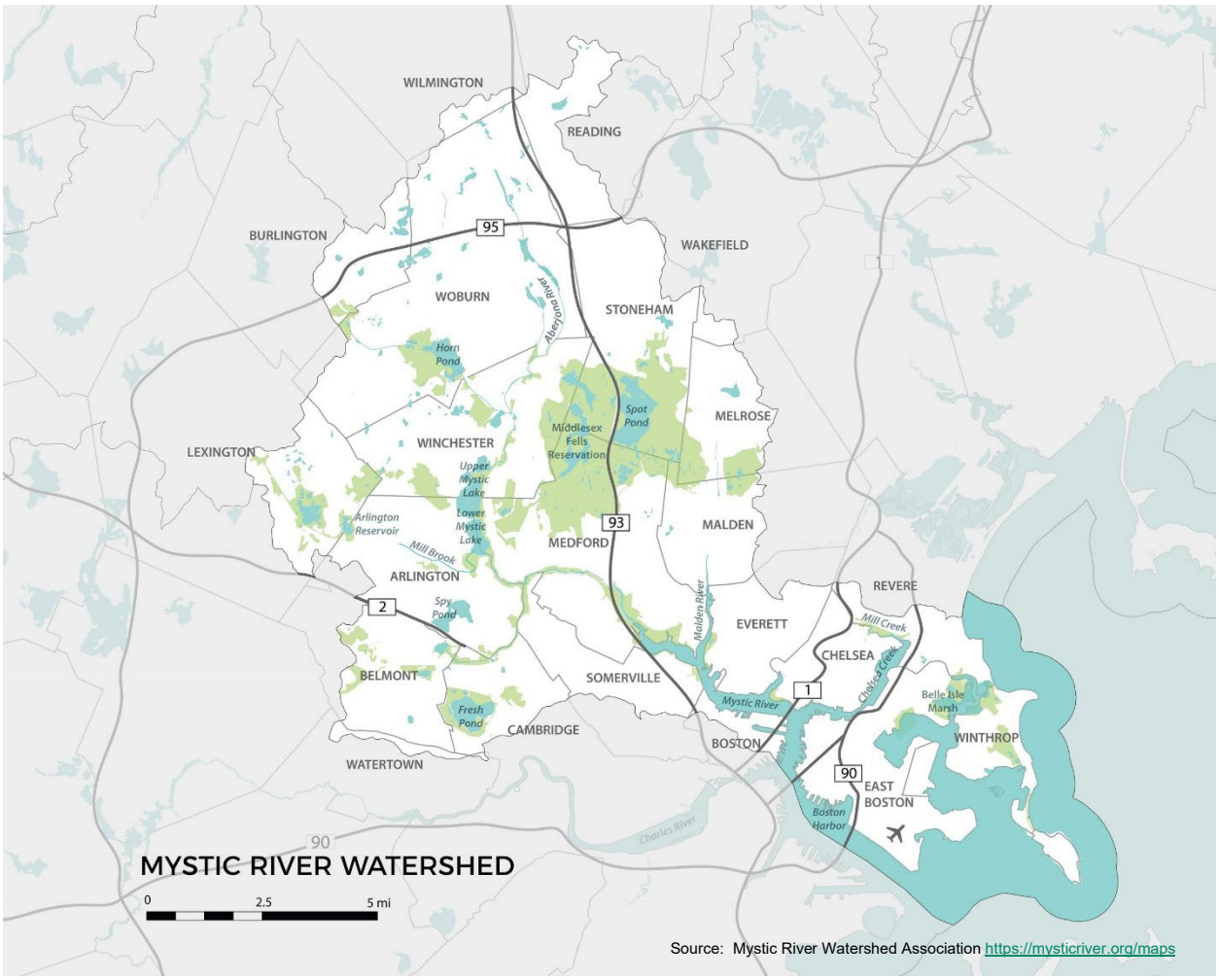



**Figure 13-12. Mystic River Watershed**

### 13.3.2 Existing Uses

The Mystic River supports a wide range of recreational activities, both on the water and along the shoreline. Commonly observed boating activities include motorized boats, jet skis, canoes, kayaks and paddleboards. **Figure 13-13** shows a map of various water-related recreational facilities on the Mystic River. This map shows a total of seven facilities, but there may be more facilities that are not shown on this figure, including the Medford Boat Club, located on the Mystic Lakes upstream of the Mystic River.

Catch-and-release fishing, both from boats and along the shoreline is a popular activity, with commonly caught species including yellow and white perch, bluegill, crappie, large and small-mouth bass, carp, and the occasional striped bass. The Massachusetts Department of Public Health Bureau of Climate and Environmental Health Freshwater Fish Consumption Advisory List[5] specifies that no fish should be consumed from the Upper Mystic River between the outlet to the Lower Mystic Lake and the Amelia Earhart Dam due to the **presence of PCBs, chlordane, and DDT**.

[5] Massachusetts Department of Public Health

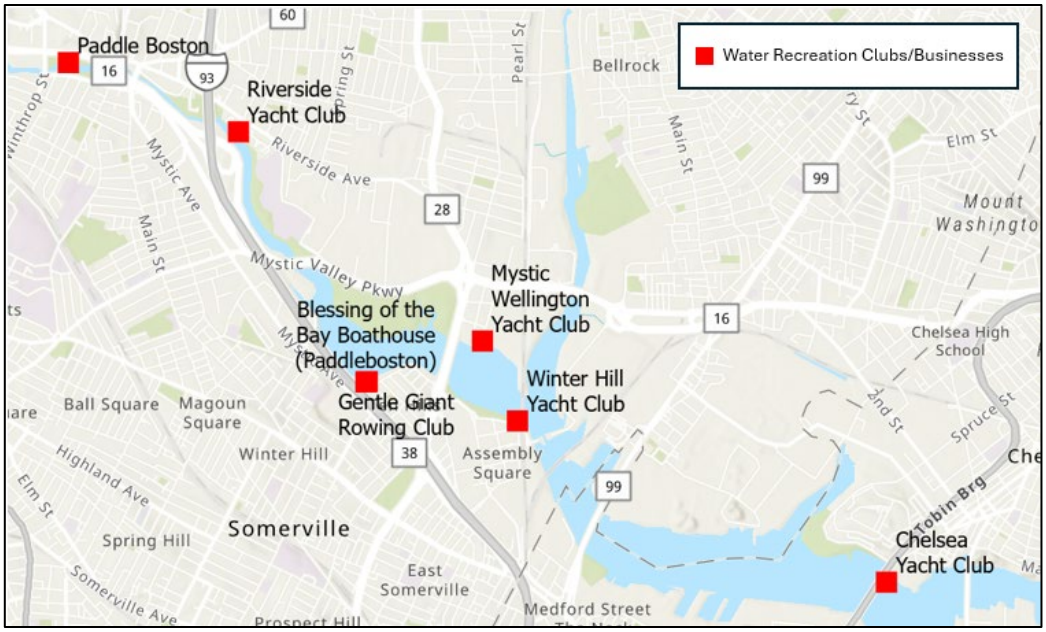



**Figure 13-13. Water-Related Recreational Facilities on the Mystic River**

Alewife and blue back herring ("river herring") have traditionally migrated up the Mystic River in the spring to spawn. The Massachusetts recreational saltwater fishing regulations prohibit the possession of river herring, as the population of these fish had declined severely over the years due to overfishing, environmental degradation, and the obstacles to migration created by the Upper Mystic Lake Dam in Medford, the Center Falls Dam in Winchester, and the Horn Pond Dam in Woburn. However, the reconstruction of the Upper Mystic Lake Dam in 2012 included incorporation of a fish ladder and eel slide. Following that work, a fish ladder was added at the Center Falls Dam in 2017, and planning is underway for a fish passage at the Horn Pond Dam. The benefits of the fish ladders have been documented through fish counts organized by the Mystic River Watershed Association. Counts of migrating river herring have increased from about 200,000 in 2014 to a record count of over 815,000 in 2025 (MyRWA, 2025).

Passive recreation is a common use along the bike and hiking paths that run along the shoreline of the Upper Mystic River. The paths are heavily used in all seasons and under a range of weather conditions, and substantial work has been completed in recent years to improve/expand the bike paths. Various athletic fields, tennis and basketball courts located in the parks along the Upper Mystic River support a variety of land-based recreational uses.

The Massachusetts Department of Public Health Beaches Dashboard[6] does not list any bathing beaches along the Upper Mystic River. Informal swimming/wading has been observed in a sandy area at the outlet from the Lower Mystic Lake. Limited access along the banks of the Upper Mystic River, in conjunction with rocky/mucky bottom conditions, the potential for encountering broken glass/rusting metal/debris and the prevalence of invasive water chestnut all combine to limit opportunities for wading along the shoreline.

[6] Interactive Beach Water Quality Dashboard | Mass.gov

### 13.3.3 Stressor Limiting Attainment of Water Quality Standards

As noted above, portions of the Upper Mystic River were channelized in the past, and the Amelia Earhart Dam changed the nature of the river from a brackish, tidally-influenced river to a freshwater river with managed levels. However, these physical changes to the river did not generally create barriers to the level of attainment of uses to the degree described above for the much narrower and shallower Alewife Brook. Rather, the Amelia Earhart Dam has likely improved the suitability of the river for boating and other secondary contact activities and improved the aesthetics for passive recreation along the banks of the river.

As noted in Section 2, the Massachusetts 303(d) List[7] includes the Upper Mystic River between the Lower Mystic Lake and the Amelia Earhart Dam under “Category 5 – Waters requiring a TMDL". The Upper Mystic River impairments are identified in the Integrated List for the Upper Mystic River (MassDEP 2023) (Refer to Table 2-3 in Section 2).

The listed impairments have been organized into the following general categories, although they may fall under more than one category:

- **Nutrients/eutrophication-related:** chlorophyll-a, dissolved oxygen, dissolved oxygen supersaturation, harmful algal blooms, total phosphorus, transparency/clarity;
- **Residual toxic chemical-related**: Chlordane, DDT and PCBs in fish tissue, arsenic, high pH, sediment bioassay [chronic toxicity freshwater];
- **Invasive species:** Eurasian water milfoil (Myriophyllum spicatum), water chestnut; and
- **Bacteriological:** *Enterococcus, E. coli*.

The water quality model for the Upper Mystic River noted above allows for the evaluation of *E. coli* and *Enterococcus* concentrations in the Upper Mystic River but does not address the other pollutants or stressors identified on the 303(d) List.

As described in Section 6, bacteria concentrations were applied to the various flow sources to the Upper Mystic River to create the bacterial mass loading inputs to the water quality model. The stormwater, baseflow and upstream boundary bacteria concentrations for the sources to the Upper Mystic River are presented in **Table 13-11** (information in this table appeared in Table 6-3 in Section 6).

**Table 13-11. Water Quality Model Parameters – Upper Mystic River**

| Bacteria | Stormwater Counts (#/100 mL) | Dry Weather Baseflow Counts (#/100 mL) | Upstream Boundary Counts (#/100mL) |
|---|---|---|---|
| *E. coli* | 25,000 (50,000 upstream of station 083) | 134 (20,000 upstream of station 083) | 10 |
| *Enterococcus* | 6,700 (20,000 upstream of station 083) | 45 (3,000 upstream of station 083) | 45 |

**Table 13-12** presents the flow-weighted sanitary fraction and the *E. coli* and *Enterococcus* counts applied to the one treated CSO discharge to the Upper Mystic River for the 2050 Typical Year (information in this table appeared in Table 6-4 in Section 6).

[7] download

### Table 13-12. Upper Mystic River CSO Bacteria Counts for the 2050 Typical Year

| Location | Flow-weighted Sanitary Fraction (%)[1] | 2050 Typical Year Baseline Conditions Flow-weighted Counts (#/100 mL) | |
|---|---|---|---|
| | | *E. coli* | *Enterococcus* |
| SOM007A/MWR205A (Somerville Marginal CSO Facility Treated Discharge) | <0.01 | 18[1] | 17[1] |

**Notes:**

(1) For outfall SOM007A/MWR205A, the sanitary fraction method was not applied to the treated discharge. The flow-weighted counts reflect the average treated discharge counts sampled from the Somerville Marginal CSO Facility effluent in 2018.

Section 7 above presents information on modeled bacteria loadings to the Upper Mystic River under Baseline Conditions for the 2050 TY, as well as the modeled impact of those loadings on bacteria concentrations in the Upper Mystic River. Tables and Figures from Section 7 demonstrating water quality impacts during wet weather for the Upper Mystic River are discussed below. Note that these figures are the same figures as presented for Alewife Brook, since the continuous model output includes both Alewife Brook and the Upper Mystic River.

## Baseline Conditions Volumes and Loadings

**Table 13-13** presents a summary of the 2050 TY Baseline Conditions volumes and *E. coli* loads to the Upper Mystic River (this table appeared as Table 7-7 in Section 7). As indicated in **Table 13-13,** the **single largest source of volume to the Upper Mystic River is the boundary flow coming into the Upper Mystic River from the Lower Mystic Lake, with dry weather base flows** (infiltration flow from storm drains or groundwater flow directly to a waterbody); **the next largest source. CSOs contribute less than 1% of the total annual volume. In terms of *E. coli* loading, separate stormwater is the predominant source at just over 90% of the total annual load.** The treated CSO contributes less than 0.01% of the total annual load. No untreated CSOs discharge directly to the Upper Mystic River, but as described in more detail below, **the influence of the Alewife Brook CSOs can be seen in the *E. coli* concentrations in the Upper Mystic River**. Since Alewife Brook and the Upper Mystic River are together part of a single continuous model, the loadings from the untreated CSOs in Alewife Brook that flow into the Upper Mystic River are accounted for within the model and were not quantified as an "external" boundary source.

### Table 13-13. Upper Mystic River 2050 Typical Year Baseline Conditions Volumes and *E. coli* Loads

| | Upper Mystic River 2050 Typical Year Baseline Conditions | | | |
|---|---|---|---|---|
| | *Volume* | | *E. coli* | |
| *Source* | Volume (MG) | Percent of Total | Loading (counts x $10^{12}$) | Percent of Total |
| Untreated CSO[1] | 0 | 0 | 0 | 0 |
| Treated CSO[2] | 27 | 0.1% | 0.018 | <0.01% |
| Stormwater | 1,366 | 6% | 1,293 | 74% |
| Dry Weather[3] | 5,233 | 21% | 147 | 8% |
| Boundary[4] | 17,915 | 73% | 312 | 18% |
| **Total** | **24,541** | **100%** | **1.753** | **100%** |

**Notes:**

(1) No untreated CSOs discharge directly to the Upper Mystic River.
(2) Treated CSO from the MWRA Somerville Marginal CSO Facility receives screening, disinfection and dechlorination.
(3) Dry weather sources are continuous dry weather flows from tributary brooks and storm drains.
(4) Boundary sources are from dry and wet weather flows into the Upper Mystic River from the Mystic Lakes.

(2) Treated CSO from the MWRA Somerville Marginal CSO Facility receives screening, disinfection and dechlorination.
(3) Dry weather sources are continuous dry weather flows from tributary brooks and storm drains.
(4) Boundary sources are from dry and wet weather flows into the Upper Mystic River from the Mystic Lakes.

### Baseline Conditions Attainment of Single Sample Maximum Criterion

Based on direction from MassDEP, the Alewife Brook/Upper Mystic River water quality model was used to assess attainment with single sample maximum criteria equal to the existing 30-day STV criteria of 410 #/100mL for *E. coli* and 130 #/100mL for *Enterococcus*.

As described above for Alewife Brook, the single sample maximum criteria were assessed by computing the proportion of modeled time in which bacterial concentrations at every defined segment along the linear model remained below the single sample maximum criterion, and by creating longitudinal plots of hours of criteria exceedance along Alewife Brook and the Upper Mystic River for the individual model segments. With these plots, the percent of river length achieving varying levels of annual attainment of the single sample maximum criteria could be assessed.

**Table 13-14** summarizes the percent attainment of the single sample maximum criteria for both *E. coli* and *Enterococcus* for the 2050 TY, using the first approach described above (this table appeared as Table 7-8 in Section 7). As indicated in **Table 13-14**, for both *E. coli* and *Enterococcus*, **no differences were predicted in the percent attainment for All Sources compared to Non-CSO Sources for the Upper Mystic River. Thus, elimination of CSO would not change this assessment of attainment.** Attainment with Stormwater Only was only a few percentage points higher than All Sources. With CSOs Only, annual attainment was 96% for the Upper Mystic River. Since the only CSO discharge directly into the Upper Mystic River is the treated CSO discharge at outfall MWR205A/ SOM007A, **the non-attainment in the Upper Mystic River for the CSO-only case is driven by the CSO loads coming into the Upper Mystic River from Alewife Brook**.

**Table 13-14. Upper Mystic River Percent Annual Attainment of the Single Sample Maximum Criteria for the 2050 Typical Year**

| Percentage Time Entire Modeled Upper Mystic River Meets the Single Sample Maximum Criteria(1) – 2050 Typical Year Baseline Conditions | | | | | | | |
|---|---|---|---|---|---|---|---|
| *E. coli* (410#/100mL) | | | | *Enterococcus* (130#/100mL) | | | |
| All Sources | Non-CSO Sources | CSO Only | Stormwater Only | All Sources | Non-CSO Sources | CSO Only | Stormwater Only |
| 52% | 53% | 96% | 54% | 53% | 54% | 97% | 57% |

**Notes:**
(1) Based on guidance from DEP, model results were analyzed for a single sample maximum equivalent to the value of the Class B Statistical Threshold Value Criterion for bacteria.

**Figure 13-3** above presents a longitudinal plot of the number of hours in the 2050 TY that the maximum *E. coli* concentration is above the MassDEP-recommended single sample maximum criterion (410#/100mL) under the All-Sources scenario (this figure appeared as Figure 7-8 in Section 7). The Y-axis also shows the values as a percentage of the total hours in the 2050 TY (8,784 total hours). This figure provides a more nuanced assessment of the spatial distribution of attainment of the single sample maximum criterion. As indicated in **Figure 13-3**, the hours of exceedance in the Upper Mystic River are about in the 25 to 30% range from the confluence with Alewife Brook to a point approximately 15,000 feet downstream, meaning that attainment with the single sample maximum criterion would be in the 70 to 75% range. The attainment improves to about 90% at the downstream end by the Malden River and the Amelia Earhart Dam.

**Figure 13-5** above presents the duration of exceedance of the *E. coli* single-sample maximum criterion for the condition of CSO loads, only (this figure appeared as Figure 7-10 in Section 7). As indicated in **Figure 13-5,** with only CSO loadings, the duration of exceedance ranges from about 40 to 45 hours from the confluence with Alewife Brook to a point approximately 15,000 feet downstream, at which point the hours of exceedance drop off to below 20 at the downstream end.

Based on **Figure 13-3** to **Figure 13-5**, controlling the non-CSO sources of *E. coli* to the Upper Mystic River would be necessary to substantially reduce the hours of exceedance of the single sample maximum criterion in those waterbodies.

### Baseline Conditions Attainment of 30-Day Geometric Mean and STV Criteria

**Figure 13-6** and **Figure 13-7** above present plots of the percent of the time over the 2050 TY that each modeled segment was in compliance with the 30-day *E. coli* geometric mean criterion, for two simulation scenarios: All-Sources, and Non-CSO Sources Only (these figures appeared as Figure 7-11 and Figure 7-12 in Section 7).

As indicated in these figures, in the Upper Mystic River below the confluence with Alewife Brook, the duration of exceedance the 30-day geometric mean criterion for *E. coli* fluctuates between about 30 and 60% of the year, then drops to near zero percent at the downstream end. The plots for All Sources and for Non-CSO Sources only are essentially identical, indicating that **CSOs have no impact on the duration of attainment of the 30-day geometric mean criterion for *E. coli*.**

**Figure 13-8** and **Figure 13-9** above present of plots of the percent of the time over the 2050 TY that each modeled segment was in compliance with the 30-day *E. coli* STV criterion, for two simulation scenarios: All-Sources, and Non-CSO Sources Only (these figures appeared as Figure 7-15 and Figure 7-16 in Section 7).

As indicated in **Figure 13-8** and **Figure 13-9**, In the Upper Mystic River **below the confluence with Alewife Brook, the 30-day STV criterion for *E. coli* criterion is exceeded for the entire year** until a point approximately 15,000 feet downstream of Alewife Brook. The plots for All Sources and for Non-CSO Sources only are essentially identical, indicating that **CSOs have no impact on the duration of attainment of the 30-day STV criterion for *E. coli*.**

### Baseline Conditions Assessment of Maximum *E. coli* Concentrations and Duration of Impact

As noted above for Alewife Brook, the limited impacts of CSOs on duration of attainment of water quality criteria over the 2050 Typical Year do not reflect the short-term impacts of CSOs on water quality during the periods of time when the CSOs are discharging. **Figure 13-10** above presents the maximum concentrations at each model segment in the Upper Mystic River under conditions of All Sources versus Non-CSO Sources Only (this figure appeared as Figure 7-19 in Section 7). **As indicated in Figure 13-10, elimination of CSO loads to both Alewife Brook and the Upper Mystic River in the 2050 Typical Year would result in substantial reductions in the peak *E. coli* concentrations in the reach of the Upper Mystic River downstream of Alewife Brook. The peak *E. coli* concentrations for the Non-CSO Sources condition would, however, still be substantially higher than the DEP-recommended single sample maximum criterion of 410 #/100mL, due mostly to the remaining stormwater loadings.**

As another means of representing the magnitude, duration, and spatial extent of impacts of wet weather bacteria loads on water quality in the Upper Mystic River, a series of plots were developed that present *E. coli* concentrations during and after the storm in the 2050 TY that generated the largest CSO volume to Alewife Brook (the December 17 storm). **Figure 13-11** above presents longitudinal plots of *E. coli* concentrations at the peak of the December 17 storm from the 2050 TY, and at intervals of 3, 6, 12, 24, and 48 hours following the peak.

As indicated in **Figure 13-11**, for the time intervals assessed, the highest *E. coli* concentrations in the Upper Mystic River occur at 3-hours after the peak of the storm. The 3-hour timestep did not catch the

maximum concentrations indicated above in **Figure 13-10**, which likely occurred between the peak rainfall and the 3-hour point. The Alewife Brook CSO-related spike in concentration can be seen moving down the Upper Mystic River between hours 3 and 12. By hour 24, the high concentrations from the CSOs in the Upper Mystic River have dissipated, and the remaining elevated *E. coli* concentrations in the Upper Mystic River would be primarily attributable to stormwater loadings.

The plots in **Figure 13-11** demonstrate that the untreated CSOs in Alewife Brook exert an influence on the peak bacteria concentrations in the Upper Mystic River downstream of Alewife Brook in storms where CSOs activate. However, the peak *E. coli* concentrations associated with the CSOs have a relatively short duration at any one point in the Upper Mystic River. The duration that the concentrations of *E. coli* in the Upper Mystic River remain above the 410 #/100mL single sample maximum criterion recommended by Mass DEP is driven by the stormwater loadings. Removal of the untreated CSO sources in Alewife Brook was predicted to substantially reduce the peak *E. coli* concentrations in the Upper Mystic River, but the duration that those concentrations would remain substantially above the 410 #/100mL single sample maximum criterion would not materially change. Removal of the treated CSO discharge at outfall SOM007A/MWR205A had no impact on the peak *E. coli* concentrations in the Upper Mystic River. As a result, removal of the untreated CSOs from Alewife Brook and/or the treated CSO at outfall SOM007A/MWR205A would not improve the level of attainment of numeric water quality criteria in the Upper Mystic River, nor change the level of attainment of uses of the waterbody.

#### Summary of Baseline Water Quality

In summary, the 303(d) List identified a wide range of impairments to the Upper Mystic River. In terms of impairments related to bacteria, CSOs from Alewife Brook contribute to the peak wet weather *E. coli* and *Enterococcus* concentrations in the Upper Mystic River but other sources, primarily stormwater also contribute to non attainment of *E.coli* and *Enterococcus* water quality criteria. Removal of CSOs from Alewife Brook would reduce peak bacteria concentrations in the Upper Mystic River during events where the CSOs would otherwise activate but would **not improve the duration of attainment of the *E. coli* and *Enterococcus* water quality criteria, due to the remaining impacts of stormwater, nor materially change the level of attainment of uses of the waterbody. Reduction of the treated CSO volume to the Upper Mystic River at outfall MWR205A/SOM007A would have no impact on attainment of the *E. coli* and *Enterococcus* water quality criteria.**

### 13.3.4 Recommended Plan

As described in Section 11, the recommended alternative for the Upper Mystic River is Alternative 2.MR Hybrid 1, which includes the following individual projects:

- 95 acres of sewer separation upstream of outfall SOM007A/MWR205A in Somerville; and
- A 7.4 MG storage tank capturing the treated overflow from outfall SOM007A/MWR205A.

In combination, these projects would eliminate the treated CSO activations to the Upper Mystic River in the 2050 TY. Due to the variable impact of the tide on the discharge volume at outfall SOM007A/MWR205A, this alternative would also capture the predicted discharge in the 2050 5-year storm if the peak of the storm occurred during the lower half of the tidal cycle.

The estimated capital cost of this alternative as presented in Sections 9 and 11 was $260M (2024 dollars, no escalation). Since the existing discharge at outfall SOM007A/MWR205A is currently treated, **providing a higher level of control for this outfall would have no impact on attainment of the numerical water quality criteria for bacteria in the Lower Mystic River**. As a result, as a practical matter, it is not likely that the supported uses of the Lower Mystic River would appreciably change during those large storm events that would be captured by, for example, a tank sized for the 2050 25-year storm, compared to the LOC provided by the recommended plan. The recommended plan, which would reduce CSO activations to zero in the 2050 TY, should be considered as part of MassDEP's UAA determination(s), along with existing and foreseeable reductions to other pollutant sources.

### 13.3.5 Factors that Could Support a Change in Water Quality Status

The applicable factors for consideration that could support a change in water quality status for the Upper Mystic River could potentially include one or both of the following:

- Factor 3: Human-caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or
- Factor 6: Controls more stringent than those required by sections 301(b) and 306 of the (Clean Water) Act would result in substantial and widespread economic and social impact."

#### Discussion of Factor 3

As described above, the designated uses for Class B waters include are "habitat for fish, other aquatic life, and wildlife, including for their reproduction, migration, growth and other critical functions, and for primary and secondary contact recreation" (314 CMR 4.05(3)(b)). MassDEP could consider that human-caused sources of pollution prevent full attainment of these uses in the Upper Mystic River.

The information on baseline water quality presented in Section 7 clearly demonstrates that even with the elimination of CSOs, the water quality criteria supporting primary contact recreation would not be met during wet weather, primarily as a result of **pollutant loadings from stormwater**. As indicated in **Table 13-11** above, the water quality model for Alewife Brook/Upper Mystic River was calibrated with average stormwater *E. coli* concentrations of 25,000 #/100mL (50,000 #/100mL upstream of water quality sampling station 083 in the Mystic River).

As described for Alewife Brook, in support of the original water quality model calibration conducted by MWRA, stormwater samples were taken at a total of 14 storm drains in Cambridge, Somerville, Medford and Arlington that discharged to either Alewife Brook, the Upper Mystic River, or the Charles River, over the course of six storms (not all locations were sampled for all storms). The overall arithmetic mean concentration of all samples was 13,394 #/100mL. To better match measured concentrations from samples taken in the Upper Mystic River during wet weather events when CSOs did not discharge, the modeled concentration for stormwater had to be increased above the average value from the samples, but the value of 25,000 #/100mL was well within one standard deviation from the mean.

In reviewing the stormwater data collected, 82% of the samples taken in wet weather had *E. coli* concentrations greater than the MassDEP-recommended single-sample maximum criterion of 410 #/100mL. Two sample locations had all samples less than 410 #/100mL for a single storm event. Thus, at most of the locations, most of the samples had values greater than 410 #/100mL. To get from an overall average of 13,394 to 410 #/100mL would require an average 97% reduction in *E. coli* concentration.

A 2002 study conducted by the USGS on the efficacy of structural stormwater controls and street sweeping focused on the Lower Charles River found that the upper bound of bacteria load removal from weekly street sweeping in combination with the upper quartile of load removal by structural controls was approximately 17%, with the lower bound of 7.5%. The range of structural controls included typical green infrastructure/stormwater BMPs such as biofiltration/bioretention, infiltration/filtration, and detention/retention (USGS, 2002). Based on those findings, an average load reduction of 97% would not reasonably be achievable through street sweeping and structural stormwater controls. Furthermore, small-scale stormwater controls implemented by individual communities are unlikely to intercept all stormwater runoff required to achieve the high average percent reduction required.

It is likely that at least some of the high bacteria concentrations captured in the sampling program are due in part to **illicit sanitary connections**. Communities along the Mystic River are required to continue to make progress in removing illicit connections through the administration of the NPDES MS4 Permit. EPA has estimated that about 340,000 gallons per day of sewage have been removed from Massachusetts

waterbodies over the course of the 2016 NPDES MS4 Permit[8]. EPA requires that communities discharging to waterbodies with bacteria and pathogen impairments prioritize areas discharging to those impaired waters, and these efforts have and will continue to improve water quality entering the Mystic River and other impaired waterways. **Other on-going work by the communities in stormwater management will also likely lead to incremental improvements in stormwater quality over the years**. However, the complete scope of work, cost, feasibility, and impacts needed to consistently reduce all stormwater concentrations into Mystic River to a level that would allow full attainment of the single sample maximum criterion cannot be defined at this time.

### Discussion of Factor 6

Refer to Factor 6 discussion in **Section 13.2.5**.

## 13.4 Charles River

### 13.4.1 Description

The portion of the Charles River that is subject to the 2024 Variance extends for approximately 8.5 miles from the Watertown Dam to the New Charles River Dam. Between the Watertown Dam and the Boston University (BU) Bridge, the width of the river varies from less than 100 feet to approximately 500 feet. In the Lower Basin below the BU Bridge, the river widens to approximately 2,000 feet before narrowing again between the Longfellow Bridge and the New Charles River Dam. **Figure 13-14** shows the full Charles River watershed. Of the total watershed area of approximately 310 square miles, approximately 268 square miles are tributary to the river upstream of the Watertown Dam, and 42 square miles are tributary downstream of the Watertown Dam (MDC 2002).

[8] https://www.epa.gov/system/files/documents/2025-11/fact-sheet-2024-ma-draft-ms4-gp.pdf

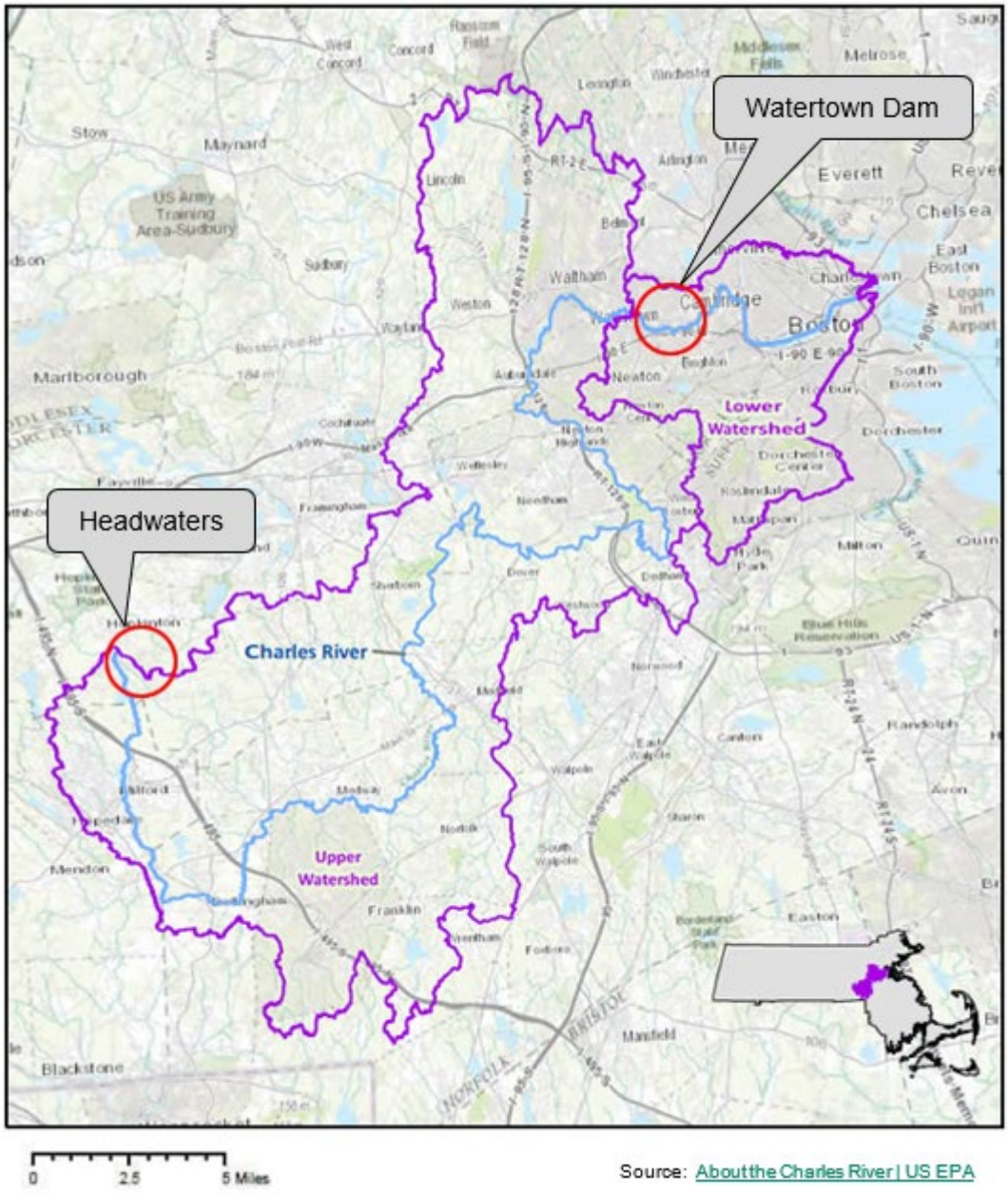



**Figure 13-14. Charles River Watershed**

Prior to 1910, the Lower Charles Basin was a tidal saltwater estuary. The construction of the original Charles River Dam in 1910 transformed the Lower Basin from a tidal marsh to a freshwater impoundment, with the water level managed by the dam. In 1978, the New Charles River Dam was constructed approximately 2,000 feet downstream of the original dam.

Busy roadways run parallel to both banks of the Lower Charles River, including Nonantum Road, Soldiers Field Road, and Storrow Drive on the south side of the river, and Charles River Road, North Beacon Street, Greenough Boulevard and Memorial Drive on the north side of the river. As described below, both sides of the river are heavily used for passive recreation, particularly the Esplanade area along the Boston shoreline, and the river itself is extensively used for rowing and recreational boating.

### 13.4.2 Existing Uses

The Charles River is a significant hub for recreational aquatic activities, being adjacent to various public parks and recreational facilities. **Figure 13-15** shows a map of various water-related recreational establishments located along the Charles River. These facilities include yacht clubs, access ramps, and university boat houses located in close proximity to the Charles River. A total of 19 facilities are shown below, but other public access points may also exist that are not identified on this map.

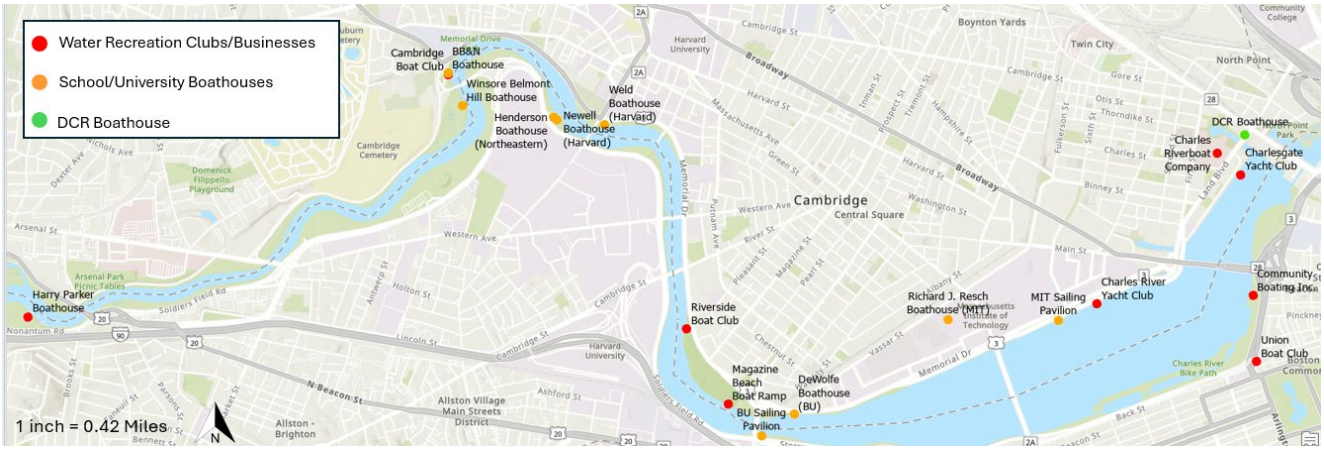



**Figure 13-15. Water-Related Recreational Facilities on the Charles River**

Several rowing teams and clubs practice and conduct racing meets on the Charles River, highlighted by the annual Head of the Charles Regatta, which in 2025 hosted over 2,600 rowers from over 850 clubs (Head Of The Charles 2025 - All Entries). Other canoe races and dragon boat races take place annually on the Charles River, and sailing is also popular. Community Boating, located in Boston along the Esplanade, is "the oldest public sailing organization in the United States" (Home - Community Boating Incorporated).

Catch-and-release fishing—both from boats and along the shoreline—is a popular activity, and commonly-caught species include yellow and white perch, bluegill, crappie, large and small-mouth bass, carp, pickerel and striped bass (Can you fish in the Charles River?). The Massachusetts Department of Public Health Bureau of Climate and Environmental Health Freshwater Fish Consumption Advisory List[9] specifies that carp and largemouth bass (for some groups) should not be consumed from the Charles River between the South Natick Dam and the Museum of Science (Old Charles River) Dam due to the presence of **PCBs, pesticides, and PFAS**.

The areas along the Charles River are heavily used for passive recreation, and feature several parks including Christian A. Herter Park, John F. Kennedy Memorial Park, Magazine Beach, and the Esplanade. Various walking and biking paths run along the banks of the Charles River, including the Dr. Paul Dudley White Path and the Healthy Heart Trail. Major annual events such as the 4th of July Concert/Fireworks and the Head of the Charles Regatta draw hundreds of thousands of people to the banks of the Charles River.

### 13.4.3 Stressors Limiting Attainment of Water Quality Standards

The Charles River Dam changed the original nature of the Lower Charles River from a brackish, tidally-influenced estuary to a freshwater impoundment with managed levels, and substantial modifications have been made to the banks of the river. However, these physical changes to the river did not generally create barriers to the level of attainment of designated uses. Rather, like the Amelia Earhart Dam on the

[9] Massachusetts Department of Public Health

Mystic River, the Charles River Dam has likely improved the suitability of the river for boating and other secondary contact activities and improved the aesthetics for passive recreation along the banks of the river.

The Massachusetts 303(d) List[10] includes the Charles River between the Watertown Dam and the Charles River Dam under “Category 5 – Waters requiring a TMDL". This section of the river is split into two segments, with the dividing line being the BU Bridge, and impairments listed for each segment. A total of 12 impairments are identified in the Integrated List for both the upper and lower reaches of the Charles River, while six are identified only for the upper reach, and six are identified only for the lower reach (MassDEP 2023) (Refer to Table 2-3 in Section 2). The listed impairments have been organized into the following general categories, although they may fall under more than one category:

- **Nutrients/eutrophication-related:** chlorophyll-a, dissolved oxygen, dissolved oxygen supersaturation (lower reach only), harmful algal blooms, nutrient/eutrophication biological indicators, total phosphorus, transparency/clarity;
- **Residual toxic chemical-related**: DDT, PCBs in fish tissue, fish bioassessments (upper reach only), high pH (upper reach only), sediment bioassay [chronic toxicity freshwater] (upper reach only), unspecified metals in sediment (upper reach only);
- **Invasive species:** Non-native fish/shellfish/zooplankton (upper reach only), water chestnut (upper reach only);
- **Bacteriological:** *E. coli*; and
- **Other:** Fish passage barrier, flow regime modification, cause unknown [sediment screening value exceedance] (lower reach only), combined biota/habitat bioassessments (lower reach only), odor (lower reach only), salinity (lower reach only), temperature (lower reach only).

The water quality model for the Charles River noted above allows for the evaluation of *E. coli* and *Enterococcus* concentrations in the Charles River but does not address the other pollutants or stressors identified on the 303(d) List.

As described in Section 6 above, bacteria concentrations were applied to the various flow sources to the Charles River to create the bacterial mass loading inputs to the water quality model. The stormwater, dry weather baseflow, CSO sanitary fraction, CSO non-sanitary fraction, and Cottage Farm treated CSO counts for the sources to the Charles River are presented in **Table 13-15** (information in this table appeared in Table 6-7 in Section 6). The bacteria concentrations at the Watertown Dam upstream boundary were computed for the 2050 TY using the build up/wash off model as described in Section 6.

**Table 13-16** presents the flow-weighted sanitary fraction and the *E. coli* and *Enterococcus* counts applied to the treated and untreated CSO discharges to the Charles River for the 2050 TY (information in this table appeared in Table 6-8 in Section 6).

[10] download

**Table 13-15. Water Quality Model Parameters – Charles River**

| Bacteria | Stormwater Counts (#/100 mL) | Dry Weather Baseflow Counts (#/100 mL) | CSO Sanitary Fraction Counts (#/100mL) | CSO non-Sanitary Fraction Counts (#/100 mL) | Cottage Farm CSO Facility Counts (#/100mL) |
|---|---|---|---|---|---|
| *E. coli* | 14,000 | 134 | 7,000,000 | 14,000 | 394 |
| *Enterococcus* | 10,000 | 45 | 1,000,000 | 10,000 | 212 |

**Table 13-16. Charles River Flow Weighted CSO Bacteria Counts for the 2050 Typical Year**

| Location | Flow-weighted Counts (#/100 mL) Baseline Conditions, 2050 Typical Year | |
|---|---|---|
| | *E. coli* (#/100mL) | *Enterococcus* (#/100mL) |
| CAM005 | 22,655 | 11,227 |
| MWR018 | 42,378 | 14,022 |
| MWR019 | 95,674 | 21,577 |
| MWR020 | 26,854 | 11,822 |
| MWR201 (Cottage Farm) | 394(1) | 212(1) |
| MWR023 | 20,056 | 10,858 |
| CAM017 | 306,118 | 51,397 |
| CAM007 | No Activations | No Activations |
| MWR010 | No Activations | No Activations |

**Notes:**

(1) For outfall MWR201, the sanitary fraction method was not applied to the treated discharge. The flow-weighted counts reflect the average treated discharge counts sampled from the Cottage Farm CSO Facility effluent in 2018. Treated CSO from the MWRA Cottage Farm CSO Facility receives screening, sedimentation, disinfection and dechlorination.

Section 7 presents information on modeled bacteria loadings to the Charles River under Baseline Conditions for the 2050 TY, as well as the modeled impact of those loadings on bacteria concentrations in the Charles River. Tables and Figures from Section 7 demonstrating water quality impacts during wet weather for the Charles River are discussed below.

### Baseline Conditions Volumes and Loadings

**Table 13-17** presents a summary of the 2050 TY Baseline Condition volumes and *E. coli* loads to the Charles River (this table appeared as Table 7-9 in Section 7). As indicated in **Table 13-17**, the single largest source of volume to the Charles River is the continuous flow over the Watertown Dam from the upstream reaches of the river. Stormwater and dry weather base flows are the next largest source, while treated and untreated CSO represent less than 0.1% of the annual volume. Stormwater is the predominant source of *E. coli* loading, followed by the upstream boundary loads. The sanitary component of untreated CSO represents a very small fraction (0.4%) of the total bacteria load to the Charles River. The impacts of these loadings on modeled *E. coli* concentrations in the Charles River are presented in the sections below.

**Table 13-17. Charles River 2050 Typical Year Baseline Conditions Volumes and *E. coli* Loads**

| | Charles River 2050 Typical Year Baseline Conditions | | | |
|---|---|---|---|---|
| | *Volume* | | *E. coli* | |
| *Source* | Volume (MG) | Percent of Total | Loading (counts x $10^{12}$) | Percent of Total |
| Untreated CSO(1) | 7.7 | 0.01% | Sanitary Component: 26<br>Stormwater Component: 4 | 0.4%<br>0.1% |
| Treated CSO(2) | 30 | 0.03% | 0.45 | 0.01% |
| Stormwater | 7,137 | 7% | 3,782 | 64% |
| Dry Weather(3) | 9,663 | 10% | 49 | 1% |
| Boundary(4) | 80,415 | 83% | 2,054 | 35% |
| **Total** | **97,252** | **100%** | **5,916** | **100%** |

**Notes:**
(1) Untreated CSO includes a sanitary sewage component and a stormwater component.
(2) Treated CSO from the MWRA Cottage Farm CSO Facility receives screening, sedimentation, disinfection and dechlorination.
(3) Dry weather sources include continuous dry weather flows from tributary brooks and storm drains
(4) Boundary sources include dry and wet weather flows over the Watertown Dam.

### Baseline Conditions Attainment of Single Sample Maximum Criterion

Based on direction from MassDEP, the Charles River water quality model was used to assess attainment with single sample maximum criteria equal to the existing 30-day STV criteria of 410 #/100mL for *E. coli* and 130 #/100mL for *Enterococcus*.

The single sample maximum criteria were assessed by computing the proportion of modeled time in which bacterial concentrations at every defined model grid cell remained below the single sample maximum criterion, and by creating mosaic plots of hours of criteria exceedance within the Charles River for the individual model grid cells. With these plots, the percent of river area achieving varying levels of annual attainment of the single sample maximum criteria could be assessed. **Table 13-18** summarizes the percent attainment of the single sample maximum criteria for both *E. coli* and *Enterococcus* for the 2050 TY, using the first approach described above (this table appeared as Table 7-10 in Section 7). As indicated in **Table 13-18**, for both *E. coli* and *Enterococcus*, no differences were predicted in the percent attainment for All Sources compared to Non-CSO Sources for the Charles River. Thus, **elimination of CSO would not change this assessment of attainment. With CSOs Only, annual attainment for both *E. coli* and *Enterococcus* was greater than 99% for the Charles River.**

**Figure 13-16** presents a contour map of the percent of time in the 2050 TY that the maximum *E. coli* concentration is below the single sample maximum criterion (410 #/100mL) under the All-Sources scenario. This figure provides a more nuanced assessment of the spatial distribution of attainment of the single sample maximum criterion. As indicated in **Figure 13-16**, nearly 60% of the river area is predicted to meet the single sample maximum criterion for *E. coli* at least 90% of the time in the 2050 TY, and over 80% of the river area is predicted to meet the single sample maximum criterion for E. coli at least 80% of the time. Areas of consistently lower attainment are just downstream of the Watertown Dam, and the area adjacent to the Muddy River confluence and MWR023 outfall. **The lower attainment downstream of the Watertown Dam is driven by the bacteria loads coming over the dam from upstream, while the lower attainment adjacent to the MWR023 outfall/Muddy River is driven primarily by the base flow and stormwater loadings from those sources.**

**Table 13-18. Charles River Percent Annual Attainment of the Single Sample Maximum Criteria for the 2050 Typical Year**

| Percentage Time Entire Modeled Charles River Meets the Single Sample Maximum Criteria(1) – 2050 Typical Year Baseline Conditions | | | | | | | |
|---|---|---|---|---|---|---|---|
| *E. coli* (410#/100mL) | | | | *Enterococcus* (130#/100mL) | | | |
| All Sources | Non-CSO Sources | CSO Only | Stormwater Only | All Sources | Non-CSO Sources | CSO Only | Stormwater Only |
| 51% | 51% | 99.7% | 63% | 34% | 34% | 99.7% | 45% |

**Notes:**
(1) Based on guidance from MassDEP, model results were analyzed for a single sample maximum equivalent to the value of the Class B Statistical Threshold Value Criterion for bacteria.

**Figure 13-17** is a similar plot for the Non-CSO Sources condition. In comparing **Figure 13-16** and **Figure 13-17**, it is apparent that **eliminating the CSO loads would not affect the spatial distribution of the duration of exceedance of the *E. coli* single-sample maximum criterion.**

**Figure 13-18** presents the duration of exceedance of the *E. coli* single-sample maximum criterion for the condition of CSO loads, only. As indicated in **Figure 13-18**, **with only CSO loadings, the entire modeled river would be below the single sample maximum criterion at least 95 percent of the time in the 2050 TY.**

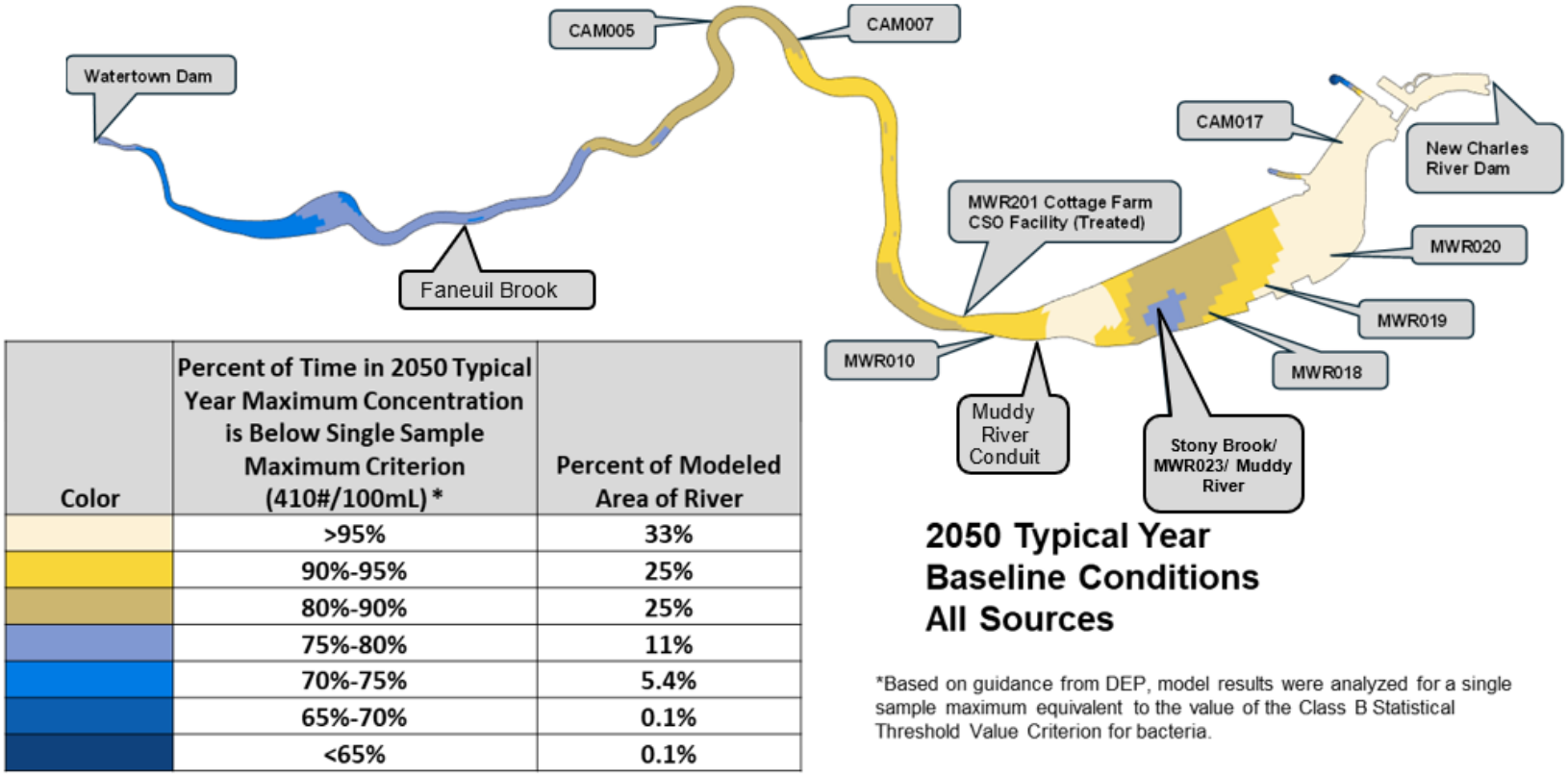
Based on **Figure 13-16** to **Figure 13-18**, **controlling the non-CSO sources** of *E. coli* to the Charles River would be necessary to substantially reduce the hours of exceedance of the single sample maximum criterion in those waterbodies.

### Baseline Conditions Attainment of 30-Day Geometric Mean and STV Criteria

**Figure 13-19** presents a series of plots of the percent of the time over the 2050 TY that each modeled cell was in attainment with the 30-day E. coli geometric mean criterion, for four simulation scenarios: All-Sources, Non-CSO Sources, CSO Only, and Stormwater Only. **Table 13-19** presents the percent of the modeled area which falls within the various categories of percent of time in attainment with 30-day E. coli geometric mean criterion for the four scenarios.

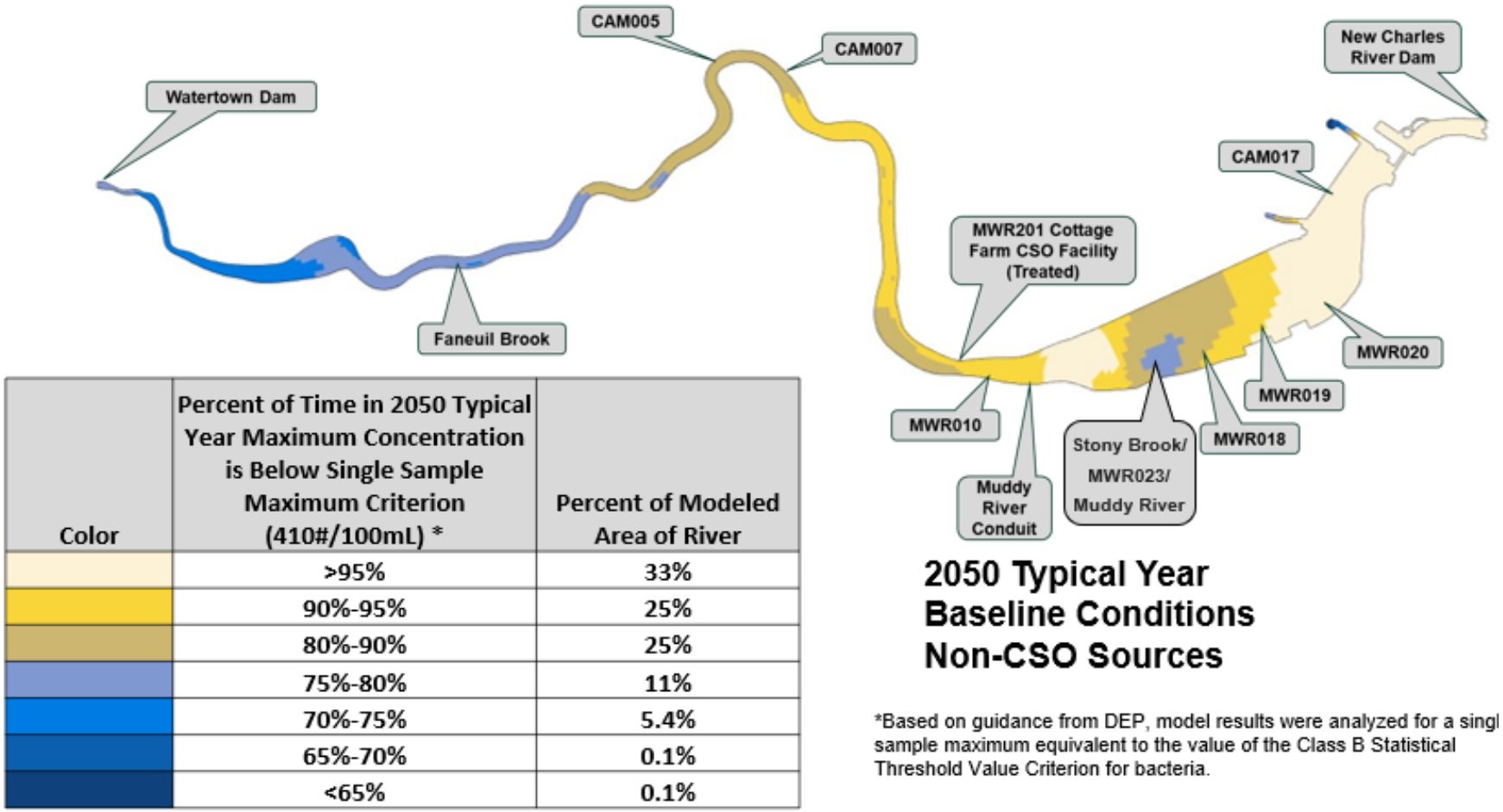
The All Sources and Non-CSO Sources plots in **Figure 13-19** are essentially identical, indicating minimal influence of CSOs in attainment of the 30-day geometric mean criterion. The CSO-only plot shows greater than 95% attainment for the entire modeled river, and Stormwater-Only plots show nearly similar attainment, indicating that **upstream sources and base flows are the key drivers of non-attainment of the 30-day E. coli geometric mean criterion.**

As indicated in **Table 13-19**, with All Sources about half of the river is in attainment with the 30-day E. coli geometric mean criterion at least 95% of the time in the 2050 TY. About 20% of the river is in attainment with the 30-day E. coli geometric mean criterion less than 65% of the time in the 2050 TY. Most of the non-attainment occurs in the relatively narrow reach of the river downstream of the Watertown Dam and upstream of the most upstream CSO (CAM005).



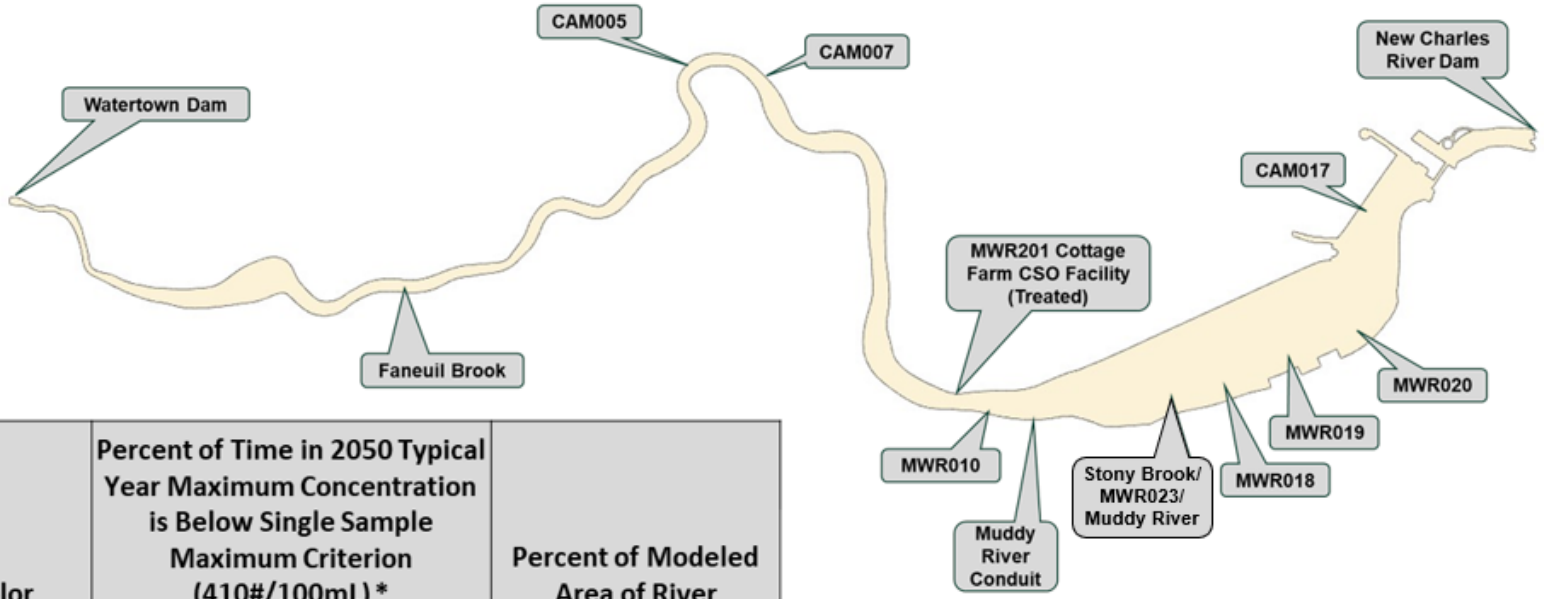

| Color | Percent of Time in 2050 Typical Year Maximum Concentration is Below Single Sample Maximum Criterion (410#/100mL) * | Percent of Modeled Area of River |
|---|---|---|
| | >95% | 33% |
| | 90%-95% | 25% |
| | 80%-90% | 25% |
| | 75%-80% | 11% |
| | 70%-75% | 5.4% |
| | 65%-70% | 0.1% |
| | <65% | 0.1% |

**Figure 13-16. Charles River Percent Annual Attainment of Single Sample Maximum Criterion for *E. coli*, 2050 Typical Year Baseline Conditions All Sources**




| Color | Percent of Time in 2050 Typical Year Maximum Concentration is Below Single Sample Maximum Criterion (410#/100mL) * | Percent of Modeled Area of River |
|---|---|---|
| | >95% | 33% |
| | 90%-95% | 25% |
| | 80%-90% | 25% |
| | 75%-80% | 11% |
| | 70%-75% | 5.4% |
| | 65%-70% | 0.1% |
| | <65% | 0.1% |

**Figure 13-17. Charles River Percent Annual Attainment of Single Sample Maximum Criterion for E. coli, 2050 Typical Year Baseline Conditions Non-CSO Sources**




| Color | Percent of Time in 2050 Typical Year Maximum Concentration is Below Single Sample Maximum Criterion (410#/100mL) * | Percent of Modeled Area of River |
|---|---|---|
| | >95% | 100% |
| | 90%-95% | 0% |
| | 80%-90% | 0% |
| | 75%-80% | 0% |
| | 70%-75% | 0% |
| | 65%-70% | 0% |
| | <65% | 0% |

*Based on guidance from DEP, model results were analyzed for a single sample maximum equivalent to the value of the Class B Statistical Threshold Value Criterion for bacteria.

**Figure 13-18. Charles River Percent Annual Attainment of Single Sample Maximum Criterion for E. coli, 2050 Typical Year Baseline Conditions CSO Sources Only**

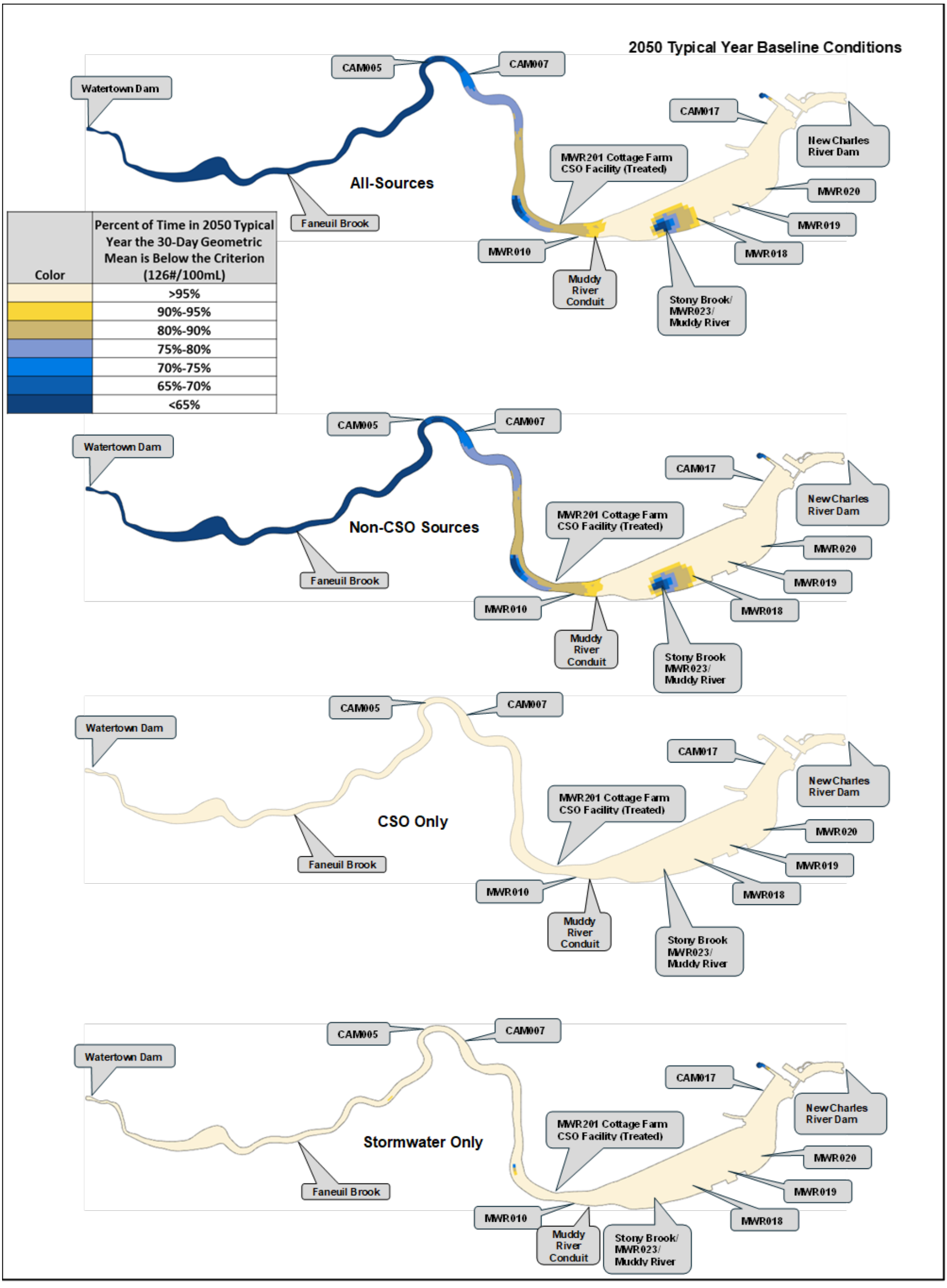



Figure 13-19. Charles River Percent Annual Attainment with *E. coli* 30-Day Geometric Mean Criterion for 2050 Typical Year Baseline Conditions

**Table 13-19. Charles River Percent of River Area and Range of Percent Attainment of *E. coli* 30-Day Geometric Mean Criterion Baseline Conditions**

| Color | Percent of Time in 2050 Typical Year the 30-Day Geometric Mean is Below the Criterion (*E. coli* 126 #/100mL) | Percent of Modeled Area | | | |
|---|---|---|---|---|---|
| | | All-Sources | Non-CSO Sources | CSO Only | Stormwater Only |
| | >95% | 53% | 54% | 100% | 99.4% |
| | 90%-95% | 4% | 4% | 0% | 0.2% |
| | 80%-90% | 11% | 11% | 0% | 0.1% |
| | 75%-80% | 7% | 6% | 0% | 0.0% |
| | 70%-75% | 2% | 2% | 0% | 0.1% |
| | 65%-70% | 2% | 2% | 0% | 0.1% |
| | <65% | 21% | 21% | 0% | 0.1% |

**Figure 13-20** presents a series of plots of the percent of the time over the 2050 TY that each modeled cell was in attainment with the 30-day *E. coli* STV criterion, for four simulation scenarios: All-Sources, Non-CSO Sources, CSO Only, and Stormwater Only. **Table 13-20** presents the percent of the modeled area which falls within the various categories of percent of time in attainment with the 30-day *E. coli* STV criterion for the four scenarios.

The All Sources and Non-CSO Sources plots in **Figure 13-20** are nearly identical, indicating **minimal influence of CSOs** in attainment of the 30-day STV criterion. The Stormwater-Only plot indicates that stormwater has a greater impact on attainment of the STV criterion than attainment of the geometric mean criterion, while **upstream sources and base flows are also key drivers of non-attainment** with the 30-day *E. coli* STV criterion. As indicated in **Table 13-20**, just over 10% of the river is in attainment with the 30-day E. coli STV criterion at least 95% of the time in the 2050 TY. More than 50% of the river is in attainment with the 30-day *E. coli* STV criterion less than 65% of the time in the 2050 TY. Between the geometric mean and STV criteria, it is the STV that creates the greater extent of non-attainment, while the **non-CSO sources are the greatest contributors to that non-attainment.**

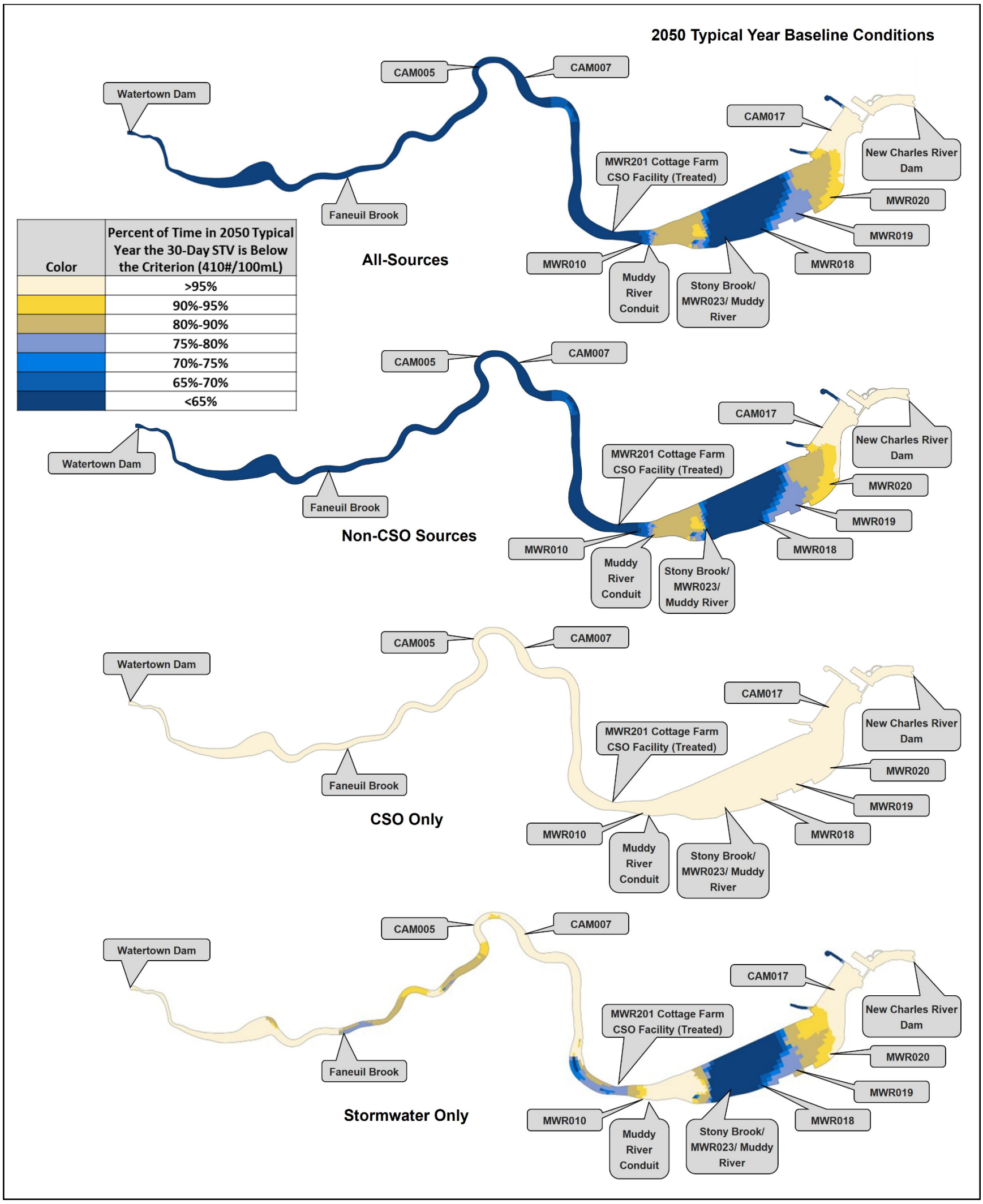



**Figure 13-20. Charles River Percent Annual Compliance with *E. coli* 30-Day STV Criterion for 2050 Typical Year Baseline Conditions**

**Table 13-20. Charles River Percent of River Area and Range of Percent Attainment of *E. coli* 30-Day STV Criterion Baseline Conditions**

| Color | Percent of Time in 2050 Typical Year the 30-Day STV is Below the Criterion (*E. coli* 410 #/100mL) | Percent of Modeled Area | | | |
|---|---|---|---|---|---|
| | | All-Sources | Non-CSO Sources | CSO Only | Stormwater Only |
| | >95% | 11% | 12% | 100% | 45% |
| | 90%-95% | 6% | 7% | 0% | 10% |
| | 80%-90% | 15% | 14% | 0% | 13% |
| | 75%-80% | 6% | 6% | 0% | 7% |
| | 70%-75% | 3% | 2% | 0% | 3% |
| | 65%-70% | 4% | 4% | 0% | 2% |
| | <65% | 55% | 55% | 0% | 20% |

### Baseline Conditions Assessment of Maximum *E. coli* Concentrations and Duration of Impact

While the preceding sections demonstrated the relatively limited impact of CSOs on attainment of water quality criteria over the 2050 TY, those assessments do not necessarily reflect the short-term impacts of CSOs on water quality during the periods of time when the CSOs are discharging. One approach to assessing those short-term impacts is by plotting the maximum concentrations at each model cell in the river under conditions of All Sources, Non-CSO Sources Only, and CSO Only. **Figure 13-21** presents the plots for All Sources and Non-CSO Sources, while **Figure 13-22** presents the plot for CSO Only. Note that the color-coded scales of maximum concentration are different between **Figure 13-21** and **Figure 13-22**.

In comparing the two plots in **Figure 13-21**, the impact of CSOs on maximum concentrations can be seen by the small differences in shading color adjacent to outfalls MWR018, MWR019 and CAM017 in the All Sources compared to the Non-CSO Sources plot. The extents of the blue shading opposite the MWR023 outfall are also slightly greater for All Sources compared to Non-CSO Sources Only. For most of the river area, however, the CSOs do not appear to affect the extent of the different ranges in maximum concentration.

**Figure 13-22** zooms in on the maximum concentrations for the CSO Only case. The relatively limited areas with peak concentrations above 410 #/100mL are clustered around the active untreated CSO outfalls (CAM005, MWR023, MWR018, MWR019, MWR020 and CAM017). The areas above 1,000 #/100mL are even more tightly centered on the model cells representing the ends of the outfalls, and the immediately adjacent model cells.

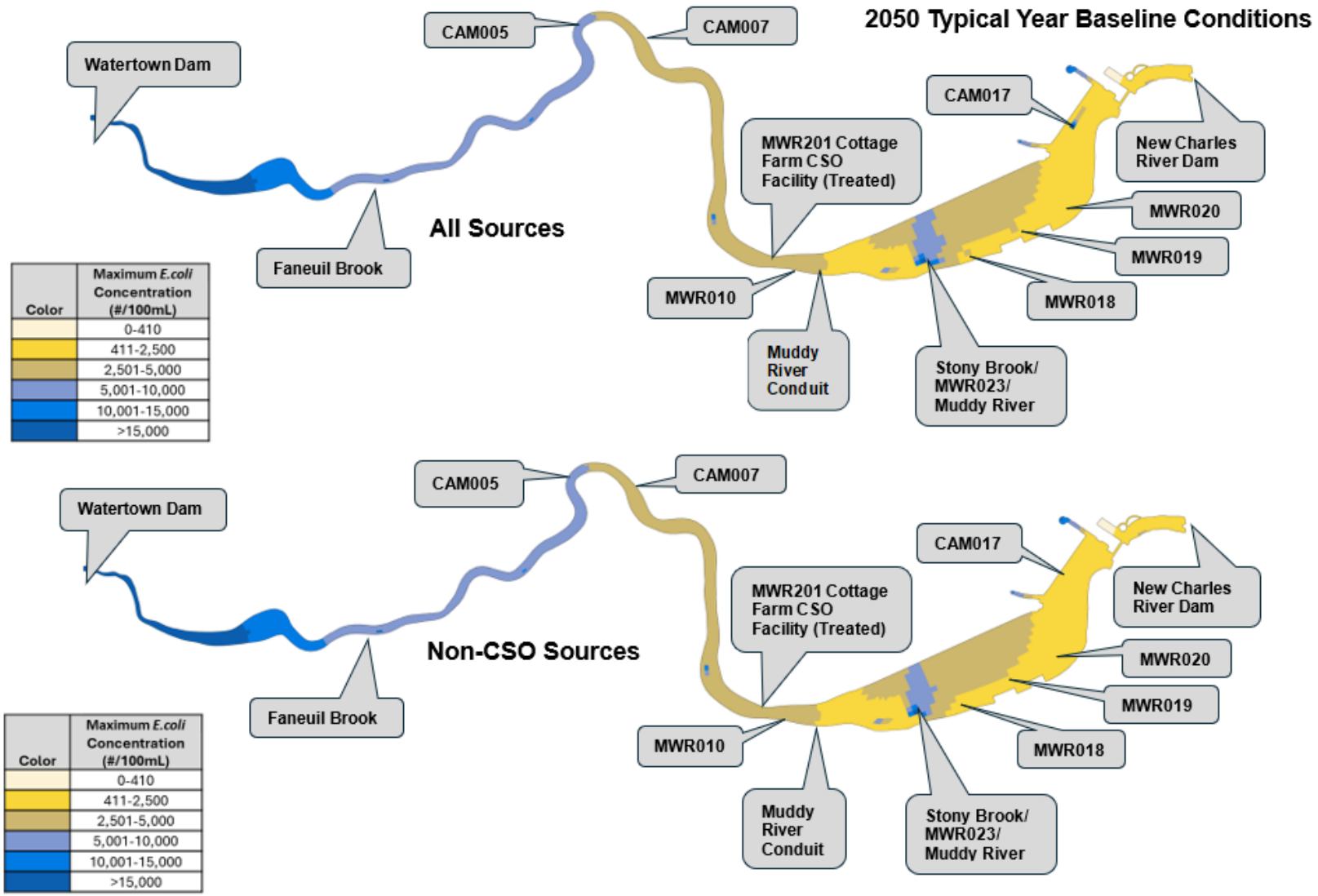



**Figure 13-21. Charles River Maximum *E. coli* Concentrations in 2050 Typical Year Baseline Conditions, All Sources and Non-CSO Sources**

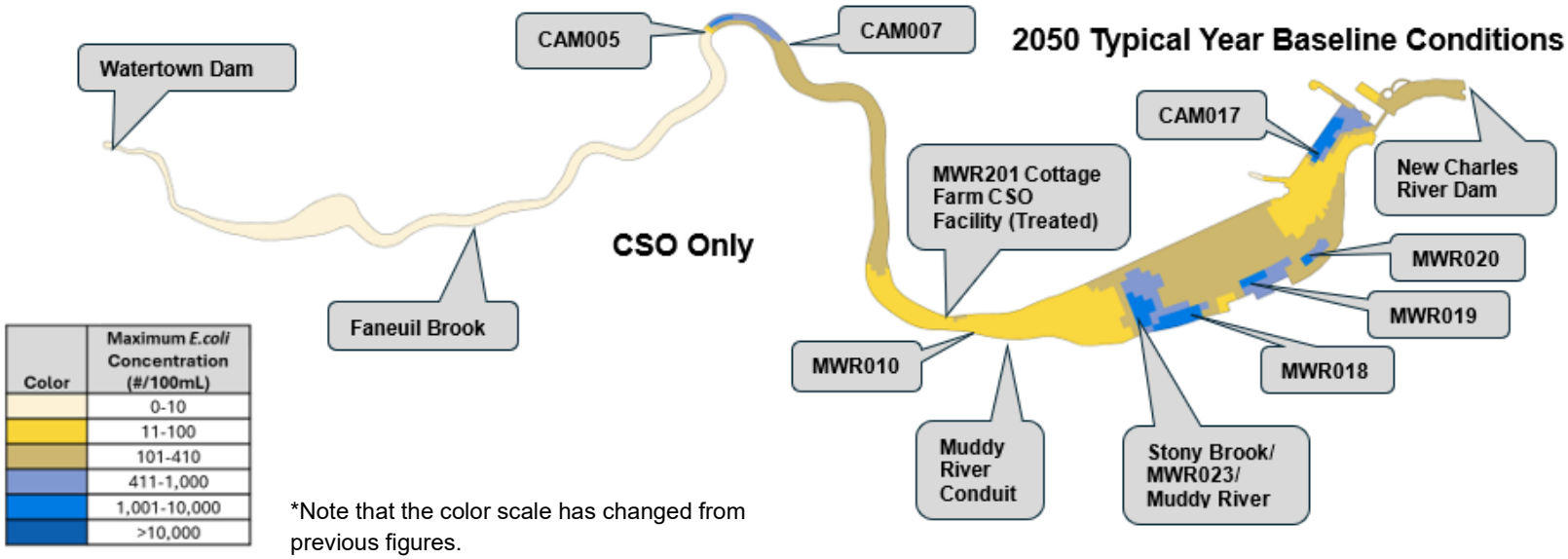



**Figure 13-22. Charles River Maximum *E. coli* Concentrations in 2050 Typical Year Baseline Conditions, CSO Only**

### *E. coli* Concentrations Over Time Following Storm Event

As another means of representing the magnitude, duration, and spatial extent of impacts of wet weather bacteria loads on water quality in the Charles River, a series of plots were developed that present *E. coli* concentrations during and after the storm in the 2050 TY that generated the largest CSO volume to the Charles River (the December 17 storm). **Figure 13-23** presents contour plots color coded by the *E. coli* concentrations at the peak of the December 17 storm from the 2050 TY, and at intervals of 6, 12, 24, 48, and 72 hours following the peak, for the All Sources.

As indicated in **Figure 13-23,** at the peak of the storm, the highest *E. coli* concentrations are in the reach of the river downstream of the Watertown Dam, at specific points associated with the MWR023, MWR018, MWR019, MWR020 and CAM017 CSO outfalls, and in the Lechmere Canal. At 6 hours after the peak of the storm, the high concentrations from the Watertown Dam have moved downstream, and the peak concentrations associated with outfalls MWR019, MWR020 and CAM017 have dissipated. A very small area of concentration above 5,000 #/100mL persists through hour 12 following the peak. That concentration is likely **driven mostly by stormwater from the Stony Brook Conduit and Muddy River,** as the CSO volume at outfall MWR023 during that storm is relatively small (0.02MG). By 48 hours after the peak of the storm, the upstream reach of the Charles River is under 410 #/100ml, while most of the lower basin is in the 410-1,260 #/100mL range. **By 72 hours after the peak, the entire modeled river is under 410 #/100mL except for an area adjacent to the MWR023 outfall**. The elevated concentrations near outfall MWR023 are due to a second rainfall event that occurred in the 2050 TY between the 48 and 72-hour marks. The **elevated concentrations are a result of stormwater loadings** from this subsequent storm rather than a prolonged effect from the original December 17 event (no CSO discharged during the second event).

**Figure 13-24** presents a similar set of contour plots color coded by the *E. coli* concentrations for those same time intervals for the CSO Sources Only condition. Note that the color-coding scale in **Figure 13-24** is different from the scale presented in **Figure 13-23**. As indicated in **Figure 13-24**, by 6 hours after the peak of the storm, the *E. coli* concentrations from CSOs have dropped below the 410 #/100mL single-sample maximum criterion level.

To provide additional detail on the impact of CSOs on peak *E. coli* concentrations, plots were developed of *E. coli* concentration over time at two specific model grid cells in the Charles River for the December 17 event. **One grid cell was located in the region of elevated concentration adjacent to the MWR023 outfall/Muddy River discharge (Figure 13-25), and one was located at the discharge point for outfall MWR020** (**Figure 13-26**)**.**

In **Figure 13-25**, the slightly higher peaks near outfall MWR023 on December 17 for the All Sources condition coincide with CSO discharges. CSOs were not discharging during the peaks on December 14 and December 20.

In **Figure 13-26**, the initial peak coincides with the CSO discharge at outfall MWR020. The second peak on December 19 reflects CSO and other loading sources moving into the area near outfall MWR020 from upstream. Note that the Y-axis scales on **Figure 13-25** and **Figure 13-26** are different.

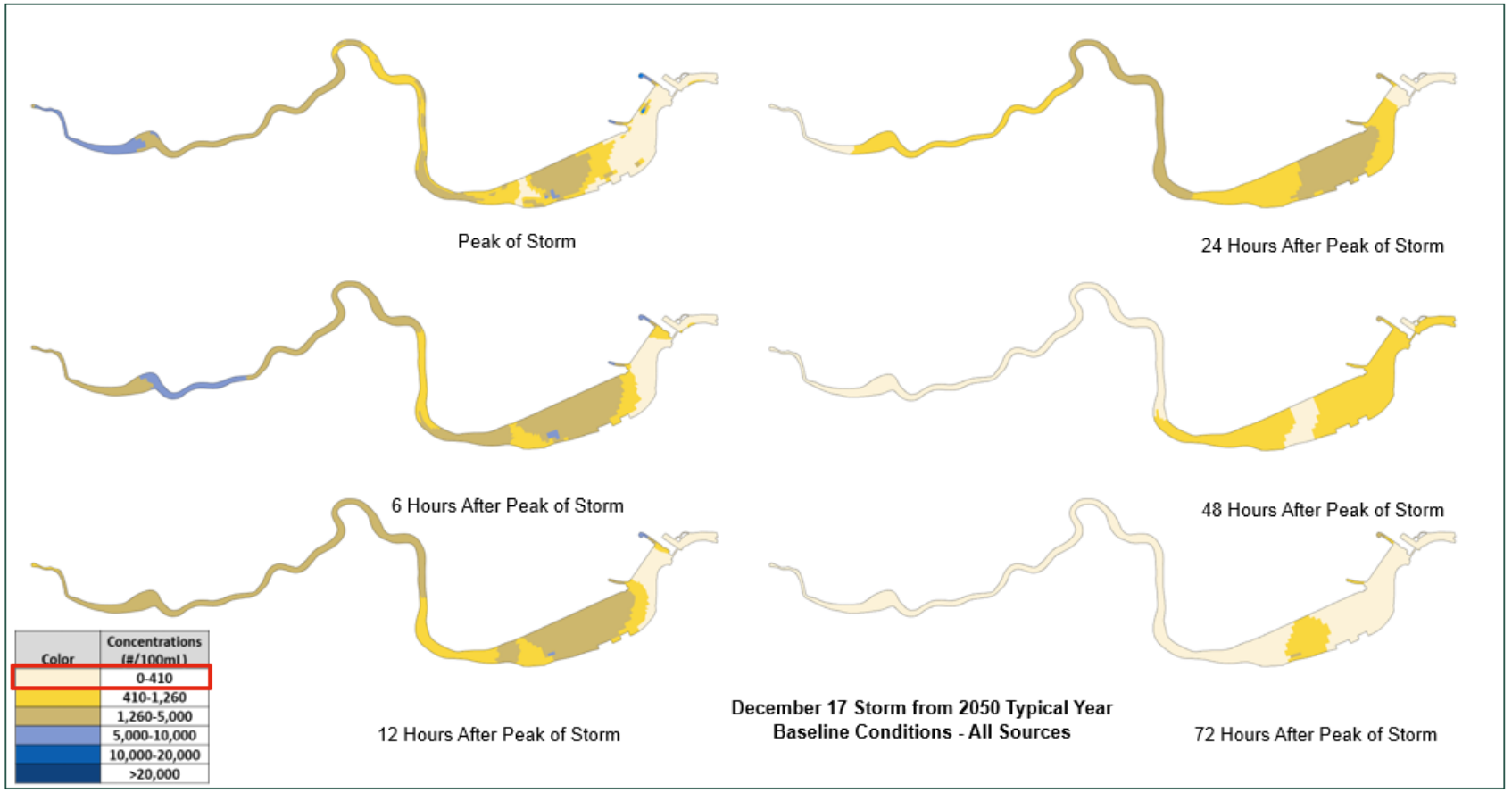



**Figure 13-23. Charles River *E. coli* Concentrations Over Time During and After the December 17 Storm from the 2050 Typical Year, Baseline Conditions, All Sources**

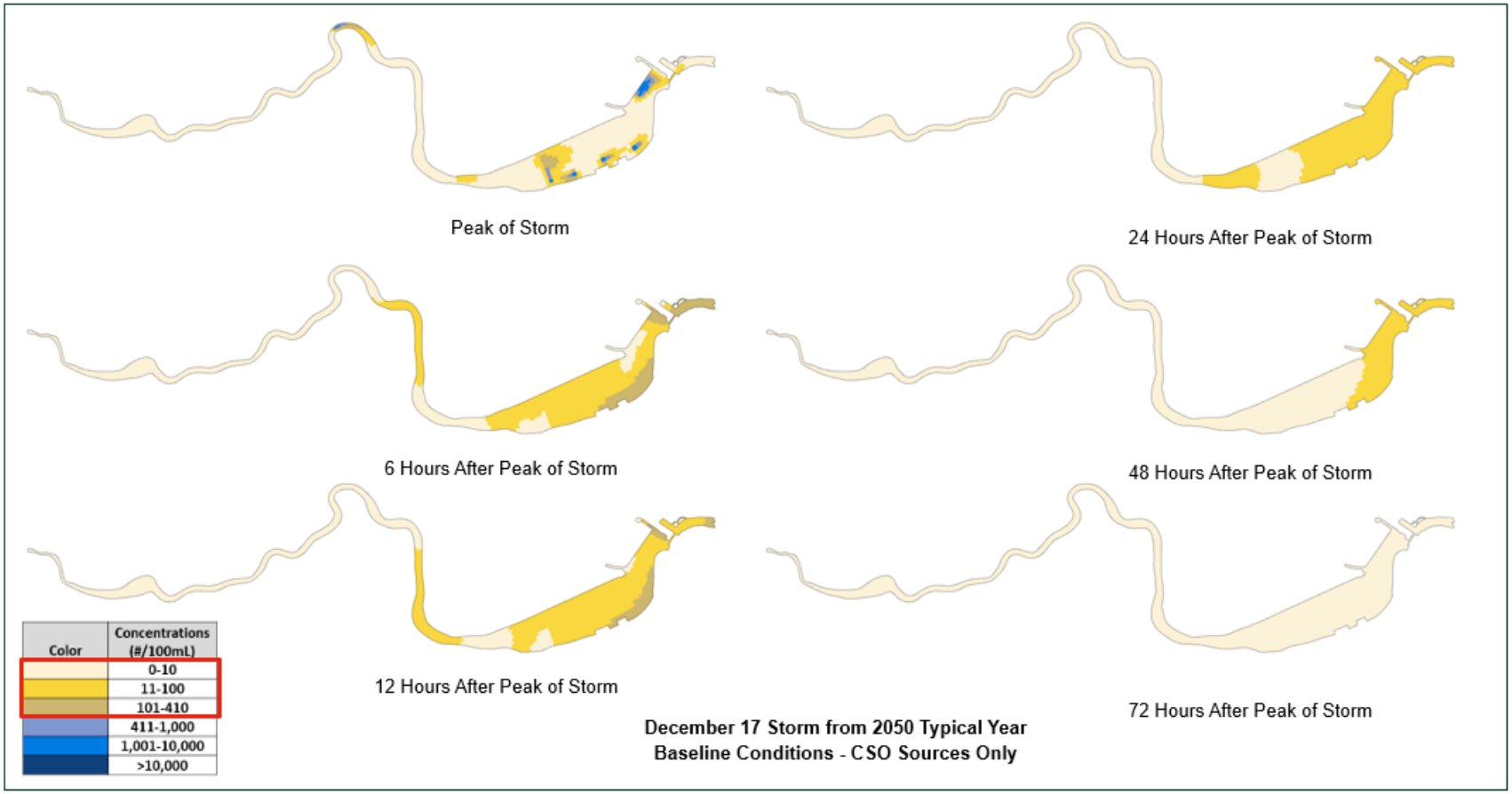



**Figure 13-24. Charles River *E. coli* Concentrations Over Time During and After the December 17 Storm from the 2050 Typical Year, Baseline Conditions, CSO Sources Only**

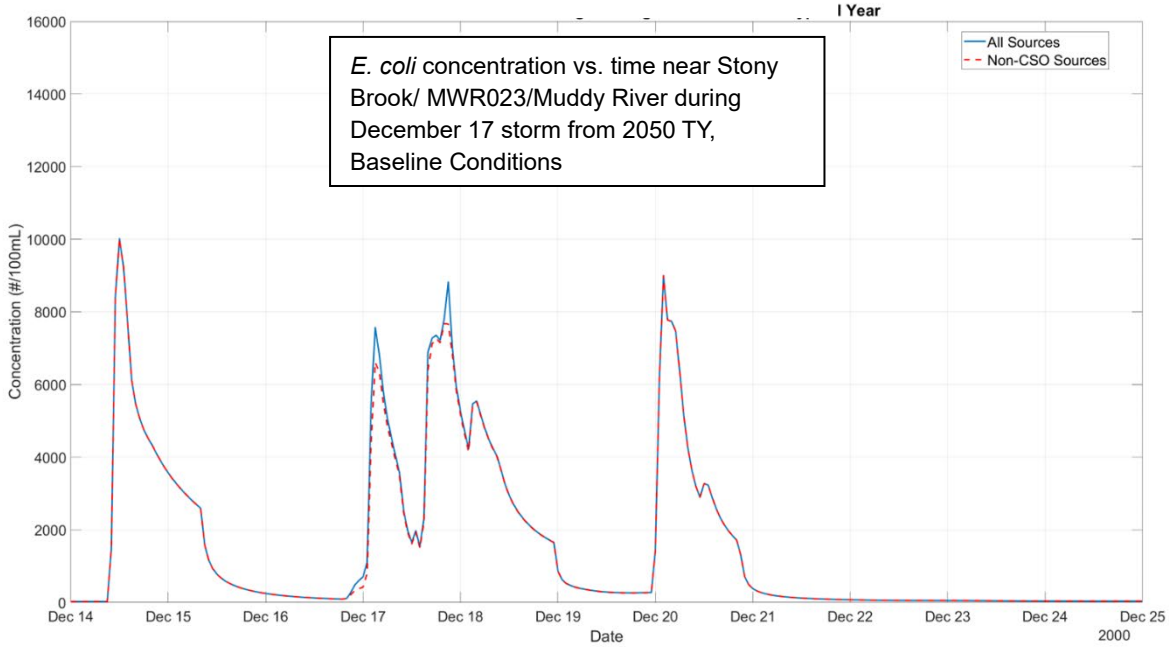



**Figure 13-25. *E. coli* Concentration vs. Time Near Stony Brook/ MWR023/Muddy River, All Sources vs. Non-CSO Sources**

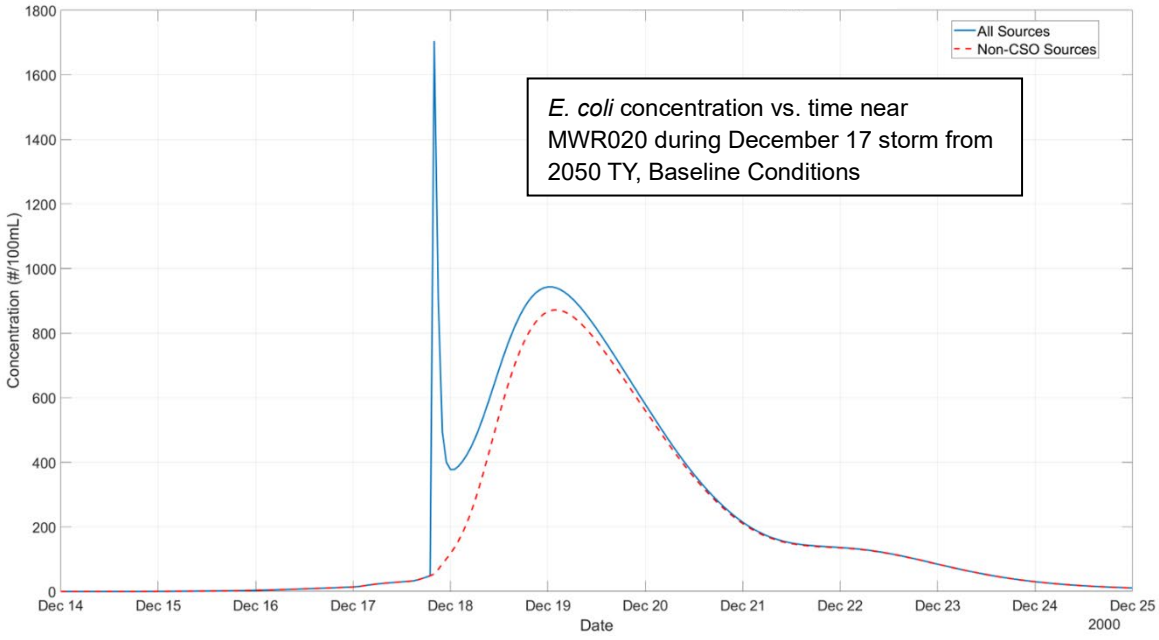



**Figure 13-26. *E. coli* Concentration vs. Time Near MWR020, All Sources vs. Non-CSO Sources**

### Summary of Baseline Water Quality for the Charles River

In summary, the 303(d) List identified a wide range of impairments to the Charles River. In terms of impairments related to bacteria, CSOs contribute to the peak wet weather *E. coli* concentrations in the Charles River but other sources, primarily stormwater and upstream boundary sources also contribute to the non-attainment of the *E. coli* water quality criteria. **Removal of untreated CSOs from the Charles River would marginally reduce peak bacteria concentrations in the Charles River during events where the CSOs would otherwise activate but would not improve the duration of attainment of numeric water quality criteria, nor materially change the level of attainment of uses of the waterbody**. Reduction of the treated CSO volume to the Charles River at outfall Cottage Farm CSO Facility (MWR201) would have no impact on attainment of the numerical water quality criteria for *E. coli*.

### 13.4.4 Recommended Plan

As described in Section 11, the recommended alternative for the Charles River is Alternative 4.CR Hybrid 3, which includes the following individual projects:

- A 2.5 MG stormwater storage tank and flow restriction upstream of outfall CAM005 in Cambridge;
- A 10.1 MG storage tank to capture flows from the Cottage Farm CSO Facility in Cambridge;
- Separation of approximately 366 acres of runoff area tributary to the Boston Marginal Conduit and outfalls MWR018/019/020 in Boston;
- A 0.16 MG storage conduit to capture overflow from regulator RE046-100 and a 0.08 MG storage conduit to capture overflow from regulator RE046-381 upstream of outfall MWR023 in Boston; and
- 80 acres of sewer separation upstream of outfall CAM017 in Cambridge.

In combination, these projects would eliminate the untreated and treated CSO activations to the Charles River in the 2050 TY.

The estimated capital cost of this alternative as presented in Sections 9 and 11 was $690M (2024 dollars, no escalation). The estimated capital cost to reach the next highest level of control evaluated, capture of the CSO volumes from the 2050 5-year, 24-hour storm, was $2,000M (11.CR 5-Year Tunnel + GSI: 4.5-mile-long, 24-foot diameter deep storage tunnel +1-mile-long microtunnel + 90 acres of GSI). The additional $1,310M cost for the 5-year tunnel alternative would result in no change in water quality or uses during the 2050 TY. The benefit would likely be seen in reduced short-term peak bacterial concentrations during storms larger than the largest storm in the 2050 TY Based on modeling of storms in the 2050 TY, it is not anticipated that the duration of exceedance of the MassDEP-recommended single-sample maximum *E. coli* criterion of 410 #/100mL would change with the 5-year alternative due to the remaining impacts from the non-CSO bacteria sources. As a result, as a practical matter, it is not likely that the supported uses of the Charles River would appreciably change during those large storm events that would be captured by the 5-year alternative compared to the LOC provided by the recommended plan. The recommended plan, which would reduce CSO activations to zero in the 2050 TY, should be considered as part of MassDEP's UAA determination(s), along with existing and foreseeable reductions to other pollutant sources.

### 13.4.5 Factors that Could Support a Change in Water Quality Status

The applicable factors for consideration that could support a change in water quality status for the Charles River could potentially include one or both of the following:

- Factor 3: Human-caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or
- Factor 6: Controls more stringent than those required by sections 301(b) and 306 of the (Clean Water) Act would result in substantial and widespread economic and social impact."

### Discussion of Factor 3

As described above, the designated uses for Class B waters include are “habitat for fish, other aquatic life, and wildlife, including for their reproduction, migration, growth and other critical functions, and for primary and secondary contact recreation” (314 CMR 4.05(3)(b)). MassDEP could consider that human-caused sources of pollution prevent full attainment of these uses in the Charles River.

The information on baseline water quality presented in Section 7 clearly demonstrates that even with the elimination of CSOs, the water quality criteria supporting primary contact recreation would not be met during wet weather, primarily as a result of pollutant loadings from stormwater and upstream loads coming over the Watertown Dam. As indicated in **Table 13-15,** the water quality model for the Charles River was calibrated with average stormwater *E. coli* concentrations of 14,000 #/100mL.

As described for Alewife Brook, in support of the original water quality model calibration conducted by MWRA, stormwater samples were taken at a total of 14 storm drains in Cambridge, Somerville, Medford and Arlington that discharged to either Alewife Brook, the Upper Mystic River, or the Charles River, over the course of six storms (not all locations were sampled for all storms). The overall arithmetic mean concentration of all samples was 13,394 #/100mL. To better match measured concentrations from samples taken in the Charles River during wet weather events when CSOs did not discharge, the modeled concentration for stormwater had to be slightly increased above the average value from the samples, but the value of 14,000 #/100mL was within 5 percent of the mean value from all samples.

In reviewing the stormwater data collected, 82% of the samples taken in wet weather had *E. coli* concentrations greater than the MassDEP-recommended single-sample maximum criterion of 410 #/100mL. Two sample locations had all samples less than 410 #/100mL for a single storm event. Thus, at most of the locations, most of the samples had values greater than 410 #/100mL. To get from an overall average of 13,394 to 410 #/100mL would require an average 97% reduction in *E. coli* concentration.

A 2002 study conducted by the USGS on the efficacy of structural stormwater controls and street sweeping focused on the Lower Charles River found that the upper bound of bacteria load removal from weekly street sweeping in combination with the upper quartile of load removal by structural controls was approximately 17%, with the lower bound of 7.5%. The range of structural controls included typical green infrastructure/stormwater BMPs such as biofiltration/bioretention, infiltration/filtration, and detention/retention (USGS, 2002). Based on those findings, an average load reduction of 97% would not reasonably be achievable through street sweeping and structural stormwater controls. Furthermore, small-scale stormwater controls implemented by individual communities are unlikely to intercept all stormwater runoff required to achieve the high average percent reduction required.

It is likely that at least some of the high bacteria concentrations captured in the sampling program are due in part to **illicit sanitary connections**. Communities along the Charles River are required to continue to make progress in removing illicit connections through the administration of the NPDES MS4 Permit. EPA has estimated that about 340,000 gallons per day of sewage have been removed from Massachusetts waterbodies over the course of the 2016 NPDES MS4 Permit[11]. EPA requires that communities discharging to waterbodies with bacteria and pathogen impairments prioritize areas discharging to those impaired waters, and these efforts have and will continue to improve water quality entering the Charles River and other impaired waterways. **Other on-going work by the communities in stormwater management will also likely lead to incremental improvements in stormwater quality over the years**. However, the complete scope of work, cost, feasibility, and impacts needed to consistently reduce all stormwater concentrations into Charles River to a level that would allow full attainment of the single sample maximum criterion cannot be defined at this time.

[11] https://www.epa.gov/system/files/documents/2025-11/fact-sheet-2024-ma-draft-ms4-gp.pdf

### Discussion of Factor 6

Refer to Factor 6 discussion in **Section 13.2.5**.

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