CITY OF SOMERVILLE, MA

CITYWIDE FLOOD MITIGATION AND WATER QUALITY IMPROVEMENTS PLAN

Sewersheds CA & M

FINAL REPORT

JANUARY 2022

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EXECUTIVE SUMMARY

Introduction

The City of Somerville is undergoing rapid development that is adding substantial pressure to its existing drainage infrastructure, which was built largely in the late 19th century and early 20th century. The combination of rapid growth, outdated infrastructure, and added pressure from climate change has resulted in high flood risk for certain areas with significant drainage limitations. The City of Somerville has already started implementing important infrastructure improvements in critical areas such as Union Square where an extensive sewer separation program is being executed along with the construction of a large stormwater pump station near Poplar Street.

The City is looking to mitigate flood risk citywide as much as feasibly possible and has been doing so in a systematic sewershed-by-sewershed approach. This report presents a detailed flood risk analysis and flood mitigation alternative evaluation for Sewersheds CA and M. While the proposed flood mitigation projects are, for the most part, physically located within the boundaries of these two sewersheds, their impacts are not just limited to Sewersheds CA or M. There are numerous cross-connections between Sewersheds CA, M, A,C2 and S2 that result in direct or indirect impacts each time an intervention is proposed within Sewershed CA or M. These impacts can be in the form of changes in flood volumes or changes in Combined Sewer Overflow (CSO) volumes. A brief description of Sewershed CA and M is provided below.

Sewershed Backgrounds

Sewershed CA:

Sewershed CA is also commonly referred to as the Tannery Brook area. Wet weather flows from this area follow many different paths depending on whether or not they are directly or indirectly tributary to the Tannery Brook conduit. The Tannery Brook conduit is a large rectangular culvert flowing east to west along Howard Street and Tannery Brook Row and crosses into Cambridge where it becomes twin 54-inch conduits. These two conduits then reach a CSO regulator referred as SOM-001A before intercepting the MWRA trunk sewer along the Alewife Brook Parkway. Any excess flows that exceed the capacity of the MWRA sewers during intense rainfall events are spilled over a weir in the same structure into the Alewife Brook.

The SOM-001A CSO regulator is one of the regulators contemplated under the City's CSO Long-Term Control Plan (LTCP) that was established as part of the United States District Court for the District of Massachusetts, Civil Action Nos. 85-0489-MA and 83-1614-MA. This CSO LTCP, which includes an ammendment for Schedule Seven (Federal Court Order), sets the maximum volume that can be spilled to the Alewife Brook in a typical rainfall year under LTCP conditions. In current conditions, regulator SOM-001A is not meeting the LTCP volume and activation goals.

Sanitary and wet weather flows generated in Sewershed CA that do not discharge directly into the Tannery Brook conduit ultimately concentrate into the Elm Street combined sewer, which is part of Sewershed C2. However, there are numerous cross-connections between the Tannery Brook system and the "pass-through" sanitary or combined system flowing towards Sewershed C2. These cross-connections activate during wet weather events and significantly contribute to CSOs at SOM-001A.

It is important to note that there is a portion of Sewershed A, located south of Holland St between Clarendon Ave and Thorndike St, that is also tributary to the Tannery Brook drain. (See Figure ES.1) While the City has historically considered this area part of Sewershed A, existing pipe configuration indicates that it should truly be considered part of Sewershed CA. For this reason, we include this area in the current report.

Sewershed M:

Wet weather flows from Sewershed M flow, for the most part, towards Medford via a 54-inch pipe on Pearson Rd. Sanitary flows in Sewershed M also flow towards Medford via conduits leaving Somerville at Pearson Road, Boston Avenue, and Winchester Street. In general, the storm and sanitary/combined system within Sewershed M is largely independent of the rest of Somerville's sewersheds with the exception of a cross-connection on Powder House Boulevard where some storm flows from Sewershed M may enter Sewershed CA and vice versa.

Development of Flood Mitigation Interventions

Given the high level of sewershed interconnectivity, any flood mitigation interventions within Sewershed CA or M will ideally meet the criteria listed below:

Proposed projects:

- Will incrementally reduce flooding within Sewershed CA and M,
- Will reduce CSO volumes at SOM-001A at completion of the program but ideally in an incremental manner,
- Will meet the SOM-001A LTCP goals at program completion, and
- Will not make flooding or CSOs worse in other cross-connected sewersheds like C2 or S2.

The report not only provides flood mitigation and CSO reduction considerations but also estimates other relevant metrics such as Infiltration and Inflow (I/I) volume reductions and water quality implications generated by the execution of flood risk reduction projects.

The proposed projects consist mostly of gray-type infrastructure. This type of infrastructure, which includes conveyance pipes and storage systems, is human-engineered and does not utilize the natural environment to achieve stormwater treatment, conveyance, or storage. In a GSI evaluation performed by the City of Somerville in 2019, it was determined that these types of practices have a very limited impact on flood protection in dense urban areas with limited available space. Based on the GSI siting analysis presented in Section 6 of this report, in a very optimistic scenario, GSI tributary areas could amount up to 10% of the total sewershed area. The GSI runoff capture volume, however, is well below the runoff volumes generated from their respective tributary areas during large storms that cause flooding such as the 10-year event. GSI is usually designed for smaller storms that have a large cumulative impact on water quality. Due to this small contribution to flood mitigation, in this report, GSI practices were evaluated only for water quality benefits within the proposed project areas as some of the projects would result in new stormwater phosphorus contributions to a receiving waterbody subject to pollutant regulatory requirements.

In this report, Dewberry studied two approaches to achieve the City's flood and CSO reduction goals for Sewershed CA.

1. The first approach (Alternative 1) consisted of developing a sequence of projects that would reduce flooding and CSO but would keep the Tannery Brook area operating as a combined sewer system. The primary improvements under Alternative 1 include installation of box culverts on Morrison Ave and Winslow Ave, sewer separation and cross-connection removal in the Vernon St area, and conduit upsizing in the area around Tufts University.

2. The second approach (Alternative 2) evaluated a sequence of interventions that would ultimately separate the Tannery Brook conduit tributary area, enable the construction of a new stormwater outfall, and possibly eliminate the SOM-001A CSO regulator altogether. The primary improvements under Alternative 2 include installation of box culverts on Morrison Ave, Winslow Ave, Grove St, Highland Ave, and Chester St as well as sewer separation in the Vernon St area, Highland Rd/Appleton St area, and an area south of Holland St. Additionally, Alternative 2 includes repurposing part of the Tannery Brook conduit to use one of its twin 54-inch pipes as a sanitary sewer and the other one as a storm drain, removing all cross-connections between the Tannery Brook conduit and existing combined sewers, and constructing a new stormwater outfall to Alewife Brook.

For Sewershed M, projects were of a more localized nature, but they also had to meet the same criteria listed previously. The proposed projects for Sewershed M consist mostly of pipe upsizing or providing additional stormwater storage to detain flows during storm events.

In general, projects involved a combination of the following types of improvements:

- Increasing in-line or off-line stormwater storage,
- Improving pipe conveyance via pipe upsizing,
- Sewer separation of strategic areas, or
- Strategic elimination of cross-connections between sanitary and stormwater conveyance pipes

Conceptual-level drawings of the proposed projects are included in Appendix A and flood maps in existing conditions and after proposed project implementation are presented in Appendix B.

Flood and I/I Reduction Benefits for Proposed Projects

Flood volumes during design storms under each system condition are presented in Table ES 1, Table ES 2, and Table ES 3. Total flood volumes were reported for projects in Sewershed CA (under Alternatives 1 and 2) for the entire Sewershed CA area plus Sewershed M and the portion of Sewershed A that is tributary to the Tannery Brook drain (See Figure ES.1) under the 10-year, 24-hour and 10-year, 30-minute design storms. Flood volumes reported for Sewershed M projects are for Sewershed M project areas only. Previous sewershed reports presented volumes specific to the proposed project boundaries; however, flood reduction benefits for proposed projects in Sewersheds CA are often realized upstream and/or downstream of the proposed improvements. Therefore, reporting volumes specific to the project area would not truly capture the flood reduction benefit achieved by each particular project. Additionally, the proposed projects in Sewershed CA (Alternatives 1 and 2) are of a sequenced nature as opposed to proposed projects in previous reports which could be implemented individually. Therefore, flood volumes presented for each project in Table ES 1 and Table ES 2 are cumulative, assuming all of the previous projects have already been implemented.

These summary tables also include estimated I/I volume reductions expected to be achieved by the project under the regulatory MassDEP 1-year, 6-hour storm event. Engineer's concept-level estimates of project costs were computed and are also included in these tables. Detailed project cost breakdowns are included in Appendix C.

Water Quality Impact Considerations

As indicated above, one approach to Sewershed CA consists of separating the currently combined sewer system that leads to the SOM-001A CSO regulator. This will result in new stormwater contributions to the Alewife Brook, which is subject to annual phosphorus load limitations. According to the Mystic River Watershed Alternative TMDL for Phosphorus Management, communities discharging stormwater to the Mystic River are required to reduce annual phosphorus loads between 59% and 62%. This reduction applies to phosphorous loadings from stormwater generated within areas that are already tributary to the Mystic River or assumed to be in the future by EPA. For new contributions outside of these areas, these reductions are likely to be more stringent. As part of this assessment, phosphorus load reduction Best Management Practices (BMP) for projects with new stormwater contributions to the Alewife Brook were evaluated, and their phosphorus reduction potential, capital and O&M costs, and general feasibility were assessed. A summary of this assessment is provided in Table ES 4.

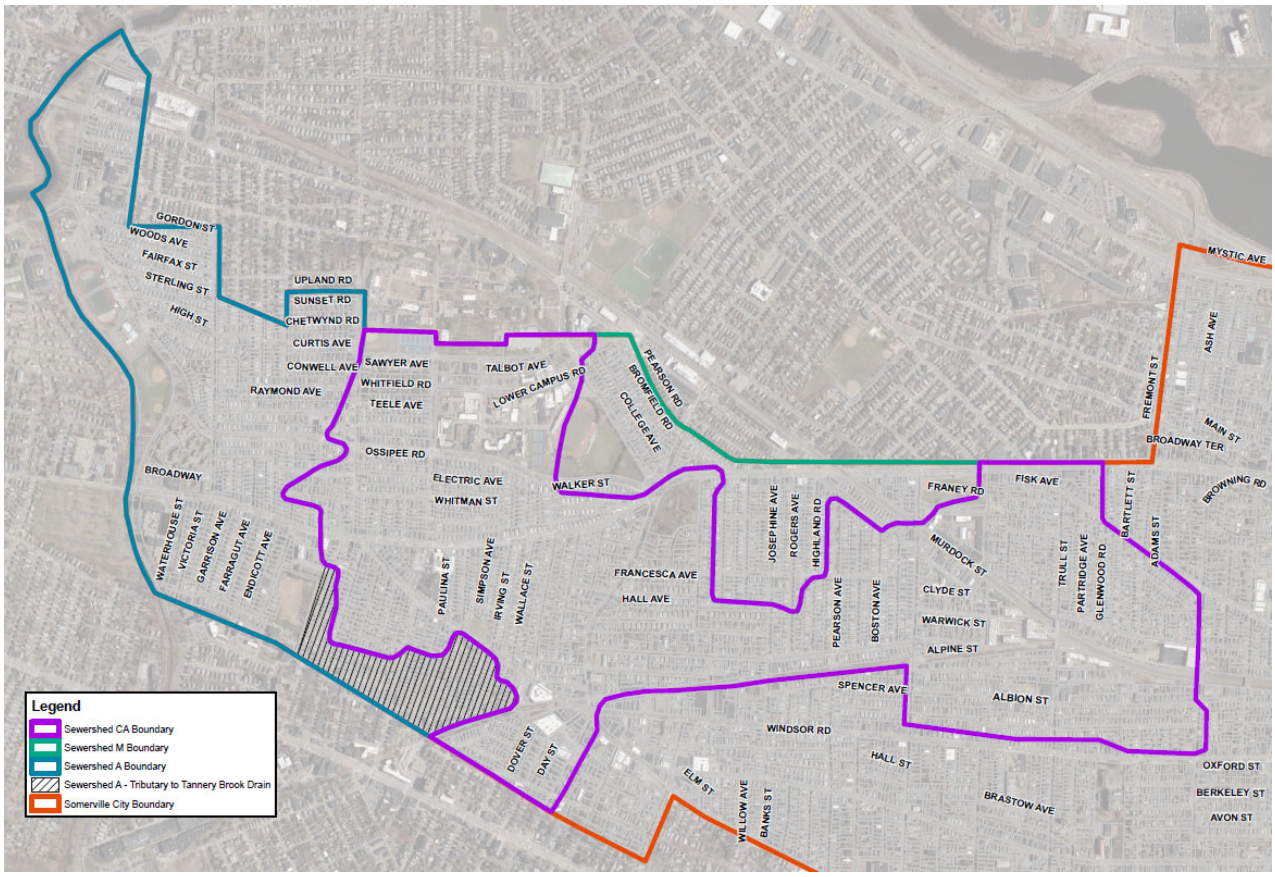


Figure ES. 1. Sewershed boundary map highlighting portion of Sewershed A tributary to Tannery Brook drain

Table ES 2. Flood and I/I Volumes and Cost Estimates for Proposed Flood Risk Mitigation Projects in Sewershed CA under **Alternative 2** (new outfall scenario)

				10-year, 24-hour Storm Event				10-year, 30-min Storm Event				
Incremental Action #	Solution	Project Name	Cost Estimate*1	Flood Volume*2 Sewershed CA (MG)	Flood Volume*2 Sewershed A (MG)	Flood Volume*2 Sewershed M (MG)	Total Flood Volume (MG)	Flood Volume*2 Sewershed CA (MG)	Flood Volume*2 Sewershed A (MG)	Flood Volume*2 Sewershed M (MG)	Total Flood Volume (MG)	Estimated I/I Reduction with Project as Proposed
0	EXC	Existing Conditions	N/A	1.997	0.003	1.122	**3.122**	1.506	0.010	0.857	**2.373**	N/A
	BL*3	Baseline Conditions	N/A	1.870	0.002	1.118	**2.990**	1.345	0.008	0.808	**2.161**	N/A
	BL+RM*4	Baseline + MWRA Regulator Modifications	N/A	1.748	0.002	1.117	**2.868**	1.335	0.008	0.793	**2.135**	N/A
1	CA-2.1	Morrison Avenue & Winslow Avenue Area	$38.1M	0.519	0.022	0.845	**1.386**	0.752	0.010	0.817	**1.579**	N/A
2	CA-2.2	Vernon Street Area	$5.7M	0.333	0.024	0.813	**1.170**	0.647	0.010	0.805	**1.461**	N/A
3	CA-2.3	Highland Road & Appleton Street Area	$4.7M	0.332	0.025	0.813	**1.170**	0.644	0.008	0.805	**1.457**	N/A
4	CA-2.4	South of Holland Street Area	$9.2M	0.333	0.004	0.813	**1.150**	0.623	0.000	0.805	**1.428**	N/A
5	CA-2.5	New Storm Outfall to Alewife Brook	$2.8M	0.563	0.001	0.819	**1.383**	0.656	0.000	0.807	**1.464**	4.602
6	CA-2.6	Highland Avenue Area	$31.4M	0.315	0.000	0.814	**1.129**	0.627	0.000	0.804	**1.432**	N/A

*1 Cost estimate does not include costs of full road reconstruction.
*2 Flood volumes reported are for the entire Sewershed CA area plus a portion of Sewershed A that is tributary to the Tannery Brook drain (See Figure ES.1). Due to the sequenced nature of the proposed projects in Sewershed CA, the flood volumes presented are cumulative and assume all previous proposed projects have been implemented.
*3 BL or Baseline conditions assumes full implementation of the Union Square Sewer Separation Program and includes the new Poplar Street pump station, Somerville Ave stormwater box culvert, and sewer separation of areas tributary to the Poplar Street pump station.
*4 BL+RM or Baseline plus regulator modifications assumes full implementation of items mentioned under baseline conditions plus additional modifications/improvements by the Massachusetts Water Resource Authority (MWRA) to the SOM-001A CSO regulator structure at the downstream end of the Tannery Brook drain.

1 PROJECT BACKGROUND

The City of Somerville is undergoing unprecedented growth and development in a City already known for its high urban density. Like most cities in the Northeast, its drainage and sanitary infrastructure was built, for the most part, in the late 19th century and early-to-mid-20th century. Drainage infrastructure was constructed with a set of design conditions and criteria that have become obsolete due to increased development. In many cases, the capacity of the existing drainage network is exceeded and is well past its useful life. Necessary upgrades of drainage and sanitary conveyance infrastructure have not been performed over time due to multiple technical and financial reasons. Additionally, new demands from additional development have increased significantly. This has created significant flood risk issues in some of the City's most vulnerable locations.

As a result of these flood risk issues, the City of Somerville is already in the process of designing and constructing projects to help mitigate flooding. A clear example is Union Square where a crucial sewer separation program, which includes a new stormwater pump station near Poplar Street, is well underway and will be the first steppingstone towards flood risk reduction in this hard-hit area. Another significant project is the rehabilitation of the culverts along McGrath Highway, which is currently underway as well. These culverts represent the arterial conveyance conduits for Sewershed S2. There are many other areas throughout the City that are vulnerable to flooding and in need of upgrades and interventions to mitigate current risk and keep pace with on-going and projected development as well as the added demands generated by an ever-changing climate. To this end, the City of Somerville has tasked Dewberry with the development of a Citywide Drainage and Water Quality Improvements Program. To date, the program has been approached on a sewershed-by-sewershed basis, considering on-going and projected infrastructure improvements while developing flood mitigation interventions. The current report, which assesses local proposed improvements for Sewershed M, takes a more regional or inter-sewershed approach for proposed projects in Sewershed CA because of its high level of interconnectivity with sewersheds A, M, C2, and S2. Figure 1 depicts the different sewersheds within Somerville as they have been traditionally delineated. More detailed maps depicting the overall flow patterns in and through Sewershed CA are presented in Section 2.

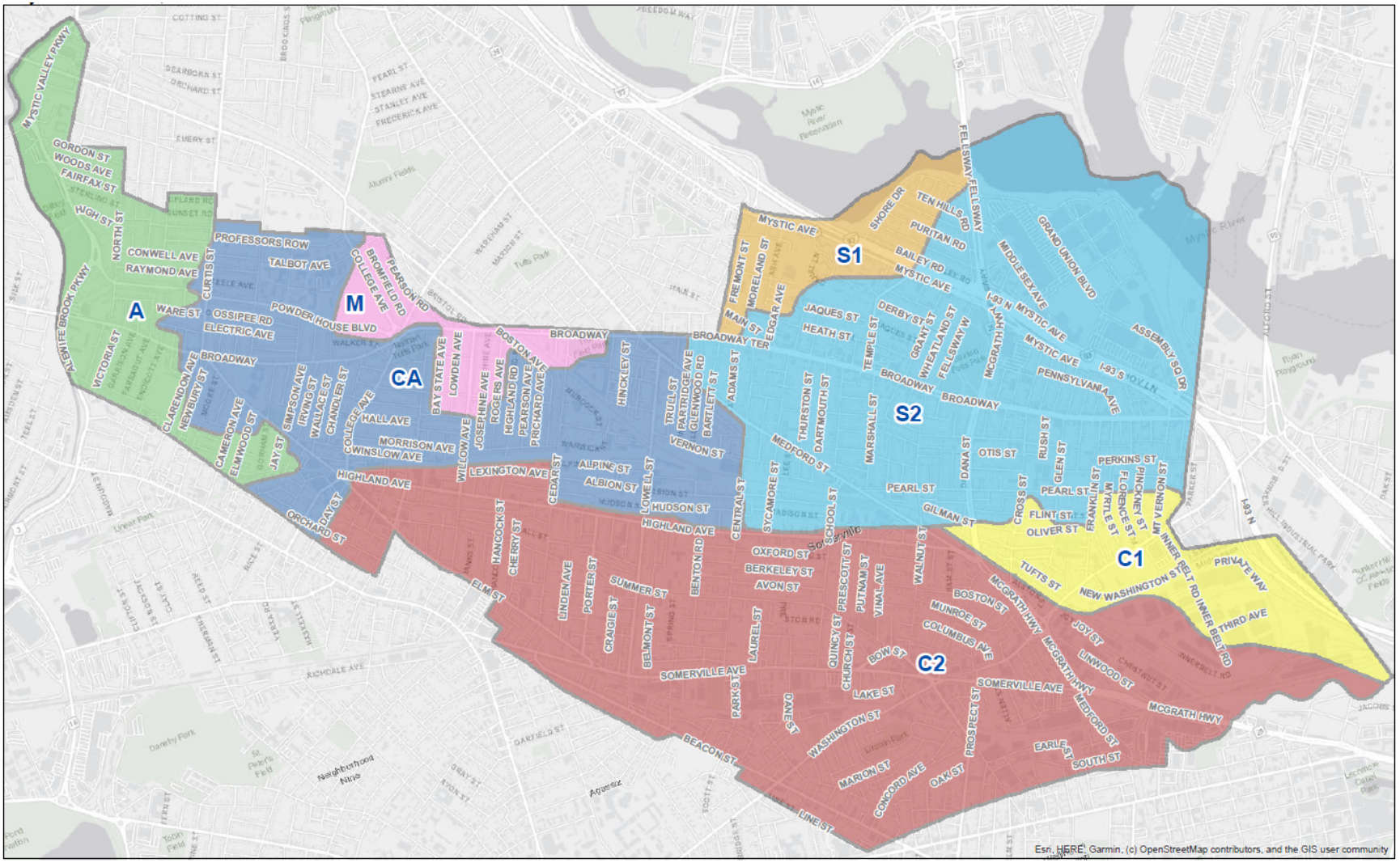


Figure 1. Overview of Somerville's Major Sewersheds

2 SEWERSHEDS CA & M CHALLENGES

2.1 Sewershed Hydrology

Sewershed CA (~500 acres) and Sewershed M (~80 acres), combined, represent 20% of the City's total area (Figure 1). The land use in Sewersheds CA and M includes both residential and commercial areas. Notable landmarks in the area are Davis Square, a commercial hub located in Sewershed CA, and Tufts University, a private institute sprawling between Sewersheds CA and M. The sewersheds are surrounded by the City of Medford to the north, Sewershed S2 to the east, Sewershed C2 to the south, City of Cambridge to the south west, and Sewershed A to the west.

Storm and sanitary flows within Sewersheds CA and M follow remarkably different paths, which blur the boundaries of the sewersheds depicted in Figure 1, which have been traditionally presented as seven distinct drainage areas. The reality is that these sewershed boundaries overlap significantly due to numerous cross-connections between Sewershed CA and M and surrounding Sewersheds A, C2, and S2. A description of the general flow patterns with Sewersheds CA and M are provided as follows:

Sewershed CA:
Sewershed CA is highly inter-connected with surrounding sewersheds. In terms of drainage it has two markedly different areas:

1/ Tannery Brook conduit and directly tributary areas. The Tannery Brook conduit currently flows west to east along Howard Street and Tannery Brook Row then it enters Cambridge to transition to two twin 54-inch pipes before reaching the SOM-001A CSO regulator. The Tannery Brook conduit, which starts near the intersection on Buena Vista Road close to the community path, has a direct tributary area with drains that capture and convey mostly wet weather flows towards the SOM-001A regulator. This direct tributary area is shown in Figure 2. Sanitary flows from this area are captured by sanitary and combined sewers that either flow towards the Elm Street trunk sewer and into Sewershed C2 or into the sanitary sewers adjacent to the Tannery Brook conduit and into Cambridge's CAM-001 CSO system, which is cross-connected with the Tannery Brook conduit near Clarendon Ave.

2/ Areas not directly tributary to the Tannery Brook conduit: These are the remaining areas within Sewershed CA that are not direct tributaries to the Tannery Brook conduit. For the most part, these areas convey sanitary and wet weather flows through Sewershed CA and into Sewershed C2 via the Holland St and Grove St combined sewers, which merge in Elm Street. Two exceptions exist as follows:

- Most of the area near Vernon St directs wet weather flows towards the conduit along the Lowell commuter rail line, which is part of Sewershed S2. Sanitary flows still flow through Sewershed CA and into C2 via the siphon across the railroad tracks on Murdock Street. Sanitary flows can overflow into the railroad conduit system via two existing common manholes on Vernon St.

- A portion of Albion St and Hudson St is drained by a storm drain that also connects to the conduit along the railroad tracks and is part of Sewershed S2. The remaining areas along Albion and Hudson streets flow through Sewershed CA and into Sewershed C2 reaching the Elm Street combined sewer.

As described above, dry weather flows and small storm flows in areas not directly tributary to the Tannery Brook conduit preferentially pass through Sewershed CA reaching the Elm Street combined sewer and into Sewershed C2. However, these two systems (Tannery Brook direct versus indirect tributary areas) are not independent of each other as multiple cross-connections exist between the two in the form of common manholes or regulator structures. For the most part, the Tannery Brook system operates as a relief point for the pass-through system pipes, which become quickly surcharged during rainfall events. These relief points prevent, to a certain extent, further flood damage to already vulnerable areas but result in increased CSOs to the Alewife Brook.

Figures 2 and 3 show the general direction of storm and sanitary flows in Sewershed CA and points of cross-connection between sewersheds.

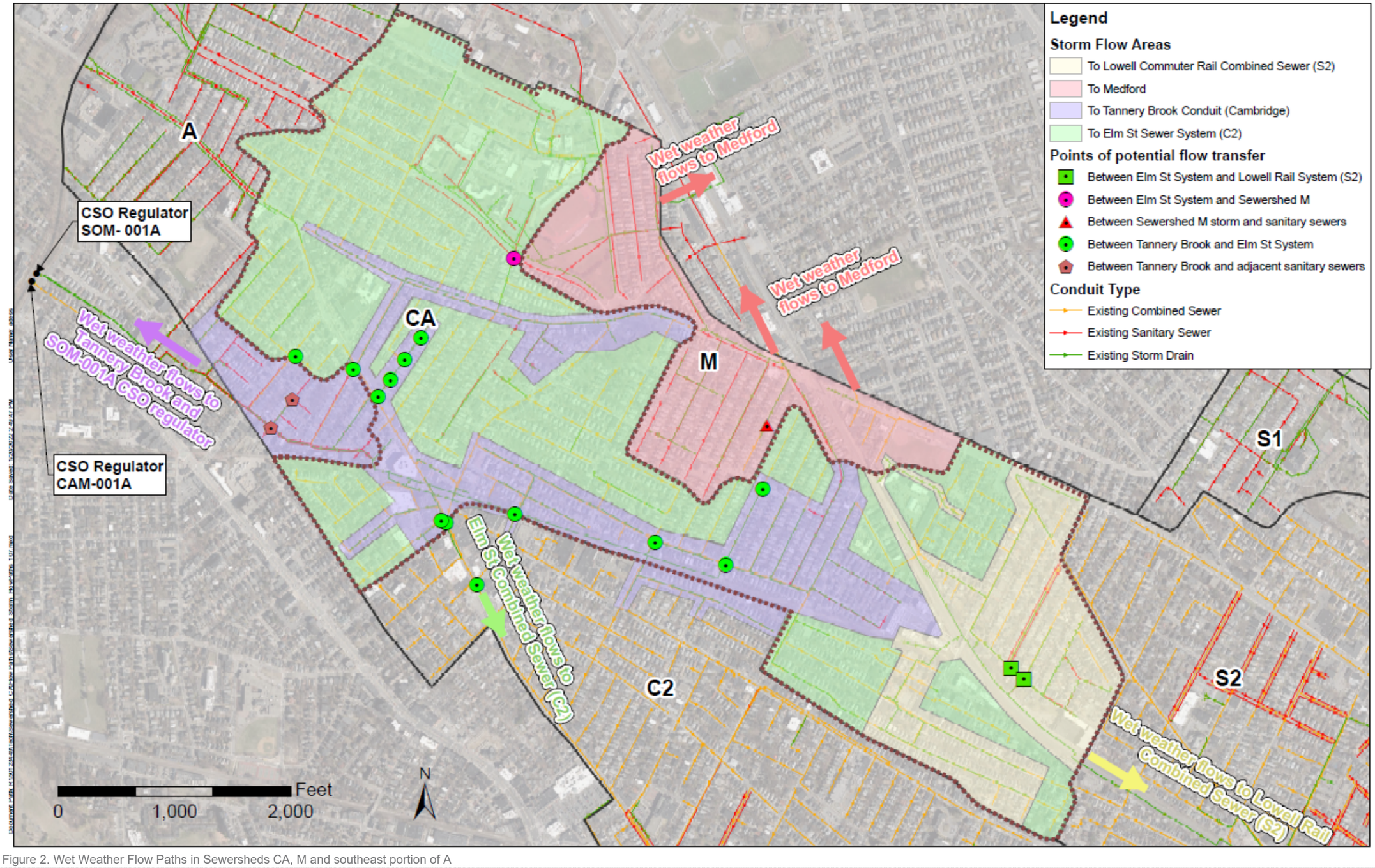


Figure 2. Wet Weather Flow Paths in Sewersheds CA, M and southeast portion of A

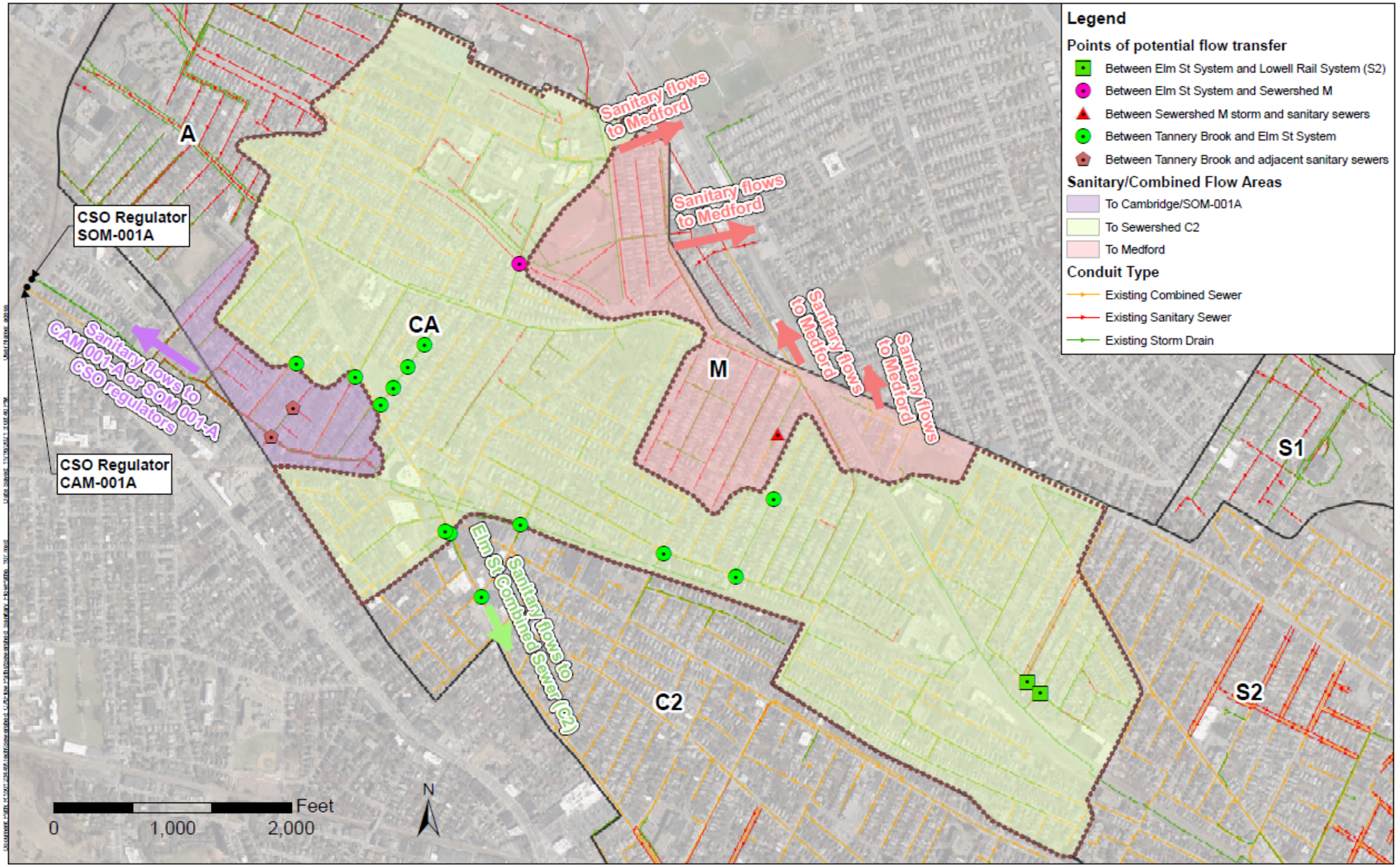


Figure 3. Sanitary Flow Paths in Sewersheds CA, M and southeast portion of A

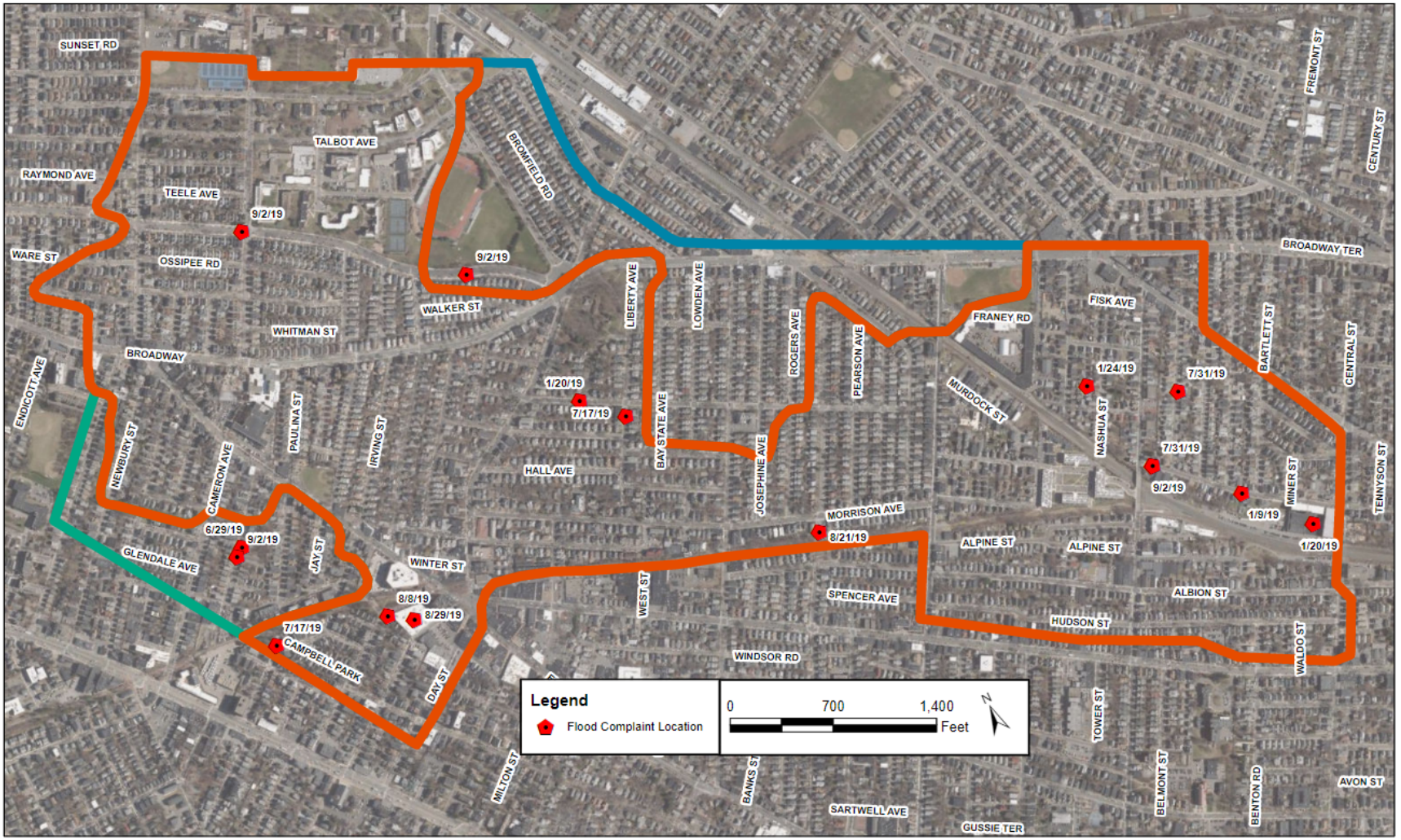


Figure 5. Flood Complaints Received in 2019 in Sewersheds CA, M, and portion of A tributary to Tannery Brook drain

2.3 Water Quality Challenges

Sewersheds CA and M face, not only drainage issues, but also water quality issues that are generated mainly by two different causes.

- **Combined Sewer Overflows (CSO):** Sewershed CA, like most of Somerville, is part of a combined sewer system that ultimately discharges dry and wet weather flows to the MWRA's Alewife Brook Conduit (ABC). When this MWRA sewer is overwhelmed during heavy rainfall events, flows in the Tannery Brook conduit exceed the rate at which they can be accommodated by the ABC at the SOM-001A CSO regulator structure. This causes the water levels in the Tannery Brook conduit to rise and eventually overtop the existing weir at the SOM-001A regulator causing a CSO. Additionally, and as detailed in Section 2.1, there are large areas within the sewershed not directly tributary to the Tannery Brook conduit that flow towards sewersheds with their own CSO limitations.
    - Areas directly tributary to the Elm Street combined sewer (see Figure 3), which is part of Sewershed C2, reach Union Square area where the SOM-009 regulator is located. Combined flows overtopping the SOM-009 regulator weir ultimately reach the MWRA Prison Point CSO pumping facility discharging into the Boston Harbor. The CSO discharge volume at Prison Point is also regulated by the Federal Court Order. Under LTCP conditions, up to 243MG can be discharged from this facility in a typical rainfall year.
    - Areas within the Vernon Street and Albion Street neighborhoods are drained by conduits connecting to the 42-inch concrete pipe along the Lowell commuter rail line, which connects to the City's system in Gilman Square at the intersection between Pearl Street and Marshall Street. The Gilman Square area is part of Sewershed S2, which also has a MWRA CSO facility in its downstream end (the Somerville Marginal Facility) that is subject to discharge limitations (3.48MG in a typical rainfall year in LTCP conditions).
    - Stormwater runoff within Sewershed M is mostly conveyed to a rectangular box culvert crossing College Ave, Bromfield Rd, and Pearson Rd perpendicularly before entering Medford. There are cross-connections between this system and the drainage along Powderhouse Boulevard, which belongs to the area indirectly tributary to the Tannery Brook within Sewershed CA. These points of connection serve as relief to both Powderhouse Boulevard as well as Sewershed M. Therefore, any changes impacting this current configuration may ultimately impact, albeit very slightly, CSOs at SOM-009 as well as SOM-001A.

  Based on this, the impacts of any interventions to improve drainage within Sewersheds CA and M may not only impact the drainage and water quality conditions within the respective sewershed and receiving waterbodies but have larger regional impacts as noted above.
- **Phosphorus and Bacteria from Stormwater Discharges in Newly Separated Areas:** In existing conditions, Sewershed CA is fully combined with no stormwater-only outfalls. Therefore, it has no water quality impacts to the Alewife Brook with the exception of CSO activations, which were addressed previously. However, any of the drainage improvement interventions that involve upstream sewer separation and construction of a new stormwater outfall to the Alewife Brook will result in new discharges of stormwater and associated loads of phosphorus and bacteria, which have been deemed a cause of impairment for the Mystic River and the Alewife Brook, one of its tributaries. Currently, non-separated areas and areas that would become separated with proposed flood mitigation projects will be subject to the discharge limitations and obligations set forth in the Mystic River Watershed Alternative TMDL for Phosphorus Management released in 2020. As mentioned previously, the Mystic River Watershed Alternative TMDL for Phosphorus Management requires communities discharging stormwater to the Mystic River to reduce annual phosphorus loads between 59% and 62% for areas assumed to be tributary under the TMDL analysis. For new contributions beyond these areas, reduction percentages are expected to be even higher.

  A second water quality concern is the presence of fecal bacteria in urban stormwater discharges. The Final Pathogen TMDL for the Boston Harbor, Weymouth, and Mystic Watersheds of October 2018 indicated that

different sections of the Mystic River are impaired by fecal bacterial loadings from CSO, SSOs, storm drain discharges, and non-point source pollution. There are no bacteria numeric effluent loading limitations listed in the Final Pathogen TMDL, meaning there are no set limits for bacteria loads from stormwater discharge to the Mystic River. However, the stormwater quality standards applicable to the receiving water bodies apply also to stormwater discharges. Maximum Extent Practical (MEP) implementation of the six minimum control measures listed in the City's NPDES MS4 Permit is the expected level of control from tributary communities discharging to a water body impaired by pathogens.

The projects and water quality analysis presented in this report focus on flood risk mitigation as well as CSO and phosphorus stormwater loading reductions. Dewberry assumed that bacteria stormwater loading will be addressed by the City using current practices to the maximum extent practicable so a detailed analysis on bacteria loading changes before and after proposed project execution has not been performed as part of this effort.

Traditionally, CSOs have been a major source of bacterial loading in receiving waters. Through the implementation of an extensive CSO Long-Term Control Plan (LTCP) by the MWRA and CSO communities, the relative contribution of CSO with respect to bacterial loads in receiving waters has been reduced drastically. However, SOM-001A continues to be problematic with CSO discharges exceeding the limits set forth in the MWRA's CSO LTCP. While the main goal of the projects presented in this report is flood mitigation rather than CSO reduction, these projects can contribute greatly to CSO reduction because they can reduce or limit the peak rate at which flows reach the MWRA system.

The MWRA is currently undergoing its post-LTCP implementation monitoring program, which evaluates the degree of compliance with bacterial water quality standards in receiving waters after completion of its CSO LTCP interventions. Preliminary findings from this study seem to suggest that receiving bacteria water quality standards may still not be fully met after completion of the LTCP and, therefore, the focus may shift towards bacterial loads originated from urban stormwater discharges as the new main source of bacterial contamination. It is likely that more resources will need to be dedicated to mitigating bacterial loading in stormwater in the near future depending on the final findings of the study by the MWRA.

3 DEVELOPMENT OF FLOOD RISK MITIGATION ALTERNATIVES

3.1 Basis of Design for Proposed Alternatives

The basis of design to size the proposed concept-level flood mitigation interventions is the following:

1. Conveyance, storage and pumping systems were sized to keep flooding within public right of way, to the maximum extent feasible, for the 10-year, 24-hour rainfall design event following a Type III SCS distribution (see hyetograph in Figure 6). The 10-year storm has traditionally been used by the City as a design goal for new drainage infrastructure. While in very specific circumstances, achieving a higher level of protection (e.g. a 25-year storm) may be possible, going beyond 10 years has proven to be unfeasible or cost prohibitive in most occasions.

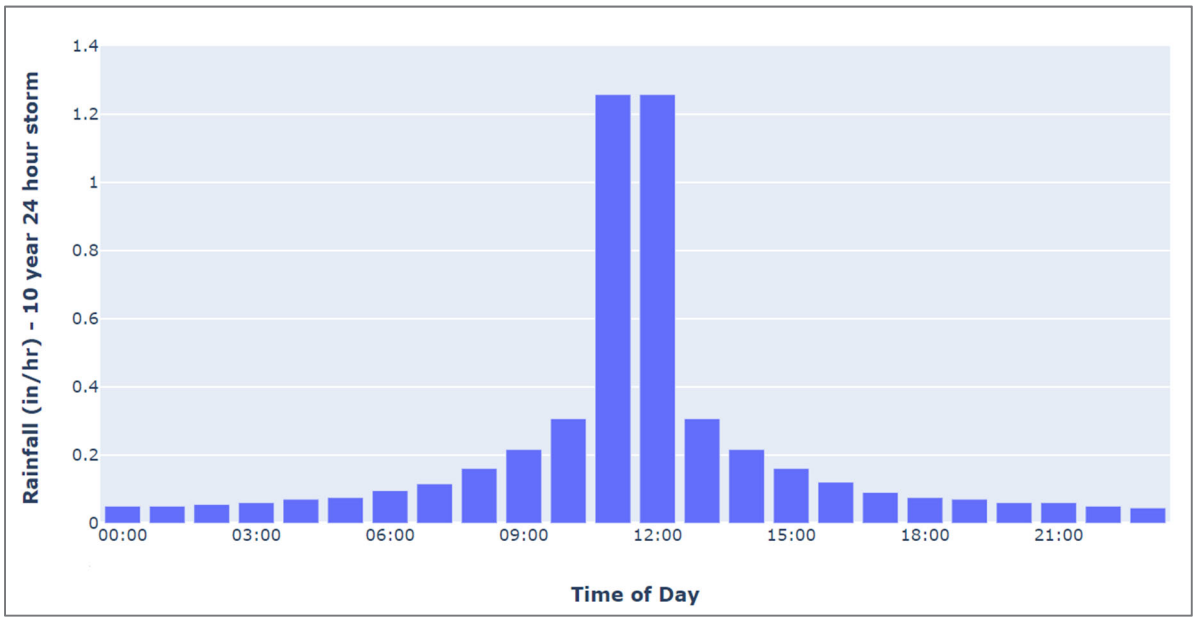


Figure 6. 10-Year, 24-Hour Design Storm Hyetograph

2. Identify areas in need of increased inlet capacity using the 10-year, 30-minute storm, representative of typical short burst summer storms, with a constant intensity of 2.64 in/h throughout the duration of the storm.

Table 1 below shows the rainfall depth-duration-frequency table from NOAA's Atlas 14 Vol.10 corresponding to Somerville. Values in red rectangles in the table indicate rainfall depths for the 10-year, 24-hour and 10-year, 30-minute storms discussed above.

Table 1. Precipitation-Duration-Frequency Tables for Somerville Based on NOAA's Atlas 14

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.302 (0.240-0.376)	0.371 (0.295-0.462)	0.484 (0.383-0.606)	0.577 (0.454-0.728)	0.706 (0.537-0.944)	0.801 (0.597-1.10)	0.904 (0.655-1.31)	1.03 (0.695-1.51)	1.22 (0.790-1.87)	1.38 (0.873-2.17)
10-min	0.428 (0.340-0.533)	0.525 (0.417-0.655)	0.685 (0.542-0.857)	0.817 (0.642-1.03)	1.00 (0.761-1.34)	1.14 (0.846-1.56)	1.28 (0.929-1.85)	1.46 (0.985-2.14)	1.72 (1.12-2.65)	1.95 (1.24-3.07)
15-min	0.503 (0.400-0.627)	0.618 (0.491-0.771)	0.806 (0.638-1.01)	0.962 (0.756-1.21)	1.18 (0.895-1.57)	1.34 (0.995-1.84)	1.51 (1.09-2.18)	1.71 (1.16-2.52)	2.03 (1.32-3.11)	2.30 (1.46-3.61)
30-min	0.687 (0.546-0.856)	0.845 (0.672-1.05)	1.10 (0.873-1.38)	1.32 (1.04-1.66)	1.62 (1.23-2.16)	1.83 (1.37-2.52)	2.07 (1.50-3.00)	2.36 (1.60-3.47)	2.80 (1.82-4.29)	3.17 (2.01-4.98)
60-min	0.871 (0.693-1.09)	1.07 (0.852-1.34)	1.40 (1.11-1.76)	1.68 (1.32-2.12)	2.06 (1.56-2.75)	2.33 (1.74-3.21)	2.64 (1.91-3.81)	3.00 (2.03-4.42)	3.57 (2.31-5.47)	4.05 (2.56-6.36)
2-hr	1.12 (0.900-1.39)	1.39 (1.12-1.73)	1.84 (1.46-2.29)	2.20 (1.75-2.76)	2.71 (2.08-3.61)	3.08 (2.32-4.22)	3.49 (2.56-5.03)	4.00 (2.72-5.84)	4.80 (3.13-7.30)	5.51 (3.49-8.55)
3-hr	1.31 (1.05-1.61)	1.62 (1.31-2.00)	2.14 (1.71-2.65)	2.57 (2.04-3.21)	3.16 (2.44-4.19)	3.60 (2.72-4.91)	4.07 (3.00-5.85)	4.68 (3.18-6.78)	5.63 (3.67-8.50)	6.46 (4.11-9.97)
6-hr	1.70 (1.38-2.08)	2.10 (1.70-2.58)	2.76 (2.22-3.39)	3.31 (2.65-4.09)	4.06 (3.14-5.33)	4.61 (3.50-6.23)	5.22 (3.85-7.41)	5.98 (4.08-8.58)	7.17 (4.69-10.7)	8.21 (5.23-12.5)
12-hr	2.18 (1.78-2.65)	2.68 (2.19-3.26)	3.50 (2.84-4.28)	4.18 (3.37-5.14)	5.11 (3.98-6.65)	5.80 (4.42-7.75)	6.55 (4.85-9.17)	7.47 (5.13-10.6)	8.89 (5.84-13.1)	10.1 (6.47-15.2)
24-hr	2.64 (2.17-3.18)	3.27 (2.68-3.95)	4.30 (3.52-5.22)	5.16 (4.19-6.30)	6.34 (4.97-8.19)	7.21 (5.53-9.56)	8.16 (6.08-11.3)	9.34 (6.44-13.1)	11.2 (7.36-16.3)	12.8 (8.19-19.0)

3.2 Flood Mitigation Alternatives in Sewersheds CA and M

Prior to the development of flood risk mitigation projects, a detailed hydraulic assessment of the drainage within the two sewersheds was performed and documented in the memorandum *"Sewersheds CA & M Flooding Root Cause Analysis"* by Dewberry. During this effort, Dewberry updated the City's hydraulic model and refined it based on new field and record information. The model was then re-calibrated using permanent and temporary flow meters installed within the sewershed area. The model was then checked against flood complaints received by City of Somerville's residents during severe rain events in order to evaluate the accuracy of its predictions. The model was upgraded to a point where most of these complaints were successfully captured and was then used to identify vulnerable areas. Figure 7 below shows an example flood map during a rainfall event that received flood complaints.

Concept-level interventions to reduce flood risk in vulnerable areas were evaluated using the updated hydraulic model. Two different incremental strategies to flood mitigation were evaluated for Sewershed CA, while two independent projects were considered for Sewershed M. See below for a list of the proposed projects.

- **Sewershed CA - Alternative 1:** Development of flood mitigation interventions **without** building a new stormwater outfall. This alternative includes the following sequence of projects:

    1. Project CA-1.1: Morrison Avenue Area
    2. Project CA-1.2: Winslow Avenue Area
    3. Project CA-1.3: Vernon Street Area
    4. Project CA-1.4: Tufts University Area

- **Sewershed CA - Alternative 2:** Development of flood mitigation interventions **with** construction of a new stormwater outfall. This alternative includes the following sequence of projects:

    1. Project CA-2.1: Morrison Avenue and Winslow Avenue Area
    2. Project CA-2.2: Vernon Street Area
    3. Project CA-2.3: Highland Road and Appleton Street Area
    4. Project CA-2.4: South of Holland Street Area (this includes the SE portion of Sewershed A)
    5. Project CA-2.5: New Storm Outfall to Alewife Brook
    6. Project CA-2.6: Highland Avenue Area

- **Sewershed M:** Development of proposed projects focused on flood mitigation at a more localized level compared to the projects proposed in Sewershed CA. These projects include:

    1. Project M-1: Pearson Road and Broadway Area
    2. Project M-2: Franey Road Area

As indicated in Section 2.3, combined sewer overflows remain a main challenge in the area because the activation and volumetric CSO limits remain above those permitted at the SOM-001A regulator even after full implementation of the MWRA's Long-Term Control Plan (LTCP) for CSOs. Therefore, both of the flood mitigation strategies above must reduce the level of CSO spills with respect to current conditions to help achieve the desired level of CSO control.

3.4 Alternative 2: Flood Mitigation Interventions with a New Stormwater Outfall

Alternative 2 evaluated a sequence of interventions in Sewershed CA that would ultimately separate the Tannery Brook conduit tributary area, enable the construction of a new stormwater outfall, and possibly eliminate the SOM-001A CSO regulator altogether. The primary improvements under Alternative 2 include the following components:

- Installation of box culverts on several streets including Morrison Ave, Winslow Ave, Grove St, Highland Ave, and Chester St.
- Sewer separation in the Vernon St area, Highland Rd/Appleton St area, and an area south of Holland St.
- Repurpose part of the Tannery Brook conduit to use one of its twin 54-inch pipes as a sanitary sewer and the other one as a storm drain.
- Remove all cross-connections between the Tannery Brook conduit and existing combined sewers.
- Construct a new stormwater outfall to Alewife Brook.

Similarly to Alternative 1, proposed projects under this scenario are to be implemented sequentially in order to realize the full intended benefit. See following sub-sections for descriptions of each project within Alternative 2.

3.4.1 Project CA-2.1: Morrison Avenue and Winslow Avenue Area

EXISTING CONDITIONS:

Project CA-2.1 Area is the combination of the Morrison Avenue Area (Project CA-1.1) and Winslow Avenue Area (Project CA-1.2) from Alternative 1 (i.e. No New Outfall scenario). For existing conditions in the Project CA-2.1 area, see previous Sections 3.3.1 and 3.3.2 where these are described in detail.

Based on model runs and flood complaints, the Morrison Avenue and Winslow Avenue Area experience recurring flooding along Morrison Avenue, particularly at the intersection with Highland Road. There is also flooding on Winslow Avenue and Pearson Avenue. This flooding is mostly driven by trunk sewer capacity limitations.

Figure 30 and Figure 31 show the Project CA-2.1 area boundaries as well as the existing piping system. Maps showing flooding in existing system conditions for the selected design storms are provided in Appendix B.

PROJECT DESCRIPTION:

The project proposed for this area primarily involves the following major components:

- Construct a series of stormwater box culverts along Morrison Avenue from Cedar Street to Grove Street and on Grove Street from Morrison Avenue to the Somerville Community Path. The culvert on Morrison Avenue was sized at 108 x 96-inch or 96 x 108-inch depending on available cover and downstream inverts. On Grove Street, culvert dimensions were sized at 84 x 84-inch. Culverts sections will be connected by orifice/weir structures and smaller diameter pipes to retain stormwater during heavy rainfall events.
- Upsize existing combined sewers on Morrison Avenue between Grove Street and Highland Road.
- Upsize local piping on side streets including combined sewers on Pearson Avenue and Prichard Avenue and storm drains on Highland Road.
- Install a new 24-inch storm drain on Cedar Street between Morrison Avenue and Alpine Street to connect the storm network in the western Albion Street area to the newly proposed box culvert on Morrison Avenue.
- Upsize existing combined sewers on Powderhouse Boulevard and Packard Avenue.
- Redirect catch basin laterals in streets where new storm drains are proposed.
- Rehabilitate pipes and manholes to remain to extend their useful life following CCTV and manhole inspections to assess their existing condition.

- Install green infrastructure where possible to reduce Phosphorous concentrations in collected stormwater. See Appendix D for GI siting analysis with maps detailing potential GI placement locations.
- Construct additional stormwater catch basins to facilitate greater flow into the conveyance system, especially at low-lying streets.

Proposed conditions for Project CA-2.1 area are depicted in Figure 32 and Figure 33.

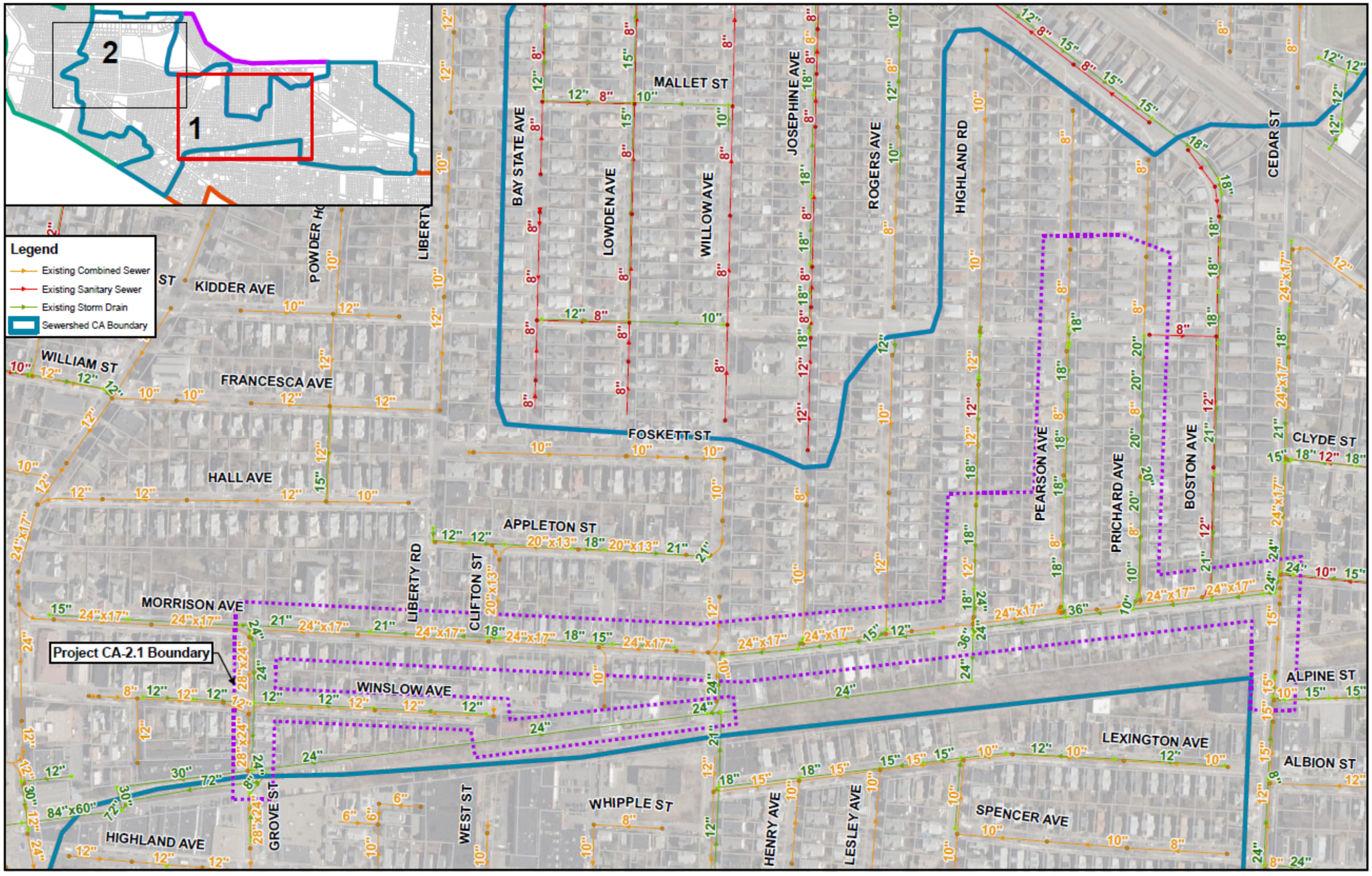


Figure 30. Project CA-2.1 Area - Existing Conditions (Page 1 of 2)

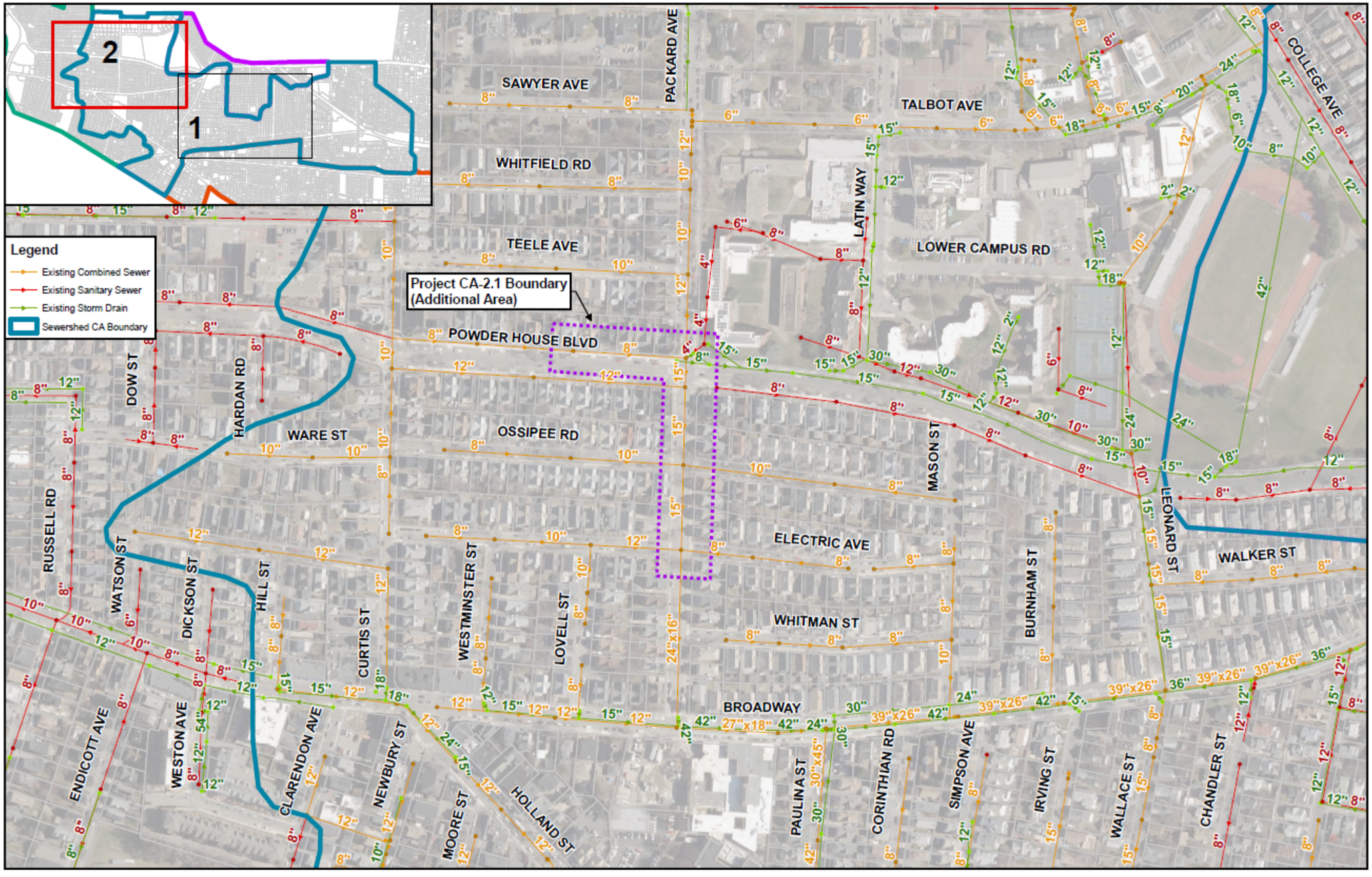


Figure 31. Project CA-2.1 Area - Existing Conditions (Page 2 of 2)

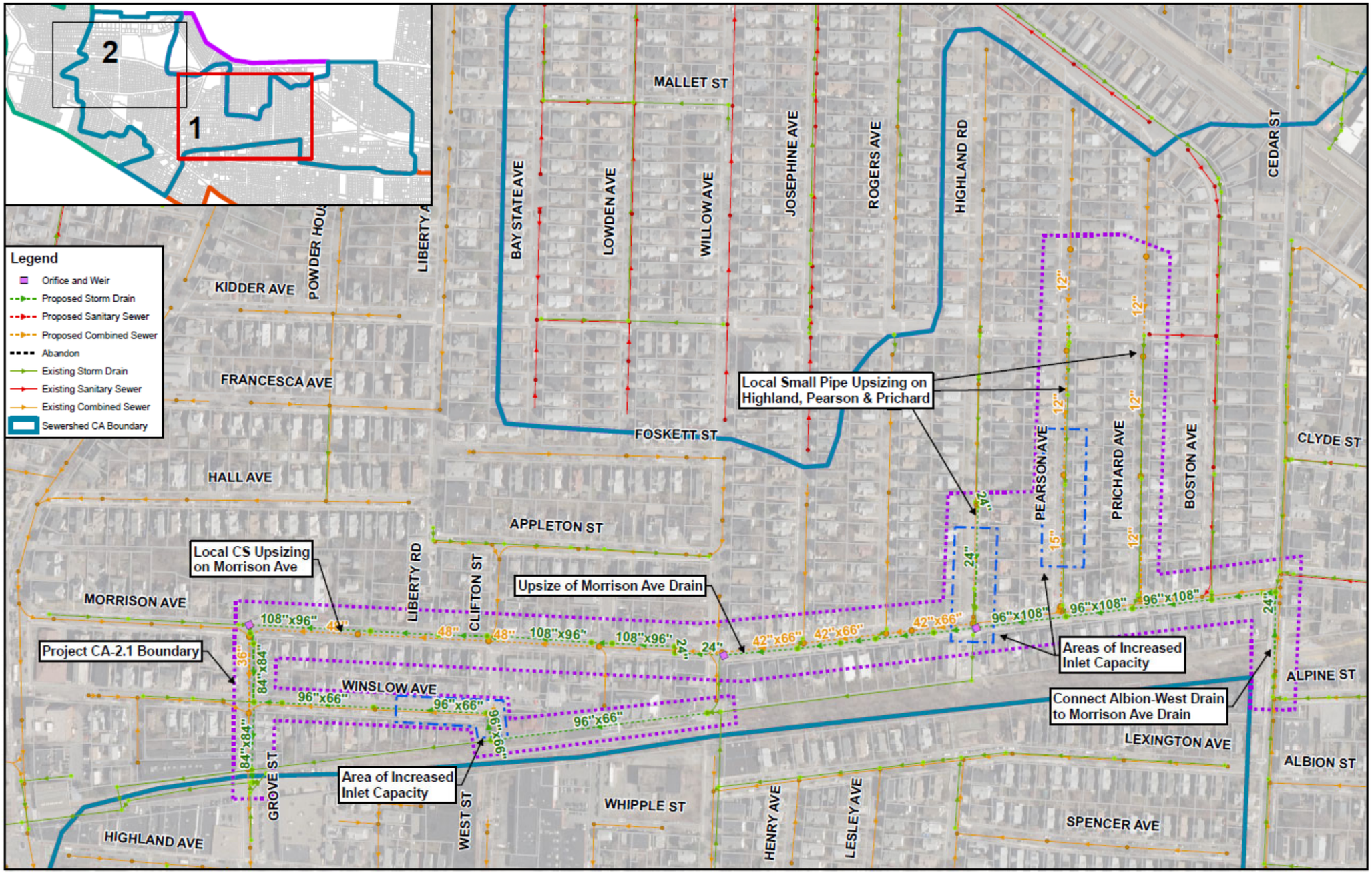


Figure 32. Project CA-2.1 Area - Proposed Improvements (Page 1 of 2)

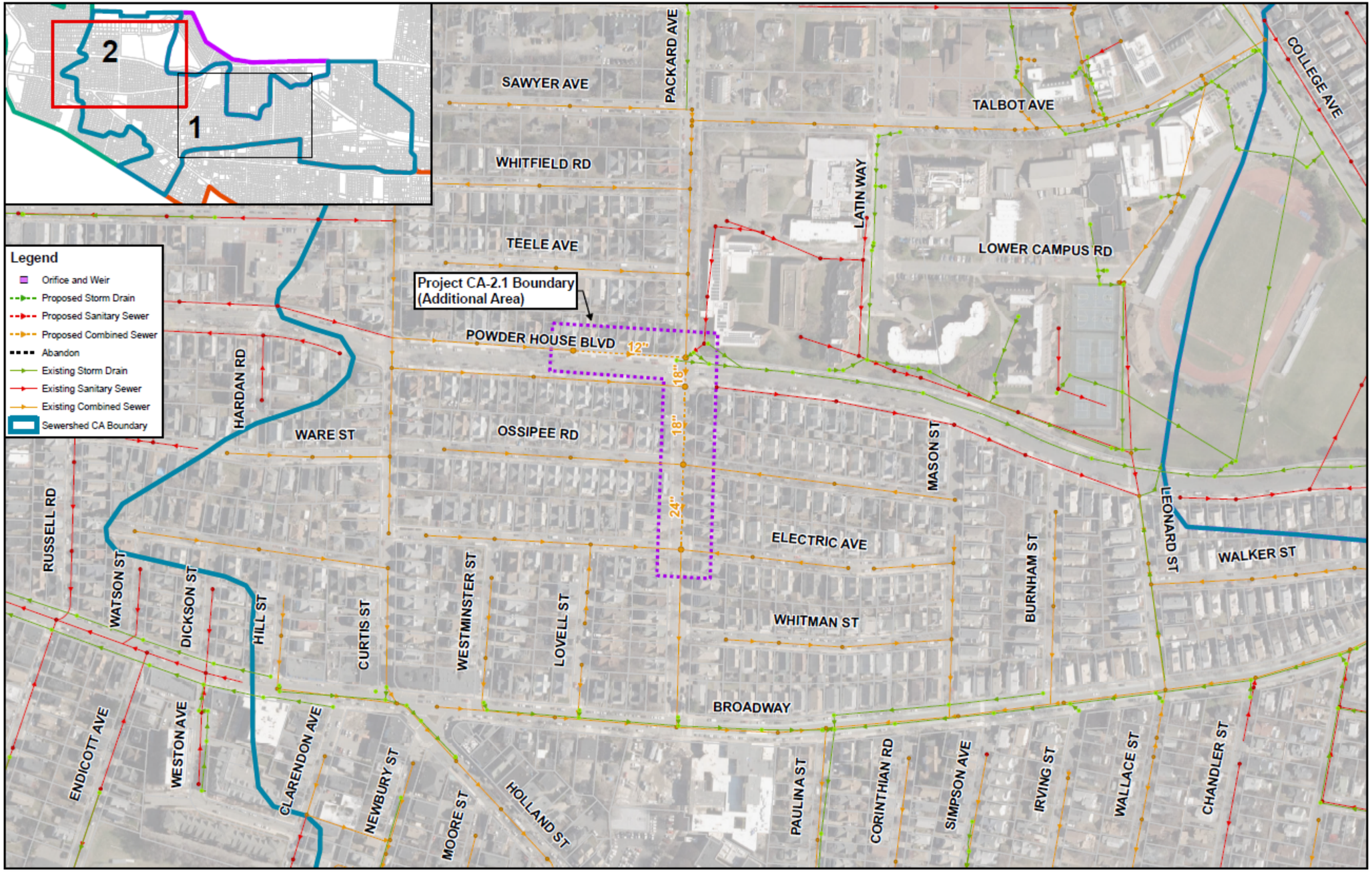


Figure 33. Project CA-2.1 Area - Proposed Improvements (Page 2 of 2)

FLOOD REDUCTION AND I/I BENEFITS:

The benefits of Project CA-2.1 in terms of flood volume reduction are summarized in the table below. Flood maps of the project area are included in Appendix B for:

1. Existing system conditions
2. Implementation of proposed project in the project area

As shown in the table below, implementation of the proposed project would greatly reduce flooding in Sewersheds CA and M, while causing a slight uptick in flooding in Sewershed A for the 10-year, 24-hour design storm. For the 10-year, 30-minute design storm, Sewershed CA also sees a significant flood reduction, while the other two sewersheds see a minimal reduction.

As indicated in Table 10, the project would result in very limited I/I reductions because the system would remain fully combined at project completion. The only I/I reductions that could be claimed at project completion would be those associated with reduced infiltration of inflow from replacing damaged pipes. This I/I benefit could not be estimated at this level of analysis. A master table providing both flood reduction and I/I benefits for all projects proposed is included in Appendix B.

Table 10. Flood Volumes in Project CA-2.1 Area during the 10-Year Storms and I/I Reduction under Different System Conditions

	Sewershed CA	Sewershed A*	Sewershed M	Total
Flooding during the 10-Yr, 24-Hr Design Event [MG]*				
Existing Conditions	1.997	0.003	1.122	3.122
After Project CA-2.1 Implementation	0.519	0.022	0.845	1.386
Flooding during the 10-Yr, 30-Min Design Event [MG]*				
Existing Conditions	1.506	0.010	0.857	2.373
After Project CA-2.1 Implementation	0.752	0.010	0.817	1.579
Estimated I/I Reduction with Project as Proposed [MG]				N/A

*Flood volumes reported for Sewershed A are only within the area tributary to the Tannery Brook drain (See Figure ES. 1)

FEASIBILITY CONSIDERATIONS:

The following are factors to be considered that could impact the feasibility and constructability of the proposed interventions:

- **Traffic Impacts**: Morrison Avenue is an essential traffic artery for Somerville. Traffic disruption along this route will likely cause significant disruption. Close coordination with the City's Department of Public Works and Police Department will be required to ensure minimal negative traffic impacts.

- **Resident Construction Fatigue:** Somerville residents have undergone and continue to endure many construction projects citywide. Some potential resident pushback is anticipated and may require a well-planned outreach campaign
- **Utility conflicts:** Based on the magnitude of the proposed culverts it is highly likely that significant utility conflicts will exist that may preclude or increase the level of effort for the design and construction of these box culverts as conceived. .it will need to be cast in place. Extensive relocation or support during construction of existing utilities should be anticipated.
- **Geotechnical and Groundwater Conditions:** A geological survey will determine the best way to support the large box culverts and manage groundwater during their construction. Additionally, the City has informed Dewberry that soil conditions along the Somerville Community Path are questionable and may present some contamination. Depending on these conditions and recommended construction techniques, costs can vary significantly.
- **Impacts to Pedestrian and Biking Routes:** The Community Path Is heavily utilized by both pedestrian and bicyclists. Reconnecting the existing drain along the Community Path and rerouting it towards Winslow Avenue will require some using at least one half of the path for construction purposes, potentially more. Since this is both a commute and a recreational way, traffic management and potential, alternative routes for bikes and pedestrians should be carefully evaluated.

SUMMARY OF ENGINEER'S ESTIMATE OF PROJECT COSTS:

Engineer's estimates of project costs were prepared for this and other projects presented in this report. Two separate estimates were developed for each project, the first one being less conservative than the second one with respect to potential project-specific issues such as type of soil and soil contamination potential, groundwater conditions, need for pipe reconnections and pipe and manhole rehabilitation, degree of implementation of Green Stormwater Infrastructure etc. Costs associated with the less conservative scenario are presented below. Detailed cost breakdowns and assumptions for each scenario are included in Appendix C. Refer to Section 6 for Green Stormwater Infrastructure details.

Table 11. Engineer's Opinion of Probable Costs for Project CA-2.1

SUMMARY OF COSTS FOR PROJECT CA-2.1	
Estimated Construction Sub-total	**$23,627,000**
Contingency (30%)	$7,088,000
Estimated Construction Total	**$30,715,000**
Engineering Design (11%)	$3,379,000
Resident Engineering (13%)	$3,993,000
Estimated Total Project Costs	**$38,087,000**

*Note: Does not include cost of full roadway reconstruction.

3.4.2 Project CA-2.2: Vernon Street Area

EXISTING CONDITIONS:

Project CA-2.2 Area is essentially the same as the Vernon Street Area (Project CA-1.3) from Alternative 1 (i.e. No New Outfall scenario). However, it includes additional area south of Murdock Street and excludes the flow throttling structures near Davis Square and the removal of the cross-connection at the intersection of Prichard Avenue and Morrison Avenue. For existing conditions for Project CA-2.2, see previous Section 3.2.3 where these conditions are described in detail.

Based on model runs and flood complaints, the Vernon Street area experiences recurring flooding primarily along Vernon St. between Glenwood Rd. and Bartlett St. as well as along Murdock St. The flooding on Vernon St. is mostly due to downstream conveyance capacity limitations while the flooding on Murdock St. is mostly related to local, undersized pipes.

Figure 34 shows the Project CA-2.2 area boundaries as well as the existing piping system. Maps showing flooding in existing system conditions for the selected design storms are provided in Appendix B.

PROJECT DESCRIPTION:

The project proposed for this area primarily involves the following major components:

- Sewer separation within both project areas, including repurposing existing combined sewers to be used as dedicated sanitary sewers or storm drains and adding new storm drains to the following streets: Trull Street, Glenwood Street, and Robinson Street.
- Upsize existing combined sewers on Murdock Street, downstream of the siphon that runs beneath the railroad.
- Removal of common manholes on Vernon Street at Glenwood Road and Bartlett Street intersections.
- Repurpose the Partridge Ave combined sewer as a drain and redirect it to the drain system on Vernon Street.
- Redirect catch basin laterals in streets where new storm drains are proposed.
- Rehabilitate pipes and manholes to remain to extend their useful life following CCTV and manhole inspections to assess their existing condition.

Proposed conditions for Project CA-2.2 area are depicted in Figure 35.

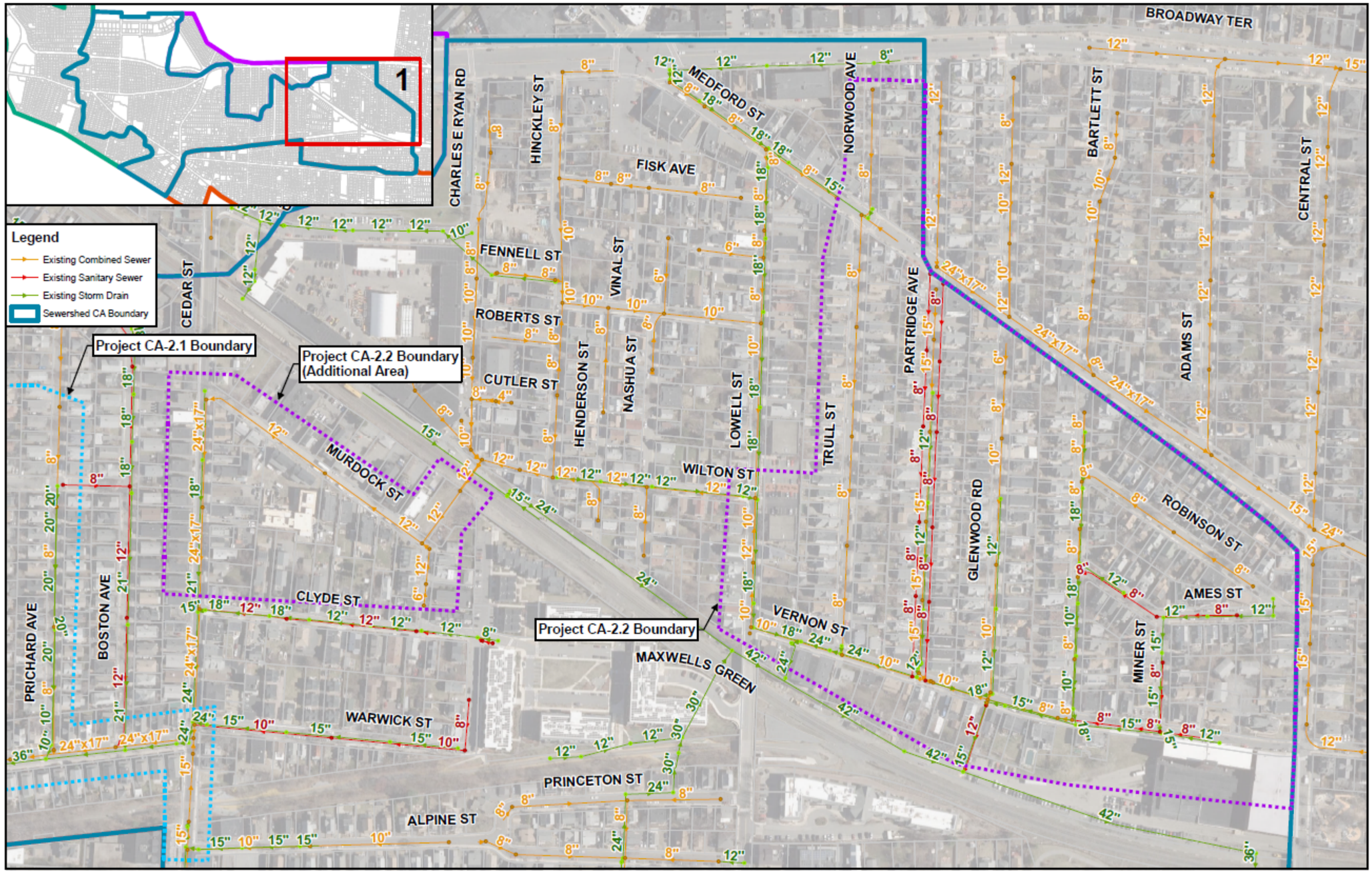


Figure 34. Project CA-2.2 Area - Existing Conditions

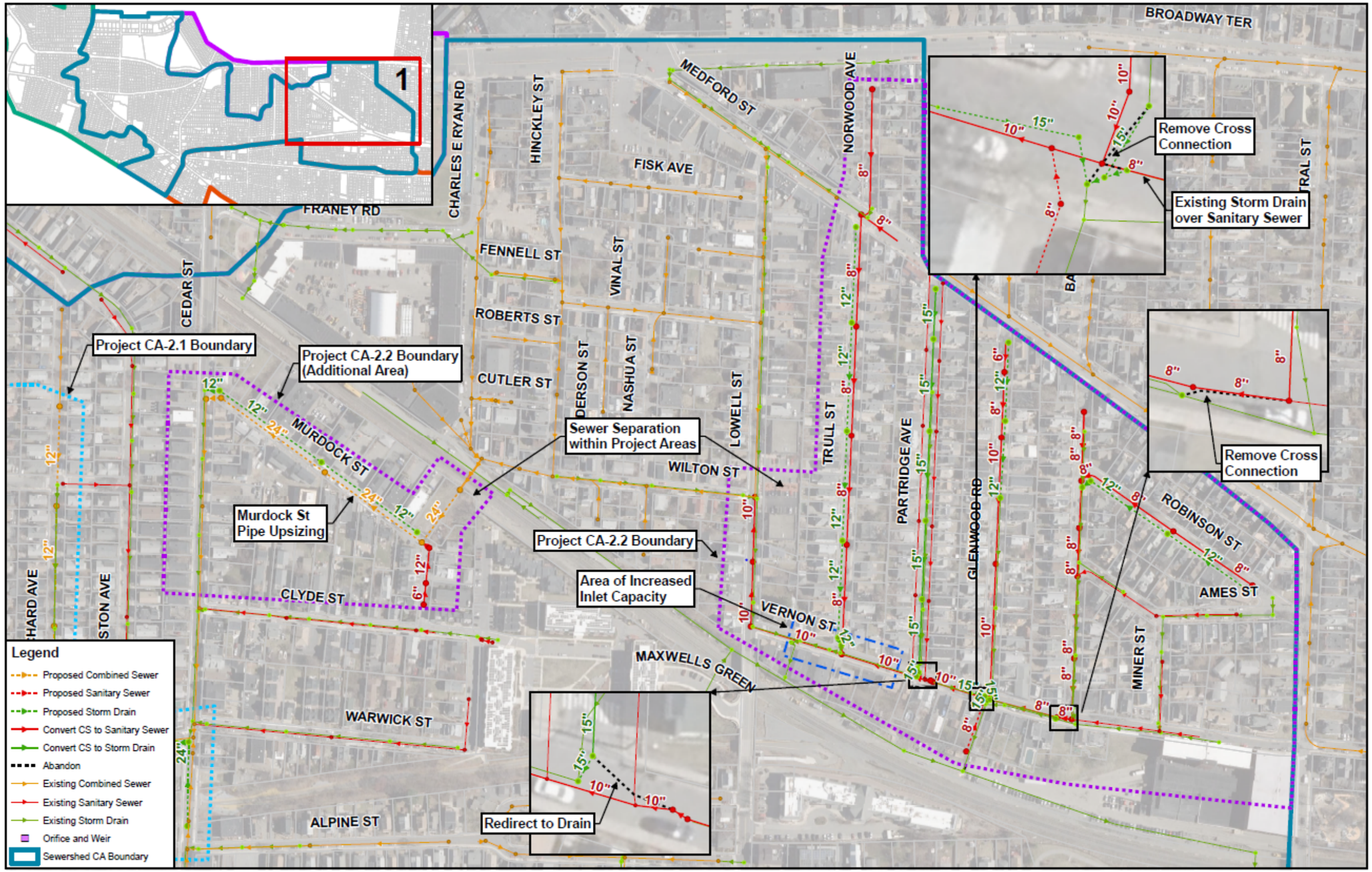


Figure 35. Project CA-2.2 Area - Proposed Improvements

FLOOD REDUCTION AND I/I BENEFITS:

The benefits of Project CA-2.2 in terms of flood volume reduction are summarized in the table below. Flood maps of the project area are included in Appendix B for:

1. Existing system conditions
2. Implementation of proposed project in the project area

As shown in the table below, implementation of the proposed project would reduce flooding in Sewersheds CA and M, while causing a slight uptick in flooding within Sewershed A for the 10-year, 24-hour design storm. For the 10-year, 30-minute design storm, there are also flood reduction benefits in both Sewersheds CA and M, while flooding in Sewershed A is left in relatively the same condition as in the previous project.

As indicated in Table 12, the project would result in very limited I/I reductions because the system would remain fully combined at project completion. The only I/I reductions that could be claimed would be those associated with reduced infiltration of inflow from replacing damaged pipes. This I/I benefit could not be estimated at this level of analysis. A master table providing both flood reduction and I/I benefits for all projects proposed is included in Appendix B.

Table 12. Flood Volumes in Project CA-2.2 Area during the 10-Year Storms and I/I Reduction under Different System Conditions

	Sewershed CA	Sewershed A*	Sewershed M	Total
Flooding during the 10-Yr, 24-Hr Design Event [MG]*				
Existing Conditions	1.997	0.003	1.122	3.122
Completion of Previous Projects under Alternative 2	0.519	0.022	0.845	1.386
After Project CA-2.2 Implementation	0.333	0.024	0.813	1.170
Flooding during the 10-Yr, 30-Min Design Event [MG]*				
Existing Conditions	1.506	0.010	0.857	2.373
Completion of Previous Projects under Alternative 2	0.752	0.010	0.817	1.579
After Project CA-2.2 Implementation	0.647	0.010	0.805	1.462
Estimated I/I Reduction with Project as Proposed [MG]				N/A

*Flood volumes reported for Sewershed A are only within the area tributary to the Tannery Brook drain (See Figure ES. 1)

FEASIBILITY CONSIDERATIONS:

The following are factors to be considered that could impact the feasibility and constructability of the proposed interventions:

- **Sewer Separation:** While sewer separation is being proposed in this area, the main goal of this effort is to direct wet weather flows towards the railroad tracks conduit and sanitary flows towards the Murdock Street siphon. Both system outlets are part of a combined sewer system that drain towards different sewersheds (Sewershed S2 and CA, respectively). Usually, as part of sewer separation, it is imperative to make sure no sanitary sources remain connected to the newly separated storm system. While this is still recommended for this project, removing all sources of sanitary flow from the storm system is not crucial as ultimately the storm system will connect to the pipe along the railroad tracks, which is combined.
- **Private Inflow Redirection:** Due to the fact that some private inflow sources are likely to be redirected to sanitary sewers, careful evaluation of the separated sanitary system performance needs to be conducted in order to assure no negative impacts to residents will occur due to back flows into buildings.
- **Resident Construction Fatigue:** Somerville residents have undergone and continue to endure many construction projects citywide. Some potential resident pushback is anticipated and may require a well-planned outreach campaign.
- **Open-trench Installations:** Project Area CA-2.2 has three streets with only a single, combined-use pipe. In order to ensure that all of the flow in the area is fully separated, Dewberry recommends that new storm drain pipes be added to these streets via open-trench installations. Partial road closures are expected as a part of this effort, and residents should be notified well in advance as on-street parking is prevalent in this area.
- **Flow Transfer between Sewersheds:** As indicated previously, the main goal of this proposed project is to direct wet weather flows towards Sewershed S2 and sanitary flows towards Sewershed CA via Murdock St. Even though the proposed projects would not represent a large deviation in the existing hydraulic conditions of the area, it would have some impact to the CSO regulators at SOM-007A and SOM-001A and therefore, subject to scrutiny by the MWRA.

SUMMARY OF ENGINEER'S ESTIMATE OF PROJECT COSTS:

Engineer's estimates of project costs were prepared for this and other projects presented in this report. Two separate estimates were developed, the first one being less conservative than the second one with respect to potential project-specific issues such as type of soil and soil contamination potential, groundwater conditions, need for pipe reconnections and pipe and manhole rehabilitation, degree of implementation of Green Stormwater Infrastructure etc. Costs associated with the less conservative scenario are presented below. Detailed cost breakdowns and assumptions for each scenario are included in Appendix C. Refer to Section 6 for Green Stormwater Infrastructure details.

Table 13. Engineer's Opinion of Probable Costs for Project CA-2.2

SUMMARY OF COSTS FOR PROJECT CA-2.2	
Estimated Construction Sub-total	**$3,525,000**
Contingency (30%)	$1,058,000
Estimated Construction Total	**$4,583,000**
Engineering Design (11%)	$505,000
Resident Engineering (13%)	$596,000
Estimated Total Project Costs	**$5,684,000**

*Note: Does not include cost of full roadway reconstruction

3.4.3 Project CA-2.3: Highland Road and Appleton Street Area

EXISTING CONDITIONS:

Project CA-2.3 Area is located north of Morrison Avenue and is roughly bounded by Liberty Street to the west, Kidder Avenue/Pearson Road to the north, Prichard Avenue to the east, and Morrison Avenue to the south. For the purposes of this report we refer to Project CA-2.3 Area as the Highland Road and Appleton Street Area.

Most of the streets within the project area are serviced by a single, combined sewer. Exceptions to this are Highland Rd. and Appleton St. where there are separate storm drains. On Highland Rd., there is an 18-inch storm drain running north to south from Kidder Ave. to Morrison Ave. This 18-inch pipe ties into the Morrison Ave. storm drain which flows onward towards the Somerville Community Path. On Appleton St., there is a drain ranging in size from 12-inch to 21-inch. This pipe starts at the western end of the street and flows eastward, eventually tying into a combined sewer near the intersection of Willow Ave. and Appleton St. Unusually, this receiving sewer carries flow in the opposite direction of the previously described storm drains, eventually discharging storm and sanitary flows into the combined sewer on Morrison Ave.

Combined sewers in the area generally flow from north to south, exiting the project area and connecting to the larger diameter combined sewer on Morrison Ave. In the Foskett St. and Appleton St. block, combined flows take a circuitous path. At the upstream end, flows move eastward along Foskett St. then turn southward at Willow Ave. The flows make another turn at Appleton Street and move westward, eventually reaching Clifton St. where they travel onward in a southerly direction, tying into the 24x17-inch combined sewer on Morrison Ave.

Based on model runs and flood complaints received, the Highland Road and Appleton Street area experiences recurring flooding along Highland Road and Kidder Avenue. Flooding along Kidder Ave. is primarily concentrated between Pearson Ave. and Prichard Ave. This flooding is mostly driven by trunk sewer capacity limitations along Morrison Ave.

Figure 36 shows the Project CA-2.3 area boundaries as well as the existing piping system. Maps showing flooding in existing system conditions for the selected design storms are provided in Appendix B.

PROJECT DESCRIPTION:

The major elements of the proposed project for this area are described below and are also shown in Figure 37:

- Sewer separation within the project area, including repurposing existing combined sewers to be used as dedicated sanitary sewers and adding new storm drains to streets with only a single pipe in the road.
- Relay existing drain on Appleton St. to flow in the opposite direction in order to ultimately connect to the storm drain on Morrison Ave.
- Perform an IDDE program to eliminate any potential sanitary connection to the storm system once sewer separation is complete to ensure absence of sanitary flows in stormwater.
- Redirect catch basin laterals in streets where new storm drains are proposed.
- Rehabilitate pipes and manholes to remain to extend their useful life following CCTV and manhole inspections to assess their existing condition.

Following the completion of Project CA-2.5, described in a later section, the storm drainage in this area will be tributary to a newly, proposed stormwater outfall to the Alewife Brook. Therefore, the goal of this particular project is to prepare the project area so that its stormwater runoff can be connected to a new discharge pathway to the Alewife Brook. With this new routing of storm flows, wet weather flows from this project area will no longer go to the combined sewer system that ultimately ends up in Sewershed C2 or the SOM-001A CSO regulator when combined sewer system overflows into the Tannery Brook system.

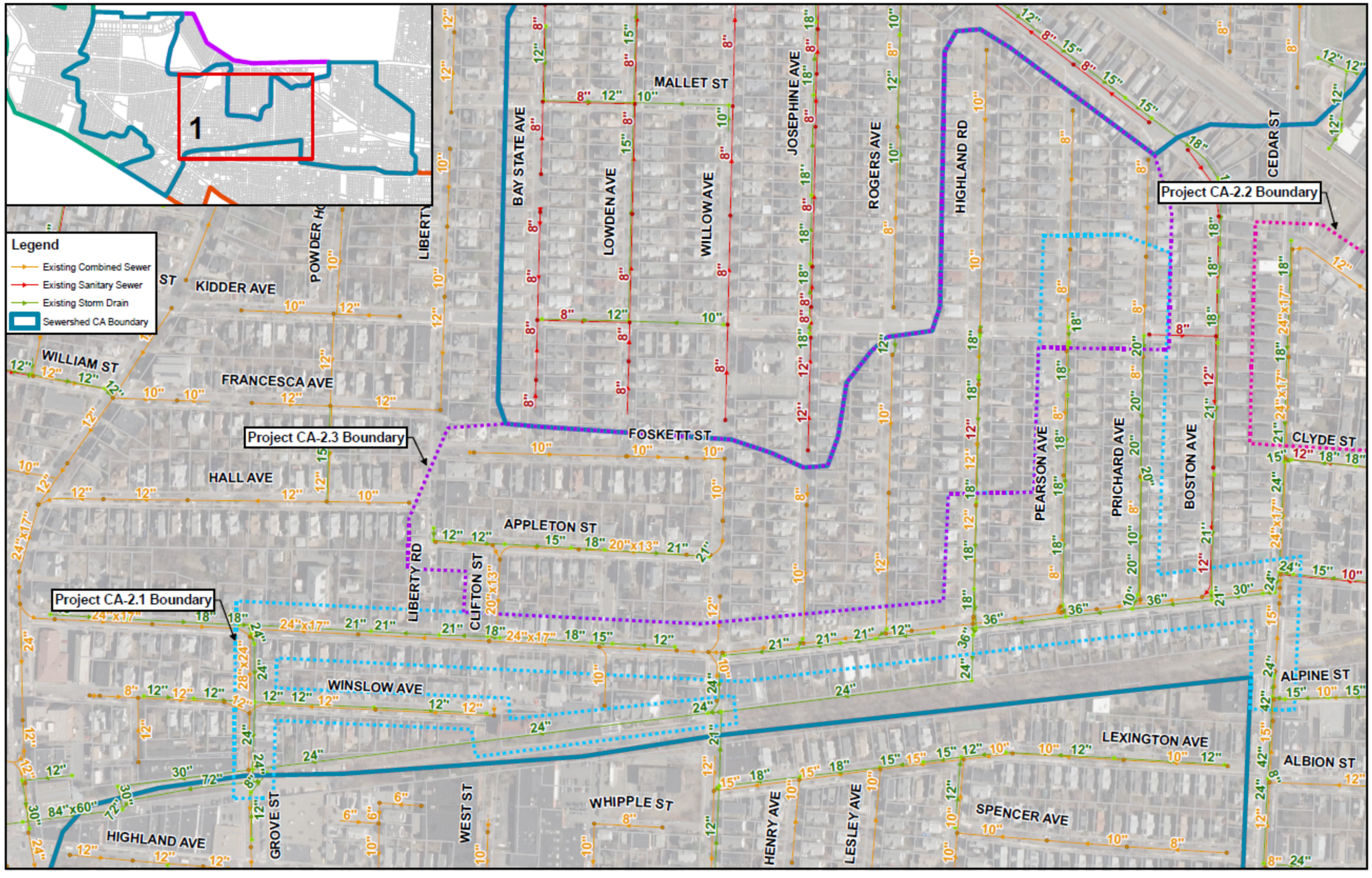


Figure 36. Project CA-2.3 Area - Existing Conditions

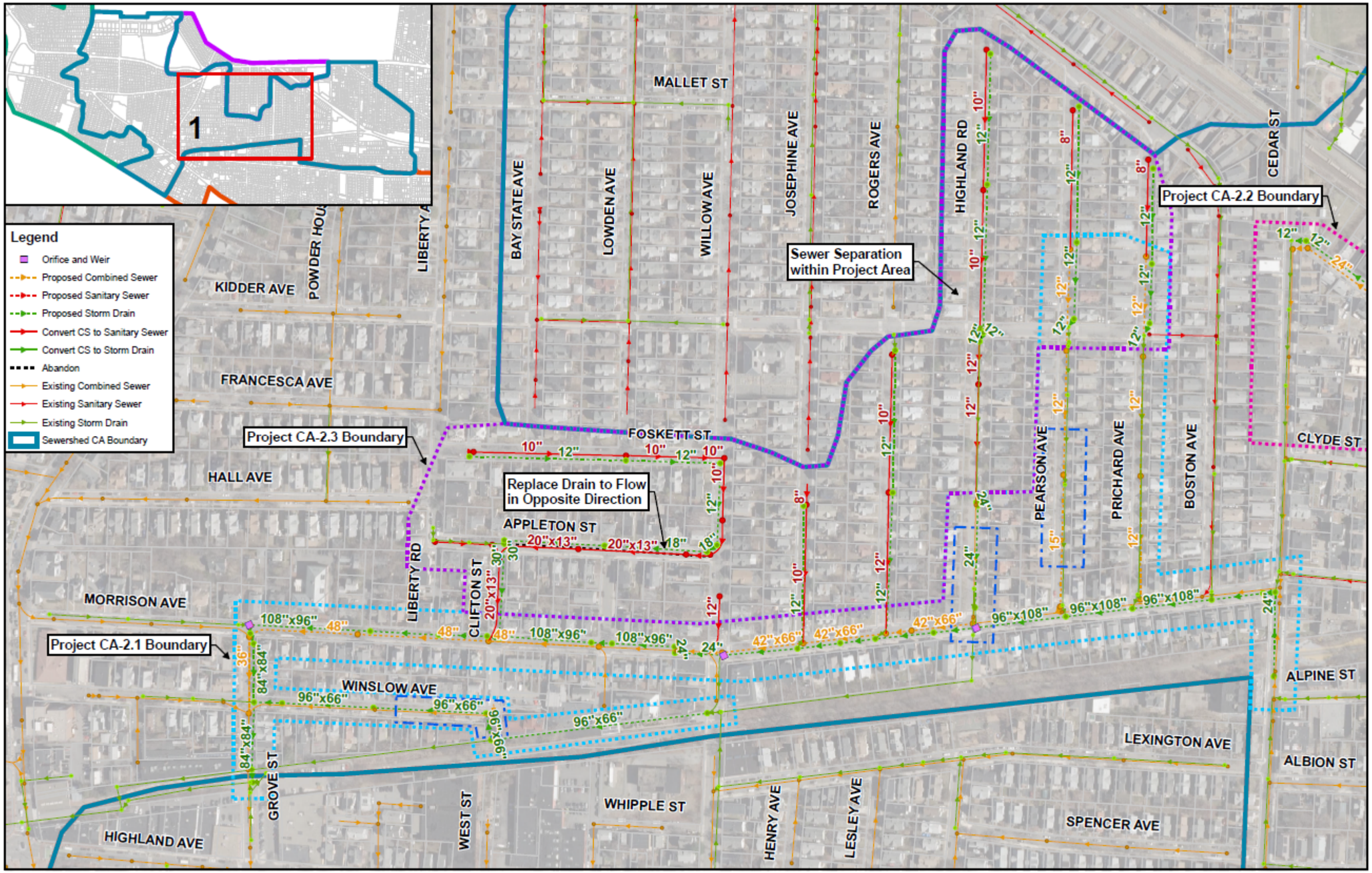


Figure 37. Project CA-2.3 Area - Proposed Improvements

FLOOD REDUCTION AND I/I BENEFITS:

The benefits of Project CA-2.3 in terms of flood reduction are summarized in the table below. Flood maps of the project area are included in Appendix B for:

1. Existing system conditions,
2. Implementation of proposed project.

As shown in the table below, implementation of the proposed project would have relatively no effect on flooding within any of the Sewershed areas for both the 10-year, 24-hour and 10-year, 30-minute design storms. It is important to note that while this project in and of itself does not yield a flood reduction benefit, it does set the stage for following projects in which storm flows from the area are taken to a new outfall. In other words, the flood reduction benefit of Project CA-2.3 is not actualized until the opening of the new outfall under Project CA-2.5.

As indicated in Table 14, the project would result in very limited I/I reductions because the system would remain fully combined at project completion. The only I/I reductions that could be claimed would be those associated with reduced infiltration of inflow from replacing damaged pipes. This I/I benefit could not be estimated at this level of analysis. A master table providing both flood reduction and I/I benefits for all projects proposed is included in Appendix B.

Table 14. Flood Volumes in the Project CA-2.3 Area during the 10-Year Storms under Different System Conditions and I/I Volume Reduction Benefits

	Sewershed CA	Sewershed A*	Sewershed M	Total
Flooding during the 10-Yr, 24-Hr Design Event [MG]*				
Existing Conditions	1.997	0.003	1.122	3.122
Completion of Previous Projects under Alternative 2	0.333	0.024	0.813	1.170
After Project CA-2.3 Implementation	0.332	0.025	0.813	1.170
Flooding during the 10-Yr, 30-Min Design Event [MG]*				
Existing Conditions	1.506	0.010	0.857	2.373
Completion of Previous Projects under Alternative 2	0.647	0.010	0.805	1.462
After Project CA-2.3 Implementation	0.644	0.008	0.805	1.457
Estimated I/I Reduction with Project as Proposed [MG]				N/A

*Flood volumes reported for Sewershed A are only within the area tributary to the Tannery Brook drain (See Figure ES. 1)

FEASIBILITY CONSIDERATIONS:

The following are factors to be considered that can impact the feasibility and constructability of the proposed interventions:

- **Sewer Separation:** Some of the streets in Project Area CA-2.3 have both storm and sanitary pipes and other streets have only one combined pipe. Since storm flows from this area will ultimately discharge to the Alewife Brook, it is imperative that the proposed drain is free of sanitary contamination. Depending on the existing conditions and current degree of separation, the effort and cost of separation can vary significantly. Therefore, Dewberry recommends that, as a next satge in planning and design, sampling and dye-testing, and/or CCTV be performed to determine this.
- **Resident Construction Fatigue:** Somerville residents have undergone and continue to endure many construction projects citywide. Some potential resident pushback is anticipated and may require a well-planned outreach campaign.
- **Open-trench Installations:** Project Area CA-2.3 has many streets with only a single, combined-use pipe. In order to ensure that all of the flow in the area is fully separated, Dewberry recommends that new storm drain pipes be added to these streets via open-trench installations. Partial road closures are expected as a part of this effort, and residents should be notified well in advance as on-street parking is prevalent in this area.
- **Traffic Impacts:** While it is likely that the streets in the project area are primarily used by the residents living on them, these streets also provide a throughway from Morrison Ave. to Broadway and may be frequented by some non-resident drivers. Work in the public right of way along these streets would have a temporary negative impact on traffic and would need to be carefully planned and managed.

SUMMARY OF ENGINEER'S ESTIMATE OF PROJECT COSTS:

Engineer's estimates of project costs were prepared for this and other projects presented int his report. Two separate estimates were developed, the first one being less conservative than the second one with respect to potential project-specific issues such as type of soil and soil contamination potential, groundwater conditions, need for pipe reconnections and pipe and manhole rehabilitation, degree of implementation of Green Stormwater Infrastructure etc. Costs associated with the less conservative scenario are presented below. Detailed cost breakdowns and assumptions for each scenario are included in Appendix C. Refer to Section 6 for Green Stormwater Infrastructure details.

Table 15. Engineer's Opinion of Probable Costs for Project CA-2.3

SUMMARY OF COSTS FOR PROJECT CA-2.3	
Estimated Construction Sub-total	**$2,900,000**
Contingency (30%)	$870,000
Estimated Construction Total	**$3,770,000**
Engineering Design (11%)	$415,000
Resident Engineering (13%)	$490,000
Estimated Total Project Costs	**$4,675,000**

*Note: Does not include cost of full roadway reconstruction

3.4.4 Project CA-2.4: South of Holland Street Area

EXISTING CONDITIONS:

Project CA-2.4 Area is generally located south of Holland St. with the exception of a half block extension along Simpson Ave. The area is roughly bounded by Clarendon Ave. to the west, Holland St. to the north, Thorndike St. to the east, and the Tannery Brook Row to the south. The southern half of this project area has previously been considered by the City as part of Sewershed A; however, because the flows in this area are tributary to the Tannery Brook drain and sewer, Dewberry is assessing this area as part of Sewershed CA. The southern-most portion of the project area, below Sewershed A, is actually located within the City of Cambridge. This area is considered as part of the analysis because the phased project solution for Alternative 2 (i.e. New Outfall scenario) calls for a new stormwater outfall at the downstream end of the Tannery Brook conduit, which is located within the City of Cambridge. The upstream, tributary area to this outfall, however, lies almost entirely within Somerville city limits. Additionally, some of the streets tributary to the Tannery Brook system within this Project CA-2.4 area are inbetween Somerville and Cambridge. A clear example is Clarendon Avenue or Newbury St. For the purposes of this report we refer to Project CA-2.4 Area as the South of Holland Street Area.

This area is partially separated with many of the streets having two pipes (sanitary and storm) in the roadway. This is especially the case in the area traditionally categorized as belonging to Sewershed A. Sanitary and combined flows in the project area follow two different routings. In general, combined flows north of Mead St. flow south, towards a 30x20-inch combined sewer on Mead St. This combined sewer starts at Newbury St. and flows eastward towards Elmwood St. where it turns north and continues onward towards Holland St., increasing in size from an oval 30x20-inch to a circular 30-inch. The combined sewer continues in a southeastern direction along Holland St. where it increases in size to 36-inches. This 36-inch combined sewer receives additional flow from Paulina St. and Simpson Ave., north of Holland St. The connecting pipes on Paulina St. and Simpson Ave. are 30x45-inch and 8-inch, respectively. The 36-inch pipe on Holland St. eventually exits the project area and connects to the Elm St. combined sewer and onward towards Sewershed C2. There are two overflow connections from this combined sewer system to the Tannery Brook conduit. These overflows are activated during severe wet weather events. One of these connections is located at the intersection of Cameron Ave. and Mead St. while the other is located at the intersection of Paulina St. and Holland St. See Figure 38 and Figure 39 below for a detailed look into the manholes where these cross connections exist.

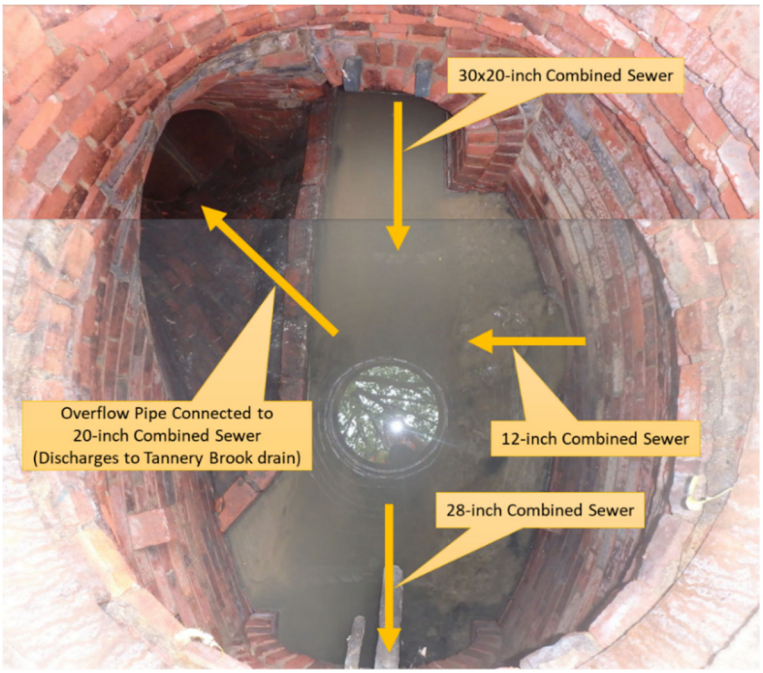


Figure 38. Manhole interior showing overflow pipe connection at Mead St. and Cameron Ave. (Photo taken from Somerville GIS – Manhole ID: CA-786 / Note: photo stitched together)

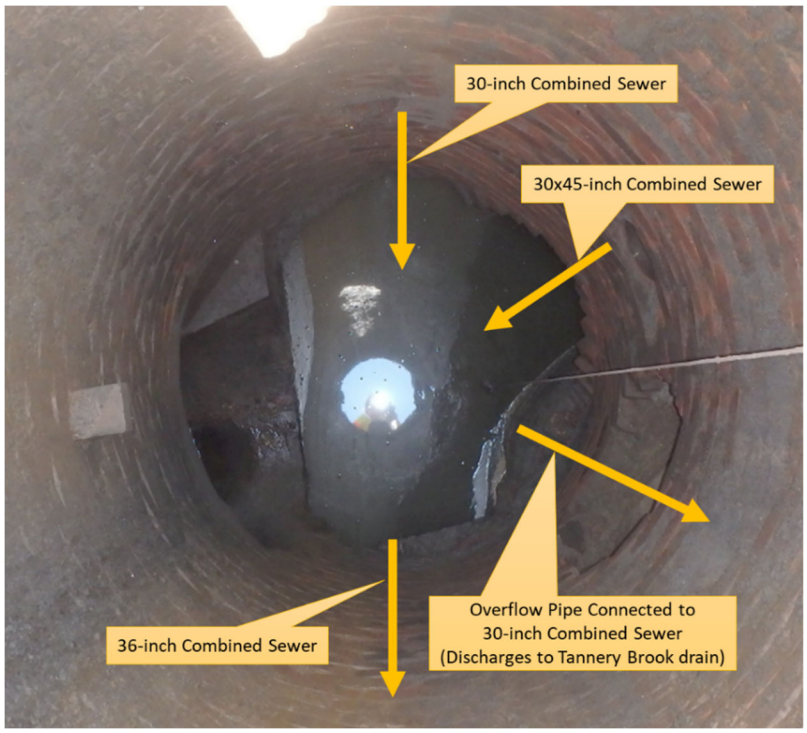


Figure 39. Manhole interior showing overflow pipe connection at Paulina St. and Holland St. (Photo taken from Somerville GIS – Manhole ID: CA-2397)

As previously mentioned, sanitary and storm flows in the southern half of the project area are mostly separated. Sanitary flows in this area, generally move in a southerly direction, connecting to a 12-inch sanitary sewer that runs along the north side of the Tannery Brook conduit. There is also a 10-inch sanitary sewer on the south side of the Tannery brook conduit that collects sanitary flows from several buildings on Elmwood St. and Thorndike St. These parallel sewers on either side of the Tannery Brook conduit eventually merge at Moore St. in Cambridge and continue onward as a 12-inch pipe. This 12-inch pipe turns southward near Clarendon Ave., connecting to a 12 to 15-inch combined sewer that ultimately discharges into an MWRA interceptor along Alewife Brook Parkway via a CSO regulator system known as CAM001. There are cross-connections on the Cambridge side of Clarendon Ave between the CAM001 system and the Tannery Brook conduit, which ultimately leads to the SOM-001A CSO regulator.

Storm drains within the project area generally flow southward towards the Tannery Brook conduit with the exception of Claremon St. whose drain ties into the 30x20-inch combined sewer on Mead St. The Tannery Brook conduit, which flows westward in the southern portion of the project area, begins as a 48x52-inch culvert and increases in size to 48x60-inch at Gorham St. Culvert size increases again at Cameron Ave. to 48x84-inch. At Clarendon Ave., the culvert transitions to twin 54-inch pipes that flow onward towards Alewife Brook Parkway to reach the SOM-001A CSO regulator, which has an underflows connection to the MWRA's Alewife Brook Conduit (ABC) interceptor and is also equipped with a baffle to control floatables and a static weir that connects to the CSO discharge pipe to the Alewife Brook once it is overtopped.

The following streets have storm drains tributary to the Tannery Brook conduit with sizes ranging from 10 to 12-inch: Newbury St., Glendale Ave., Yorktown St., Elmwood St., Simpson Ave., and Jay St. Apart from these smaller-diameter drains, there is also a 30-inch drain tributary to the Tannery Brook conduit that enters the project area from Paulina St. This pipe acts as a storm drain during normal conditions but serves as an overflow conduit to the Holland St and Broadway combined sewers during heavier rainfall events.

Based on model runs and flood complaints, the South of Holland Street Area experiences recurring flooding along streets with low-lying points such as Elmwood St. or Jay St. In particular, flooding in this area occurs more frequently during short-duration, high-intensity storms such as the 10-yr, 30-min storm. Some of this flooding is related to insufficient inlet capacity while some is related to inadequate conveyance capacity downstream. Cross connections within the area allow for points of relief that limit flooding under existing conditions.

Figure 40 shows the Project CA-2.4 area boundaries as well as the existing piping system. Maps showing flooding in existing system conditions for the selected design storms are provided in Appendix B.

PROJECT DESCRIPTION:

The project proposed for this area primarily involves the following major components:

- Sewer separation within the project area, including repurposing existing combined sewers to be used as dedicated sanitary sewers or storm drains and adding new sanitary sewers or storm drains to streets with only a single pipe in the road.
- Upsize existing storm drains on Jay St. from 12-inch to 36-inch and existing sanitary sewers on Cameron Ave. from 8-inch to 30-inch.
- Provide new sanitary connections at the intersection of Mead St. and Cameron Ave. and midblock on Elmwood St. to act as relief points for the newly separated sanitary sewer that will remain tributary to the Elm St. combined sewer. These new connections will direct overflow towards the existing 12-inch sanitary pipe that runs along the north side of the Tannery Brook conduit.
- Provide a new storm connection at the intersection of Mead St. and Cameron Ave. in order to route storm flows southward towards the Tannery Brook drain.
- Disconnect the existing combined sewer at the Claremon St. and Holland St. intersection and install a new 30-inch combined sewer on Holland St. from Claremon St. to Elmwood St. This new 30-inch combined sewer will provide a more direct path for combined flows from the upstream side of Holland Street, eliminating the current circuitous pathway along Mead Street and back to Holland Street.
- Remove existing cross connection at Holland St. and Paulina St. and eliminate common manholes along Simpson Ave. and Elmwood St. via abandonment of existing storm-over-sanitary configuration.
- Redirect building sanitary laterals in streets where new sanitary sewers are proposed.
- Redirect catch basin laterals in streets where new storm drains are proposed.
- Rehabilitate pipes and manholes to remain to extend their useful life following CCTV and manhole inspections to assess their existing condition.
- Install green infrastructure where possible to reduce Phosphorous concentrations in collected stormwater. See Appendix D for GI siting analysis with maps detailing potential GI placement locations.
- Construct additional stormwater catch basins to facilitate greater flow into the stormwater system, especially at low-lying locations, such as Mead St. and Jay St.
- Install a backflow prevention valve on the 30-inch combined sewer on Holland Street immediately downstream of the junction with the 30-inch combined sewer from Elmwood Street.
- Perform an IDDE program to eliminate any potential sanitary connection to the newly separated storm system. Upstream areas appear to be sewer separated; however, because storm flows will be discharged into the Alewife Brook, it is necessary to ensure all sanitary flows are removed.

Proposed conditions for Project CA-2.4 area are depicted in Figure 41.

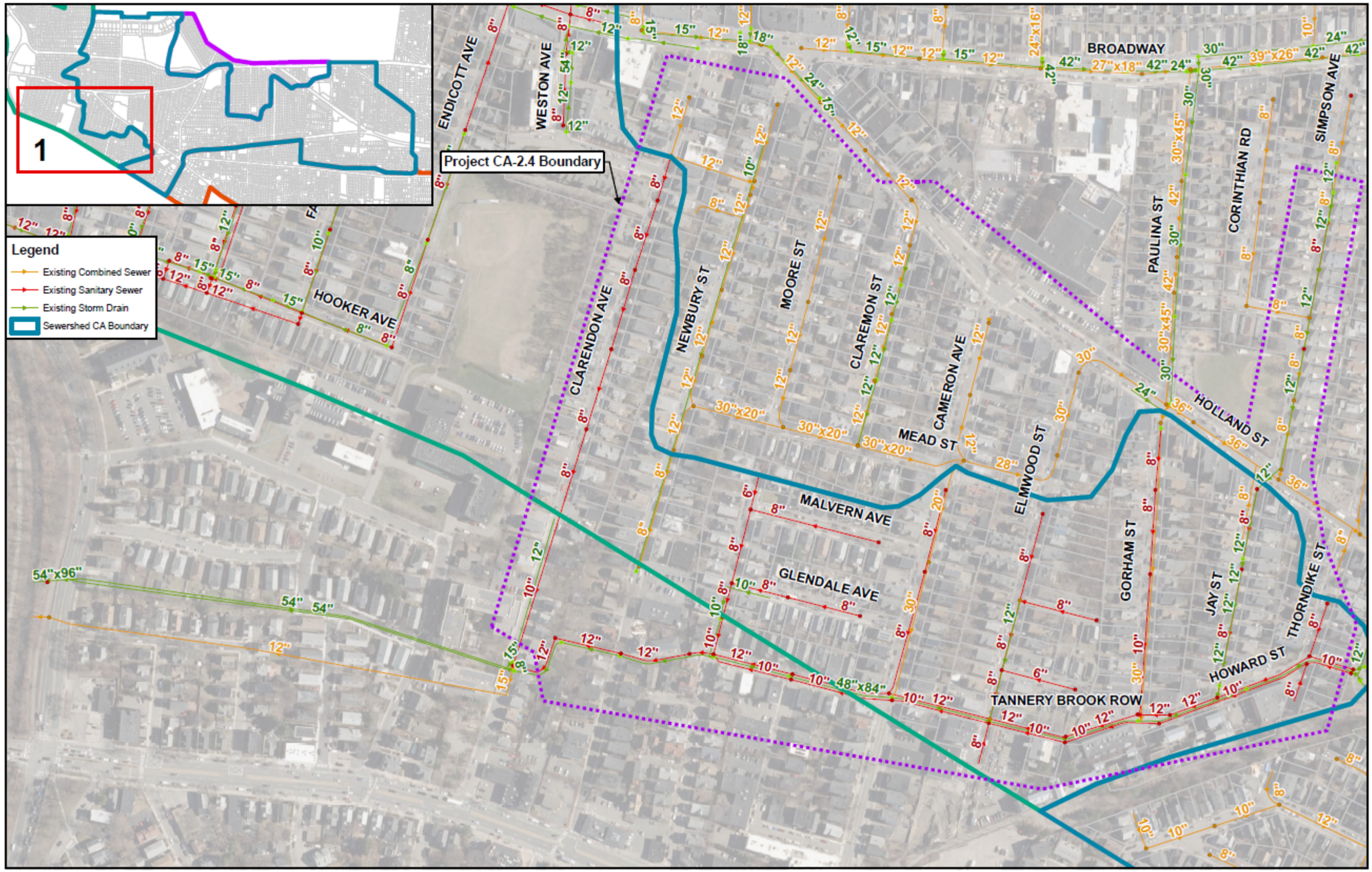


Figure 40. Project CA-2.4 Area - Existing Conditions

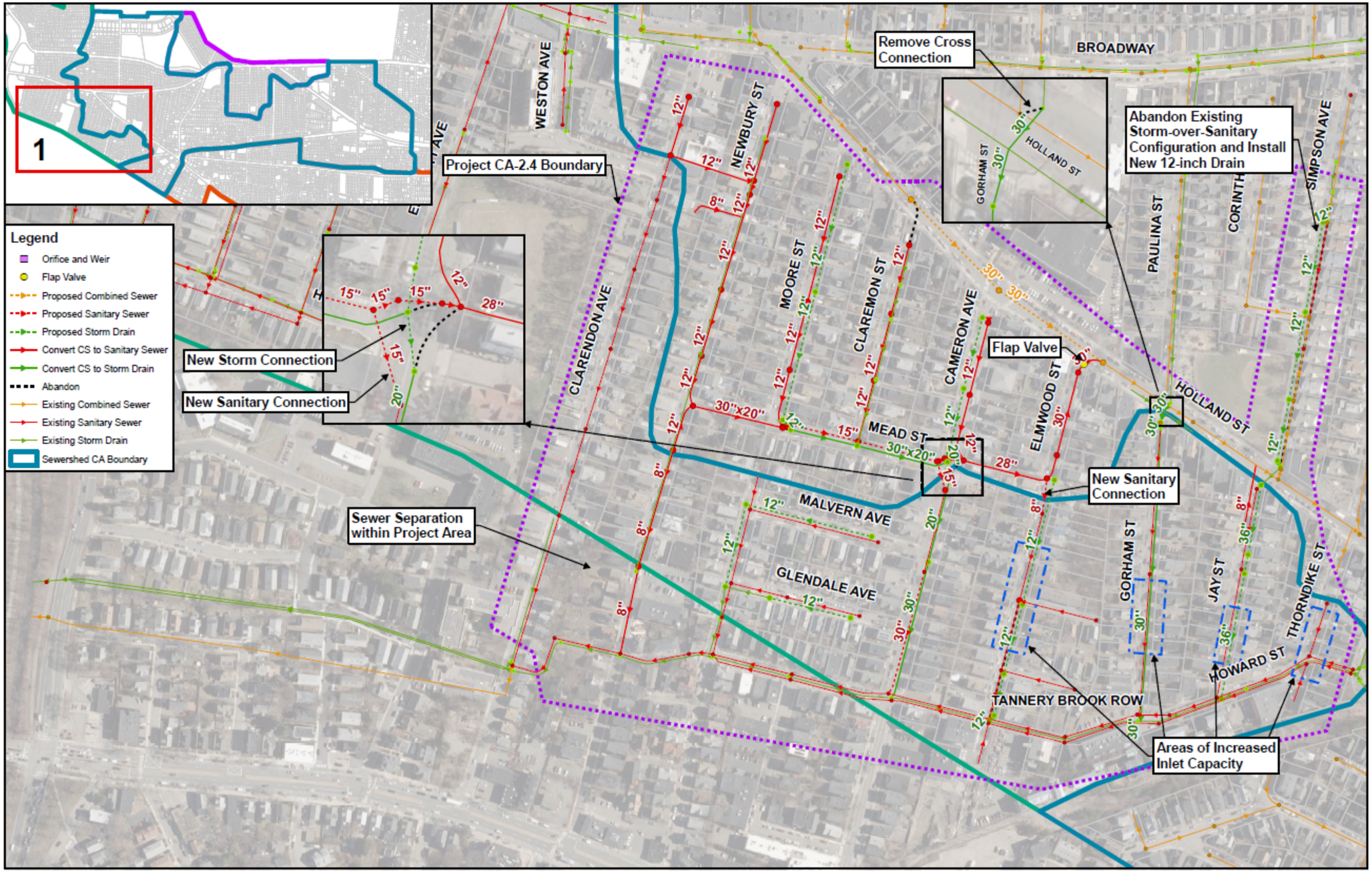


Figure 41. Project CA-2.4 Area - Proposed Improvements

FLOOD REDUCTION AND I/I BENEFITS:

The benefits of Project CA-2.4 in terms of flood volume reduction are summarized in the table below. Flood maps of the project area are included in Appendix B for:

1. Existing system conditions
2. Implementation of proposed project in the project area

As shown in the table below, implementation of the proposed project would have a very minimal effect on flooding in Sewersheds CA and M and minor reduction in Sewershed A for the 10-year, 24-hour and 10-year, 30-minute design storms. It is important to note that while this project in and of itself does not yield a significant flood reduction benefit, it does set the stage for following projects in which storm flows from the area are taken to a new outfall. In other words, the flood reduction benefit of Project CA-2.4 is not actualized until the opening of the new outfall under Project CA-2.5.

As indicated in Table 16, the project would result in very limited I/I reductions because the system would remain fully combined at project completion. The only I/I reductions that could be claimed would be those associated with reduced infiltration of inflow from replacing damaged pipes. This I/I benefit could not be estimated at this level of analysis. A master table providing both flood reduction and I/I benefits for all projects proposed is included in Appendix B.

Table 16. Flood Volumes in Project CA-2.4 Area during the 10-Year Storms and I/I Reduction under Different System Conditions

	Sewershed CA	Sewershed A*	Sewershed M	Total
Flooding during the 10-Yr, 24-Hr Design Event [MG]*				
Existing Conditions	1.997	0.003	1.122	3.122
Completion of Previous Projects under Alternative 2	0.332	0.025	0.813	1.170
After Project CA-2.4 Implementation	0.333	0.004	0.813	1.150
Flooding during the 10-Yr, 30-Min Design Event [MG]*				
Existing Conditions	1.506	0.010	0.857	2.373
Completion of Previous Projects under Alternative 2	0.644	0.008	0.805	1.457
After Project CA-2.4 Implementation	0.623	0.000	0.805	1.428
Estimated I/I Reduction with Project as Proposed [MG]				N/A

*Flood volumes reported for Sewershed A are only within the area tributary to the Tannery Brook drain (See Figure ES. 1)

FEASIBILITY CONSIDERATIONS:

The following are factors to be considered that could impact the feasibility and constructability of the proposed interventions:

- **Sewer Separation:** While approximately half of the streets inside Project CA-2.4 area have both a sanitary and a storm drain pipe, it is unclear whether the existing storm drains receive only storm flows or if there is sanitary sewage comingled with it. Depending on the existing conditions, the effort and cost of separation can vary significantly. Therefore, Dewberry recommends that, as a next stage in planning and design, sampling, dye testing, and/or CCTV be performed to determine if this is the case.
- **Private Inflow Redirection:** Due to the fact that some private inflow sources are likely to be redirected to sanitary sewers, careful evaluation of the separated sanitary system performance needs to be conducted in order to assure no negative impacts to residents will occur due to back flows into buildings.
- **Traffic Impacts:** Holland St. is an essential traffic artery for Somerville connecting Davis Square and Teele Square. Traffic detours during construction along this route will likely cause some disruption. Close coordination with the City's Department of Public Works and Police Department will be required to ensure minimal negative traffic impacts.
- **Resident Construction Fatigue:** Somerville residents have undergone and continue to endure many construction projects citywide. Some potential resident pushback is anticipated and may require a well-planned outreach campaign.
- **Open-trench Installations:** Project Area CA-2.4 has several streets with only a single, combined-use pipe. In order to ensure that all of the flow in the area is fully separated, Dewberry recommends that new storm drains or sanitary sewers be added to these streets via open-trench installations. Partial road closures are expected as a part of this effort, and residents should be notified well in advance as on-street parking is prevalent in this area.

SUMMARY OF ENGINEER'S ESTIMATE OF PROJECT COSTS:

Engineer's estimates of project costs were prepared for this and other projects presented in this report. Two separate estimates were developed, the first one being less conservative than the second one with respect to potential project-specific issues such as type of soil and soil contamination potential, groundwater conditions, need for pipe reconnections and pipe and manhole rehabilitation, degree of implementation of Green Stormwater Infrastructure etc. Costs associated with the less conservative scenario are presented below. Detailed cost breakdowns and assumptions for each scenario are included in Appendix C. Refer to Section 6 for Green Stormwater Infrastructure details.

Table 17. Engineer's Opinion of Probable Costs for Project CA-2.4

SUMMARY OF COSTS FOR PROJECT CA-2.4	
Estimated Construction Sub-total	**$5,711,000**
Contingency (30%)	$1,714,000
Estimated Construction Total	**$7,425,000**
Engineering Design (11%)	$817,000
Resident Engineering (13%)	$966,000
Estimated Total Project Costs	**$9,208,000**

*Note: Does not include cost of full roadway reconstruction

3.4.5 Project CA-2.5: New Storm Outfall to Alewife Brook

EXISTING CONDITIONS:

Project CA-2.5 Area is located entirely within the City of Cambridge, with the exception of the Somerville cross-connections to be eliminated concurrently with the construction of the new outfall. As mentioned in Section 3.2.3, this area is included in the analysis because the phased project solution for Alternative 2 (i.e. New Outfall scenario) calls for a new stormwater outfall at the downstream end of the Tannery Brook conduit, which is located within the City of Cambridge. The upstream, tributary area to this outfall, however, is almost entirely within Somerville city limits. Project CA-2.5 Area follows the Tannery Brook conduit corridor from Clarendon Ave. to the western side of Alewife Brook Pkwy. This corridor is located primarily along Muller Ave. and through an easement between Murray Hill Rd. and Foch St. For the purposes of this report we refer to Project CA-2.5 Area as the New Storm Outfall to Alewife Brook Area.

As mentioned, this project area encompasses the downstream end of the Tannery Brook conduit. At the eastern end of the project area, the Tannery Brook drain exists as a 48x84-inch box culvert. At Clarendon Ave., this culvert transitions into twin 54-inch pipes, adding additional storm flow from a 12 to 15-inch storm drain on Clarendon Ave. The twin 54-inch pipes travel through a short easement south of The Cambridge Matignon School onto Muller Avenue. The pipes continue through another easement between Murray Hill Rd. and Foch St. and onward towards Alewife Brook Parkway to reach the SOM-001A CSO regulator. This structure has an underflow connection to the MWRA's Alewife Brook Conduit (ABC) interceptor and is also equipped with a baffle to control floatables and a static weir that connects to the CSO discharge pipe to the Alewife Brook once it is overtopped.

Sanitary flows move in and out of the project area at the eastern end, near Clarendon Ave. At this location, a 12-inch sanitary sewer, running parallel to the Tannery Brook conduit, combines with a 10-inch sanitary sewer running southward on Clarendon Ave. Flows from these pipes continue onward in a southerly direction, exiting the project area via a 15-inch combined sewer. This combined sewer turns west off of Clarendon Ave. roughly 100-feet south of the point of merging and continues onward as a 12-inch pipe. The sewer follows a series of easements onto Foch St., eventually connecting to an MWRA interceptor on the Alewife Brook Parkway as well. There is an existing CSO regulator owned by Cambridge, CAM-001, located at this MWRA connection point.

Based on model runs and flood complaints, this area does not experience significant flooding. However, current configurations do limit upstream conveyance, which results in flooding in other areas within Sewershed CA.

Figure 42 shows the Project CA-2.5 area boundaries as well as the existing piping system. Maps showing flooding in existing system conditions for the selected design storms are provided in Appendix B.

PROJECT DESCRIPTION:

The project proposed for this area primarily involves the following major components:

- Convert one of the Tannery Brook twin 54-inch pipes into a dedicated storm drain and keep the second one as a combined sewer.
- Open up a new 54-inch stormwater outfall to the Alewife Brook at the downstream end of the existing Tannery Brook conduit. Eliminate the existing pipe connection that joins the twin 54-inch pipes on the eastern side of Alewife Brook Pkwy.
- Remove all remaining cross connections between the new storm drain system tributary to the new outfall and the combined system within Sewershed CA to ensure only stormwater reaches the proposed outfall.
- Reconfigure pipe alignments/connections and vault structure at Clarendon Ave. where the Tanney Brook conduit transitions from a box culvert to twin 54-inch pipe in order to isolate the 54-inch pipes from each other.
- Perform CCTV and manhole inspections to assess the condition of existing conduits and manholes to

remain in-place in order to provide recommendations on rehabilitation options to extend their useful life.

- Perform an IDDE program to eliminate any potential sanitary connection to the newly separated storm system. Upstream areas appear to be sewer separated; however, because storm flows will be discharged into the Alewife Brook, it is necessary to ensure all sanitary flows are removed.

- Rehabilitate pipes and manholes to remain to extend their useful life following CCTV and manhole inspections to assess their existing condition.

This project is expected to essentially eliminate the need for the SOM-001A CSO. The City may choose to leave the CSO in place to potentially provide relief during very large events but modeling results indicate that future activation would be highly unlikely under the proposed conditions.

Proposed conditions for Project CA-2.5 area are depicted in Figure 43.

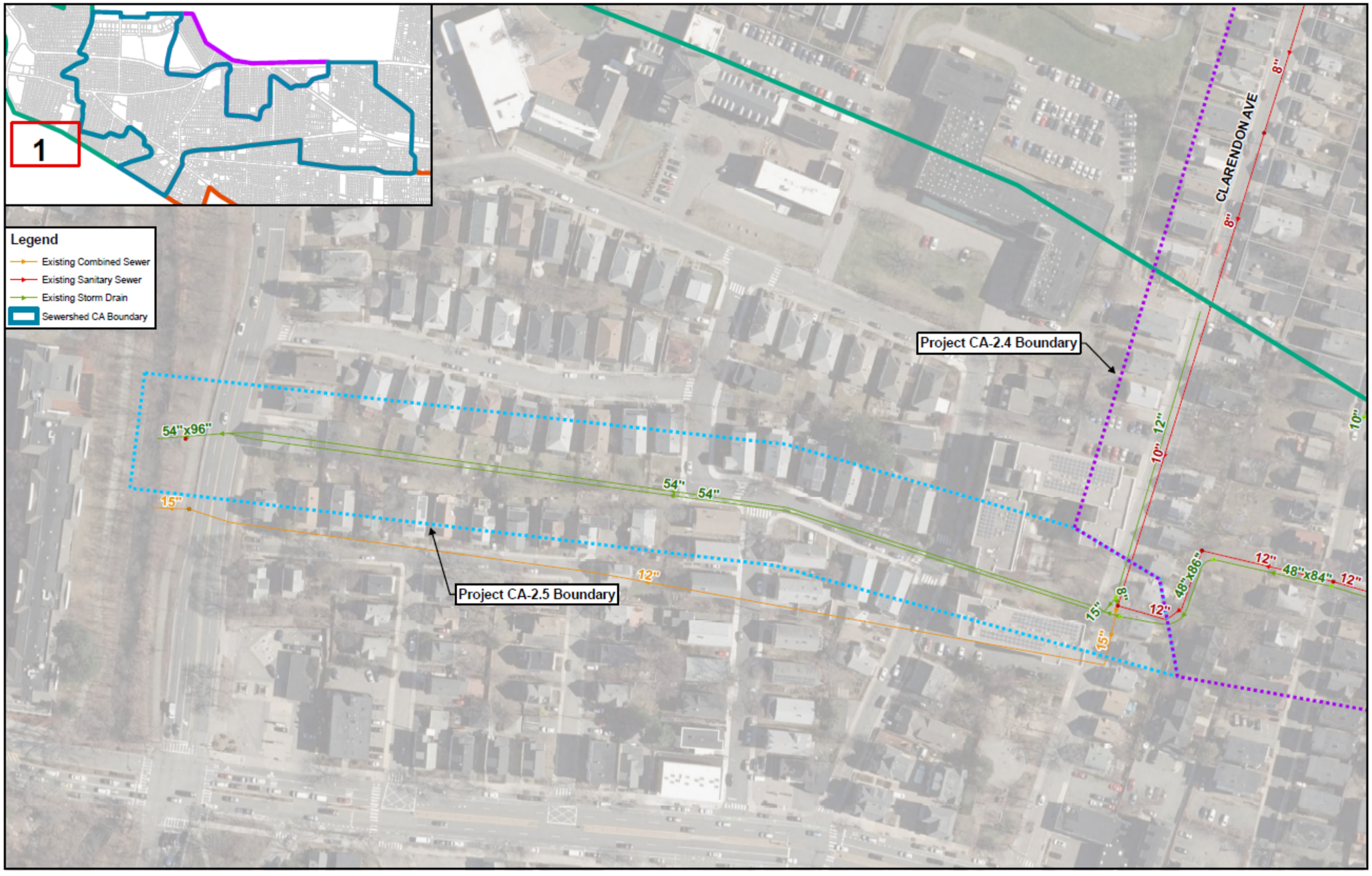


Figure 42. Project CA-2.5 Area - Existing Conditions

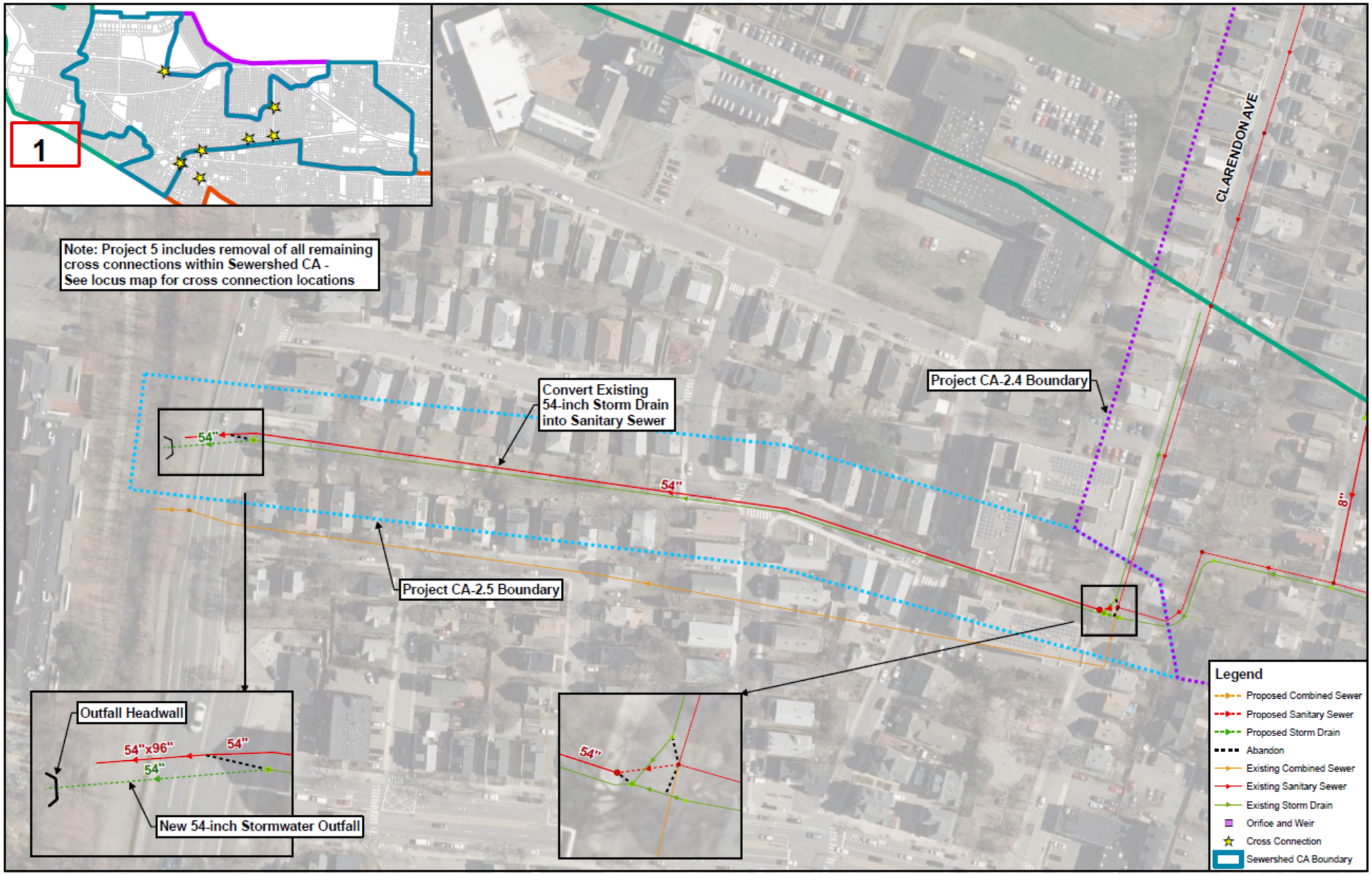


Figure 43. Project CA-2.5 Area - Proposed Improvements

FLOOD REDUCTION AND I/I BENEFITS:

The benefits of Project CA-2.5 in terms of flood volume reduction are summarized in the table below. Flood maps of the project area are included in Appendix B for:

1. Existing system conditions
2. Implementation of proposed project in the project area

As shown in the table below, implementation of the proposed project would increase flooding in Sewershed CA, while having minimal impact on flooding within Sewersheds A and M for the 10-year, 24-hour design storm. Flood volumes for the 10-year, 30-minute design storm follow a similar trend. While this project opens up a new outfall, providing an enormous I/I reduction benefit, closing the cross connections throughout the tributary system results in new surface flooding of combined sewers that can no longer find relief in the Tannery Brook conduit. The following project, Project CA-2.6, was crafted to address this resultant flooding.

Table 18 also presents potential I/I reduction that would be realized with the project. I/I reduction was estimated using the 1-year, 6-hour MassDEP storm per MassDEP guidelines. A master table providing both flood reduction and I/I benefits for all projects proposed is included in Appendix B.

Table 18. Flood Volumes in Project CA-2.5 Area during the 10-Year Storms and I/I Reduction under Different System Conditions

	Sewershed CA	Sewershed A*	Sewershed M	Total
Flooding during the 10-Yr, 24-Hr Design Event [MG]*				
Existing Conditions	1.997	0.003	1.122	3.122
Completion of Previous Projects under Alternative 2	0.333	0.004	0.813	1.150
After Project CA-2.5 Implementation	0.563	0.001	0.819	1.383
Flooding during the 10-Yr, 30-Min Design Event [MG]*				
Existing Conditions	1.506	0.010	0.857	2.373
Completion of Previous Projects under Alternative 2	0.623	0.000	0.805	1.428
After Project CA-2.5 Implementation	0.656	0.000	0.807	1.464
Estimated I/I Reduction with Project as Proposed [MG]				4.602

*Flood volumes reported for Sewershed A are only within the area tributary to the Tannery Brook drain (See Figure ES. 1)

FEASIBILITY CONSIDERATIONS:

The following are factors to be considered that could impact the feasibility and constructability of the proposed interventions:

- **New Outfall Pipe:** This pipe will be installed across Alewife Brook Pkwy. and will discharge into the Alewife Brook. Dewberry anticipates that significant discussion and coordination efforts with MassDEP and other state agencies will be required. Since the Alewife Brook Parkway is jurisdiction of MassDCR, permitting and coordination with this entity will be necessary. There are two MWRA interceptor pipes along Alewife Brook Pkwy. that will need to be crossed. There may also be other, unidentified utilities in the vicinity of the proposed outfall. These utilities should be verified and addressed in a later design phase.
- **Permitting:** This project will require a significant permitting effort with multiple state and local agencies because of the location of the proposed stormwater outfall pipe and the construction of a new outfall. Dewberry anticipates permits will be required from MWRA, MassDCR, the Conservation Commission, Environmental Protection Agency (EPA), and MassDEP at a minimum.
- **Discharge of New Stormwater Flows:** As mentioned, project CA-2.5 will open up a new outfall to Alewife Brook, adding additional storm flows to the water body. Prior to discharge, these storm flows may need to be treated for phosphorus which could come at a significant cost and carry significant O&M requirements.
- **Coordination with City of Cambridge:** Because the proposed project is located within the City of Cambridge, Somerville will need to coordinate efforts with Cambridge in order to operate outside of their jurisdiction or coordinate the project efforts with the neighboring municipality. This may require a series of meetings and development of operational protocols to ensure both parties are in agreement with the proposed plan and work activity.
- **Traffic Impacts:** The new, 54-inch stormwater outfall pipe will cross Alewife Brook Pkwy. which is a main thoroughfare for the Cities of Somerville and Cambridge. This effort will need to be carefully coordinated to minimize traffic impacts. A trenchless installation or nighttime construction may need to be considered at a later design stage.
- **Easement Access:** The existing 54-inch pipes to be repurposed as separate, storm and combined sewers run through multiple easements before reaching Alewife Brook Pkwy. Although these pipes are to remain in-place, it may be necessary to access them in order to perform rehabilitative work. Work within the easement should be discussed with nearby residents to ease concern and reduce complaints.

SUMMARY OF ENGINEER'S ESTIMATE OF PROJECT COSTS:

Engineer's estimates of project costs were prepared for this and other projects presented in this report. Two separate estimates were developed, the first one being less conservative than the second one with respect to potential project-specific issues such as type of soil and soil contamination potential, groundwater conditions, need for pipe reconnections and pipe and manhole rehabilitation, degree of implementation of Green Stormwater Infrastructure etc. Costs associated with the less conservative scenario are presented below. Detailed cost breakdowns and assumptions for each scenario are included in Appendix C. Refer to Section 6 for Green Stormwater Infrastructure details.

Table 19. Engineer's Opinion of Probable Costs for Project CA-2.5

SUMMARY OF COSTS FOR PROJECT CA-2.5	
Estimated Construction Sub-total	**$1,715,000**
Contingency (30%)	$514,000
Estimated Construction Total	**$2,229,000**
Engineering Design and Permitting Outfall (14%)	$312,000
Resident Engineering (13%)	$290,000
Estimated Total Project Costs	**$2,831,000**

*Note: Does not include cost of full roadway reconstruction or sewer separation work within City of Cambridge (outside of what is shown in Figure 43)

3.4.6 Project CA-2.6: Highland Avenue Area

While Project CA-2.5 serves to essentially eliminate the need for the SOM-001A CSO, the removal of cross connections to the Tannery Brook conduit adds new stress to the combined sewer system as these relief points will no longer exist, causing combined sewer flooding within the Davis Square area. In order to prevent new flooding in this area, additional storage is needed in the immediate downstream area. Project CA-2.6 addresses this need via a series of large pipe upsizings that provide in-line storage.

EXISTING CONDITIONS:

Project CA-2.6 Area is primarily located within Sewershed C2 with the exception of Day St. which is in Sewershed CA. The project area is roughly bounded by Day St. to the west, Highland Ave. to the north, Chester St./Grove St. to the east, and Orchard St. to the south. For the purposes of this report we refer to Project CA-2.6 Area as the Highland Ave. Area.

The existing sewer system in the project area is primarily combined with most streets having a single pipe in the roadway. Exceptions to this statement are Day St., Herbert St., Elm St., and Grove St. which all have storm drains collecting a portion of their drainage. On Day St., there is a 12-inch storm drain flowing in a northeast direction towards Elm St. This drain picks up additional flow from a 12-inch drain on Herbert St. before continuing on to Elm St. where it unites with a 30-inch drain. This 30-inch drain, which starts at the Elm St. and Chester St. intersection, flows to the north, out of the project area and towards the Tannery Brook conduit. On Grove St., there is a 12-inch drain that starts mid-block between Highland Ave. and the Somerville Community Path. This drain flows north and connects with a 72-inch pipe, headed west through Davis Square. This 72-inch pipe can be considered the upstream end of the Tannery Brook conduit.

Combined sewage in the project area generally flows towards Elm St. where there is a 42-inch pipe that carries it southward, out of the project area and towards Union Square. This pipe picks up flow at Day St. and Chester St. via 24x17-inch combined sewers. Both of these 24x17-inch conduits collect flow from Orchard St. while the Chester St. conduit also collects flow from an 8-inch combined sewer on Chester Pl. and a 12-inch combined sewer on Herbert St. There is an existing cross-connection between the Elm St combined sewer and the adjacent 30-inch drain at the Day St and Elm St intersection. This 30-inch drain connects to the Tannery Brook conduit so during large storm events, flows from the Elm St combined sewer may overflow and reach the Tannery Brook conduit. Downtream of this point. the Elm St. sewer picks up additional flow at Bowers Ave. via an 8-inch connection and at Grove St. via a 28x24-inch connection. This 28x24-inch conduit on Grove St. starts at Morrison Ave. with flows from upstream areas and moves in a southerly direction towards Elm St., picking up flows from Winslow Ave. and Highland Ave. Pipes on Winslow Ave. and Highland Ave. range in size from 8 to 15-inch. Finally, before exiting the project area, the Elm St. sewer adds even more flow via a 15-inch connection on Russell St. and a 24x17-inch connection of Cutter Ave. Flows from the Elm St. combined sewer eventually make their way to Union Square where they are discharged to the MWRA's Cambridge Branch Sewer at the SOM-009 regulator structure.

Based on model runs, the Day St., Dover St., and Meacham Rd. areas will experience new or more severe flooding following the implementation of Project CA-2.5. This is a consequence of removing the cross-connections between the newly separated Tannery Brook drainage system and the existing combined system that merges in Elm Street. Under this alternative, these points of relief would no longer exist. Under current conditions, flooding is not as severe in these areas; however, some flooding does exist along Orchard St. and Chester St. during short duration, high intensity storms. This flooding is mostly driven by local piping and inlet system conditions.

Figure 44 shows the Project CA-2.6 area boundaries as well as the existing piping system. Maps showing flooding in existing system conditions for the selected design storms are provided in Appendix B.

PROJECT DESCRIPTION:

The project proposed for this area primarily involves the following major components:

- Construct a series of combined culverts or large-diameter pipes on the following streets:
  - Highland Ave. from Davis Square to Willow Ave. (96x66-inch)
  - Grove St. from the Somerville Community Path to Elm St. (96x96-inch)
  - Day St. from Orchard St. to Elm St. (96x42-inch)
  - Chester St. from midblock beween Massachusetts Ave. and Orchard St. to Elm St. (96x54-inch)
  - Elm St. from Grove St. to Cutter Ave. (84-inch - circular)
- Redirect catch basin laterals in streets where combined sewers are proposed to be upsized.
- Rehabilitate pipes and manholes to remain to extend their useful life following CCTV and manhole inspections to assess their existing condition.

Proposed conditions for Project CA-2.6 area are depicted in Figure 45.

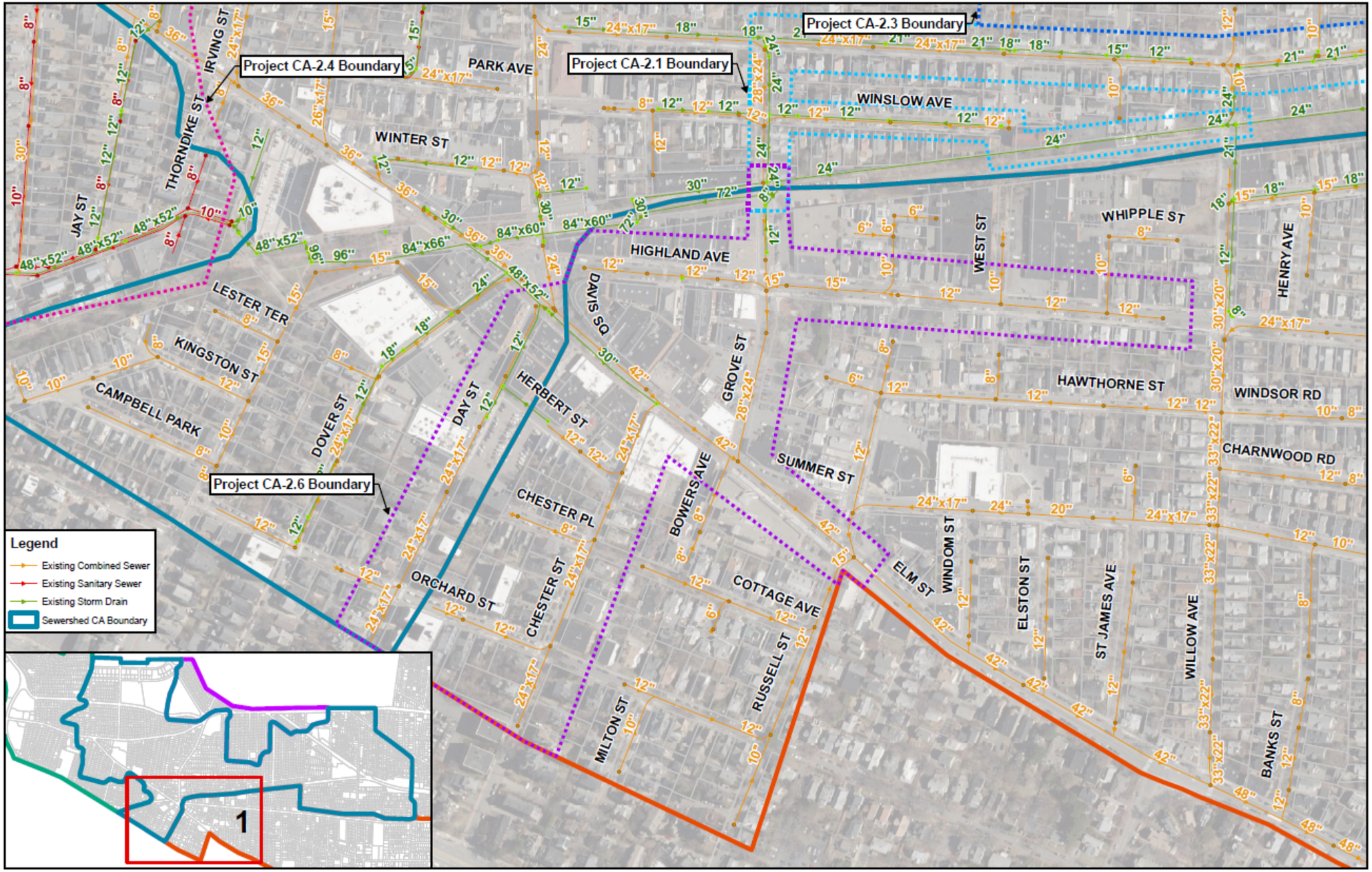


Figure 44. Project CA-2.6 Area - Existing Conditions

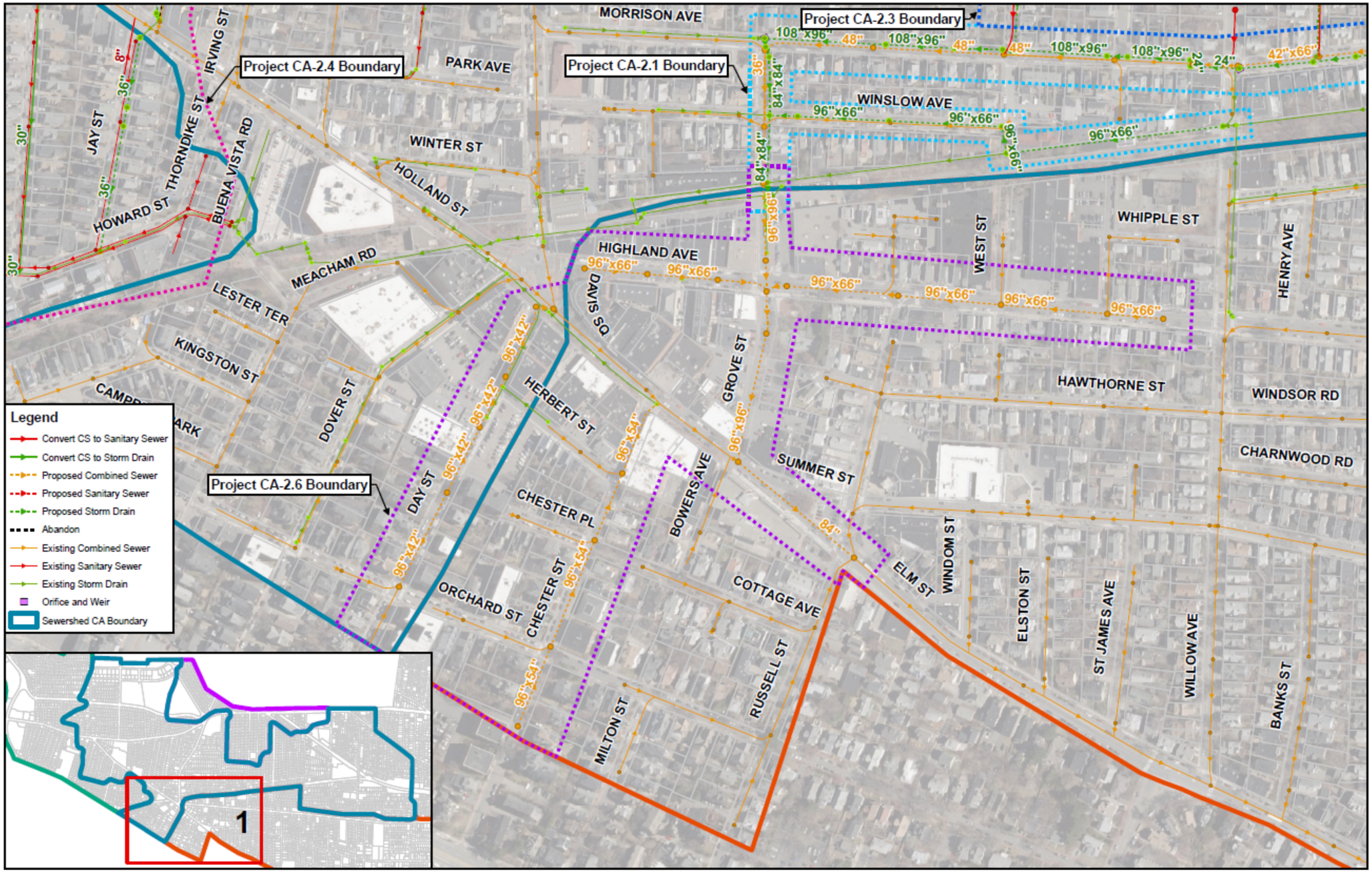


Figure 45. Project CA-2.6 Area - Proposed Improvements

FLOOD REDUCTION AND I/I BENEFITS:

The benefits of Project CA-2.6 in terms of flood volume reduction are summarized in the table below. Flood maps of the project area are included in Appendix B for:

1. Existing system conditions
2. Implementation of proposed project in the project area

As shown in the table below, implementation of the proposed project would greatly reduce flooding in Sewershed CA while having minimal impact on flooding in Sewersheds A and M for the 10-year, 24-hour design storm. For the 10-year, 30-minute design storm, flooding in Sewershed CA is reduced by a lesser degree and again flooding in Sewersheds A and M remain close to the same as in the previous project.

As indicated in Table 20, the project would result in very limited I/I reductions because the project area system would remain fully combined at project completion. The only I/I reductions that could be claimed would be those associated with reduced infiltration of inflow from replacing damaged pipes. This I/I benefit could not be estimated at this level of analysis. A master table providing both flood reduction and I/I benefits for all projects proposed is included in Appendix B.

Table 20. Flood Volumes in Project CA-2.6 Area during the 10-Year Storms and I/I Reduction under Different System Conditions

	Sewershed CA	Sewershed A*	Sewershed M	Total
Flooding during the 10-Yr, 24-Hr Design Event [MG]*				
Existing Conditions	1.997	0.003	1.122	3.122
Completion of Previous Projects under Alternative 2	0.563	0.001	0.819	1.383
After Project CA-2.6 Implementation	0.315	0.000	0.814	1.129
Flooding during the 10-Yr, 30-Min Design Event [MG]*				
Existing Conditions	1.506	0.010	0.857	2.373
Completion of Previous Projects under Alternative 2	0.656	0.000	0.807	1.464
After Project CA-2.6 Implementation	0.627	0.000	0.804	1.431
Estimated I/I Reduction with Project as Proposed [MG]				N/A

*Flood volumes reported for Sewershed A are only within the area tributary to the Tannery Brook drain (See Figure ES. 1)

FEASIBILITY CONSIDERATIONS:

The following are factors to be considered that could impact the feasibility and constructability of the proposed interventions:

- **Traffic Impacts:** Both Elm St. and Highland Ave. are essential traffic arteries for Somerville. Traffic modifications during construction along these routes will likely cause significant disruption. Close coordination with the City's Department of Public Works and Police Department will be required to ensure minimal negative traffic impacts.
- **Resident Construction Fatigue:** Somerville residents have undergone and continue to endure many construction projects citywide. Some potential resident pushback is anticipated and may require a well-planned outreach campaign.
- **Utility conflicts:** Based on the size of the proposed culverts and large-diameter pipes it is highly likely that significant utility conflicts will exist that may preclude or increase the level of effort for the design and construction of these box conduits. Extensive relocation or support of existing utilities during construction should be anticipated.
- **Open-trench Installations:** Proposed improvements for Project Area CA-2.6 includes upsizing/replacing a number of combined sewers via open-trench installations. Partial road closures are expected as a part of this effort, and residents should be notified well in advance as on-street parking is prevalent in this area.
- **Geotechnical and Groundwater Conditions:** A geological survey will determine the best way to support the large box culverts and manage groundwater during their construction. Depending on these conditions and recommended construction techniques, costs can vary significantly.
- **Constructability Issues:** Thes large conduits may pose constructability limitations due to its especially in narrower streets. Installing pipes of such dimensions is challenging especially when overhead wires and other elements may get in the way of construction machinery necessary for a job this size. While not unsurmountable, careful consideration will need to be paid to these details before proceeding with bidding andf construction.

SUMMARY OF ENGINEER'S ESTIMATE OF PROJECT COSTS:

Engineer's estimates of project costs were prepared for this and other projects presented in this report. Two separate estimates were developed, the first one being less conservative than the second one with respect to potential project-specific issues such as type of soil and soil contamination potential, groundwater conditions, need for pipe reconnections and pipe and manhole rehabilitation, degree of implementation of Green Stormwater Infrastructure etc. Costs associated with the less conservative scenario are presented below. Detailed cost breakdowns and assumptions for each scenario are included in Appendix C. Refer to Section 6 for Green Stormwater Infrastructure details.

Table 21. Engineer's Opinion of Probable Costs for Project CA-2.6

SUMMARY OF COSTS FOR PROJECT CA-2.6	
Estimated Construction Sub-total	**$19,463,000**
Contingency (30%)	$5,839,000
Estimated Construction Total	**$25,302,000**
Engineering Design (11%)	$2,784,000
Resident Engineering (13%)	$3,290,000
Estimated Total Project Costs	**$31,376,000**

*Note: Does not include cost of full roadway reconstruction

3.5 Proposed Local Flood Mitigation Projects in Sewershed M

Prior to the development of flood risk mitigation projects, a detailed hydraulic assessment of the sewersheds' drainage was performed and documented in the memorandum *"Sewersheds CA & M Flooding Root Cause Analysis"* by Dewberry. During this effort, Dewberry updated the City's hydraulic model and refined it based on new field and record information. The model was then re-calibrated using permanent and temporary flow meters installed within the sewershed area. The model was then checked against flood complaints received by City of Somerville's residents during severe rain events in order to evaluate the accuracy of its predictions. The model was upgraded to a point where most of these complaints were successfully captured and was then used to identify vulnerable areas. Figure 7 in Section 3.2 shows an example flood map during a rainfall event that caused flood complaints.

Concept-level interventions to reduce flood risk in vulnerable areas were evaluated using the updated hydraulic model. Proposed project descriptions, flood reduction, and Infiltration and Inflow (I/I) reduction benefits, as well as project feasibility considerations are described in detail as follows.

3.5.1 Project M-1: Pearson Road and Broadway Area

EXISTING CONDITIONS:

Project M-1 Area is located in Sewershed M to the east of Powder House Square. The project area is bounded roughly by Pearson Road and Broadway to the north, Rogers Avenue to the east, Foskett Street to the south, and Bay State Avenue to the west. For the purposes of this report we refer to Project M-1 Area as the Pearson Road and Broadway area.

Stormwater drainage in the Pearson Road and Broadway area generally flows northward towards a 24-inch storm drain running east to west on Broadway. This 24-inch drain turns northwest from Broadway onto Pearson Road where it continues onward, eventually combining with a 42x60-inch culvert that becomes a 54-inch pipe and discharges into the City of Medford's storm drain system.

Sanitary flows in the area follow two different flow paths. Sanitary flows south of Broadway flow northward to Broadway where they are collected by an 8 to 12-inch sanitary sewer flowing west to east. This sanitary sewer on Broadway connects to an 8-inch combined sewer near the intersection of Broadway and Rogers Avenue. At this junction, the flow changes direction, moving northwest into the City of Medford's sewer system. Sanitary flows on Pearson Road, north of Broadway, flow to the northwest via an 8-inch sanitary sewer. This pipe combines with an 8-inch and a 10-inch pipe on Pearson Road and passes through an easement into the City of Medford's sewer system.

Streets in the Pearson Road and Broadway area generally have a sanitary sewer and storm drain running parallel to one another. A couple of exceptions to this statement are Willow Avenue and Bay State Avenue, where a portion of the roadway has only a single sanitary sewer pipe. Stormwater on these streets is collected at the Mallet Street and Willow Avenue intersections and is brought over to Lowden Avenue where it flows northward towards Broadway. Rogers Avenue is another exception, having a combined sewer for only half of the roadway and a combined sewer paired with a storm drain for the other half. Based on this information, Dewberry believes sanitary and stormwater flows in the area are separated apart from Rogers Avenue.

Based on available information, Dewberry has identified a single cross connection in the project area in the form of a common manhole. This manhole is located on Rogers Avenue, midblock between Broadway and Kidder Avenue. See Figure 46 for an image inside the manhole obtained from the City's GIS viewer.

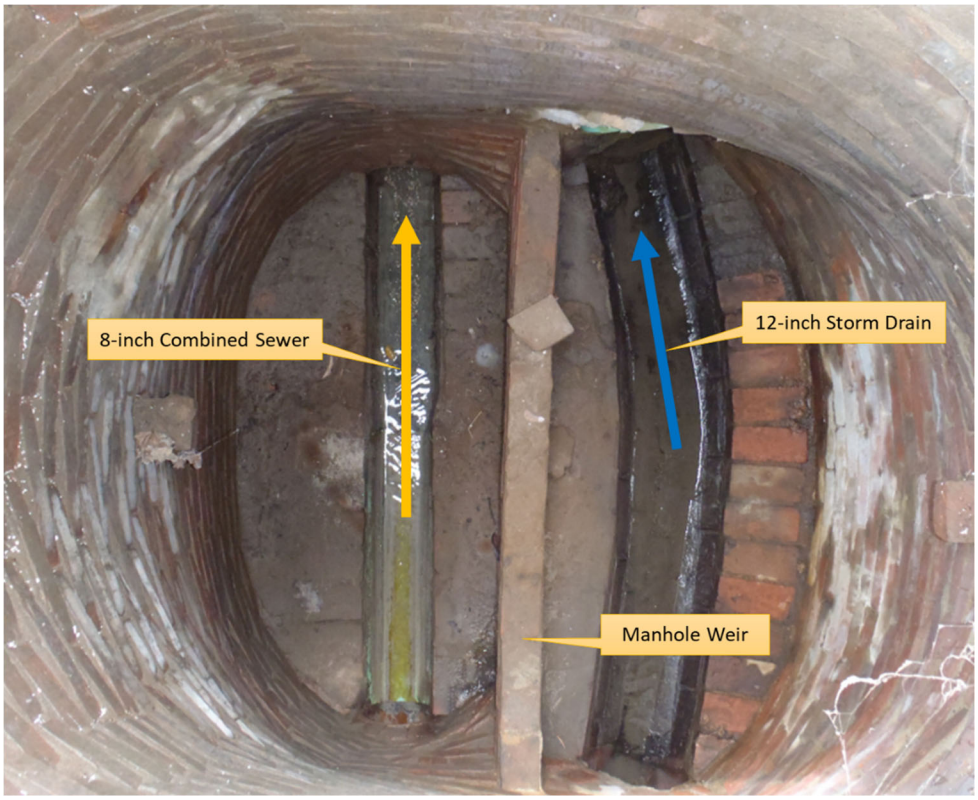


Figure 46. Common Manhole Interior with Vertical Weir on Rogers Ave. (Photo taken from Somerville GIS – Manhole ID: M-146)

Based on model runs and flood complaints received, the Pearson and Broadway area experiences recurring flooding primarily in the block that includes Mallet Street, Willow Avenue, Kidder Avenue, and Lowden Avenue. This flooding is mostly driven by localized conveyance capacity limitations.

Figure 47 shows the Project M-1 area boundaries as well as the existing piping system. Maps showing flooding in existing system conditions are included in Appendix B.

PROJECT DESCRIPTION:

The major elements of the proposed project for this area are described below and are also shown in Figure 48:

- If the receiving Medford system is separated, ensure that the stormwater drains and sanitary sewers in the project area are fully separated. Although the area appears to be mostly separated within Somerville, some sanitary connections to the storm drain system may still exist and should be corrected if identified via closed-circuit television (CCTV) or dye testing.
- Upsize existing storm drains on Kidder Avenue, Lowden Avenue, and Pearson Road to increase conveyance capacity and provide temporary in-line storage.
- Rehabilitate pipes and manholes to remain to extend their useful life following CCTV and manhole inspections to assess their existing condition.
- Install green infrastructure where possible to reduce Phosphorous concentrations in collected stormwater. See Appendix D for GI siting analysis with maps detailing potential GI placement locations.
- If the receiving Medford system is separated, eliminate all cross connections in the project area, particularly

the shared manhole on Rogers Avenue.

- If the receiving Medford system is separated, perform an IDDE program to eliminate any potential sanitary connection to the storm system once sewer separation is complete to ensure absence of sanitary flows in stormwater.
- Increase inlet capacity in low-lying areas along Broadway where surface runoff accumulation is an issue.

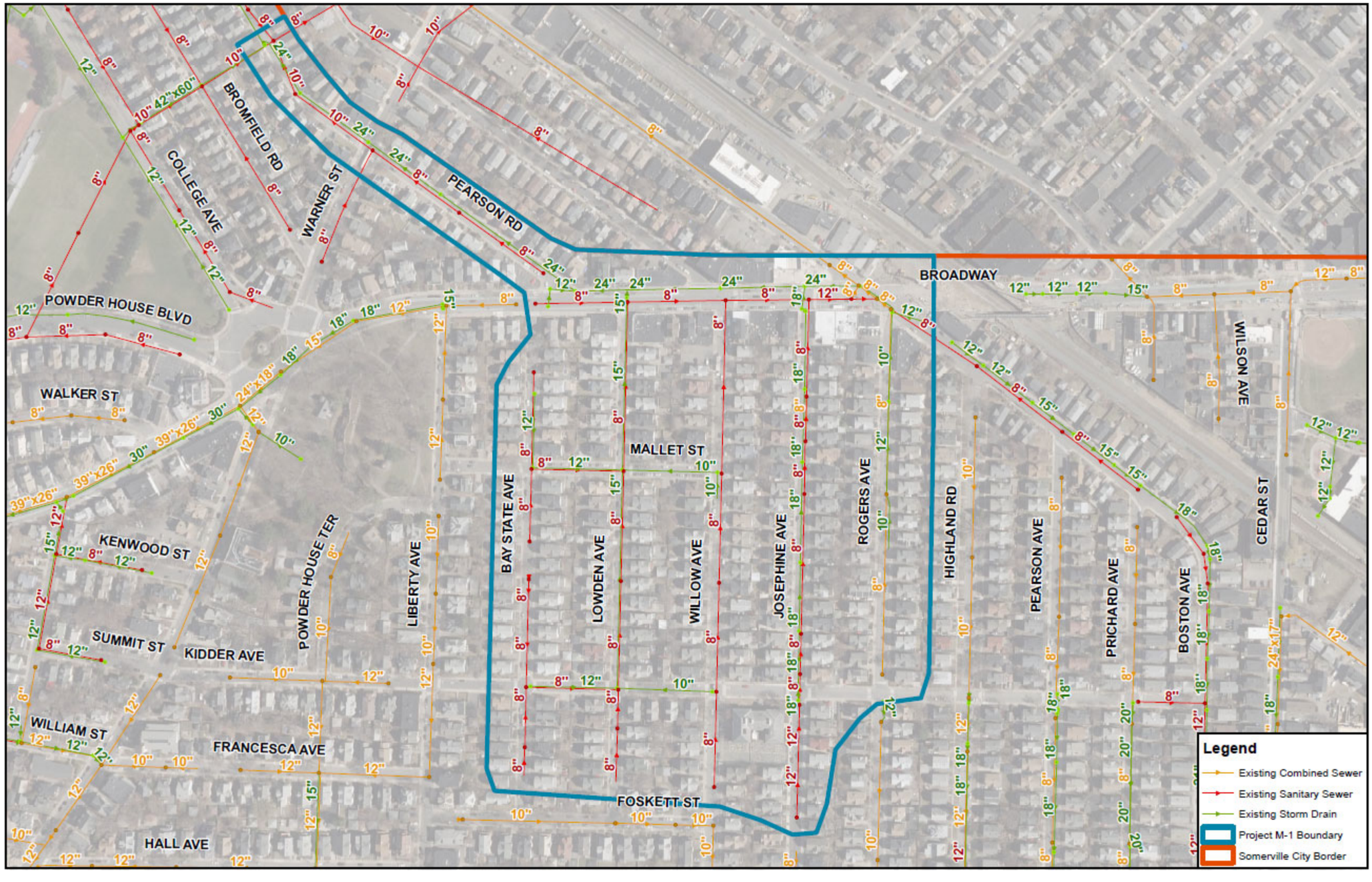


Figure 47. Project M-1 Area - Existing Conditions

Figure 48. Project M-1 Area - Proposed Improvements

APPENDIX A
Proposed Projects Concept Drawings

Project CA-2.1 - Morrison Avenue Area (Page 2 of 2)

City of Somerville, Massachusetts

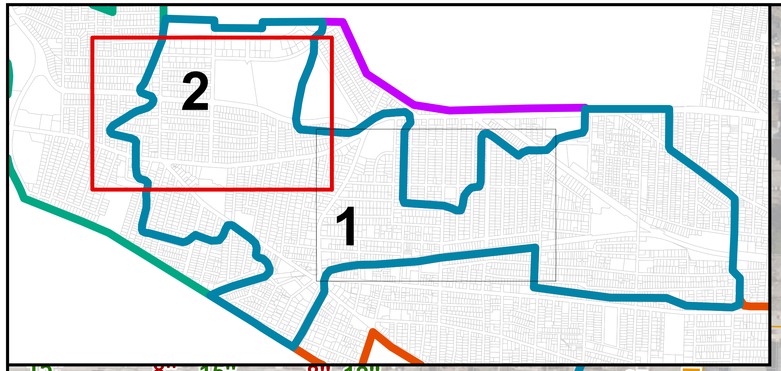
0 100 200 400 Feet

N

Existing Conditions

Alt 2: New Outfall Scenario

Dewberry



Legend

- Existing Combined Sewer
- Existing Sanitary Sewer
- Existing Storm Drain
- Sewershed CA Boundary

Project CA-2.1 Boundary (Additional Area)

SAWYER AVE
PACKARD AVE
WHITFIELD RD
TEELE AVE
POWDER HOUSE BLVD
TALBOT AVE
LATIN WAY
LOWER CAMPUS RD
COLLEGE AVE
DOW ST
HARDAN RD
WARE ST
OSSIPEE RD
MASON ST
RUSSELL RD
WATSON ST
DICKSON ST
HILL ST
CURTIS ST
WESTMINSTER ST
LOVELL ST
ELECTRIC AVE
WHITMAN ST
BURNHAM ST
LEONARD ST
WALKER ST
ENDICOTT AVE
WESTON AVE
CLARENDON AVE
NEWBURY ST
MOORE ST
HOLLAND ST
BROADWAY
PAULINA ST
CORINTHIAN RD
SIMPSON AVE
IRVING ST
WALLACE ST
CHANDLER ST

Project CA-2.1 - Morrison Avenue Area (Page 1 of 2)

City of Somerville, Massachusetts

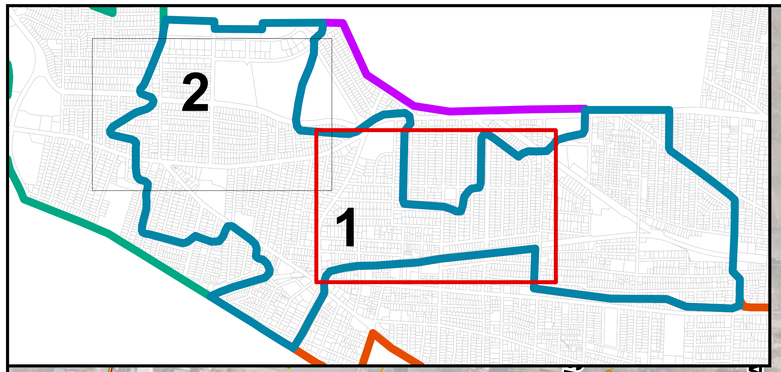
0 100 200 400 Feet

N

Proposed Conditions

Alt 2: New Outfall Scenario

Dewberry



Legend

- Orifice and Weir
- Proposed Storm Drain
- Proposed Sanitary Sewer
- Proposed Combined Sewer
- Abandon
- Existing Storm Drain
- Existing Sanitary Sewer
- Existing Combined Sewer
- Sewershed CA Boundary

MALLET ST
BAY STATE AVE
LOWDEN AVE
WILLOW AVE
JOSEPHINE AVE
ROGERS AVE
HIGHLAND RD
CEDAR ST
KIDDER AVE
POWDER HOUSE
LIBERTY A
FRANCESCA AVE
FOSKETT ST
HALL AVE
APPLETON ST
LIBERTY RD
CLIFTON ST
MORRISON AVE
WINSLOW AVE
GROVE ST
WEST ST
WHIPPLE ST
HENRY AVE
LESLEY AVE
SPENCER AVE
HIGHLAND AVE
PEARSON AVE
PRICHARD AVE
BOSTON AVE
CLYDE ST
ALPINE ST
LEXINGTON AVE
ALBION ST

Local Small Pipe Upsizing on Highland, Pearson & Prichard

Local CS Upsizing on Morrison Ave

Upsize of Morrison Ave Drain

Project CA-2.1 Boundary

Areas of Increased Inlet Capacity

Connect Albion-West Drain to Morrison Ave Drain

Area of Increased Inlet Capacity

12" 12" 12" 12" 12" 12" 24" 24" 15" 24" 24" 36" 84"x84" 84"x84" 108"x96" 48" 48" 48" 108"x96" 108"x96" 24" 24" 42"x66" 42"x66" 42"x66" 96"x108" 96"x108" 96"x108" 96"x66" 96"x66" 96"x66" 96"x66"

Project CA-2.1 - Morrison Avenue Area (Page 2 of 2)

City of Somerville, Massachusetts

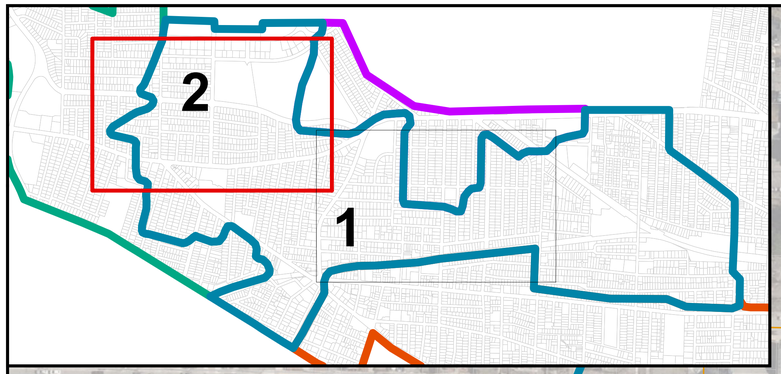
0 100 200 400 Feet

N

Proposed Conditions

Alt 2: New Outfall Scenario

Dewberry



Legend

- Orifice and Weir
- Proposed Storm Drain
- Proposed Sanitary Sewer
- Proposed Combined Sewer
- Abandon
- Existing Storm Drain
- Existing Sanitary Sewer
- Existing Combined Sewer
- Sewershed CA Boundary

Project CA-2.1 Boundary (Additional Area)

12"

18"

18"

24"

SAWYER AVE
PACKARD AVE
TALBOT AVE
COLLEGE AVE
WHITFIELD RD
LATIN WAY
TEELE AVE
LOWER CAMPUS RD
POWDER HOUSE BLVD
HARDAN RD
WARE ST
OSSIPEE RD
MASON ST
RUSSELL RD
WATSON ST
DICKSON ST
HILL ST
CURTIS ST
WESTMINSTER ST
LOVELL ST
ELECTRIC AVE
BURNHAM ST
LEONARD ST
WALKER ST
WHITMAN ST
BROADWAY
ENDICOTT AVE
WESTON AVE
CLARENDON AVE
NEWBURY ST
MOORE ST
HOLLAND ST
PAULINA ST
CORINTHIAN RD
SIMPSON AVE
IRVING ST
WALLACE ST
CHANDLER ST

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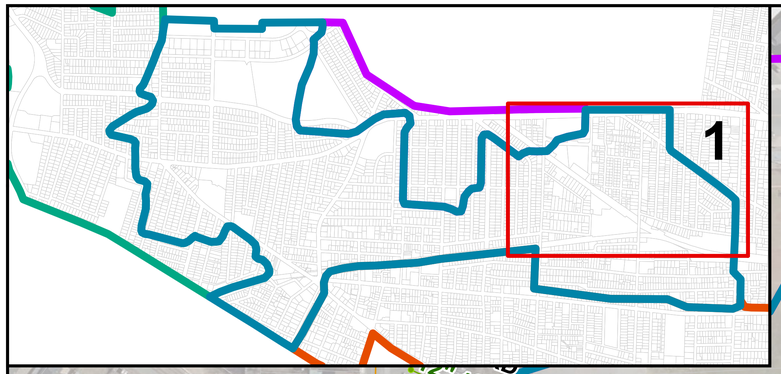
Project CA-2.2 - Vernon Street Area
City of Somerville, Massachusetts

0 100 200 400 Feet

N

Existing Conditions
Alt 2: New Outfall Scenario

Dewberry



Legend
- Existing Combined Sewer
- Existing Sanitary Sewer
- Existing Storm Drain
- Sewershed CA Boundary

Project CA-2.1 Boundary

Project CA-2.2 Boundary (Additional Area)

Project CA-2.2 Boundary

BROADWAY TER
CHARLES E RYAN RD
HINCKLEY ST
MEDFORD ST
NORWOOD AVE
FISK AVE
BARTLETT ST
CENTRAL ST
FENNELL ST
CEDAR ST
VINAL ST
ROBERTS ST
HENDERSON ST
NASHUA ST
CUTLER ST
LOWELL ST
TRULL ST
PARTRIDGE AVE
ADAMS ST
MURDOCK ST
WILTON ST
GLENWOOD RD
ROBINSON ST
CLYDE ST
VERNON ST
AMES ST
MINER ST
PRICHARD AVE
BOSTON AVE
MAXWELLS GREEN
WARWICK ST
PRINCETON ST
ALPINE ST

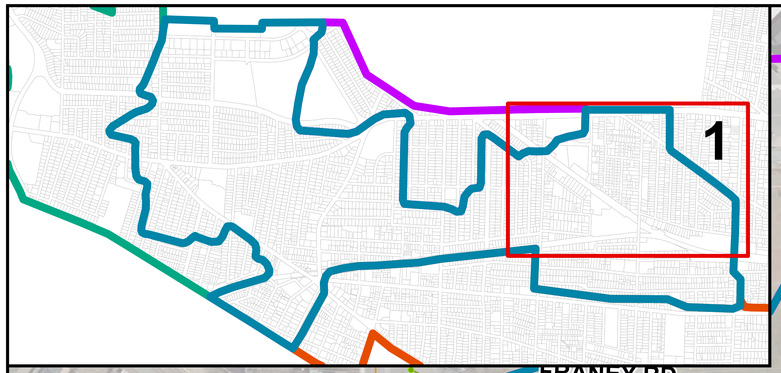
Project CA-2.2 - Vernon Street Area
City of Somerville, Massachusetts

0 100 200 400 Feet

N

Proposed Conditions
Alt 2: New Outfall Scenario

Dewberry



Project CA-2.1 Boundary

Project CA-2.2 Boundary (Additional Area)

Murdock St Pipe Upsizing

Sewer Separation within Project Areas

Project CA-2.2 Boundary

Area of Increased Inlet Capacity

Redirect to Drain

Remove Cross Connection

Existing Storm Drain over Sanitary Sewer

Remove Cross Connection

BROADWAY TER
MEDFORD ST
FISK AVE
FRANEY RD
CHARLES E RYAN RD
HINCKLEY ST
NORWOOD AVE
FENNELL ST
VINAL ST
ROBERTS ST
CEDAR ST
CUTLER ST
NASHUA ST
LOWELL ST
TRULL ST
PARTRIDGE AVE
GLENWOOD RD
WILTON ST
MURDOCK ST
CLYDE ST
VERNON ST
MAXWELLS GREEN
WARWICK ST
ALPINE ST
ROBINSON ST
AMES ST
MINER ST

Legend

- Proposed Combined Sewer
- Proposed Sanitary Sewer
- Proposed Storm Drain
- Convert CS to Sanitary Sewer
- Convert CS to Storm Drain
- Abandon
- Existing Combined Sewer
- Existing Sanitary Sewer
- Existing Storm Drain
- Orifice and Weir
- Sewershed CA Boundary

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Project CA-2.3 - Highland Road and Appleton Street Area

City of Somerville, Massachusetts

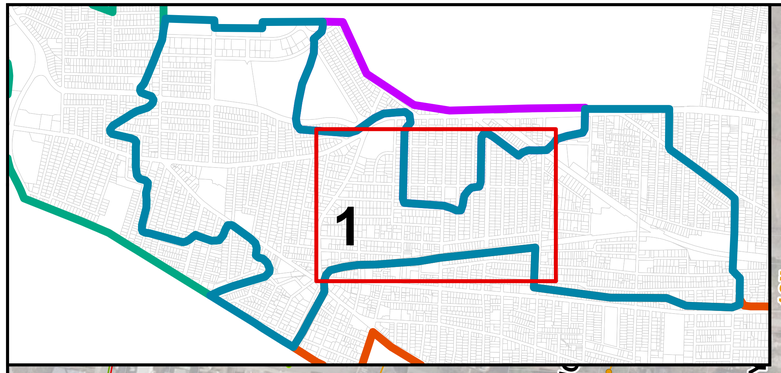
0 100 200 400 Feet

N

Existing Conditions

Alt 2: New Outfall Scenario

Dewberry



Legend

- Existing Combined Sewer
- Existing Sanitary Sewer
- Existing Storm Drain
- Sewershed CA Boundary

Project CA-2.2 Boundary

Project CA-2.3 Boundary

Project CA-2.1 Boundary

MALLET ST
BAY STATE AVE
LOWDEN AVE
WILLOW AVE
JOSEPHINE AVE
ROGERS AVE
HIGHLAND RD
CEDAR ST
KIDDER AVE
WILLIAM ST
FRANCESCA AVE
FOSKETT ST
HALL AVE
APPLETON ST
LIBERTY RD
CLIFTON ST
PEARSON AVE
PRICHARD AVE
BOSTON AVE
CLYDE ST
WINSLOW AVE
ALPINE ST
LEXINGTON AVE
ALBION ST
HIGHLAND AVE
GROVE ST
WEST ST
WHIPPLE ST
HENRY AVE
LESLEY AVE
SPENCER AVE

Project CA-2.3 - Highland Road and Appleton Street Area

City of Somerville, Massachusetts

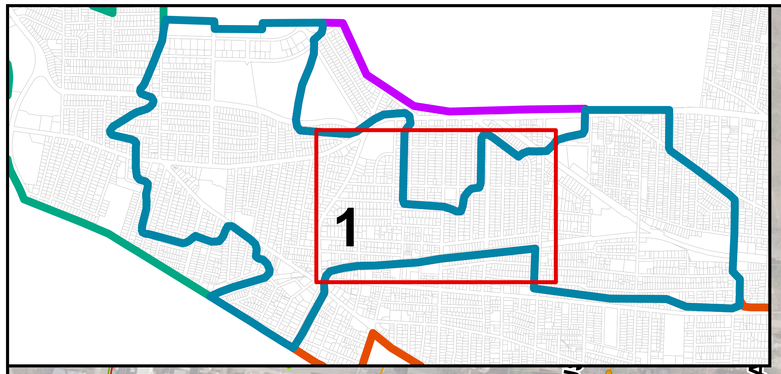
0 100 200 400 Feet

N

Proposed Conditions

Alt 2: New Outfall Scenario

Dewberry



Legend

- Orifice and Weir
- Proposed Combined Sewer
- Proposed Sanitary Sewer
- Proposed Storm Drain
- Convert CS to Sanitary Sewer
- Convert CS to Storm Drain
- Abandon
- Existing Combined Sewer
- Existing Sanitary Sewer
- Existing Storm Drain
- Sewershed CA Boundary

Project CA-2.3 Boundary

Project CA-2.2 Boundary

Project CA-2.1 Boundary

Sewer Separation within Project Area

Replace Drain to Flow in Opposite Direction

MALLET ST
BAY STATE AVE
LOWDEN AVE
WILLOW AVE
JOSEPHINE AVE
ROGERS AVE
HIGHLAND RD
CEDAR ST
KIDDER AVE
POWDER HOUSE
LIBERTY ST
FRANCESCA AVE
FOSKETT ST
HALL AVE
APPLETON ST
LIBERTY RD
CLIFTON ST
MORRISON AVE
WINSLOW AVE
GROVE ST
WEST ST
WHIPPLE ST
HENRY AVE
LESLEY AVE
HIGHLAND AVE
SPENCER AVE
LEXINGTON AVE
ALBION ST
ALPINE ST
CLYDE ST
PEARSON AVE
PRICHARD AVE
BOSTON AVE

10" 12" 8" 15" 18" 20"x13" 24" 30" 36" 42"x66" 48" 84"x84" 96"x66" 96"x99" 96"x108" 108"x96"

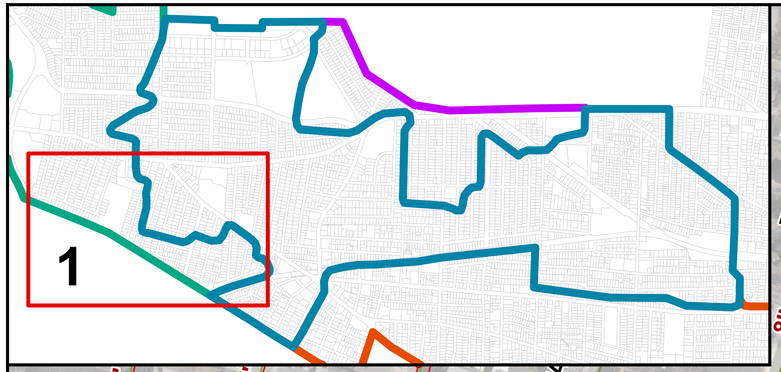
Project CA-2.4 - South of Holland Street Area
City of Somerville, Massachusetts

0 100 200 400
Feet

N

Existing Conditions
Alt 2: New Outfall Scenario

Dewberry



Project CA-2.4 Boundary

Legend
- Existing Combined Sewer
- Existing Sanitary Sewer
- Existing Storm Drain
- Sewershed CA Boundary

ENDICOTT AVE
WESTON AVE
HOOKER AVE
CLARENDON AVE
NEWBURY ST
MOORE ST
CLAREMON ST
CAMERON AVE
MEAD ST
MALVERN AVE
GLENDALE AVE
ELMWOOD ST
GORHAM ST
JAY ST
THORNDIKE ST
HOWARD ST
TANNERY BROOK ROW
HOLLAND ST
PAULINA ST
CORINTHIAN RD
SIMPSON AVE
BROADWAY

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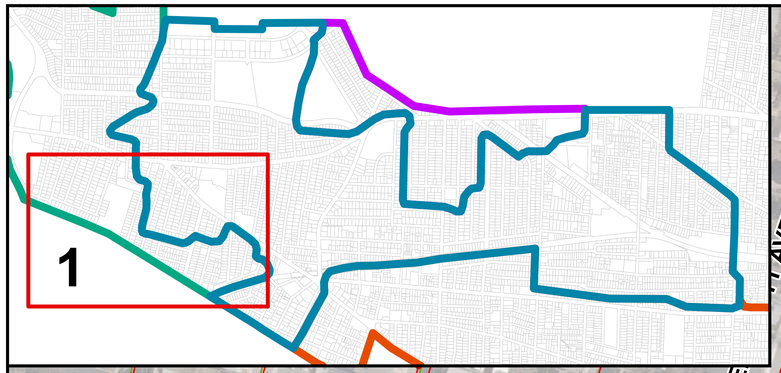
Project CA-2.4 - South of Holland Street Area
City of Somerville, Massachusetts

0 100 200 400 Feet

N

Proposed Conditions
Alt 2: New Outfall Scenario

Dewberry



Legend
- Orifice and Weir
- Flap Valve
- Proposed Combined Sewer
- Proposed Sanitary Sewer
- Proposed Storm Drain
- Convert CS to Sanitary Sewer
- Convert CS to Storm Drain
- Abandon
- Existing Combined Sewer
- Existing Sanitary Sewer
- Existing Storm Drain
- Sewershed CA Boundary

Project CA-2.4 Boundary

Remove Cross Connection

Abandon Existing Storm-over-Sanitary Configuration and Install New 12-inch Drain

Flap Valve

New Storm Connection

New Sanitary Connection

New Sanitary Connection

Sewer Separation within Project Area

Areas of Increased Inlet Capacity

BROADWAY
WESTON AVE
NEWBURY ST
CLARENDON AVE
MOORE ST
CLAREMON ST
CAMERON AVE
ELMWOOD ST
HOLLAND ST
PAULINA ST
CORINTH
SIMPSON AVE
GORHAM ST
HOLLAND ST
MEAD ST
MALVERN AVE
GLENDALE AVE
GORHAM ST
JAY ST
THORNDIKE ST
HOWARD ST
TANNERY BROOK ROW

Project CA-2.5 - New Storm Outfall to Alewife Brook

City of Somerville, Massachusetts

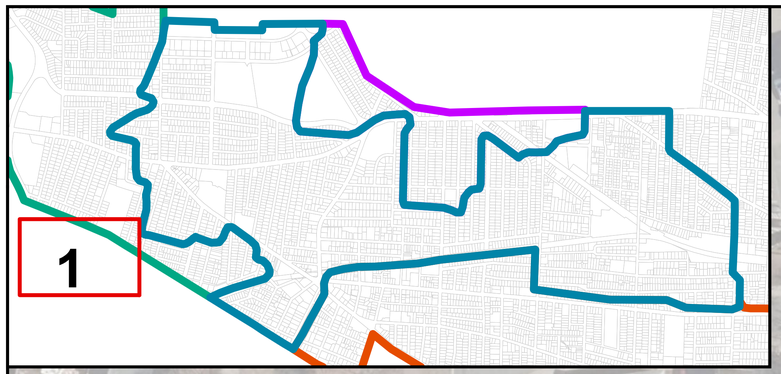
0 50 100 200 Feet

N

Existing Conditions

Alt 2: New Outfall Scenario

Dewberry



Legend

- Existing Combined Sewer
- Existing Sanitary Sewer
- Existing Storm Drain
- Sewershed CA Boundary

Project CA-2.4 Boundary

Project CA-2.5 Boundary

CLARENDON AVE

8"

8"

10"

12"

10"

54"x96"

54"

54"

15"

12"

15"

8"

12"

48"x86"

12"

48"x84"

12"

15"

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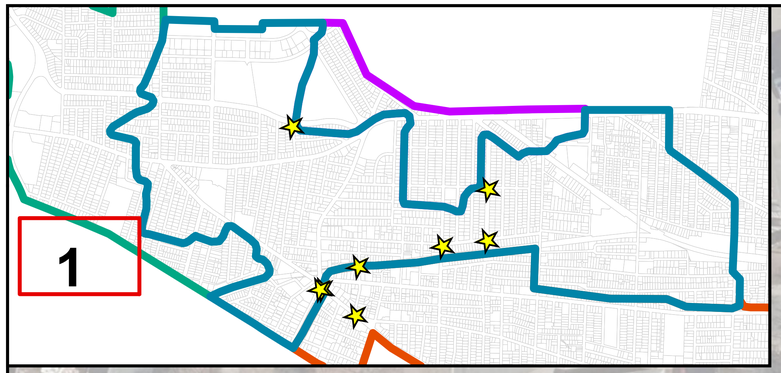
Project CA-2.5 - New Storm Outfall to Alewife Brook
City of Somerville, Massachusetts

0 50 100 200 Feet

N

Proposed Conditions
Alt 2: New Outfall Scenario

Dewberry



Note: Project 5 includes removal of all remaining cross connections within Sewershed CA - See locus map for cross connection locations

Convert Existing 54-inch Storm Drain into Sanitary Sewer

54"

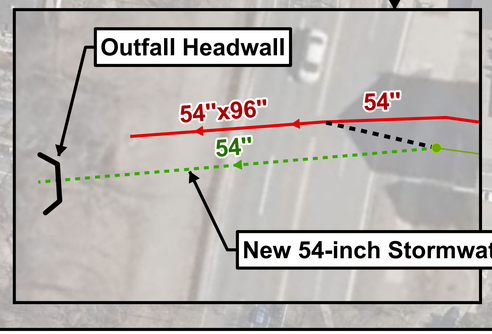
54"

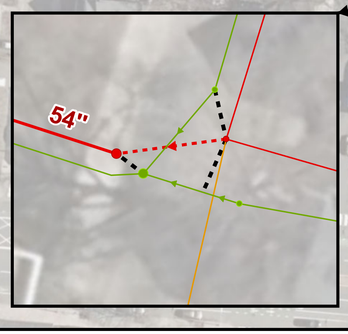
Project CA-2.5 Boundary

Project CA-2.4 Boundary

CLARENDON AVE

8"





Legend

- Proposed Combined Sewer
- Proposed Sanitary Sewer
- Proposed Storm Drain
- Abandon
- Existing Combined Sewer
- Existing Sanitary Sewer
- Existing Storm Drain
- Orifice and Weir
- Cross Connection
- Sewershed CA Boundary

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Project CA-2.6 - Highland Avenue Area
City of Somerville, Massachusetts

0 100 200 400 Feet

N

Existing Conditions
Alt 2: New Outfall Scenario

Dewberry

Project CA-2.3 Boundary
Project CA-2.4 Boundary
Project CA-2.1 Boundary
Project CA-2.6 Boundary

IRVING ST
THORNDIKE ST
JAY ST
PARK AVE
WINTER ST
WINSLOW AVE
HIGHLAND AVE
WHIPPLE ST
WEST ST
HENRY AVE
LESTER TER
KINGSTON ST
CAMPBELL PARK
DOVER ST
DAY ST
HERBERT ST
DAVIS SQ
GROVE ST
HAWTHORNE ST
WINDSOR RD
CHARNWOOD RD
SUMMER ST
CHESTER PL
CHESTER ST
ORCHARD ST
BOWERS AVE
COTTAGE AVE
RUSSELL ST
MILTON ST
ELM ST
WINDOM ST
ELSTON ST
ST JAMES AVE
WILLOW AVE
BANKS ST

Legend
- Existing Combined Sewer
- Existing Sanitary Sewer
- Existing Storm Drain
- Sewershed CA Boundary

1

Project CA-2.6 - Highland Avenue Area
City of Somerville, Massachusetts

0 100 200 400 Feet

N

Proposed Conditions
Alt 2: New Outfall Scenario

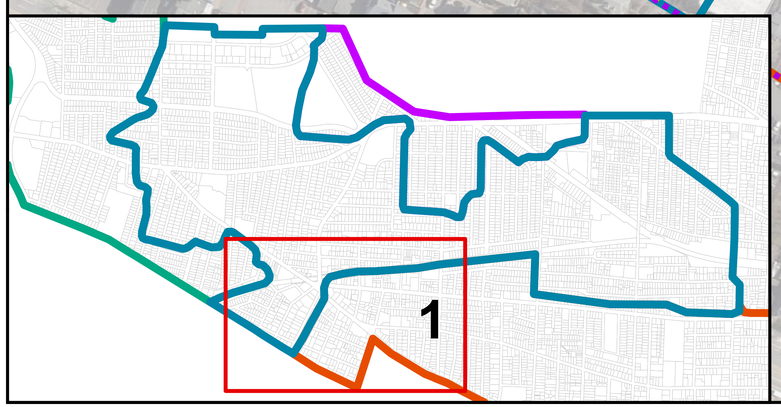
Dewberry

Project CA-2.3 Boundary
Project CA-2.4 Boundary
Project CA-2.1 Boundary
Project CA-2.6 Boundary

MORRISON AVE
PARK AVE
IRVING ST
JAY ST
THORNDIKE ST
BUENA VISTA RD
HOWARD ST
WINTER ST
HOLLAND ST
MEACHAM RD
LESTER TER
KINGSTON ST
DOVER ST
DAY ST
HERBERT ST
DAVIS SQ
HIGHLAND AVE
GROVE ST
WINSLOW AVE
WEST ST
WHIPPLE ST
HENRY AVE
HAWTHORNE ST
WINDSOR RD
CHARNWOOD RD
SUMMER ST
CHESTER PL
CHESTER ST
ORCHARD ST
BOWERS AVE
COTTAGE AVE
ELM ST
WINDOM ST
ELSTON ST
ST JAMES AVE
WILLOW AVE
BANKS ST
RUSSELL ST
MILTON ST

108"x96" 48" 108"x96" 48" 48" 108"x96" 108"x96" 24" 24" 42"x66"
36" 84"x84" 84"x84" 96"x96"
96"x66" 96"x66" 96"x66" 96"x66" 96"x66" 96"x66" 96"x66" 96"x66" 96"x66" 96"x66"
30" 8" 36" 36" 30"
96"x42" 96"x42" 96"x42" 96"x54" 96"x54" 96"x54" 96"x54" 96"x96"
84"

Legend
- Convert CS to Sanitary Sewer
- Convert CS to Storm Drain
- Proposed Combined Sewer
- Proposed Sanitary Sewer
- Proposed Storm Drain
- Abandon
- Existing Combined Sewer
- Existing Sanitary Sewer
- Existing Storm Drain
- Orifice and Weir
- Sewershed CA Boundary



APPENDIX C

Engineer's Estimate of Probable Costs

Sewersheds CA & M

Engineer's Opinion of Probable Costs

Produced by: Dewberry Engineers, Inc.

City of Somerville, Massachusetts

November 2, 2021

City of Somerville
Sewersheds CA & M
Cost Comparison Summary
Tuesday, November 2, 2021

	Morisson Avenue Area (Project CA-1.1)		Winslow Avenue Area (Project CA-1.2)		Vernon Street Area (Project CA-1.3)	
	Normal	Conservative	Normal	Conservative	Normal	Conservative
Estimated Construction Sub-total	$ 19,277,973	$ 24,214,636	$ 4,804,680	$ 5,941,812	$ 3,162,358	$ 5,319,957
Contingency	$ 5,783,392	$ 7,264,391	$ 1,441,404	$ 1,782,544	$ 948,707	$ 1,595,987
Estimated Construction Total	**$ 25,061,365**	**$ 31,479,027**	**$ 6,246,084**	**$ 7,724,356**	**$ 4,111,065**	**$ 6,915,944**
Engineering Design (11%)	$ 2,756,750	$ 3,462,693	$ 687,069	$ 849,679	$ 452,217	$ 760,754
Resident Engineering (13%)	$ 3,257,977	$ 4,092,274	$ 811,991	$ 1,004,166	$ 534,438	$ 899,073
Estimated Project Total	**$ 31,076,092**	**$ 39,033,994**	**$ 7,745,144**	**$ 9,578,201**	**$ 5,097,720**	**$ 8,575,771**

	Tufts University Area (Project CA-1.4)		Morrison Avenue & Winslow Avenue Area (Project CA-2.1)		Vernon Street Area (Project CA-2.2)	
	Normal	Conservative	Normal	Conservative	Normal	Conservative
Estimated Construction Sub-total	$ 3,004,538	$ 4,737,286	$ 23,626,495	$ 29,708,545	$ 3,524,499	$ 5,960,369
Contingency	$ 901,361	$ 1,421,186	$ 7,087,949	$ 8,912,564	$ 1,057,350	$ 1,788,111
Estimated Construction Total	**$ 3,905,899**	**$ 6,158,472**	**$ 30,714,444**	**$ 38,621,109**	**$ 4,581,849**	**$ 7,748,480**
Engineering Design (11%)	$ 429,649	$ 677,432	$ 3,378,589	$ 4,248,322	$ 504,003	$ 852,333
Resident Engineering (13%)	$ 507,767	$ 800,601	$ 3,992,878	$ 5,020,744	$ 595,640	$ 1,007,302
Estimated Project Total	**$ 4,843,315**	**$ 7,636,505**	**$ 38,085,911**	**$ 47,890,175**	**$ 5,681,492**	**$ 9,608,115**

	Highland Road & Appleton Street Area (Project CA-2.3)		South of Holland Street Area (Project CA-2.4)		New Stormwater Outfall to Alewife Brook (Project CA-2.5)	
	Normal	Conservative	Normal	Conservative	Normal	Conservative
Estimated Construction Sub-total	$ 2,899,075	$ 4,978,011	$ 5,710,307	$ 9,265,227	$ 1,714,838	$ 2,611,079
Contingency	$ 869,723	$ 1,493,403	$ 1,713,092	$ 2,779,568	$ 514,451	$ 783,324
Estimated Construction Total	**$ 3,768,798**	**$ 6,471,414**	**$ 7,423,399**	**$ 12,044,795**	**$ 2,229,289**	**$ 3,394,403**
Engineering Design (11-14%)*	$ 414,568	$ 711,856	$ 816,574	$ 1,324,927	$ 312,100	$ 475,216
Resident Engineering (13%)	$ 489,944	$ 841,284	$ 965,042	$ 1,565,823	$ 289,808	$ 441,272
Estimated Project Total	**$ 4,673,310**	**$ 8,024,554**	**$ 9,205,015**	**$ 14,935,545**	**$ 2,831,197**	**$ 4,310,891**

	Highland Avenue Area (Project CA-2.6)		Pearson Road & Broadway Area (Project M-1)		Franey Road Area (Project M-2)	
	Normal	Conservative	Normal	Conservative	Normal	Conservative
Estimated Construction Sub-total	$ 19,462,274	$ 23,138,183	$ 3,121,195	$ 5,011,921	$ 7,024,335	$ 7,911,484
Contingency	$ 5,838,682	$ 6,941,455	$ 936,359	$ 1,503,576	$ 2,107,301	$ 2,373,445
Estimated Construction Total	**$ 25,300,956**	**$ 30,079,638**	**$ 4,057,554**	**$ 6,515,497**	**$ 9,131,636**	**$ 10,284,929**
Engineering Design (11%)	$ 2,783,105	$ 3,308,760	$ 446,331	$ 716,705	$ 1,004,480	$ 1,131,342
Resident Engineering (13%)	$ 3,289,124	$ 3,910,353	$ 527,482	$ 847,015	$ 1,187,113	$ 1,337,041
Estimated Project Total	**$ 31,373,185**	**$ 37,298,751**	**$ 5,031,367**	**$ 8,079,217**	**$ 11,323,229**	**$ 12,753,312**

*Engineering design for Project CA-2.5 is 14% to account for costs related to permitting new outfall. Engineering design for Projects CA-2.3 & CA-2.4 are 11%.

APPENDIX D

Green Stormwater Infrastructure Siting Desktop Analysis and

Non-Structural BMP Annual Phosphorus Load Reductions Calculations

Sewersheds CA, M, and southeast of A (Sheet 1 of 6)

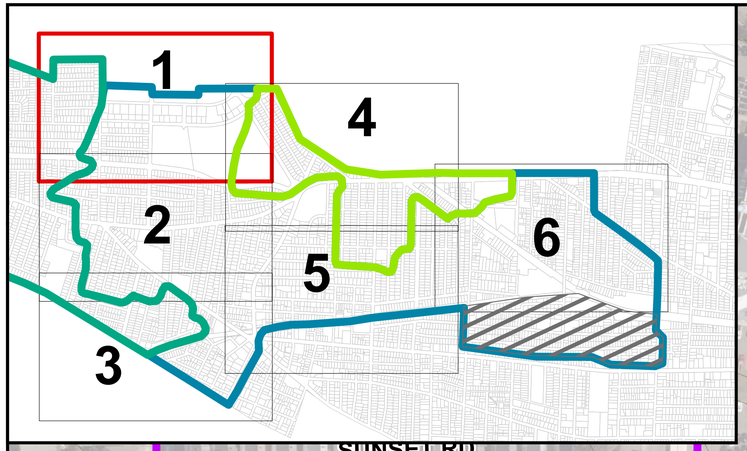
City of Somerville, Massachusetts

0 100 200 400 Feet

N

Green Infrastructure Candidate Locations

Dewberry



Legend

- 50% Phosphorus Removal
- Bumpout
- Rain Garden
- Subsurface Trench
- SW Planter Box
- Approximate BMP Drainage Area
- Sewershed CA Boundary
- Sewershed A Boundary
- Sewershed M Boundary
- Somerville Boundary

Albion Street area excluded from current GI analysis as this area was included in the GI analysis for sewershed C2. For extents of Albion Street area, see hatched area in locus map above.

SUNSET RD
CHETWYND RD
CURTIS AVE
CONWELL AVE
RAYMOND AVE
WHITFIELD RD
TEELE AVE
POWDER HOUSE BLVD
OSSIPEE RD
WARE ST
DOW ST
HARDAN RD
CURTIS ST
SAWYER AVE
PACKARD AVE
PROFESSORS ROW
TALBOT AVE
LATIN WAY
LOWER CAMPUS RD
DEARBORN RD
COLLEGE AVE

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Sewersheds CA, M, and southeast of A (Sheet 2 of 6)

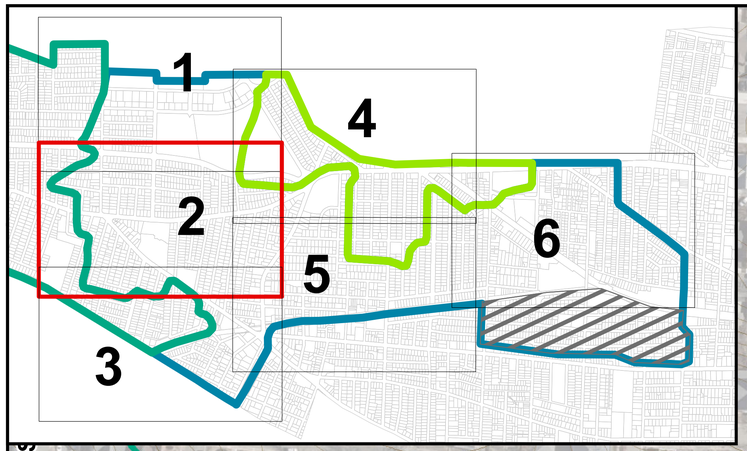
City of Somerville, Massachusetts

0 100 200 400 Feet

N

Green Infrastructure Candidate Locations

Dewberry



Legend

- 50% Phosphorus Removal
- Bumpout
- Rain Garden
- Subsurface Trench
- SW Planter Box
- Approximate BMP Drainage Area
- Sewershed CA Boundary
- Sewershed A Boundary
- Sewershed M Boundary
- Somerville Boundary

Albion Street area excluded from current GI analysis as this area was included in the GI analysis for sewershed C2. For extents of Albion Street area, see hatched area in locus map above.

MASON ST
ELECTRIC AVE
WHITMAN ST
BURNHAM ST
LEONARD ST
WALKER ST
WESTMINSTER ST
LOVELL ST
BROADWAY
CHANDLER ST
WILLIAM ST
CHAPEL ST
COLLEGE AVE
HALL AVE
MORRISON AVE
CORINTHIAN RD
SIMPSON AVE
IRVING ST
WALLACE ST
PAULINA ST
HOLLAND ST
GORHAM ST
ELMWOOD ST
CAMERON AVE
CLAREMON ST
MOORE ST
NEWBURY ST
CLARENDON AVE
MEAD ST
ENDICOTT AVE
WESTON AVE

Sewersheds CA, M, and southeast of A (Sheet 3 of 6)

City of Somerville, Massachusetts

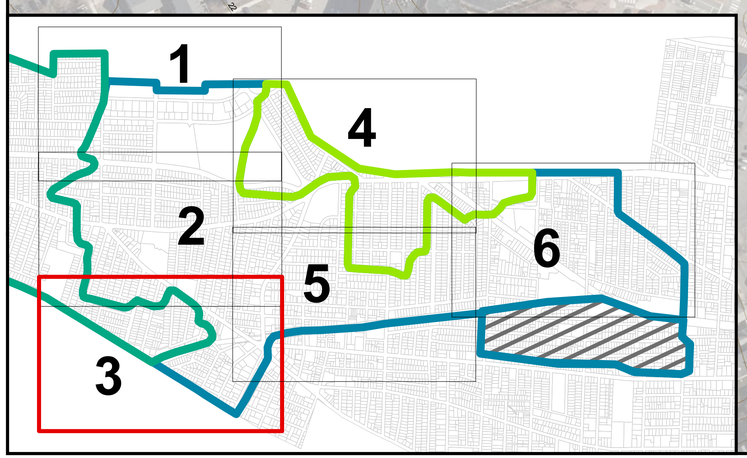
0 100 200 400 Feet

N

Green Infrastructure Candidate Locations

Dewberry

Albion Street area excluded from current GI analysis as this area was included in the GI analysis for sewershed C2. For extents of Albion Street area, see hatched area in locus map below.



Legend

- 50% Phosphorus Removal
- Bumpout
- Rain Garden
- Subsurface Trench
- SW Planter Box
- Approximate BMP Drainage Area
- Sewershed CA Boundary
- Sewershed A Boundary
- Sewershed M Boundary
- Somerville Boundary

Sewersheds CA, M, and southeast of A (Sheet 4 of 6)

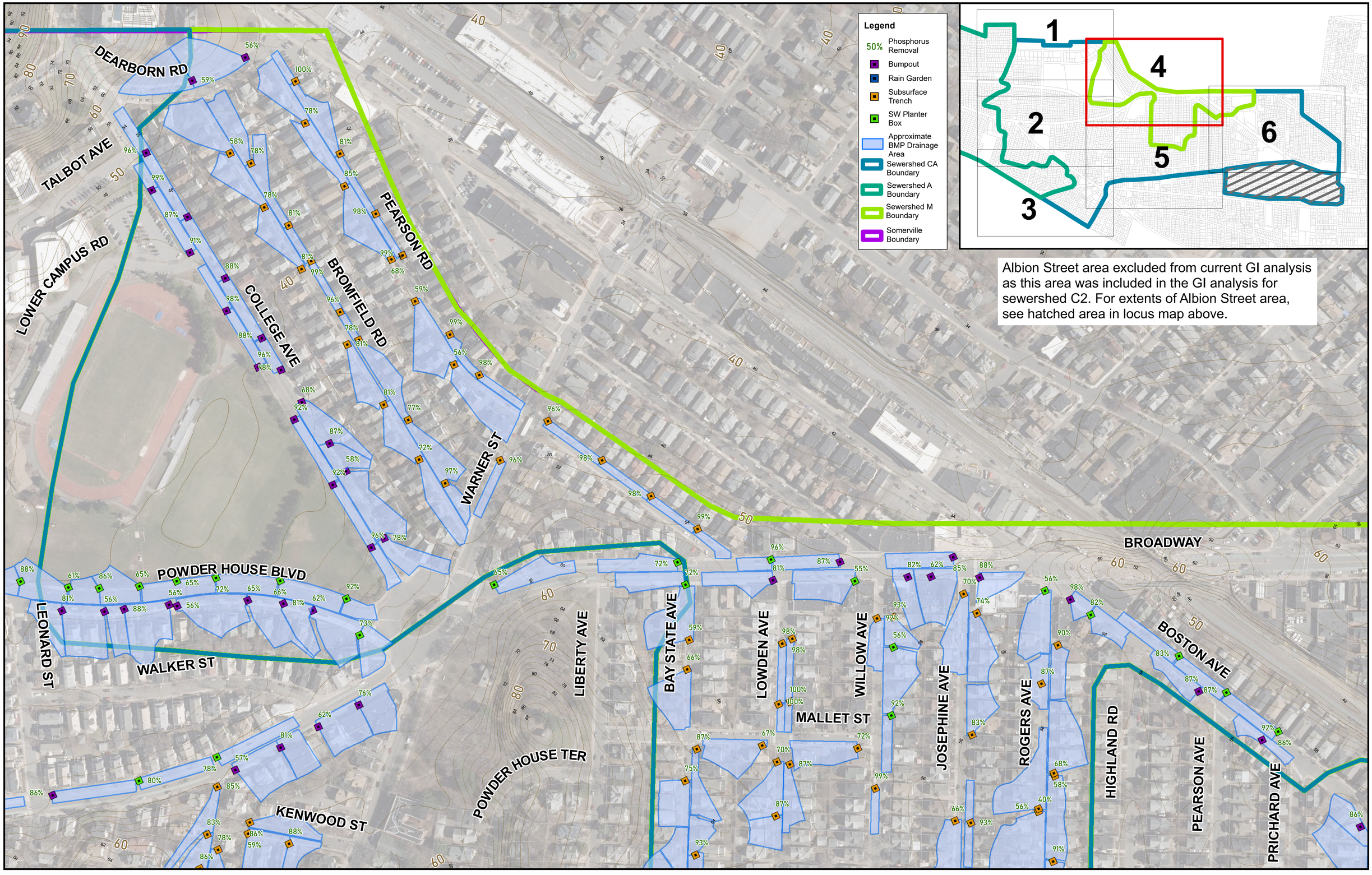
City of Somerville, Massachusetts

0 100 200 400 Feet

N

Green Infrastructure Candidate Locations

Dewberry



Sewersheds CA, M, and southeast of A (Sheet 5 of 6)

City of Somerville, Massachusetts

0 100 200 400 Feet

N

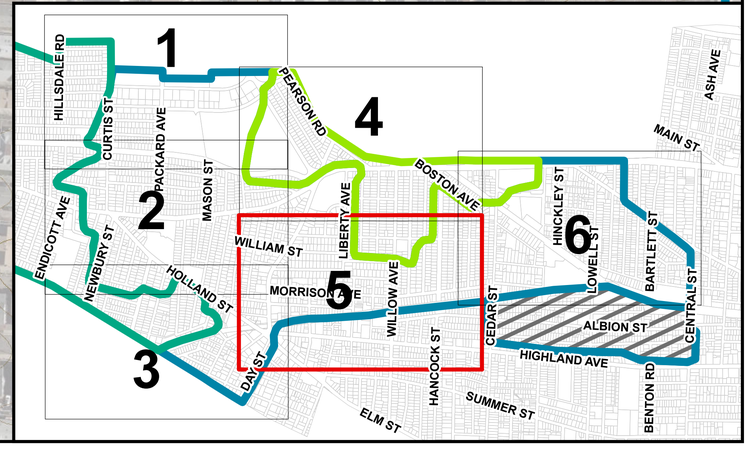
Green Infrastructure Candidate Locations

Dewberry

Albion Street area excluded from current GI analysis as this area was included in the GI analysis for sewershed C2. For extents of Albion Street area, see hatched area in locus map below.

Legend

- 50% Phosphorus Removal
- Bumpout
- Rain Garden
- Subsurface Trench
- SW Planter Box
- Approximate BMP Drainage Area
- Sewershed CA Boundary
- Sewershed A Boundary
- Sewershed M Boundary
- Somerville Boundary



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Sewersheds CA, M, and southeast of A (Sheet 6 of 6)

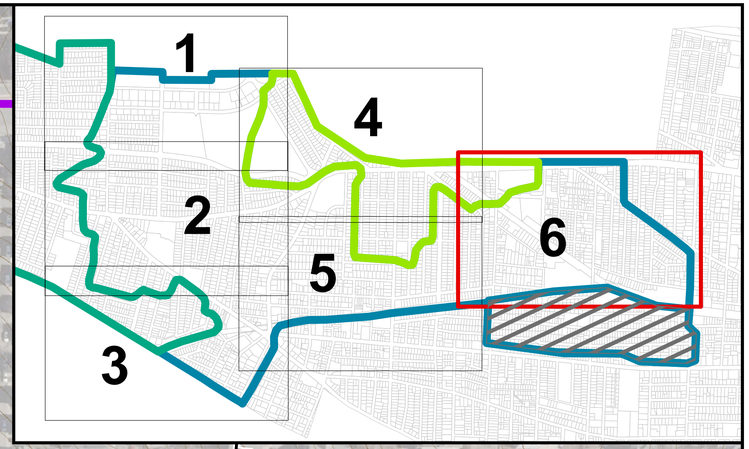
City of Somerville, Massachusetts

0 100 200 400 Feet

N

Green Infrastructure Candidate Locations

Dewberry



Albion Street area excluded from current GI analysis as this area was included in the GI analysis for sewershed C2. For extents of Albion Street area, see hatched area in locus map above.

Legend

- 50% Phosphorus Removal
- Bumpout
- Rain Garden
- Subsurface Trench
- SW Planter Box
- Approximate BMP Drainage Area
- Sewershed CA Boundary
- Sewershed A Boundary
- Sewershed M Boundary
- Somerville Boundary

BROADWAY
WILSON AVE
CHARLES E RYAN RD
HINCKLEY ST
MEDFORD ST
NORWOOD AVE
FISK AVE
FRANEY RD
CEDAR ST
FENNELL ST
VINAL ST
ROBERTS ST
CUTLER ST
HENDERSON ST
NASHUA ST
LOWELL ST
TRULL ST
PARTRIDGE AVE
GLENWOOD RD
ADAMS ST
ROBINSON ST
AMES ST
MINER ST
MURDOCK ST
WILTON ST
CLYDE ST
VERNON ST
MAXWELLS GREEN
WARWICK ST
PRINCETON ST
ALPINE ST
PRICHARD AVE
BOSTON AVE

Albion Street Area
See Note Under Locus Map for More Details