Section 3

Collection System Evaluation

3.1 Collection System History

Bridgeport (the City) is the largest city in Connecticut with a population of approximately 145,000. The City was first settled in the 17th Century and was chartered in 1836. The City of Bridgeport was a center for trading and whaling through the 1800s, due to its sheltered harbors. Bridgeport eventually grew into an industrial center with the opening of the railroad in 1840. Like many other large cities in the northeast, combined sewer pipes were originally designed to carry both sewage and stormwater to open discharges into the harbors.

Eventually, interceptor sewers were built to convey the combination of sanitary sewage and stormwater to two wastewater treatment plants (WWTPs) to receive primary treatment. Combined sewer overflow (CSO) regulators remained active throughout the system as points of hydraulic relief during periods of wet weather when the capacity of the interceptor systems and/or the capacity of the WWTPs were exceeded. Over time, many of these historical CSO regulators have been closed as hydraulic conditions have allowed. In the 1970s, a total of 78 overflow locations were reported. Today, there are 26 total CSO structures, with 20 serving the West Side collection system, and 6 serving the East Side collection system.

The 1978 Wastewater Collection and Treatment Facilities Plan estimated that most of the separated sewers were built of tile or concrete in the 1950s and 1960s during a period of city-wide development. It was estimated in 1978 that 25% of the collections system (both separated and combined) was over 70 years old, and approximately 30% of the system was between 50 and 70 years old. This information illustrates the excessive age of the existing sewer system. It is believed that approximately half of the collection system is 100 years old or greater.

The Water Pollution Control Authority (WPCA) has been completing sewer separation projects and lining projects since the early 2000s to address CSOs and infiltration and inflow (I/I) in their collection system. Most recently, the WPCA has constructed a series of lining and separation contracts that were recommended in the 2011 CSO Long Term Control Plan (LTCP). This recent work has helped renew targeted portions of the collection system, but in general the WPCA's collection system is aging and in need of additional investment.

The WPCA is responsible for the collection system and delegates operations and maintenance of the system to the contract operator, Inframark. This report section outlines the existing features and challenges facing the WPCA's collection system, provides background on the hydraulic modeling analysis, illustrates potential future sewer areas, and provides initial recommendations for collection system improvements.

3.2 Existing Conditions

Generally, the combined sewers are located in the older, southern portion of the City along the coast, with some stretching to the north. The separated sewers are mostly located in the northern half of the City and were built in the 1950s and 1960s during a period of expansion. The separated sewers are largely located in more residential areas.

Key characteristics of the collection system are outlined in the following list. Approximate values were obtained from the updated hydraulic model, the WPCA's agreement with Inframark, and the City's geographic information system (GIS) files.

- 26 CSO regulator structures, with 28 CSO weirs discharging to 25 CSO outfalls, 20 structures are located within the West Side WWTP tributary area, and six structures are located within the East Side WWTP tributary area.
- 113 miles of combined gravity sewer, ranging in size from 6-inch to 72-inch in diameter for circular sewers, and 10-inch by 12-inch to 41-inch by 60-inch for rectangular conduits.
- 170 miles of separated gravity sewer, ranging in size from 4-inch to 72-inch for circular sewers, and 10-inch by 15-inch to 20-inch by 30-inch for rectangular conduits.
- Nine pumping stations within the City of Bridgeport.
- Greater than 7,600 sewer manholes (separated and combined).
- Greater than 8,500 catch basins, cleaned annually by WPCA (separated and combined).
- Eight sewer siphons.
- Five storage conduits.

These major collection system features can be seen on the overall collection system summary map included in Section 2 (Figure 2.3-1).

3.2.1 CSO Regulators

The WPCA currently has 26 active CSO regulator structures within their collection system. There are 28 overflow weirs within these structures. The ANTH and ARBOR regulators each have two weirs that discharge to a single outfall. TERN and TERS also have a shared outfall for discharge. Therefore, there are a total of 25 CSO outfalls in Bridgeport; 19 throughout the West Side WWTP tributary area, and six throughout the East Side WWTP tributary area.

The purpose of these structures is to regulate internal system flow (head) and relieve excess flow to avoid manhole surcharge or flooding throughout the system. Overflow regulators allow excess wet weather flow to discharge to receiving water bodies without causing direct hazard to public health via street flooding or backups in basements. These regulators allow flow from a combined pipe to enter another sewer pipe, storm drain, or receiving water. In most cases, the downstream pipes within the regulators are designed to be smaller in diameter than the upstream pipes. This was an intentional design feature typical of CSO regulators to protect downstream systems by backing up flow until the depth of flow could relieve itself over the weir to an outfall.

CSO overflows in Bridgeport are tributary to several different water bodies, including Ash Creek, Black Rock Harbor, Burr Creek, Bridgeport Harbor, Cedar Creek, Island Brook, Johnson's Creek, Pequonnock River, and Yellow Mill Channel. **Table 3.2-1** provides a list of all active regulators throughout the WPCA's combined sewer system. Regulator locations, as well as the receiving water are listed, along with the mnemonic regulator names used by the WPCA. These regulators do not have provisions for permanent flow monitoring in place, but a weir block observation method is used to record overflows and tidal inflow. Collection systems staff visit these regulators daily for inspection of the chambers.

Table 3.2-1 Active CSO Regulators

Regulator Name	Regulator Location	Tributary WWTP	Receiving Water	Tide Gate on Outfall?
ANTH[1]	Saint Stephens Road at Anthony Street	West Side	Burr Creek	Yes
ARBOR[1]	Admiral Street at Harbor Street	West Side	Cedar Creek	Yes
CAP	Main Street and Capital Avenue	West Side	Island Brook	No
CEM/MAPE	Dewey Street at Cemetery	West Side	Ash Creek	No
CON	Congress Street at Main Street	West Side	Pequonnock River	No
DEW	Dewey Street at State Street	West Side	Ash Creek	Yes
EWAS	East Washington Avenue at Housatonic Avenue	West Side	Pequonnock River	No
FAIR	Fairfield Avenue at Water Street	West Side	Pequonnock River	Yes
GRAND	Grand Street at Housatonic Avenue	West Side	Pequonnock River	No
HOUS	Housatonic Avenue at North Washington Avenue	West Side	Pequonnock River	No
HUNT	Huntington Road at Vernon Street	West Side	Pequonnock River	No
OVER	Congress Street at Main Street (Fire Station)	West Side	Pequonnock River	No
RAILS	Broad Street at Railroad Avenue	West Side	Yellow Mill Channel	Yes
SEAB	Seabright Avenue at Brewster Street	West Side	Black Rock Harbor	Yes
STATEA	State Street at Water Street	West Side	Pequonnock River	Yes
TERN[2]	North Frontage Street at Water Street	West Side	Pequonnock River	Yes
TERS[2]	North Frontage Street at Water Street	West Side	Pequonnock River	Yes
TIC	Main Street at Henry Street	West Side	Bridgeport Harbor	Yes
WALL	Water Street at John Street	West Side	Pequonnock River	Yes
WORD	Wordin Avenue at Howard Avenue	West Side	Cedar Creek	Yes
BAYEL	Bay Street at Mildner Drive	East Side	Johnson's Creek	No
BARN	Barnum Avenue at Seaview Avenue	East Side	Yellow Mill Channel	No
CHUR	Church Street at Waterview Avenue	East Side	Yellow Mill Channel	No
DEAC	Deacon Street at Seaview Avenue	East Side	Yellow Mill Channel	No
STRAT	Stratford Avenue at Connecticut Avenue	East Side	Yellow Mill Channel	Yes
WANN	Waterview Avenue and Ann Street	East Side	Yellow Mill Channel	Yes

1 ANTH and ARBOR each have two overflow weirs within one chamber
2 TERN and TERS share a single outfall

3.2.2 Pumping Stations

Within the WPCA's combined sewer system (Bridgeport city limits only) there are a total of nine collection system pumping stations. Eight pumping stations are tributary to the West Side WWTP, and one is tributary to the East Side WWTP. These pumping stations collect and raise flow from low laying points in the system. A list of the pumping stations is provided as **Table 3.2-2**. These pumping stations were inspected for the purposes of this facilities plan.

Table 3.2-2 WPCA Pumping Stations

Pumping Station Name	Type	Approximate Rehab Year	Station Capacity (gpm)	Tributary WWTP
Evers Street	Dry Pit Submersible	2007	1,233	East
Harborview Avenue	Dry Pit Submersible	2010	2,142	West
Lake Forest Beach	Submersible	2011	142	West
Lakeside Drive	Dry Pit Submersible	2014	783	West
River Street	Dry Pit Submersible	2013	695 (1,527 with 2 pumps)	West
Rooster River	Dry Pit Submersible	2008	1,800	West
Seaside Park	Submersible	2003	85	West
Sequoia Road	Submersible	2011	110	West
Waller Road	Dry Pit Submersible	2014	654	West

On September 24, 2020, CDM Smith inspected eight of the nine pumping stations to assess general condition and observe any obvious deficiencies. Three of the pumping stations are submersible style with pumps located in a wet well below-grade. The remaining six stations are arranged in a dry-pit/wet-pit configuration with pumps located in dry, accessible building adjacent to a wet well. Many of the pumps have been standardized around a single manufacturer, Flygt, to ease operations and maintenance efforts. All inspected pumping stations had permanent, natural gas fueled generators for backup power. All inspected pumping stations communicate alarm and status conditions to the West Side WWTP via hard wired telephone auto dialers. A photograph of one of the auto dialers is included in **Figure 3.2-1**.

Figure 3.2-1
Telephone Auto Dialer (Lake Forest)

In general, all inspected pumping stations were in good condition due to their recent upgrades and consistent, routine maintenance. No deficiencies were noted that could impact the conveyance ability of the pumping stations; however, gas detection at the dry-pit submersible stations was not functional at the time of inspection. While this does not affect the functionality of the pumping station, it does pose a hazard to operator safety. No other deficiencies were noted during the inspections. The only pumping station not inspected was Seaside Park, but per the WPCA, this pumping station is also in good condition. With continued maintenance, it is expected that all pumping stations will remain reliable for years to come.

3.2.3 Siphons

The WPCA has eight siphons within their sewer system. Siphons allow wastewater to flow by gravity under an obstruction, usually a river, stream, utility, or railroad where installation or operation of a typical gravity sewer is impractical. Flow through the siphon is maintained by a difference in hydrostatic pressure that creates a pressurized condition without the need for pumping. One disadvantage of siphons is that they are constructed in an "inverted" orientation, and while flow can pass through the conduit successfully, low velocities in the siphon can allow sediments to accumulate which reduces hydraulic capacity. It is believed that the siphons within the WPCA's collection system have considerable amounts of accumulated sediment based on anecdotal information received from the WPCA. A summary of the siphon locations and sizes are shown in **Table 3.2-3.**

Table 3.2-3 Sewer Siphons

Siphon Number	Name/Location	Number of Barrels	Diameter (inch)	Material	Length (feet)
1	Johnson's Creek	2	24	Cast Iron	236
2	Orange Street	1	27	Reinforced Concrete	29
3	Yellow Mill Pond	2	30	Cast Iron	673
4	Congress Street	2	30	Cast Iron	470
5*	Beardsley Park	2	10	Asbestos Cement	466
6	Brooklawn Avenue	2	14, 18	Ductile Iron	152
7	Laurel Avenue	2	20	Ductile Iron	54
8	Stratford Avenue	1	18	Reinforced Concrete	84

*Siphon remains in place but conveys no flow.

3.2.4 Storage Conduits

The City of Bridgeport has five, in-line storage conduits throughout the collection system. The locations, cross sectional size, and the approximate lengths of these in-line storage conduits are included in **Table 3.2-4**. Storage conduits Number 1 and Number 3 run parallel to a smaller sewer and are primarily operated during wet weather. The other storage conduits are the only available sewers in the area and are used for conveyance during both dry and wet weather conditions. It is believed that there has been excessive sediment accumulation in these storage conduits over the years that limits the overall storage capacity. A few of the storage conduits are believed to be half-full of sediment. In addition to accumulated sediment, modulating gates have been identified on the plans for some of the storage conduits. These gates are no longer operated and are considered to be inoperable.

Table 3.2-4 Storage Conduits

Storage Conduit Number	Name/Location	Cross Sectional Dimension (ft by ft)	Length (ft)
1	Ash Creek, near CEM/MAPE and DEW regulators	5 x 7	1,500
2	CHUR, upstream of CHUR regulator	4 x 5, 4 x 8	430, 1,200
3	Bay Street, downstream of BAYEL regulator	4.2 x 10	920
4	Wilmot Avenue, upstream of BAYEL regulator	3 x 4.5	1,500
5	Connecticut Avenue, upstream of BAYEL regulator	3 x 4.5	1,050

3.2.5 Infiltration and Inflow

Infiltration and Inflow (I/I) can contribute a significant amount of flow to any sewer system. Significant sources of inflow include street drainage, as well as private roof leaders and sump pumps that could be connected to the sewer. Infiltration, or groundwater that seeps into the sewers, commonly occurs where there are loose joints, broken pipe sections, or root intrusion. Infiltration can add a considerable amount of flow to the collection system, especially in areas with high groundwater tables. It is desirable to remove I/I sources from any sewer collection and treatment system, in order to maximize the system's hydraulic capacity and to eliminate the expense of pumping and treating stormwater and groundwater at the WWTPs.

In Bridgeport, tidal inflow is a concern. Anecdotal information from WPCA staff indicates that only a total of 13 outfalls are equipped with tide gates (11 outfalls on the West Side and two outfalls on the East Side). Furthermore, it is believed that these tidal gates leak substantially. Leaks are likely caused from a combination of corrosion, debris, and barnacle growth that prevent the gates from closing properly. A photograph of one representative CSO tide gate is included as **Figure 3.2-2.** Several of the outfalls that do not have gates are believed to be submerged under most tidal conditions. During high tide, seawater enters into the collection system in several locations through reverse flow in the CSO outfall pipes.

Figure 3.2-2
CSO Tide Gate (SEAB)

The neighboring communities (Trumbull, Stratford, and Fairfield) that contribute flow to the collection system have separated sanitary and storm water collection systems. However, since these communities contribute I/I, they also use wet weather capacity and indirectly contribute to CSOs in Bridgeport. It is recommended that any future agreements with neighboring communities, particularly Trumbull, be structured in a way that would allow the WPCA to limit and mitigate I/I from neighboring communities.

Overall, there is a significant I/I contribution within the WPCA's collection system. The calculated flows indicate that over half of the flow at each of the East Side and West Side WWTPs can be attributed to I/I. This is a substantial flow component, confirming that a large portion of system is combined and the aging collection system is susceptible to leaks and tidal influence. The system also receives I/I from neighboring communities, notably Trumbull whose estimated I/I accounts for approximately 50% of the Town's flow.

3.2.6 Operations and Maintenance Activities

As of early 2020, the collection systems crew was staffed with 28 employees to operate the system and conduct maintenance activities. Additionally, the collections systems crew has five vacuum trucks and two closed circuit television (CCTV) trucks. The crew is responsible for cleaning and CCTV inspecting approximately 30 miles of pipe annually (about 10% of the system) and cleaning every catch basin in the City on an annual basis. Bridgeport's collections systems crew also has significant repair capabilities including repairing manholes, catch basins, and smaller point repairs with bypass pumping (up to 12 feet in depth). As stated previously, there is a separate CSO crew responsible for checking the CSO chambers and weir statuses daily.

3.2.7 Existing Collection System Summary

Overall, the existing collection system is old and contributes a substantial amount of I/I to both the East Side and West Side WWTPs. There are 20 CSO regulator structures tributary to the West Side WWTP and six structures tributary to the East Side WWTP. These CSO regulators discharge to multiple receiving waterbodies. Pumping stations throughout the system have been recently upgraded and are generally in good condition. Preventative maintenance activities by the WPCA are ongoing, but problem areas include the siphons and storage conduits which are in need of additional attention (cleaning and repair), and missing or malfunctioning tide gates which contribute inflow to the system. Recent lining and separation projects recommended in the 2011 LTCP are helping to repair portions of the collection system.

3.3 Future Sewer Service Area

The existing sewer service area was described in Section 2. Over the course of the facilities planning effort, the service area and collection system tributary to the East Side and West Side WWTPs are expected to expand, primarily in Trumbull and Monroe. In order to plan properly for future expansion of service and increased flows to the WWTPs, assumptions regarding the expansion of sewered areas were made for each community. These assumptions for each community over the course of the planning period are defined in the subsections below.

3.3.1 Bridgeport

It is not expected that sewers within the City of Bridgeport will be expanded. Service is already provided to essentially the entirety of the City. It is likely that sewer rehabilitation projects will continue to reduce I/I and ultimately reduce flows to the WWTPs.

In Bridgeport's recent history, population has remained relatively stagnant. Over the course of the planning period, Bridgeport's population is projected to increase slightly. It is not expected that an increase in population will require sewer system expansion. There are numerous abandoned or underdeveloped properties within the city that are targeted for redevelopment. A few of these potential redevelopment locations were obtained from the City Planner's office and are included in the collection system map included in Section 2.

3.3.2 Trumbull

Trumbull has been aggressively expanding its sewer system since the 1980s. It is expected the Town of Trumbull will expand the sewer service area during the planning period. Trumbull currently has a WPCA and are encouraging residents to connect to local sewers. Homeowners can postpone connecting to sewer if their septic tank is relatively new, but if ownership of a property changes, they are mandated to connect the property to sewer. Trumbull recently completed the Jog Hill and North Nichols sewer expansion projects, and the South Nichols/Beardsley Parkway area is currently being constructed. It is believed that approximately 65% of Trumbull's population is currently connected to sewer. Over the planning period of this facilities plan (30 years), it is expected that sewers would be expanded to the most of Trumbull, but some more rural areas may remain unsewered. Trumbull's collection system flow has a substantial I/I component, and it is anticipated that any new sewer connections would be partially offset by reductions in I/I. Section 5 of this report further discusses the flows and loads associated with Trumbull's intermunicipal agreement.

Population in the Town of Trumbull is slowly declining due to aging population and lack of young adults and families moving into the town. For the purposes of this report, to remain conservative, it was assumed population would remain constant. The Town of Trumbull wants to maintain its residential and village feel so new commercial development over the planning period was assumed to be minimal.

3.3.3 Monroe

The Town of Monroe is located to the north of Trumbull, CT. Monroe has established a WPCA and has been planning to install sewer along main roads to service commercial and industrial areas for over 20 years. If implemented, it is expected that Monroe would install approximately three miles of sewer along two major roads, CT-25 and CT-111. These sewers would service approximately 300 acres of commercial and industrial land. This expansion of the collection system would likely be tributary to Trumbull, and ultimately Bridgeport. This future expansion of sewer service was included in the facilities planning process.

3.3.4 Fairfield and Stratford

No sewer expansions in Fairfield or Stratford were considered as a part of this Facilities Plan. Fairfield and Stratford each have their own wastewater treatment plants and their collection systems are mostly developed along their borders with Bridgeport. It was assumed for this facility plan that additional sewers are unlikely to be connected from Fairfield or Stratford into the Bridgeport collection system. It was assumed that the few existing direct bill customers will be maintained.

3.4 State Office of Policy and Management Review

The existing service areas outlined in Section 2 and the expected future sewer service area expansions outlined in Section 3.3 were evaluated and compared to the State Office of Policy and Management's (OPM) Conservation and Development Policies Conservation and Development Policies: The Plan for Connecticut, for 2013-2018 (C&D Plan). This is the most recent version of the C&D Plan, as the Draft 2018-2023 State C&D Plan was still under review by the General Assembly at the time this Facilities Plan was prepared.

The C&D Plan is intended to serve as the framework for resource management and development for the State, with the goal of balancing growth while protecting the State's environmental resources. Consistency with the C&D Plan is required if state (or federal) funding will be provided for subsequent projects. Locational guide maps were developed for the Towns tributary to Bridgeport's WWTPs and are included as **Figures 3.4-1 to 3.4-4**. These maps depict the state priority funding areas, balanced priority funding areas, conservation areas, protected lands, and more. These guide maps were created from geographic information system.

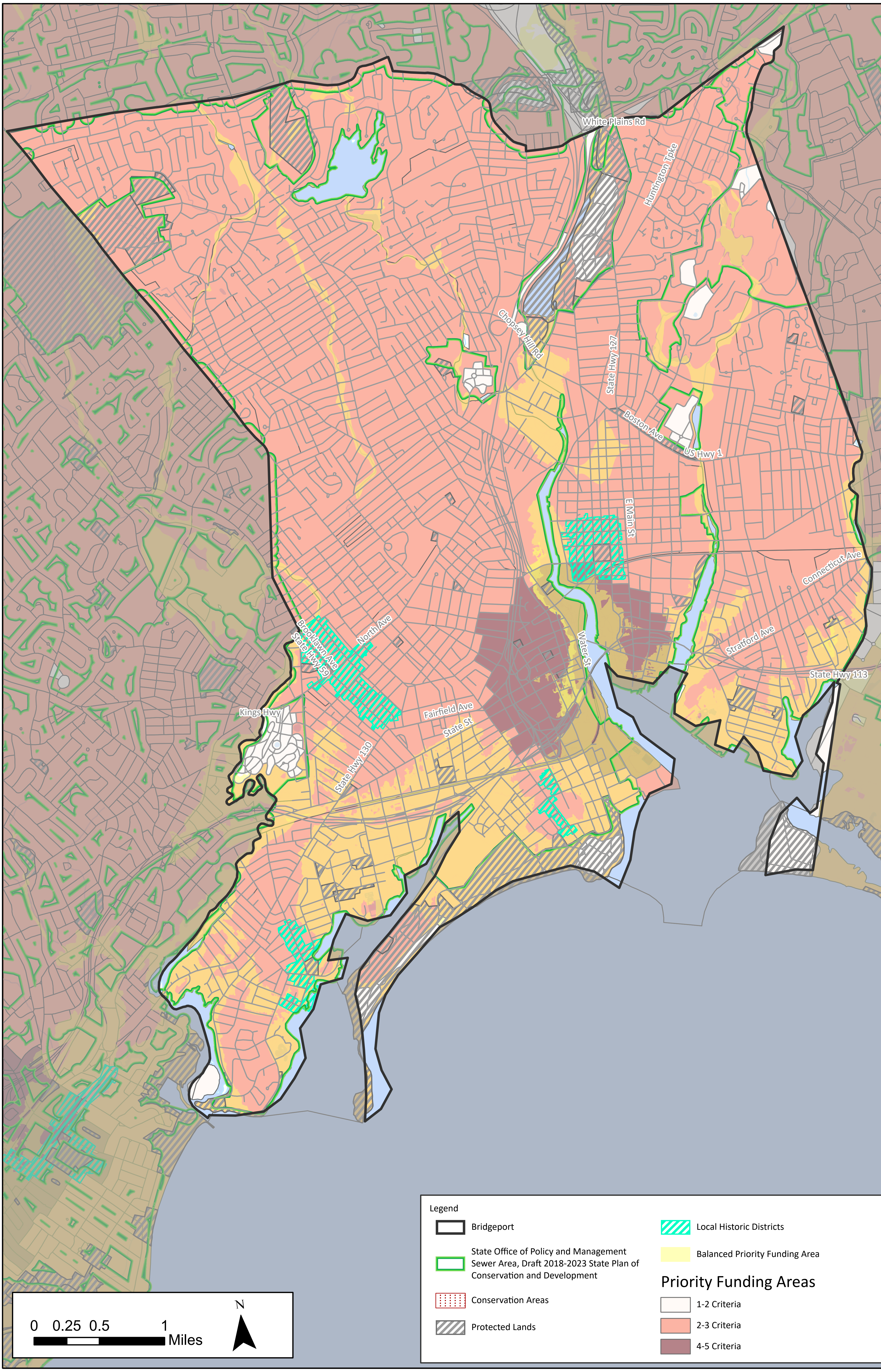

Figure 3.4-1
Bridgeport, CT

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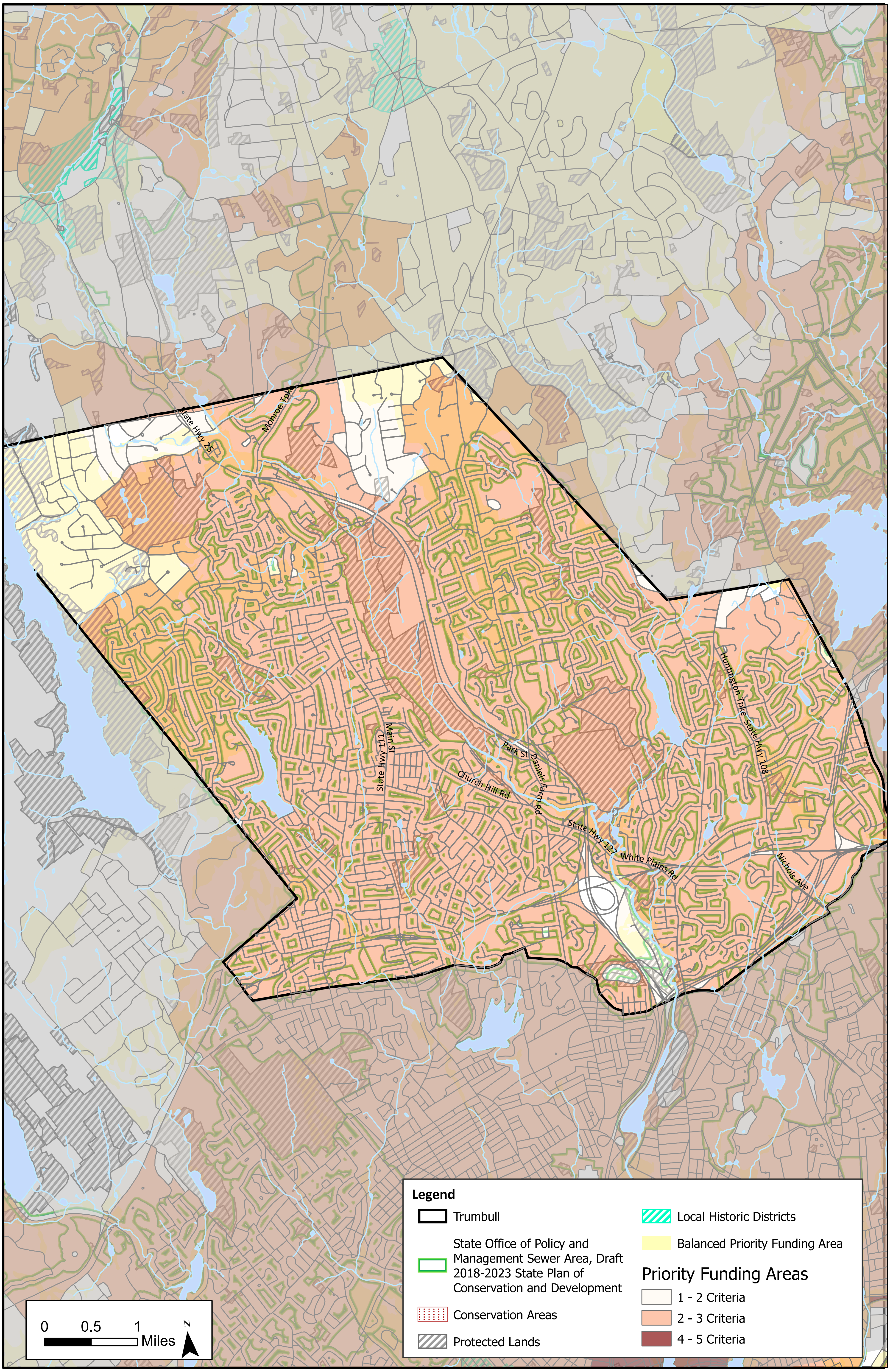

CDM Smith

Figure 3.4-2
Trumbull, CT

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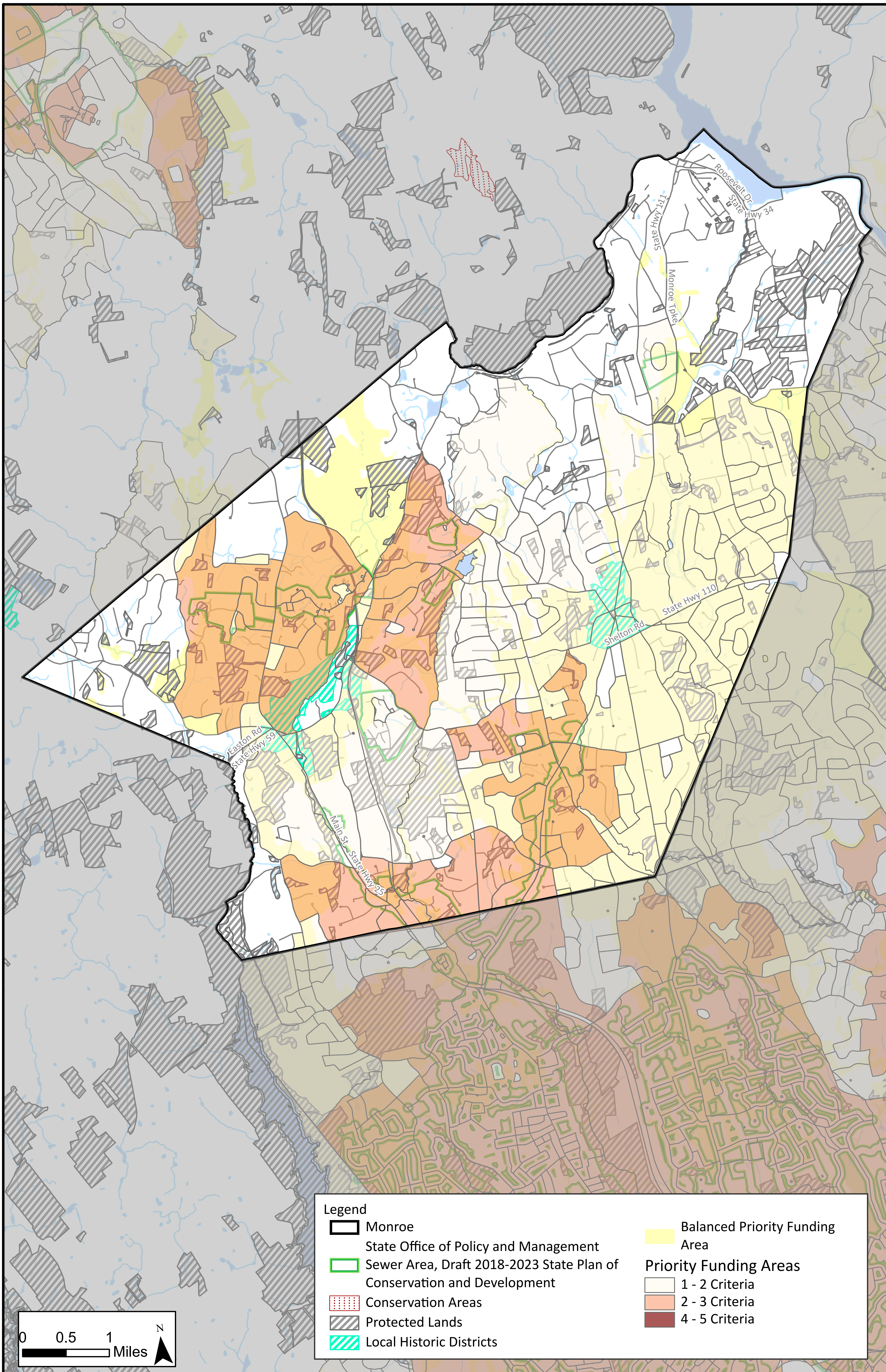

Figure 3.4-3
Monroe, CT

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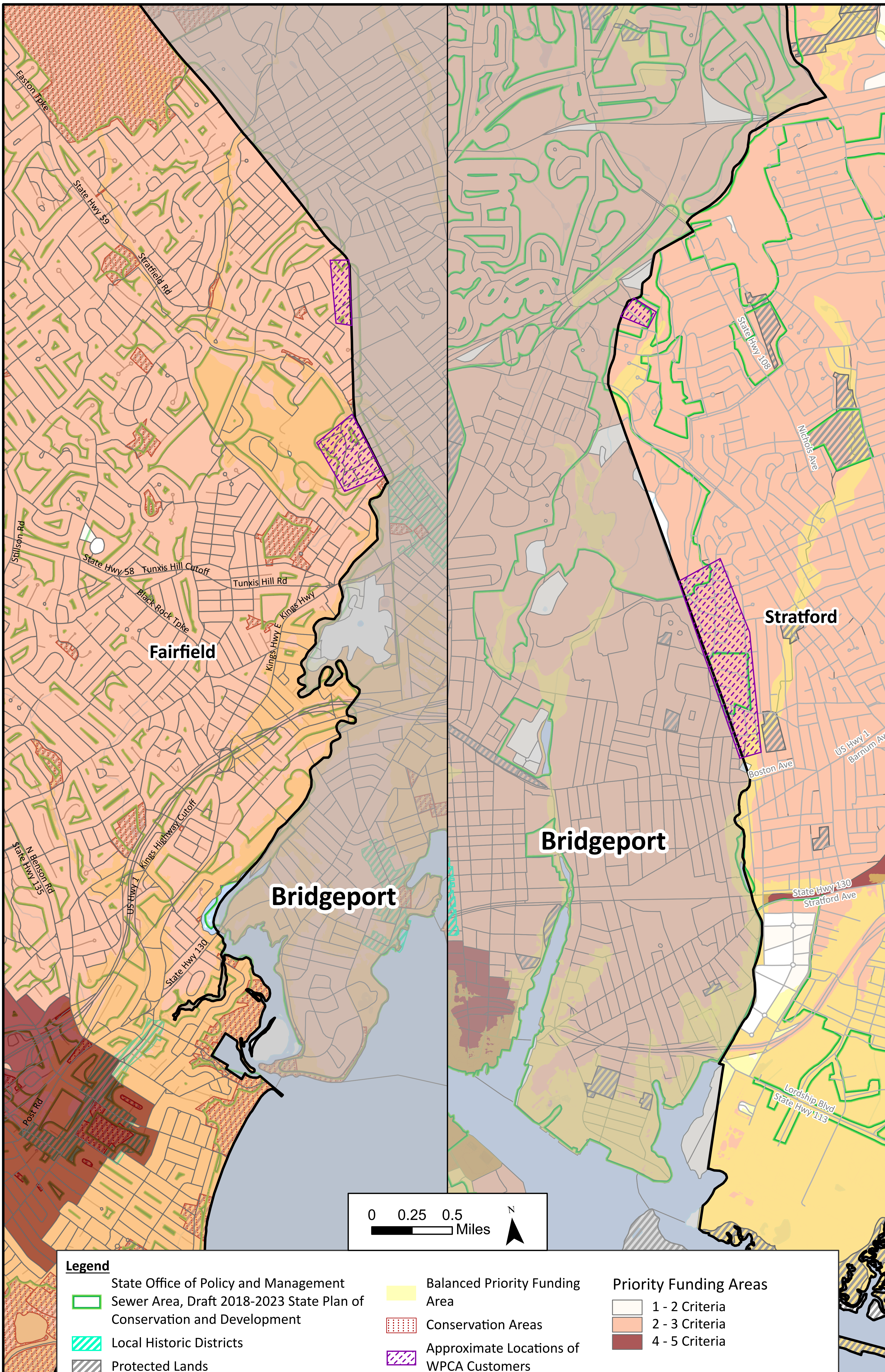

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Figure 3.4-4
Fairfield & Stratford, CT

Water Pollution Control Authority, City of Bridgeport
Facilities Plan

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Table 3.4-1 was adapted from the State of Connecticut C&D Plan and provides a guide to the categories included on the maps.

Table 3.4-1 Summary of C&D Location Guide Map Areas

Priority Funding Areas	Balanced Priority Funding Areas	Village Priority Funding Areas	Conservation Areas	Undesignated Areas
Growth-related projects may proceed without an exception	Growth-related projects may proceed without an exception, if the sponsoring agency documents how it will address any potential policy conflicts	Growth-related projects may proceed without an exception, if the sponsoring agency documents how it will help sustain village character	Growth-related projects may proceed with an exception*	Growth-related projects may proceed with an exception*

* Note: In order for a growth-related project to be funded outside of a PFA, CGS Section 16a35d requires the project to be supported by the municipal plan of conservation and Development and to be approved by OPM.

The categories shown on the C&D guide map are further defined as:

- Priority Funding Area (PFA): delineated based on conditions that exist at the Census Block level (smallest geographical unit delineated by the U.S. Census Bureau). Census Blocks are statistical areas which in Connecticut are typically bounded by visible features, such as streets, roads, streams, and railroad lines. Priority Funding Areas are classified by Census Blocks that include:
  - Designation as an Urban Area or Urban Cluster in the 2010 Census
  - Boundaries that intersect a ½ mile buffer surrounding existing or planned mass-transit stations
  - Existing or planned sewer service from an adopted Wastewater Facility Plan
  - Existing or planned water service from an adopted Public Drinking Water Supply Plan
  - Local bus service provided seven days a week
- Conservation Area: based on the presence of factors that reflect environmental or natural resource values. Conservation Areas include any one or more of the following factors:
  - Core Forest Areas Greater than 250 acres based on the 2006 Land Cover Dataset
  - Existing or potential drinking water supply watersheds
  - Aquifer Protection Areas
  - Wetland Soils greater than 25 acres
  - Undeveloped Prime, Statewide Important and locally important agricultural soils greater than 25 acres
  - Category 1, 2, or 3 Hurricane Inundation Zones
  - 100-year Flood Zones

   - Critical Habitats (depicts the classification and distribution of 25 rare and specialized wildlife habitats in the state)
   - Locally Important Conservation Areas (based on data authorized/submitted by municipalities)

- Balanced Priority Funding Area: areas meeting the criteria of both Priority Funding Areas and Conservation Areas. State agencies that propose certain actions in these areas must provide balanced consideration of all factors in determining the extent to which it is consistent with the policies of the C&D Plan
- Protected Land: lands with some form of restriction on development, such as permanently protected open space or water company owned land
- Local Historic District: established by the town to help ensure that the distinctive characteristics of each district are protected, by having local preservation commissions review architectural changes for compatibility
- Undesignated Land: typically rural in nature and lack the criteria necessary for being delineated as either Priority Funding Areas or Conservation Areas

3.4.1 Bridgeport

A map of Bridgeport with the OPM guide map areas is included as Figure 3.4-1. As stated previously, Bridgeport is nearly completely sewered aside from a few protected areas such as parks, cemeteries, and conservation areas. There are cross-country sewers that run through Beardsley Park, and Veteran's Memorial Park which are both listed as protected areas. These existing sewers are interceptors with no service connections as they pass through these undeveloped park areas. A similar situation occurs in the Park Cemetery, which is categorized as an undesignated area. Finally, there is local sewer and a small pump station within Seaside Park (which is listed as a protected area), that serve restrooms at Seaside Beach.

Although Bridgeport's existing collection system has a few variations with the OPM guide maps, it is not expected that Bridgeport will expand their collection system within city limits during the planning period.

3.4.2 Trumbull

A map of Trumbull with the OPM guide map areas is included as Figure 3.4-2. It is expected that Trumbull will continue to expand their sewers throughout the Town, particularly to the northwest and northeast corners of the town. These areas where sewer expansion is likely includes some areas in the balanced priority areas where growth related projects can occur without an exception, undesignated areas where an exception may be required for growth related projects, and some protected lands.

Trumbull would need a revised agreement with Bridgeport to expand their sewers and send additional flow to the West Side WWTP. Trumbull would also need to follow OPM's guidance and requirements laid out in the C&D plan when considering expansion to any currently unsewered areas.

3.4.3 Monroe

As stated previously, the Town of Monroe has established a WPCA and has planned for quite some time to expand sewer to some of their major commercial areas on the southern end of town. If implemented, this plan would entail the installation of approximately three miles of sewer along two major roads, CT-25 and CT-111. These areas within these commercial areas are included in OPM's guide maps as sewer areas already, and this can be seen in Figure 3.4-3.

These potential expansion areas would flow into Trumbull, and eventually to Bridgeport's West Side WWTP.

Monroe cannot construct sewers and connect into Trumbull's collection system without prior approval from Bridgeport, as this would require modification of the Bridgeport-Trumbull agreement. Monroe would also need to follow OPM's guidance and requirements in the C&D plan and plan sewer improvements only in approved areas.

3.4.4 Fairfield and Stratford

Bridgeport serves a limited number of direct bill customers in Fairfield and Stratford. These customers are located on the outlying borders of both Towns. OPM guide maps for both Fairfield and Stratford are included as Figure 3.4-4. Both Fairfield and Stratford have their own wastewater treatment plants, and expansion of sewers and/or connections tributary to Bridgeport's WWTPs is not expected.

3.5 Collection System Model Review and Update

This Facilities Plan evaluates the current needs and future improvements to the two WWTPs operated by the WPCA—the East Side WWTP and the West Side WWTP. To support the development of the Facilities Plan, the WPCA's existing collection system model was updated and used to evaluate peak flow delivered by the collection system to the East Side and West Side WWTPs. This section summarizes the model development, data sources, validation, and updated baseline CSO estimates used as the basis for alternatives analysis in the Facilities Plan.

3.5.1 Data Sources

The collection system model was updated with the best-available information on the existing collection system, including several system improvement projects that the WPCA has implemented since the last model update in 2010. Data gathering and analysis for this model update focused on both the physical attributes of the system and system performance. CDM Smith worked collaboratively with the WPCA to collect and verify this information, as described in this section.

3.5.1.1 SWMM Model

A hydraulic model of the WPCA's collection system was developed in 1999 to support development of a Long-Term Control Plan (LTCP). The original model was developed in Visual Hydro (a variant of XPSWMM). The model was converted to US Environmental Protection Agency Stormwater Management Model version 5 (EPA SWMM), updated, and calibrated in 2009 and 2010 to support the WPCA's 2011 LTCP (Arcadis/Malcom Pirnie, 2017).

CDM Smith received the latest version of the model from the WPCA in June 2019. The model had been maintained by Arcadis since the 2011 LTCP and most recently had been used to compare simulated and observed overflows during the 2016 and 2017 Pilot Telemetry Program (Arcadis, 2018). This version of the model was the starting point for this analysis.

3.5.1.2 Spatial and Timeseries Data

Several large, publicly available spatial and timeseries datasets were used to refine model hydrology and set model boundary conditions. These datasets were downloaded from national and state resources identified below:

- 2010 census block outlines and population data from the University of Connecticut State Data Center (US Census Bureau, 2012);
- 2012 imperviousness data from the Department of Energy and Environmental Protection (DEEP) Connecticut Environmental Conditions Online (CT ECO) system with 1-foot resolution (DEEP, 2012);
- Raster based digital elevation (DEM) from the CT ECO system. DEM was developed from 2016 Lidar mission completed in March and April, with 1-meter resolution (Capitol Region Council of Governments, 2016);
- Daily Norwalk River discharge from the United States Geologic Survey (USGS) station 01209700 at South Wilton, CT (USGS, 2020);
- Hourly precipitation, daily temperature, and daily snow depth data from Sikorsky Airport (USW00094702) from the National Centers for Environmental Information (NCEI) (NOAA, 2020a); and
- Hourly tidal stage data from the National Oceanic and Atmospheric Administration (NOAA) station 8467150 in Bridgeport (NOAA, 2020b).

3.5.1.3 Record Drawings

WPCA provided city-wide mapping including the Fuller Sewer Atlas and WPCA’s GIS data, as well as record drawings for key locations and projects throughout the collection system:

- CSO regulators;
- Marine CSO Improvement Contract C;
- Sewer Separation Contracts F-1, F-2, F-3, F-4, G-1, G-2, G-4, H-1, and H-2;
- Sewer Lining Contracts H-1, H-2, H-3, H-4, H-5, H-6, and H-7; and
- New River Street Pump Station.

3.5.1.4 Flow and CSO Monitoring

Existing monitoring data were used to calibrate system performance in dry and wet weather, as well as to add a variable baseflow component to the model. The following data sources were used to evaluate system performance and for validation of the updated model:

- CSO block testing results at all available CSO regulators for 2017 and 2019;
- Minimum, maximum, and average daily flow (ADF) and both the East Side and West Side WWTP's for 2017 – 2019;
- CSO level sensing at West Side regulators ANTH, ARBOR, GRAND, and HUNT and East Side regulators WANN, CHUR, STRAT, and BAYEL regulators from the 2016-2017 Pilot Telemetry Program (Arcadis, 2018);
- 2009 flow monitoring program, which included four area-velocity meters on the West Side and two area-velocity meters on the East Side deployed from August through November, 2009 (Malcom Pirnie, 2017); and
- 1999 flow monitoring program which included 21 area-velocity meters deployed from May through September 1999 (Malcom Pirnie, 2017).

3.5.1.5 Additional Information on System Performance

In addition to system monitoring, anecdotal information about system performance was provided by WPCA, including confirmation of the following:

- known flooding areas;
- general condition and verification of tide gates on CSO outfalls; and
- general locations of sediment and debris buildup throughout the collection system.

3.5.2 Model Update

The WPCA collection system model was updated and improved to develop baseline conditions for the existing system to support the Facilities Plan. The updated model incorporates revised hydraulics, hydrology, dry weather flow estimates, and wet weather response. This section generally describes the improvements made to the model. More detailed technical information on the model update can be found in Technical Memorandum M-1, included as **Appendix D** to this Facilities Plan.

3.5.2.1 Software

The WPCA collection system model uses EPA SWMM. SWMM is the preeminent model for planning, analysis, and design related to stormwater runoff, combined and sanitary sewers, and other drainage systems in urban areas. SWMM can be used with its EPA interface; it has also been adapted into commercial products that offer varying degrees of compatibility with the EPA program. For this project, much of the work was conducted using PCSWMM software from CHI, Inc. Modeling was supported with custom software developed by CDM Smith, NetSTORM

(Heineman, 2004), which provides tools for meteorological data pre-processing and analysis and SWMM calibration.

3.5.2.2 Datum and Coordinates

All modeling inputs and outputs use the City of Bridgeport vertical datum and the Connecticut State Plane North American Datum 1983 (NAD83) coordinate system with length units of feet. Flows are reported in million gallons per day (mgd). Bridgeport City datum is 14.6 feet below the North American Vertical Datum of 1988 (NAVD88); elevations in NAVD88 (feet) can be converted to Bridgeport City datum by adding 14.6 ft.

3.5.2.3 Hydraulics

The modeled pipe network builds upon the dataset described in the 2011 LTCP. The starting model network consisted of 3,958 links (pipes, weirs, orifices, and pumps). The updated model has 4,032 links. Details were added at CSO regulators, and pipes were extended into the separated sanitary service area in the northern portion of the City. The updated model has a median pipe diameter of 15 inches, including 813 10-inch and smaller pipes. The updated model represents 156 miles of pipe. This updated pipe network can be seen in **Figure 3.5-1**.

Hydraulics at all CSO regulators were thoroughly checked against record drawings, notes provided by the WPCA, and video taken during CSO block inspections. The updated model has 22 active CSO regulators discharging to 19 outfalls on the West Side and six CSO regulators discharging to six East Side outfalls. CSO regulator configurations were discussed with the WPCA and updated as appropriate, including the representation of recent WPCA efforts to raise weirs. Thirteen CSO outfalls have tide gates in the updated model, including two on the East Side and 11 on the West Side.

The hydraulics of all siphons were also reviewed and updated as needed. While no siphon record drawings were available, the WPCA provided information about locations and capacity.

Six miles of 24-inch and larger pipe were added to the model to extend the network into separated sanitary sewersheds in the northern portion of the City. The model extension includes the new River Street Pump Station sewershed and two miles of the Bridgeport-Trumbull Interceptor (BTI), which receives sanitary inflow from Trumbull via the Beardsley Pump Station and Sunnydale Crossover. No pipes in the Trumbull collection system were included in the updated model, but its sanitary flow and infiltration and inflow (I/I) were explicitly accounted for as loads to the BTI.

Simulated sediment depths were verified by WPCA and updated as needed. Friction and form losses were completely revised for the model update.

Representations of both the East Side and West Side WWTPs were simplified and reflect current operations at both facilities. The starting model contained unique outlet rating curves to control inflow to each facility based on the hydraulic grade line (HGL) in the collection system. The rating curves were removed from the updated model and replaced with a flow limit on the influent to each facility. Based on maximum daily flow data from the WPCA, the flow limit of the West Side WWTP was set to 80 mgd and the flow limit of the East Side WWTP was set to 35 mgd.

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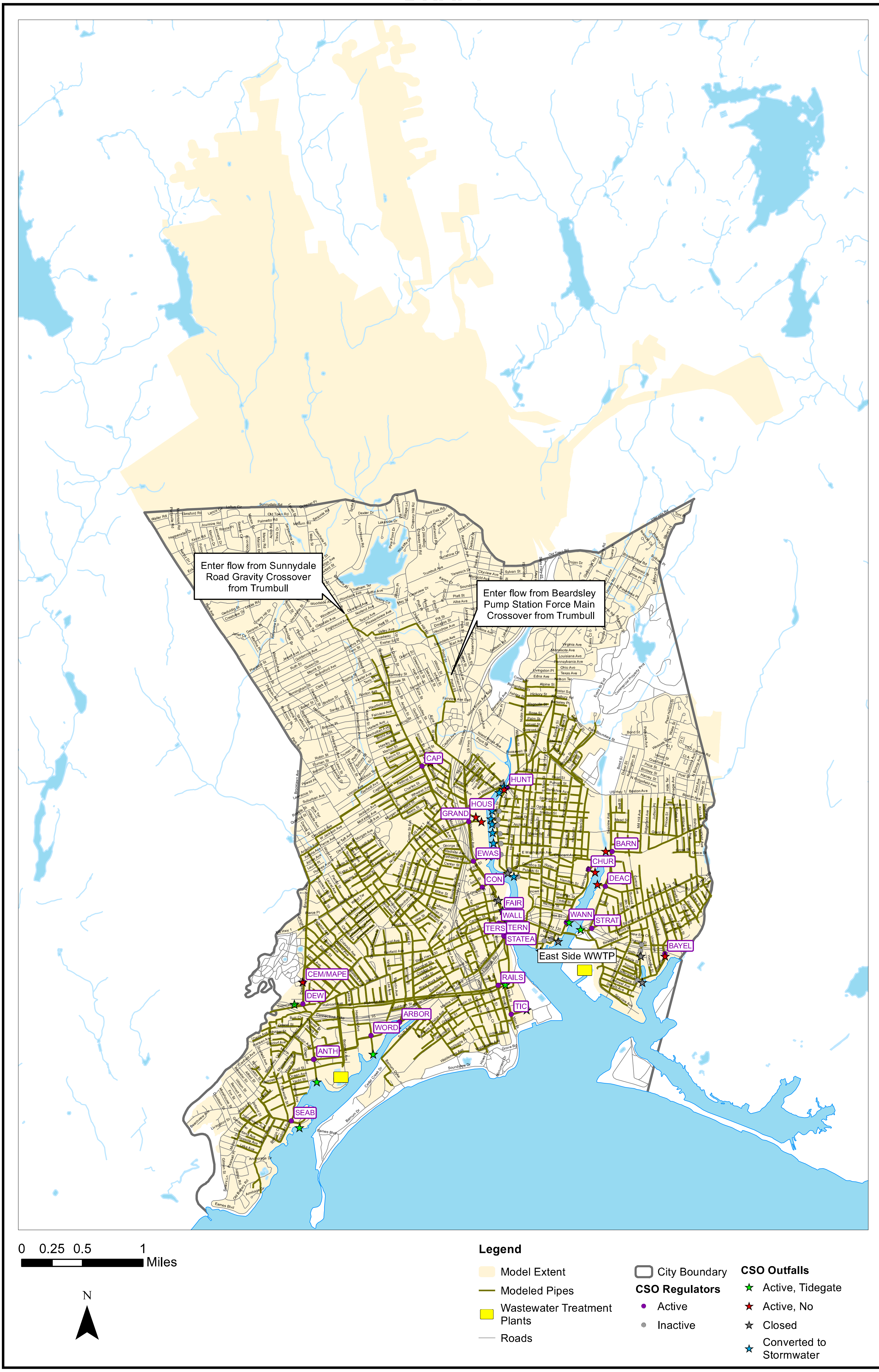

CDM Smith

Figure 3.5-1
Model Network

Water Pollution Control Authority, City of Bridgeport
Facilities Plan

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3.5.2.4 Hydrology

The model's surficial hydrology was revised extensively. Subcatchments were re-delineated from 1900 census blocks within the city. Census blocks were subdivided as needed to eliminate dry pipes and were typically routed to the upstream-most model node within the subcatchment. New subcatchments cover the City of Bridgeport and the sewered portion of Trumbull. The updated model contains 2,152 subcatchments in Bridgeport and two in Trumbull as shown in **Figure 3.5-2**.

Subcatchment area was assigned according to GIS area in fully combined sewersheds. Separated sanitary sewersheds in the northern portion of the City were assigned 5 percent of the GIS area. More recently separated areas within the combined portion of the system were reduced to 10 to 99 percent of the GIS area according to the reported degree of separation (Figure 3.5-2).

Imperviousness was assigned using 2012 impervious data (DEEP, 2012), which defines percent imperviousness statewide at 1-foot pixel resolution. Effective imperviousness is calibrated in the model through adjustment of the Percent Routed parameter, which identifies the fraction of a subcatchment's impervious surface that drains onto adjacent pervious ground (e.g. roof leaders that drain to lawns).

3.5.2.5 Dry Weather Inflow

Dry weather flow in the model is simulated as the sum of three distinct components: sanitary flow, constant infiltration, and seasonal infiltration. Sanitary flow is specified as average discharge adjusted by hourly factors.

The WPCA executed multiple contracts to line large interceptors and connected pipes on the West Side collection system. Model junctions that are located within lining contracts H-1 through H-7 have reduced infiltration and do not have any base infiltration applied.

Sanitary flow was estimated for the West Side and East Side WWTP collection systems and for sanitary inflow from Trumbull using ADF data from each WWTP and monthly records from Trumbull. Sanitary flow was distributed throughout the system using population data from the 2010 census. Sanitary flow of 63 gallons per day per capita was applied to the East Side and West Side collection systems and 60 gallons per day per capita was applied to Trumbull. An hourly diurnal pattern was applied to all sanitary inflow nodes.

3.5.3 Model Calibration

The model was calibrated to the available datasets with consideration of their differing ages and value. The following datasets supported model calibration and validation:

- 21 flow meters deployed throughout the system in 1999
- Six flow meters deployed in 2009
- CSO duration and frequency recorded at eight CSOs in the 2016-2017 Pilot Telemetry Program

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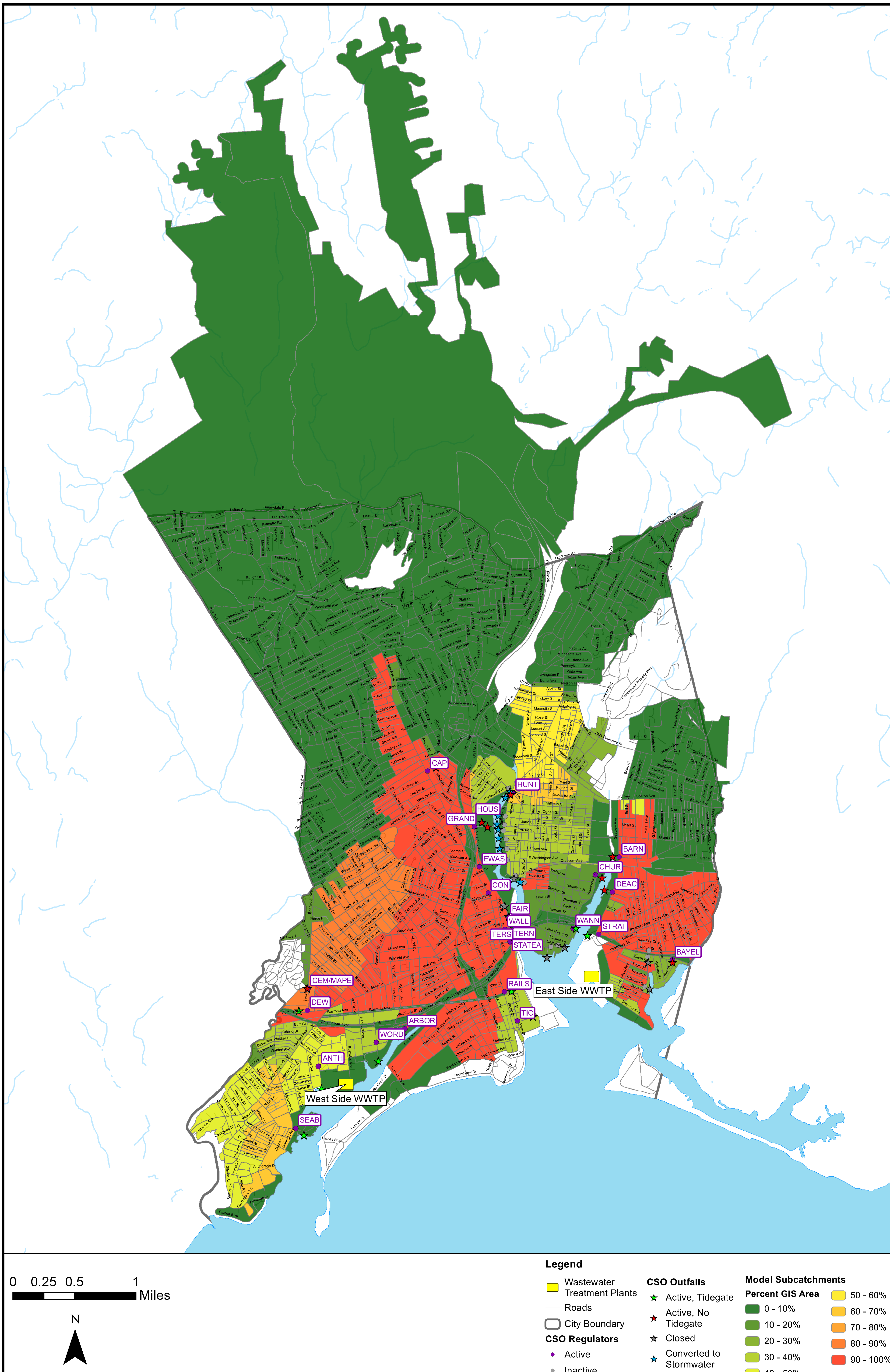

Figure 3.5-2
Model Subcatchments

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- CSO frequency and tidal inflow occurrence observed in 2017-2018 block testing
- Monthly flow records from the two connection points from Trumbull for 2016-2019
- Daily average, maximum, and minimum flows recorded at the WWTPs for 2017-2019
- Thrice-weekly measurements of five-day biochemical oxygen demand (BOD_5) at the WWTPs for 2017-2019 were used to inform the relative contributions of sewage and ground water infiltration (GWI)
- Weekly measurements of chloride at the West Side WWTP from January 2019 through April 2020 were used to identify the magnitude of seawater leakage into the West Side collection system

Since the WPCA has made many improvements to the collection system over the past two decades, data from the older programs has reduced value for calibration to current conditions. The improvements include sewer separation and lining, which reduce flows throughout the collection system, and weir modifications at CSO regulators, which reduce CSO and increase wet weather flow depth. Data from the older programs was used to verify model performance with consideration of the expected changes in system behavior. A higher level of scrutiny was placed on model performance compared with recent CSO measurements and the Trumbull and WWTP data, all of which represent current conditions.

3.5.3.1 Dry Weather

Dry weather flow includes diurnally-varied sanitary flow along with GWI. Modeled sanitary flows were estimated from ADF observed at the East Side and West Side WWTPs and monthly flows reported for Trumbull from 2016 through 2019 and allocated throughout the system according to 2010 census data. GWI is represented with both constant and seasonally-varied components. Constant groundwater baseflow was correlated linearly with model junction invert, representing infiltration to deep, large pipes. Seasonally varied groundwater infiltration was derived from flow observed in the Norwalk River correlated with observed flow at the WWTPs and scaled at each load point according to contributing sewershed area. The Norwalk River was selected for this purpose as GWI consistently correlates well with river baseflow within a 25-mile radius. The Norwalk River gauge is the closest gauge to the WWTPs (approximately 12 miles west) with continuous records for nearly 60 years.

3.5.3.2 Wet Weather

The model accounts for drainage from combined areas and I/I from separated and combined areas. Hydrology was calibrated to daily flow data at the WWTPs, depth data from the 2016-2017 Pilot Telemetry Program, and CSO frequency from 2017 and 2019 CSO block testing and checked against the 1999 and 2009 flow monitoring programs.

3.5.3.3 Validation Results

A high level of scrutiny was placed on simulated flows at the WWTPs and simulated frequency of CSO. Overall, simulated ADF tracks well with observed values at both facilities. The updated model mimics seasonal variation in baseflow and matches trends of higher spring ADF and lower summer and fall ADF at both facilities. The updated model matches the block testing data reasonably well. East Side CSO and tidal inflow is much less frequent than on the West Side.

The model is reasonably calibrated to dry and wet weather conditions. It robustly represents flow to the WWTPs and discharge via CSOs. It offers a useful tool for assessing the existing state of the system and analyzing the impacts of potential improvements to the WWTPs. A complete explanation of the model update and calibration process can be found in **Appendix D**. Validation charts, simulated vs. observed CSO volume bar charts, and other supplemental technical modeling information are included in the technical memorandum.

3.5.4 Baseline Conditions

The updated model was used to characterize CSO and flow at the WWTPs for the 1-year design storm. This design storm is described in Section 5 of the 2011 LTCP and is the same design storm referred to as the "1 year, 24-hour storm" in DEEP's Administrator Order WRMU18002 issued to the City of Bridgeport on June 14, 2018 (DEEP, 2018). This storm was recorded at Sikorsky Airport on August 20, 1950. Its hourly hyetograph was used to run the model. A total of 2.74 inches of rain was observed over 17 hours, with a peak hourly depth of 0.75 inches.

Peak flows and total volumes for the 1-year design storm are summarized by CSO outfall and WWTP in **Table 3.5-1**. Total simulated East Side CSO volume is 5.4 million gallons (MG), with 6 of 6 CSOs active, based on a maximum capacity of 35 mgd at the East Side WWTP. West Side CSO totals 44.4 MG, with 21 of 22 CSO regulators active, based on a maximum capacity of 80 mgd at the West Side WWTP.

Table 3.5-1 Baseline Conditions: 1-Year Design Storm Summary

WWTP	CSO	Overflow Volume (MG)	Peak Overflow Rate (mgd)	Duration of Overflow (hr)
East Side	BARN	0.3	4.1	3.8
	BAYEL	0.9	13.7	4.3
	CHUR	0.4	8.4	2.0
	DEAC	0.4	5.3	2.5
	STRAT	2.2	16.5	6.3
	WANN	1.2	8.8	6.3
West Side	ANTH[1]	5.8	28.1	11.3
	ARBOR[1]	8.2	84.4	6.5
	CAP	0.4	9.6	2.0
	CEM/MAPE	2.6	26.6	5.8
	CON	<0.01	0.2	1.0
	DEW	1.8	15.1	6.5
	EWAS	1.4	13.4	6.3
	FAIR	3.5	19.6	9.8
	GRAND	3.3	28.1	8.8
	HOUS	3.9	22.6	9.5
	HUNT	3.0	29.3	7.0
	OVER	0.3	5.4	2.5
	RAILS	0.2	7.8	1.5
	SEAB	2.3	22.5	7.0
	STATEA	3.0	24.1	8.5
	TERN[2]	1.8	10.8	7.5
	TERS[2]	1.1	6.9	9.0
	TIC	0.3	7.1	1.5
	WALL	1.5	10.0	9.0
	WORD	0	0	0

1 ANTH and ARBOR regulators both have two regulating weirs. CSO reported in this table is the sum of the discharge over both weirs.

2 TERN and TERS share an outfall.

3.6 Baseline Collection System Recommendations

As stated previously, the collection system is aging, has a noteworthy inflow and infiltration (I/I) response, and is believed to have sediment accumulation throughout. This section outlines baseline improvements that do not represent significant physical changes to the collection system, but will improve system performance, restore overall capacity, and reduce CSO discharges. These improvements involve minor repairs, cleaning, and O&M activities that should be continued.

The updated collection system model was utilized to evaluate more major collection system alterations and piping improvements. These more substantial collection system improvements are discussed later in the report. The recommendations outlined in this section represent "low hanging fruit" that can be addressed in the near term and provide substantial collection system enhancement for a moderately low cost.

3.6.1 Routine and Targeted Cleaning

Although the WPCA's operation crew conducts routine cleaning, problem areas of sediment accumulation have been identified. These areas were represented in CDM Smith's hydraulic model to properly represent the existing system capacity and performance. To increase system hydraulic capacity, it is recommended that all pipes with identified sediment accumulation be thoroughly cleaned and maintained. A summary of the modeled pipe sizes and approximate pipe lengths with sediment are included in **Table 3.6-1**.

The values presented in Table 3.6-1 are based upon the updated collection system model described previously and known problem areas of sediment accumulation. Therefore, these values are approximate, and may not be representative of the total length of pipe within the collection system that might require targeted cleaning. A map of the modeled sediment locations is included as **Figure 3.6-1.**

In addition to the areas identified in the model, it is also recommended that the WPCA continue their routine cleaning activities throughout the system. The WPCA's contract operator agreement states that 30 miles of pipe each year are cleaned and CCTV inspected. The CCTV work often involves pre-cleaning the pipe segments as well, so more than 30 miles of pipe are cleaned annually. It is recommended that these cleaning levels should be maintained to ensure sediment accumulation does not restrict the overall collection system capacity.

Table 3.6-1 Approximate Length of Sewer to be Cleaned

Pipe Diameter (in)	Cleaning Length (ft)		
	West Side	East Side	Total
8	860	0	860
15	630	0	630
27	940	0	940
30	2,100	1,000	3,100
33	160	0	160
36	800	1700	2500
39	0	1400	1400
45	0	470	470
48	1,900	1,400	3,300
50	430	1,000	1,430
54	80	3,100	3,180
60	290	0	290
72	0	100	100
Total	**8,190**	**10,170**	**18,260**

3.6.2 Siphons and Storage Conduit Cleaning

In addition to typical pipe cleaning, siphons and storage conduits are known areas of sediment accumulation that require attention, additional cleaning, and sediment removal. As discussed previously, the WPCA's system contains a total of eight siphons (seven active) and five storage conduits. In general, inverted siphons are common locations for sediment accumulation, and WPCA staff believe that these siphons have collected significant amounts of sediment. The storage conduits have also been identified by WPCA staff as containing large quantities of sediment. Two of the five storage conduits are filled only during wet weather events, when the depth of flow in the dry weather sewer pipe increases and spills over a weir. The remaining three storage conduits carry both dry and wet weather. Modulating gates have been identified on the plans for some of the storage conduits, but these gates are no longer used, and believed to be inoperable.

It is recommended that in addition to the targeted cleaning presented above, the siphons and storage conduits within the WPCA's collection system all be thoroughly cleaned, and a periodic cleaning schedule should be established in order to keep the structures clean. Details on these collection system features are included earlier in Section 3.2. This additional cleaning totals approximately 3,300 feet of siphon barrel cleaning (ranging from 14 to 30 inches in diameter), and 6,600 feet of storage conduit cleaning (ranging from 3 feet by 4.5 feet to 4.2 feet by 10 feet in cross sectional area). Removing sediment from these important collection system features will increase system conveyance and storage, as well as reduce CSO discharges. The storage conduit modulation gates should be investigated in more detail and repaired if needed. Proper maintenance and operation of these gates would help improve system storage capacities.

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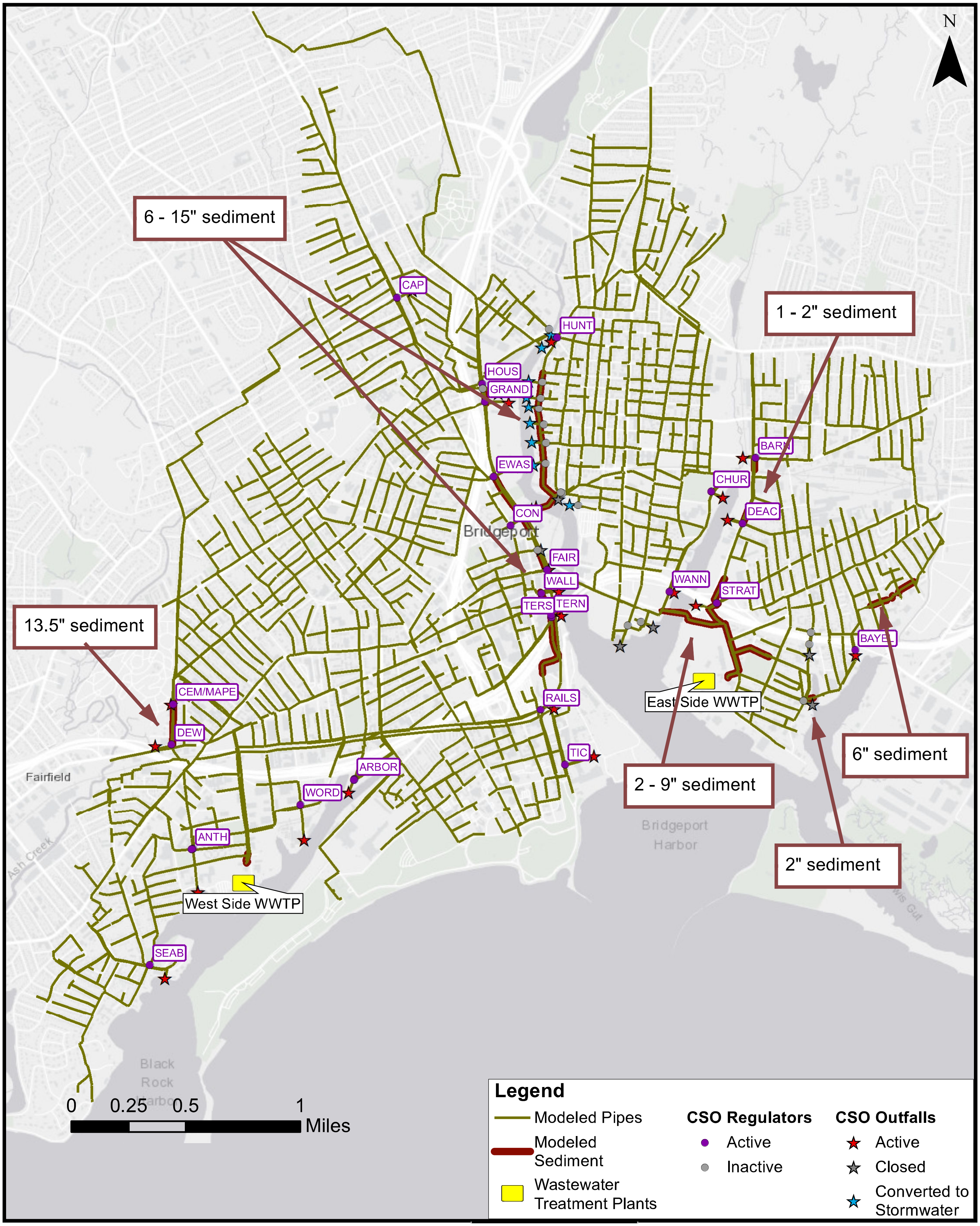

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Figure 3.6-1
Modeled Sediment

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3.6.3 CMOM Activities

The WPCA is well-equipped and well-staffed to complete preventative maintenance, inspection and repair activities throughout the collection system and has an aggressive program in place to perform O&M. Collection system crews have annual goals for sewer cleaning - 30 miles of pipe, clean and CCTV - 30 miles of pipe, and catch basin cleaning – 8,500 basins. These established goals have been exceeded every year for over 15 years. Overall, there are very few bypass events annually attributed to blockages or other failures in the WPCA collection system. The WPCA has recently completed sewer separation and lining activities initiated as part of the recommendations from the 2011 LTCP. These programs to improve and renew the aging collection system infrastructure will continue.

In 2020, WPCA completed a revised CMOM Self-Assessment Checklist and updated its CMOM Corrective Action Plan (CAP). Completion of the Checklist did identify some areas for additional focus and these are addressed in the CAP. Many of the proposed corrective actions relate to tracking, management, and prioritizing efforts. An update of the collection system GIS is currently underway to improve mapping and establish unique identifiers for collection system assets. The CAP also recommended completion of an Asset Management Needs Assessment to review current practices and evaluate if a formal Asset Management System should be deployed. Other areas of focus include improved tracking and logging of response to blockage calls and customer complaints; review and reassessment of chronic maintenance areas; increased public outreach; improved FOG management and inspections; improved tracking of cleaning and inspection activities; and development of a right of way maintenance program. Items identified in the CAP will be initiated over the next three years in accordance with an established schedule and a re-assessment is recommended at the end of this period. The WPCA remains under contract with its contract operator through June 2023. The WPCA should consider adjustments in the next contracting period that are consistent with its goals and the corrective actions identified in the CMOM Self-Assessment and CAP.

3.6.4 Tide Gates

Tidal inflow is a concern in Bridgeport. Approximately half of the CSO outfalls do have tide gates, but the existing tide gates are believed to be leaky from a combination of rust, debris, and barnacles that prevent the gates from closing properly. During high tide, this can introduce seawater into the collection system through reverse flow in the CSO outfall pipes. Block testing data from 2017 indicated an average of 21 tidal inflow events per outfall per year. The most active regulators for tidal inflow included TERN, FAIR, WALL, STATEA, and ARBOR.

It is recommended that these tide gates be inspected further and repaired as soon as possible. Improvements and repairs to the tide gates represent a relatively low-cost system improvement that could result in a significant decrease in tidal inflow. Treating any amount of tidal inflow at the WWTPs is an unnecessary cost, and the presence of tidal inflow in the collection system during a wet weather event could result in an increase in CSO and potentially street flooding.

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