City of Haverhill Combined Sewer Overflow Public REVISED Notification Plan

February 2024

Contents

Appendices

Section 1 – Facility Information

- Name of Facility or System: City of Haverhill
- Permittee contact name: Isaiah Lewis
- Phone: 978-374-2382
- Email: ilewis@haverhillwater.com
- Permittee mailing address: 40 South Porter Street Haverhill, MA 01835
- NPDES Permit #: MA0101621

Haverhill owns and operates a wastewater treatment plant (WWTP) and sewer and storm collection systems. The collection system Currently has 36 Pumps stations. Wastewater is collected throughout the city, which is conveyed from approximately 193 miles of gravity sewer pipes and force mains, to the WWTP by its interceptor piping network.

The sewer collection system is comprised of separated and combined sewersheds. Separated sewersheds, primarily located outside of the densely populated downtown areas, only convey sanitary flow. Stormwater is conveyed through a separate pipe network that discharges directly into a receiving water body. Combined sewersheds convey both stormwater and sanitary flow through the same pipe network. Dry weather flow and a portion of the wet weather flow are conveyed to the WWTP and excess wet weather flow is discharged out of the CSO outfalls.

Haverhill's combined sewer system currently has 15 CSO regulators/structures that are connected to 13 outfalls. Of the 13 outfalls, five discharge to the Little River, and eight discharge to the Merrimack River (See Appendix A: CSO Map).

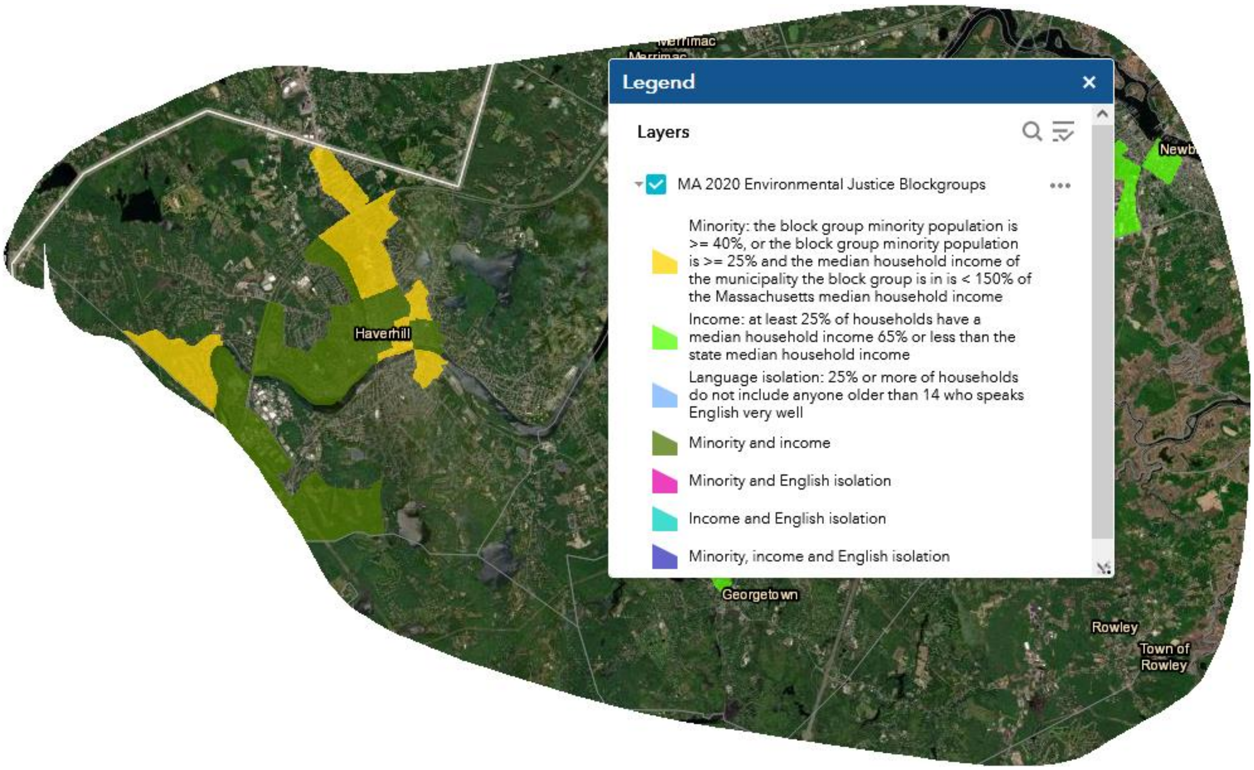
The WWTP is located off of South Porter Street. It provides primary treatment, secondary treatment and disinfection of wastewater prior discharging it through an outfall to the Merrimack River. The WWTP has an average day design capacity of 18 million gallons per day (mgd) and a peak wet weather flow capacity of 65 mgd. During wet weather event, as much flow as possible is passed through secondary treatment and the remaining wet weather flow is bypassed to protect the secondary process/system.

Municipalities downstream of any potential untreated discharges from the City of Haverhill, include Groveland, West Newbury, Merrimac, Amesbury, Newburyport, Newbury, and Salisbury. The Merrimack River is used recreationally for boating and fishing. There are no downstream communities using the river as a drinking water source (See Appendix B: EPA Map). Shell Fishing is prohibited along most of the downstream Merrimack communities and conditionally restricted in coastal communities on the river (See Appendix C: Shell Fisheries).

Section 2 – Environmental Justice Population

The City has approximately fifty percent of its population living in Environmental Justice (EJ) Block Groups. Haverhill meets the EJ population criteria for Minority and Income (see Appendix D: Environmental Justice Map).

Information on EJ populations: https://www.mass.gov/info-details/environmental-justice-populations-in-massachusetts



Less than seven percent of households lack English Language proficiency in only two EJ block groups. Signage for CSO outfalls are in English and Spanish, as required by our NPDES permit. There are no downstream communities with language isolation block groups.

Section 3 – Discharges, Overflows and Public Notification

As required in 314 CMR 16.03 (1) (a-e), a permittee is required to issue a public notification for the following:

- Any Combined Sewer Overflow;
- Any discharge of partially treated wastewater, including blended wastewater;
- Any Sanitary Sewer Overflow (SSO) that discharges through a wastewater outfall, either directly or indirectly, into a surface water of the Commonwealth;
- Any SSO that flows into a surface water of the Commonwealth and is the result of the sanitary sewer system surcharging under high flow conditions when peak flows cannot be conveyed to a POTW due to capacity constraints; and
- Any SSO that flows into a surface water of the Commonwealth and is the result of a failure of a wastewater pump station or associated force main designed to convey peak flows of 1 million gallons per day or greater.

The City of Haverhill developed this public notification plan for combined sewer overflows (CSO) that may occur from the City's thirteen (13) CSO discharge outfalls located along the Little and Merrimack Rivers.

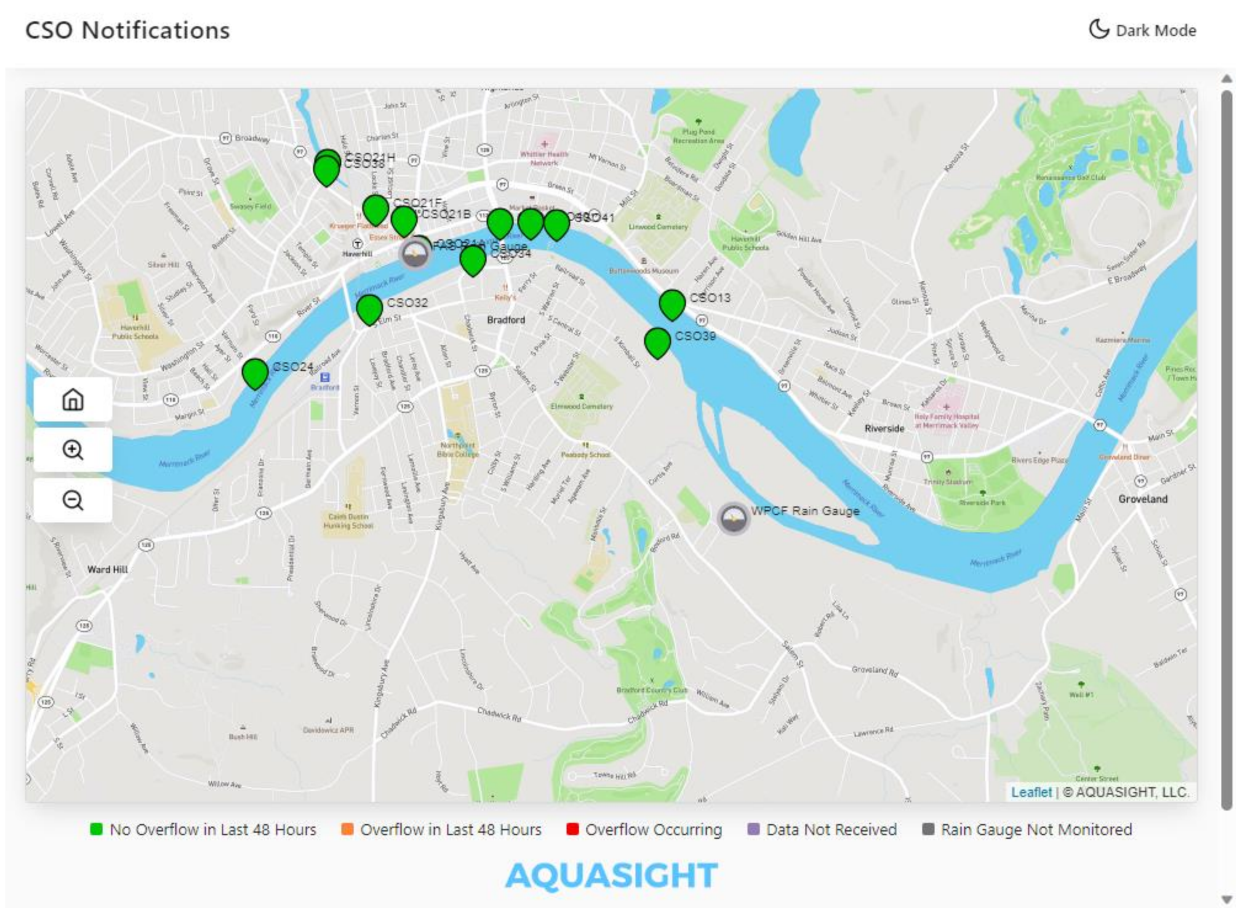
3.1 CSO Monitoring

The City contracts with Flow Assessment Services (FAS) to monitor Haverhill's CSOs. FAS conducts monthly maintenance to verify that their equipment is functioning correctly. At the beginning of each new month, FAS staff analyzes the overflow data, checks for accuracy, and sends it to Haverhill Wastewater staff. This Data is used to create monthly and annual CSO reports. The City has access to FAS's website to view each CSO meter along with rain gauge information. However, the City can only view preliminary CSO volumes.

The Upper (024) and Lower Siphon (013) CSO Structures are the active flow control structures which transmit Data to the WWTP Supervisory Control and Data Acquisition System (SCADA). The City owns and operates the equipment at these locations. The CSO gates are monitored by FAS and activations are available on the City's CSO map. CSO volumes are calculated using a weir equation. These flow rates (MGD) are sent to Flow Assessment, which convert the flow rate to total gallons discharged.

3.2 CSO Activations

The City contracted with Aquasight to develop an automated system to provide CSO information to the public. Initial and supplemental notification of a CSO activation will be provided through the City's website. A link on the City's website displays a map showing the CSOs activation status using color coded symbols. Below is a picture of the map taken from the website.



Activation Data includes the permittee information, outfall number and location, date and time, preliminary overflow volume, and the receiving waters for each outfall.

Access to the map as well as CSO notification subscriber instructions can be found here: https://www.cityofhaverhill.com/departments/public_works_department/water_wastewater/wastewater/wastewater_collection_system/cso_public_notification.php

Additional information regarding CSOs can be found on the City's website, including a five-minute YouTube video explaining CSO discharges and impacts. This video can be found here:

https://www.youtube.com/watch?v=UBjVCFOoKLY&t=1s

Note: The City of Haverhill CSO Website is included on EPA's website https://www.epa.gov/merrimackriver/environmental-challenges-merrimack-river# **CSO**

3.3 Haverhill CSO Impact Study Area

The City contracted with CDM Smith to develop a comprehensive CSO Impact Study See Appendix M for complete details.

3.3.1 Recommendation

Figure 7 shows the locations of the 95% and 99% impact distances along the Merrimack River. **CDM Smith recommends using the 99% impact distance as a threshold for signage**. This is more reasonable than taking a "worst case" event alone, such as the largest CSO event on record, and is in accordance with established precedence by regulators for discharge permitting in most states. The distribution of event data demonstrates that the largest event in Haverhill's record, which totaled 19 million gallons, is an outlier that is nearly two times larger than any other events on record. Relying on statistical extremes like the 95% and 99% distances is much more reasonable, as it safe guards from extreme outliers, which could be the result of reporting errors, measurement errors, etc. The majority of events in Haverhill's record do not result in in-river concentrations above the standards anywhere in the Merrimack River downstream of initial cross sectional mixing. The 95% distance for Enterococcus is 6.7 miles downstream. The 99% distance is 9.1 miles. These distances are shown on the map in Figure 7.

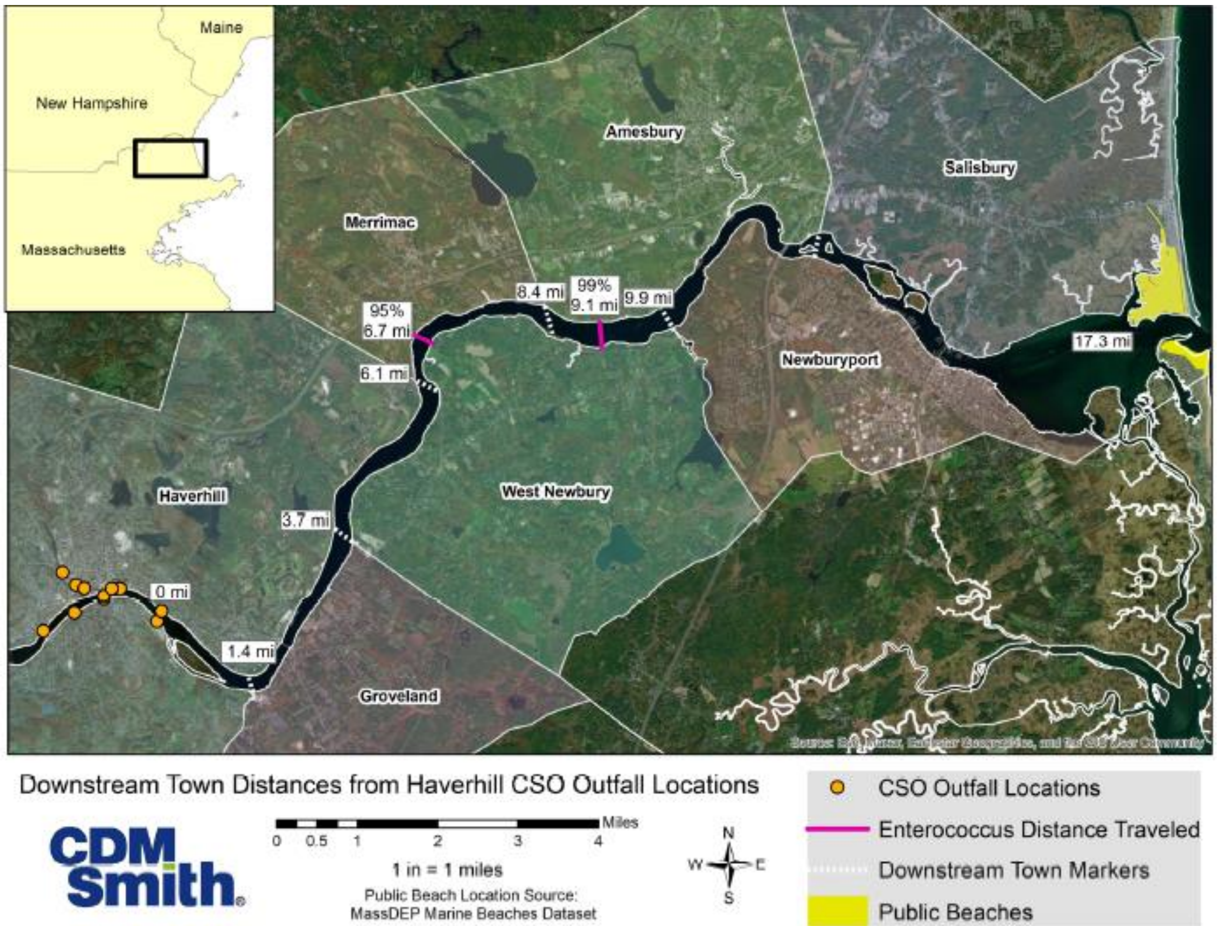


Figure 7. Mapped impact distances and distances to municipal boundaries downstream of Haverhill.

3.4 CSO Email Notification

The CSO email notification will be a subscriber-based system. Members of the public can subscribe to the notifications on the City's website. Once an individual or organization subscribes, they will begin to receive email notifications when a CSO activates. This email will contain a link to open the CSO map shown above. An email will also be sent providing an eight-hour update if necessary.

This email subscriber list is developed and maintained by City of Haverhill. The notification list will include the email addresses shown in Appendix F: Email Notification List.

The City has develop an automatic email system through a new vender AquaSight. Previous attempts to develop this automatic system were unavailable. Now when a CSO event occurs the email heading starts with "**SAMI".** The City will send an introductory email notifying that the City has switch to a new email system. If you receive an email with the subject line "SAMI" this is from the City of Haverhill. This email will occur after DEP reviews and accepts this revised CSO Public Notification.

Once FAS's meters are activated, indicating that a CSO is occurring, an email will be sent from FAS's system to the AquaSight email account. City staff will investigate the overflow and send out a notification within two hours of a confirmed discovery. Below is a sample of the notification:

City of Haverhill

Wastewater Division

Combined Sewer Overflow Notification

This email is to notify you the City of Haverhill has experienced a combined sewer overflow (CSO) activation from one or more of its CSO regulators. For more information about this CSO activation, click CSO map.

CSO discharges consist, or likely consist, of untreated or partially treated sewage and waste. Public health officials recommend avoiding contact with water bodies during rainstorms and for 48 hours afterward, as there may be increased health risks due to bacteria or other pollutants associated with urban stormwater runoff or discharges of untreated or partially treated wastewater.

For additional information about CSOs and Haverhill's CSO Abatement Program, click combined sewer overflows.

To unsubscribe from these alerts, click unsubscribe.

This email is system generated. Please do not reply.

There will be one notification sent for each rainstorm that causes a CSO activation. Since many CSOs intermittently discharge, the first activation will trigger the email notification. Subscribers can view the website at any time to find the status of the 13 CSO outfalls. In the rare event that a CSO lasts for more than eight (8) hours, an update email will be sent. Each email notification will have a link to the City's website with access to the live CSO map.

3.5 SSO Email Notification

SSO events are most commonly communicated to WWTP staff by the public, through phone calls, emails, or the City's 311 Alert System. When Collection System Staff confirm a SSO occurrence, he/she will contact their immediate supervisor. For any SSO that meets the requirements of 314 CMR 16.03, the WWTP supervisory staff member is responsible for sending a notification to the subscriber list (Appendix F: Email Notification List) that includes:

- Mass DEP Sanitary Sewer Overflow (SSO)/Bypass Notification Form
- GIS Map showing the location of the SSO/Bypass
- CMMS Work Order

Any SSO that does not meet the requirements of 314 CMR 16.03 will be emailed to the recipients shown in Appendix G: SSO Email Notification List.

Section 4 – Discovery and Notification

As required by 314 CMR 16.04 (5) (a), (b) & (c), a permittee must "discover" a discharge or overflow event within the following required timelines. The City of Haverhill collection system staff is scheduled to work from 7:00 am to 3:00 pm Monday through Friday (forty hours per week).

314 CMR 16.04(5)(a) states: "In no event shall a permittee spend longer than four hours to confirm a discharge, commencing from the time a communication is sent by a meter deployment, if the permittee does not have operational staff on site 24 hours per day, seven days per week." The following describes how the City will adopt the discovery and notification process of SSOs and CSOs.

4.1 CSO Outfalls

FAS uses a continuous wave area-velocity flow monitor. These measure flow velocity and flow area simultaneously. Flow area is derived from the level of flow above a weir. This is measured with a microprocessor-based level sensor that reduces drift. The level sensor has the added advantage of measuring surcharge levels. FAS's rigorous measurement and calibration on installation as well as required maintenance provides the City with high quality flow data.

The data collected is used to build Haverhill's CSO activation Map. False activations are relatively uncommon but do occur each year. The WWTP staff will work to retract any false activations within **48 hours** of public notice. Because the flow meters are monitored by a third-party contractor, some retractions may occur up to **72 hours** after the false activation.

4.4.1 Future CSO Notifications

Full Automation of CSO notification has proven to be challenging. Currently, the City is bringing all CSO data into its SCADA Historian. Data from Historian will be used by the City's Artificial Intelligence Software, Apollo, to maintain an email subscriber list and send public notifications in real time. The software will have built in logic to help eliminate false activations.

It is the City's intent to further evaluate the feasibility of developing this software to include automated reporting and live CSO analytics. CSO Analytics can be used to trend overflows and may provide City personnel with advanced notice of problems, allowing the city to perform preventative maintenance tasks that could stop a CSO from occurring.

4.2 SSO Discharge

When WWTP staff receives an alert of a potential SSO, Collection system staff are deployed to determine if there is a public health threat. If it is determined that there is an SSO discharge to receiving waters with the potential to affect public health, the collection system operator will notify his/her immediate supervisor. This will be as soon as possible, but no later than four hours from the initial alert. If the collection system staff is unable to determine an SSO has occurred, then he/she will assume it has. The supervisor will send out a public notification to the subscribers list (Appendix F: Email Notification List) as soon as possible, but no later than two hours after confirmation from his/her staff.

4.3 Partially Treated Wastewater

In 2006, the City of Haverhill installed secondary treatment bypass facilities, designed to provide the controlled diversion, disinfection, sampling and monitoring of up to 45 mgd (peak hourly flow). The bypass chamber is comprised of an isolation gate, modulating weir, chlorine diffuser, sample pump, and a Parshall flume for flow monitoring via SCADA. This system is to be operated only during wet weather events and flow to the secondary system must be maximized. The Operations Staff rely on the WWTP's high flow management plan to determine the need for secondary bypasses (Appendix H: High Flow Management Plan). The bypass has been activated on one occasion since September of 2017 totaling 0.04 mgd.

WWTP staff initiates a bypass when no other options exist, triggering an Alarm from SCADA. The city utilizes TopView, a notification engine, to send SCADA alarms to WWTP supervisory staff. In the event of a bypass notification, the supervisor will send an email to the subscribers list in Appendix F: Email Notification List.

Although there is very little bypass data over the last five years, the blended discharge is expected to meet effluent limits for Haverhill's NPDES Permit. The single event in September of 2017 met all NPDES discharge limits. The City will continue to collect data related to blended wastewater events and update this plan as necessary. A GIS map of the blended wastewater discharge location is available in appendix L.

Section 5 – CSO Permittee Website

The City, in conjunction with FAS, will continue to maintain the CSO page on its website. The city will make improvements as necessary to continue to provide the public with high quality overflow data.

The City will update CSO discharge data each month within fifteen days of the final day of the month. CSO Annual reports are also available on the City's website, which include information on the locations of the City's CSOs, a summary of CSO activations and volumes, status and progress of CSO abatement work, and contacts for additional information on CSOs and water quality. The website will include links to websites providing information on the closure or advisory status of shellfish growing areas, bathing beaches, or other water resource areas potentially affected by the discharge or overflow. The website will also provide important information to the public including, but not limited to:

- Summary of SSO's in the city over the last calendar year
- Information related to blended or partially treated wastewater
- Information on CSOs and their affects to public health
- Consent Decree Reports
- Haverhill's Final Long Term Control Plan
- NPDES Discharge Permit

Section 6 – Signage

The City installed and maintains identification signs at or near all CSO outfall locations. The signs are easily readable by the public from the land and water. The signs are shown below:

The City will install signage (appendix J), provided we have permission and confirm access to the river, at the following public locations within Haverhill:

Haverhill, MA	BL	Abbots Marina Service	Located
	BL	Riverrest Park	Located
	CL, F, P, SF	Riverside Park	Located
	P, F, SF	Riveredge Park	Located
	BL	Lighthouse Landing Marina	Located
	BL	Kazmiera Marina	Located
	BL	Crescent Yacht Club	Located
	CL, F	City Landing at Rock's Village	Located

Notes: BL= boat launch, CL= canoe launch, F= fishing, H= hiking, C= camping, XC= skiing, S= swimming. P= picnicking, SF=sport facilities, K- kayaking

Each sign at a public access point shall identify:

- the existence of the outfall;
- the permittee;
- a link to information about weather events that may cause a discharge;
- a warning of the potential threat to public health by recreating in, or using waters and shores affected by a discharge; and
- a link for information on how to subscribe to notifications about discharges in local area waters.

Haverhill has eight (8) sign locations. This is included in Appendix I CSO Public Sign Locations, with all locations on a GIS map.

6.1 Downstream Sign Locations

The City, using "*Merrimack River Watershed Assessment Study Description of Existing Conditions*" click here , identified the following potential sign location from table 4-7. Table 4-7 shows there are no public swimming locations on the Merrimack River from Haverhill downstream to the Atlantic Ocean. The City has met with most downstream communities to confirm these locations. Not all downstream communities have responded to our attempts to identify all potential locations. The city will provide signs (appendix J), and materials to install signage at each location. Signs will measure 8" X 12" at a minimum. Sign posts will provide downstream Boards of Health with enough space to attach a notice, if that is the method of notification they choose. The City will coordinate with downstream communities to install signs on confirmed locations before May 26, 2023.

Table 4.7: Recreational Facilities Along the Lower Merrimack River

Community	Activities Offered	Facility
Haverhill, MA	BL	Abbots Marina Service
	BL	Riverrest Park
	CL, F, P, SF	Riverside Park
	P, F, SF	Riveredge Park
	BL	Lighthouse Landing Marina
	BL	Kazmiera Marina
	BL	Crescent Yacht Club

	CL, F	City Landing at Rock's Village
Groveland, MA	P, SF SF BL, CL, P, SF F, SF	Elm Park Shanahan Field The Pines Pentucket Middle School
Merrimac, MA	CL, F, P CL, F, P	Locust St. Landing Duck landing
Merrimackport, MA	CL, F, P BL	Waterfront Park Wallace Bros Boat Co.
West Newbury, MA	F, H, SF BL, CL, F, P F, H, P, SF F, H, P	Pentucket High School Rock's Village Landing Page School

Notes: BL= boat launch, CL= canoe launch, F= fishing, H= hiking, C= camping, XC= skiing, S= swimming. P= picnicking, SF=sport facilities, K- kayaking

The City has not performed an affected area study of its CSO outfalls. If allowed by MassDEP in other CSO Communities, the city reserves the right to update this report and affected locations downstream of its CSO outfalls.

Section 7 – Public Notification Recipients

Media Outlets

The City of Haverhill Wastewater Division has connected with North of Boston Media group to obtain contacts for public notifications. North of Boston Media group encompasses several media outlets, including the Haverhill Gazette and Eagle Tribune. They also maintain several North Shore magazines and websites available to the public. Their contacts are below and can be found in Appendix F Email Notification List:

- Dave Shultz - Haverhill Advertising Manager: dshultz@eagletribune.com
- Mike LaBella Haverhill Reporter: mlabella@northofboston.com
- Tracey Rauh North of Boston Media Editor: trauh@northofboston.com

Electronic Submittal Required Contacts

The public advisory notification, and any updates required by 314 CMR 16.04(7) and (8), shall be issued electronically to the parties listed in Appendix F: Email Notification List. The Following Recipients are included in the Notification List:

- The Massachusetts Department of Environmental Protection
- the U.S. Environmental Protection Agency;
- the Massachusetts Department of Public Health;
- the municipal board of health or the health department where the outfall or overflow is located;

- the board of health or the health department and shellfish constables (if applicable) for any municipality directly impacted by the discharge or overflow;
- any person who subscribed to receive such public advisory notifications by email;
- the Massachusetts Division of Marine Fisheries where shellfish growing areas may be affected;
- the Massachusetts Department of Conservation and Recreation when its water recreation properties may be affected;
- the Massachusetts Division of Fisheries and Wildlife when its boat ramps and fishing piers may be affected;
- Operators of any potentially affected bathing beaches, as defined in 105 CMR 445.00: *Minimum Standards for Bathing Beaches (State Sanitary Code: Chapter VII)*.

Section 8 – Detection Method Maintenance

As described above in section 4.1, FAS uses a continuous wave area-velocity flow monitor. These measure flow velocity and flow area simultaneously. Flow area is derived from the level of flow above a weir. This is measured with a microprocessor-based level sensor that reduces drift. The level sensor has the added advantage of measuring surcharge levels. FAS's rigorous measurement and calibration on installation as well as required maintenance provides the City with high quality flow data. FAS is solely responsible for the maintenance of their meters. City staff will alert FAS to any problems that arise

At the upper and lower siphon gate structures, City staff routinely exercise the gates and use SCADA to monitor levels for abnormalities. Collections staff is deployed upon recognition of any potential problems.

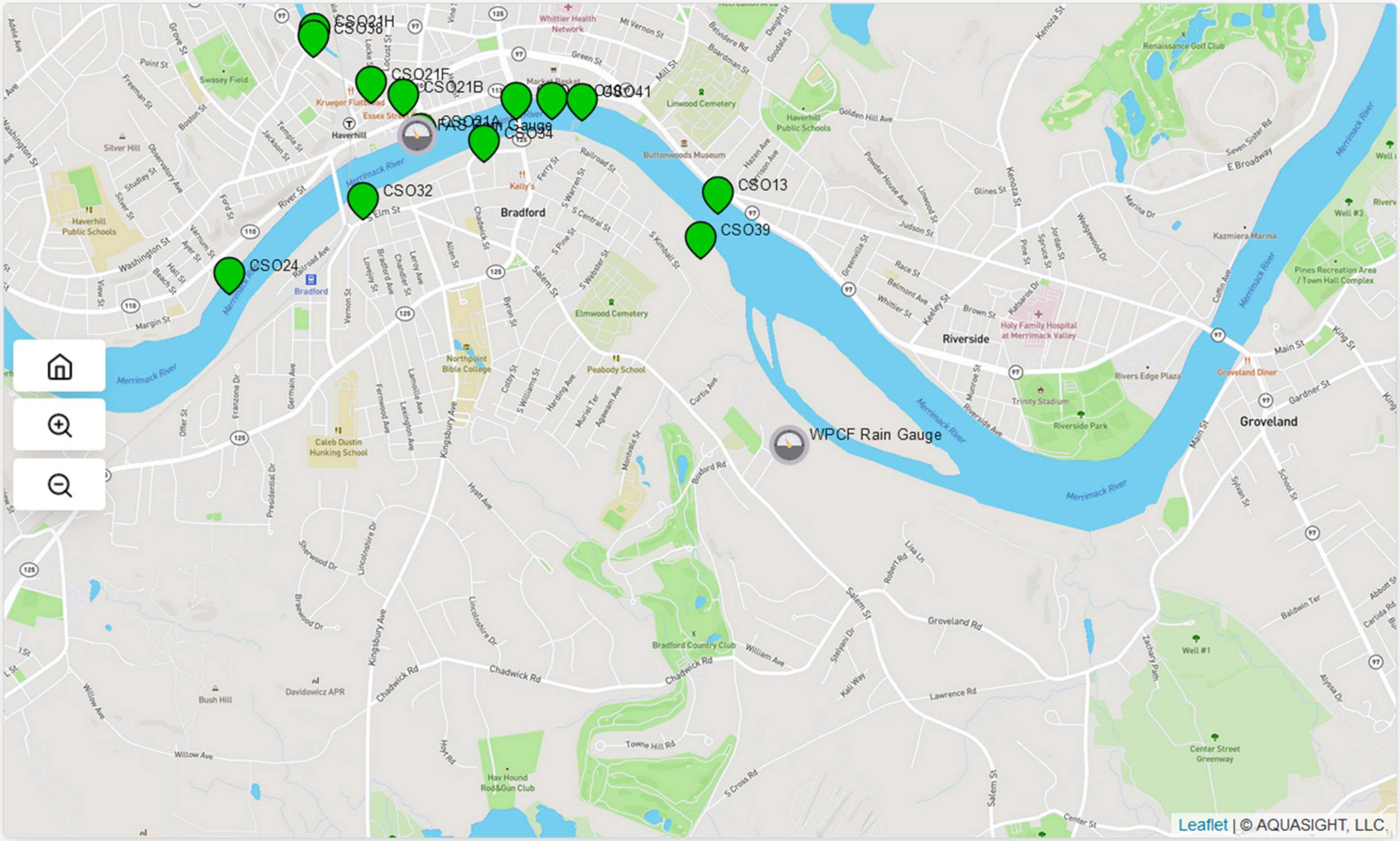
Section 9 – Public Notice

Before January 12, 2023, the city will submit a public notice to the Environmental Monitor at MEPA@mass.gov. The Public Notice will also appear in the Eagle Tribune before January 25, 2023. The public notice announcement is available in Appendix K. A link to the Final plan will be included in the public notice with instructions on how to comment.

APPENDIX A

CSO Notifications

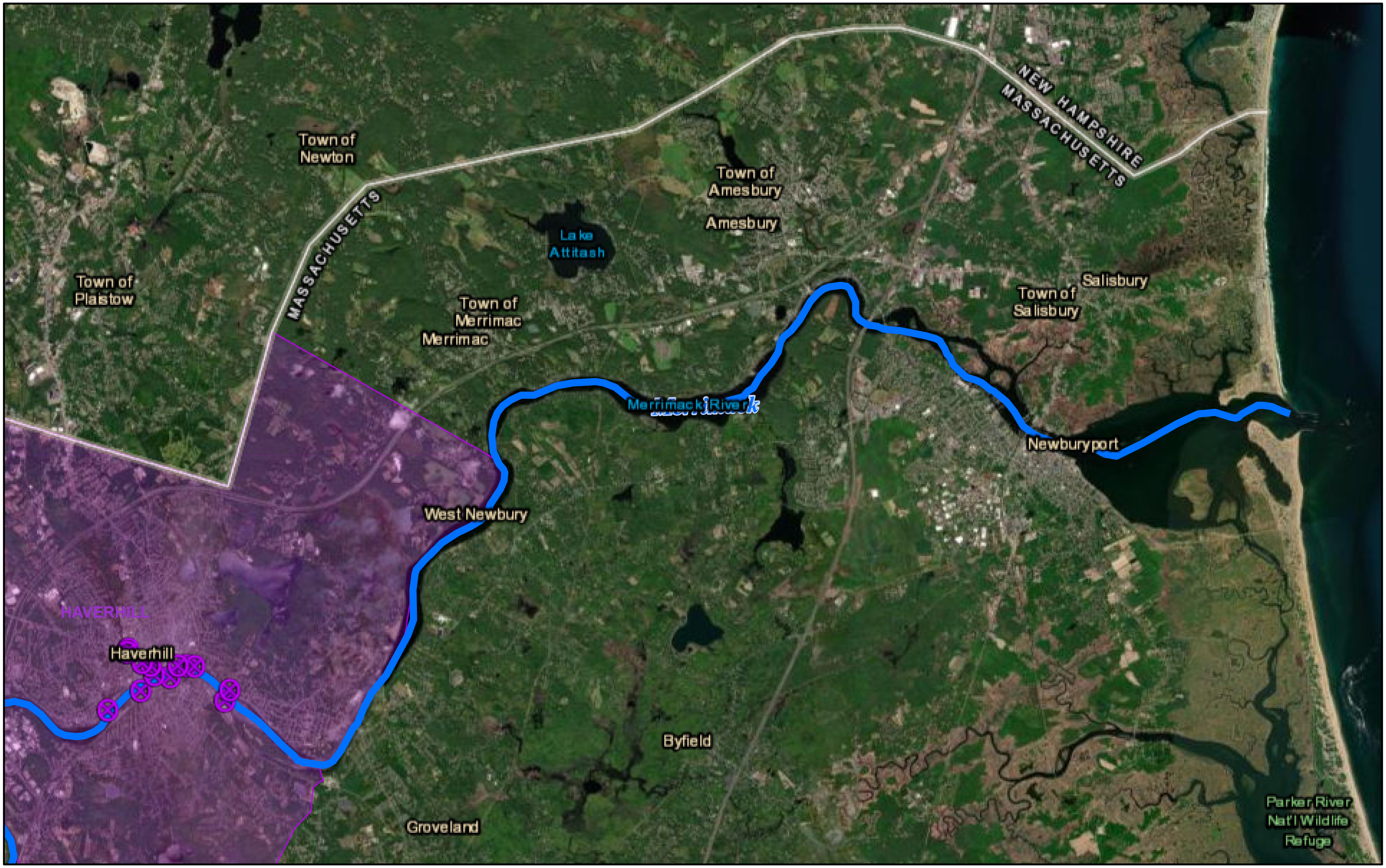
Dark Mode



No Overflow in Last 48 Hours | Overflow in Last 48 Hours | Overflow Occurring | Data Not Received | Rain Gauge Not Monitored

APPENDIX B

ArcGIS Web Map



1/21/2022, 10:33:31 AM

Merrimack Watershed Combined Sewer Overflows (CSOs)

Merrimack R. and Major Tributaries

Merrimack River

Communities Drinking from Merrimack

Merrimack Watershed Communities with Combined Sewers

1:144,448

0 0.75 1.5 3 mi

0 1.25 2.5 5 km

Esri, HERE, Garmin, Earthstar Geographics

ArcGIS Web AppBuilder

Earthstar Geographics | US EPA | US Environment Protection Agency | Esri, HERE, Garmin |

APPENDIX C

MarineFisheries
Commonwealth of Massachusetts

Massachusetts
Division of Marine Fisheries

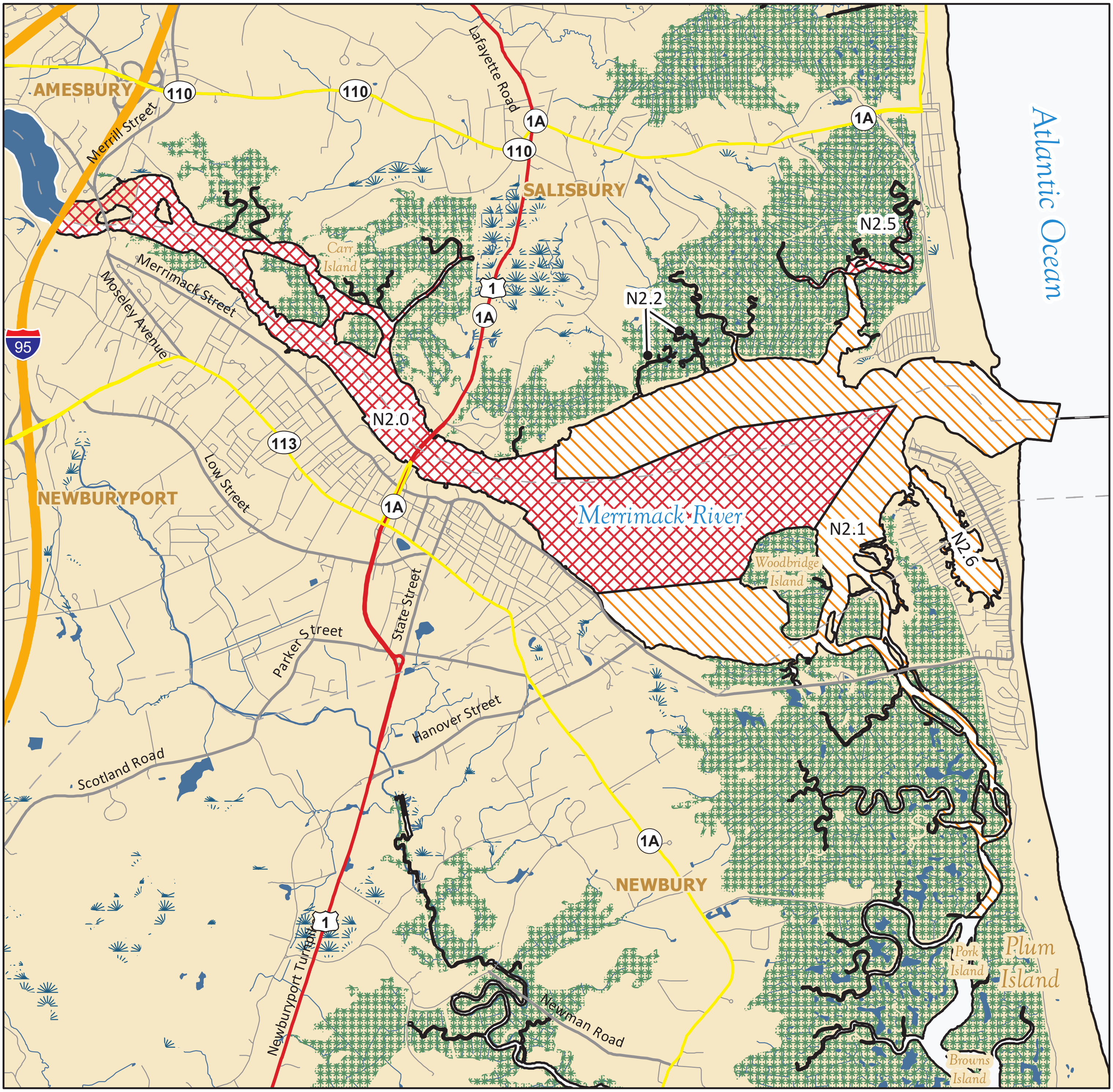
SHELLFISH SANITATION AND MANAGEMENT

Growing Area Code: N2
Area Name: MERRIMACK RIVER
Area Town(s): Amesbury, Newbury, Newburyport, Salisbury

Shellfish Area Classification

- Approved
- Conditionally Approved
- Restricted
- Conditionally Restricted
- Prohibited

Produced: 6/7/2021



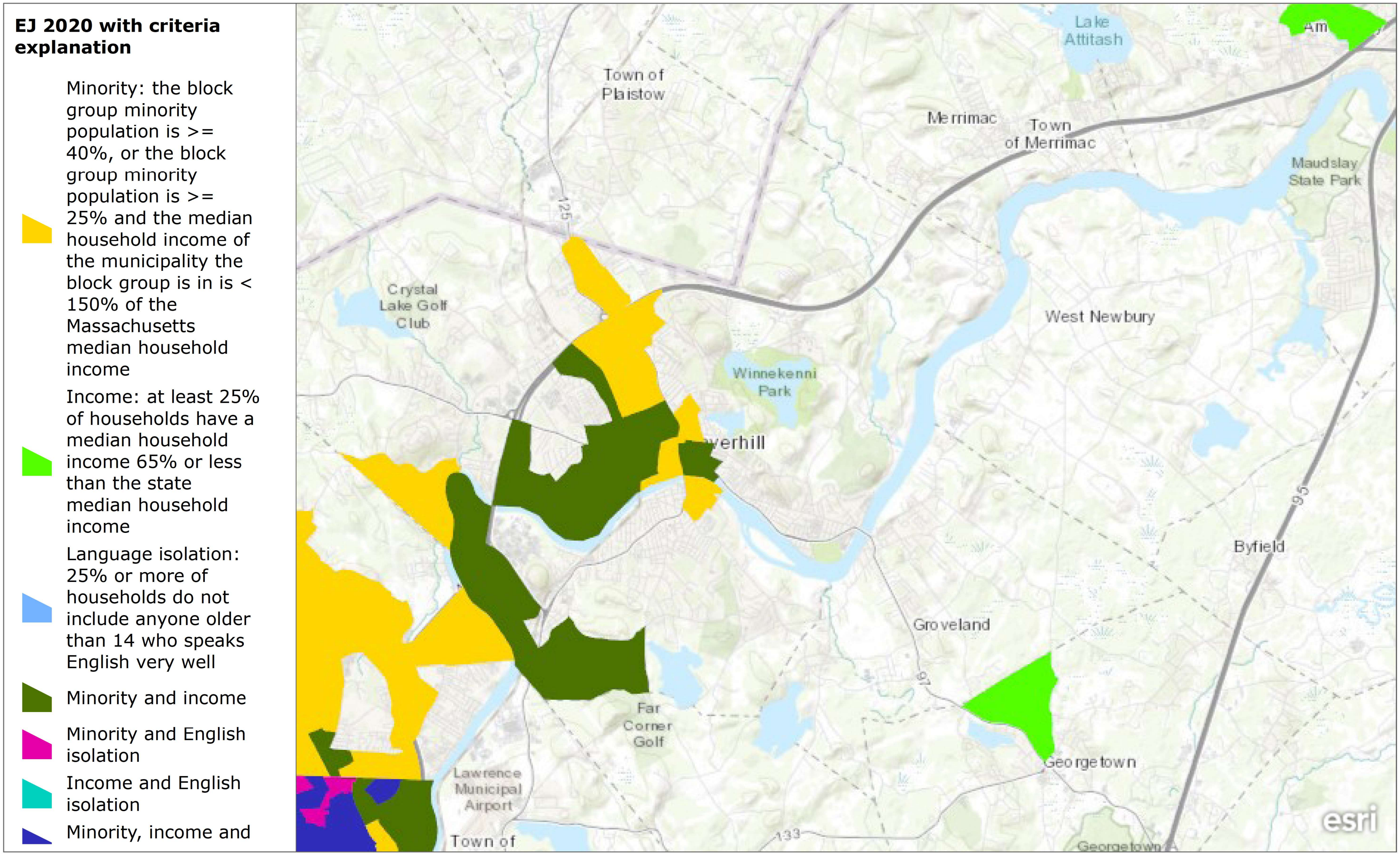
This map depicts the MarineFisheries' sanitary classification of shellfish growing waters in accordance with the National Shellfish Sanitation Program. It does not indicate the current status, either "open" or "closed" to harvesting due to shellfish management or public health reasons. Always confirm the status with local authorities and/or MarineFisheries. Information on this map may be out-dated or otherwise incorrect, and should not be relied upon for legal purposes.

Marsh/Wetland — Saltmarsh — Pond/Lake/Reservoir — Town Boundaries — Stream/Ditch/Canal

NORTH — 0 — 0.5 — 1 miles

APPENDIX D

EJ 2020 with criteria explanation



Environmental Justice neighborhood, i.e., block groups are defined in Chapter 8 of the Acts of 2021: "Environmental justice population", a neighborhood that meets 1 or more of the following criteria: (i) the annual median household income is not more than 65 per cent of the statewide annual median household income; (ii) minorities comprise 40 per cent or more of the population; (iii) 25 per cent or more of households lack English language proficiency; or (iv) minorities comprise 25 per cent or more of the population and the annual median household income of the municipality in which the neighborhood is located does not exceed 150 per cent of the statewide annual median household income;"

APPENDIX E

Section 5

Water Quality Objectives

5.1 Introduction

All discharges to the waters within the Commonwealth of Massachusetts should meet the requirements of the federal Clean Water Act (CWA, passed in 1972) and the state's Surface Water Quality Standards (WQS) as described under 314 CMR 4.00. The water quality standards identify the anticipated recreational, fisheries, water supply and other designated uses of the receiving waters and provide numerical (and narrative) standards for key pollutants that should be achieved to maintain these designated uses.

When it rains, pollutant loads from surface water runoff are discharged to receiving waters from both point and non-point sources. Non-point sources are difficult to identify, quantify, and control. However, point source loads - such as stormwater drain outfalls and CSO outfalls – can be located and are more easily characterized. Thus, point source loads receive more regulatory attention. The USEPA regulates these point source discharges via the NPDES permit program. The Haverhill WWTP and CSO outfalls each have a unique NPDES permit number while the city's stormwater outfalls are covered under a blanket general permit as part of the Phase II Stormwater NPDES MS4 program.

Discharges are held to numeric limits in order to maintain the designated uses of the receiving water. If these uses are unattainable, given natural conditions and/or due to existing discharges that cannot be removed, the regulations allow a modification of the receiving water uses. However, the regulatory modification process requires a comprehensive review of alternatives for intermediate pollutant control levels and estimates of costs, and involves the public and interested parties.

Both federal and state agencies recognize that compliance with state quality standards for CSO discharges is costly. Accordingly, both governments have developed separate, but similar, CSO control policies to guide the abatement of CSO discharges given the technical, social, and economic challenges for each community.

This section presents a summary of the federal and state CSO policies, and the water quality standards for the Little River and Merrimack River in Haverhill. The section also includes a summary of existing river water quality data and analyses that provide an understanding of the current status of the rivers with respect to the standards and potential attainment of any impacted designated uses. This information considers the receiving water benefits that could result with the implementation of each of the various CSO control alternatives (developed and analyzed in the proceeding sections).

5.2 USEPA CSO Policy

Under the federal CSO policy, CSO discharges are subject to both the technology-based and water quality based requirements. The CSO Control Policy, issued in April 1994 (see Appendix F), provides the EPA guidance for controlling CSOs. A two-part approach to CSO control is incorporated into the policy: (1) the implementation of best management practices called the Nine Minimum Controls, and (2) the development and implementation of an LTCP provided the implementation of the NMCs are not adequate on their own to meet state water quality standards.

5.2.1 Nine Minimum Controls

The minimum technology-based controls are the nine minimum controls (NMCs). The CSO Control Policy required all communities to implement the NMCs by January 1997.

Haverhill's compliance with the NMCs was detailed in a previous CDM report entitled "City of Haverhill, Massachusetts Wastewater Division Draft Report on Nine Minimum Control Measures for CSOs" dated September 1996.

As part of this LTCP, the City contracted CDM Smith to review its nine minimum controls report and provide an update to the program based on the city's current inspection procedures, system maintenance activities, public notifications, and public educations as it relates to the combined sewer system. This discussion is included in Section 3 of this report.

Nine Minimum Control Measures:

1. Monitoring to characterize CSO impacts and the efficacy of CSO controls.
2. Proper operation and regular maintenance programs for the sewer system and the CSOs
3. Maximum use of the collection system for storage
4. Review and modification of pretreatment requirements to minimize CSO impacts
5. Maximize flow to the POTW for treatment
6. Prohibition of dry-weather CSOs
7. Control of solid and floatable materials in CSOs
8. Pollution prevention programs
9. Public notification of CSO occurrences/impacts.

5.2.2 Long-term Control Plans

The NPDES regulating authority (EPA Region 1 in the case of Haverhill) determines whether the NMCs satisfy the technology-based requirements of the CWA. If further controls are necessary to meet water quality standards, then the NPDES authority will require the development of a Long-Term Control Plan (LTCP).

EPA issued the Draft Guidance On Implementing Water Quality Based Provisions of CSO Control Policy. This document indicates that if the receiving water is on the State's 303(d) list for the development of a total maximum daily load (TMDL), then the TMDL studies and LTCP should be linked, and should include a schedule for WQS reviews. To date, however, only a draft TMDL has been developed for the Merrimack and Little Rivers, and no final TMDL is in place for either receiving water to define all point and non-point sources of pollution.

By the requirements in the Clean Water Act, CSO discharges that remain after implementation of the CSO controls must not interfere with the attainment of state's WQS. Under the CSO Control Policy, communities with combined sewer systems are expected to develop a LTCP to provide for attainment of the water quality and uses over a reasonable period of time.

The EPA CSO Control Policy presents two alternatives to selecting long term control plans for CSO's: the "presumptive approach" and the "demonstrative approach".

5.2.2.1 Presumptive Approach

The "presumptive approach" is based on the presumption that achievement of certain performance criteria will be sufficient to meet current applicable water quality standards. The presumptive approach involves meeting one of the following three criteria:

- No more than an average of 4 overflow events per year;
- Elimination or the capture of no less than 85% by volume of the combined sewage collected in the combined sewer system during precipitation events on a system-wide annual average basis; or
- Elimination or removal of no less than the mass of pollutants identified as causing water quality standards impairment.

As part of the presumptive approach, there must also be sufficient information available to indicate that these levels of control can reasonably be expected to meet the state water quality standards. Communities following the presumption approach are also expected to conduct post LTCP monitoring to show that water quality standards are being met. If a community is at no more than 4 overflows per year or captures 85% of their flow, and instream water quality standards are still being exceeded, then further CSO controls are needed.

Haverhill still has CSO activations that exceed 4 times per year but the existing system does capture 98 percent of the wet weather generated by the combined sewer system.

5.2.2.2 Demonstrative Approach

The demonstrative approach (that favored by DEP and EPA Region I for Haverhill) was developed to address instances where compliance with the presumptive approach would result in greater investments in control than necessary to achieve water quality standards. Under the demonstrative approach, communities collect and present data in the LTCP that is sufficient to show that the proposed control alternative is adequate to meet appropriate state water quality standards. The CSO Control Policy lays out four criteria for successful use of the "demonstrative approach." A LTCP should show that the:

- CSO control program will protect water quality standards unless the standard cannot be met as a result of natural conditions or other pollution sources;
- Overflows remaining after implementation of the control program will not prevent the attainment of water quality standards;
- Planned control program will achieve the maximum pollution reduction benefits reasonably attainable; and
- Planned control program is designed to allow cost effective expansion or cost effective retrofitting if additional controls are subsequently determined to be necessary to meet water quality standards.

- When water quality standards cannot be met because of natural conditions or other pollution sources, a TMDL or other means should be used to apportion pollutant loads within the watershed.

5.3 Massachusetts Policy for Abatement of CSOs

In August of 1997, the Commonwealth issued its own CSO Control policy (see Appendix G). This policy is similar to the EPA policy in many ways, but also has several significant differences.

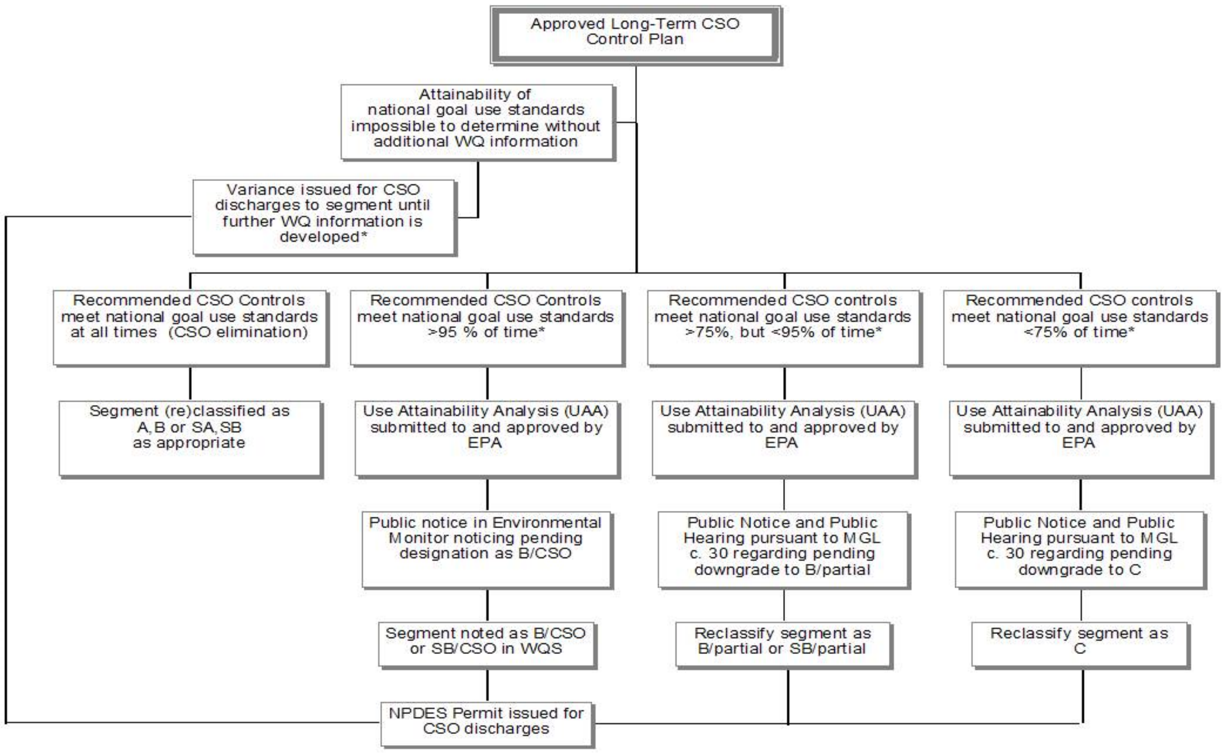
States are required to develop water quality standards applicable to their water bodies. While EPA reviews and approves these standards, the establishment of the standard is the responsibility of the state. In Massachusetts, any NPDES permit for a CSO discharge must comply with Massachusetts Surface Water Quality Standards (314 CMR 4.00). Massachusetts has chosen to designate all waters in the state as fishable and swimmable. For freshwater, all water bodies were originally designated as either Class A (drinking water source) or Class B (swimmable). For marine waters, all water bodies are either Class SA (shellfish) or Class SB (shellfish restricted).

Massachusetts' regulatory options for CSO control are implemented through different water body classifications, as follows:

- Class B or SB – No discharges are allowed that impact WQS (such as untreated CSO dischargers).
- Class B (CSO) - CSOs may remain but must be compatible with water quality goals of the receiving water. The water body must meet uses more than 95 percent of the time. DEP considers 4 overflows events per outfall per year as satisfying the 95 percent time period. Two water bodies in the state have been re-classified as B(CSO).
- Variance - CSOs may remain under a short-term modification of water quality standards. Currently, portions of the Charles River have a variance while studies are underway to determine the final designation. Also, GLSD located a few towns upstream of Haverhill, requested a variance as part of their Phase II CSO LTCP.
- Partial Use Designation - CSOs may remain with moderate impacts resulting in impairment of water quality goals. Moderate impacts are defined as short-term impairments and water quality standards would be met 75 percent of the time.
- Class C - Where the State is certain that the CSOs will prevent the attainment of national use goals more than 75 percent of the time, the water body is classified as Class C.

Under the Massachusetts program, one permanent solution to CSO control, besides river reclassification to BCSO of the water body, is the complete elimination of the CSO discharge. This has usually been interpreted to mean almost complete separation of the combined sewer system, even though there is strong evidence to suggest that untreated stormwater created by separation may itself cause exceedances of the water quality standards.

The permittees must go through a number of technical and procedural steps to permanently reclassify the receiving water, or to provide temporary modifications to the classification. The steps associated with this process are included in Figure 5-1. The procedural steps involve the notice of proposed changes in the Environmental Monitor, and the conduct of various public meetings and hearings and the official publication of the reclassification of the State's Water Quality Standards Regulations.



*One of the criteria of 314 CMR 4.03(4) must be met

Figure 5-1 CSO Controls – WQS Coordination

Underlying these procedural steps are supporting technical analyses that show that fully achieving the designated Class B uses everywhere all the time is not attainable. The studies are generally called Use Attainability Analyses (UAA). In order to permanently reclassify the receiving waters, the UAA must show that one of the following conditions exist:

1. Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or
2. Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in a way that would result in the attainment of the use; or
3. Naturally occurring pollutant concentrations prevent the attainment of the use; or

4. Natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating state water conservation requirements to enable uses to be met; or

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

6. Controls more stringent than those required by sections 310(b) and 306 of the Act would result in substantial and widespread economic and social impact.

According to DEP policies, the justification for a variance, which are temporary rather than permanent suspensions of the designated uses, involve the same substantive requirements as a change in use although the evaluation needed are less rigorous. As discussed later in this report, reasons 1 and 2 stated above may be applicable to the Merrimack and Little Rivers, respectively, and may warrant a variance from their intended uses.

5.4 River Classification and Uses

5.4.1 Classification

All water bodies, streams, rivers, ponds, lakes, and coastal areas in the state are classified in the Massachusetts Surface WQS 314 CMR 4.00 (December 2013). These standards designate uses of the waters such as water supply or shellfishing. To protect the designated uses, the MADEP prescribes the minimum water quality criteria required to sustain the designated uses.

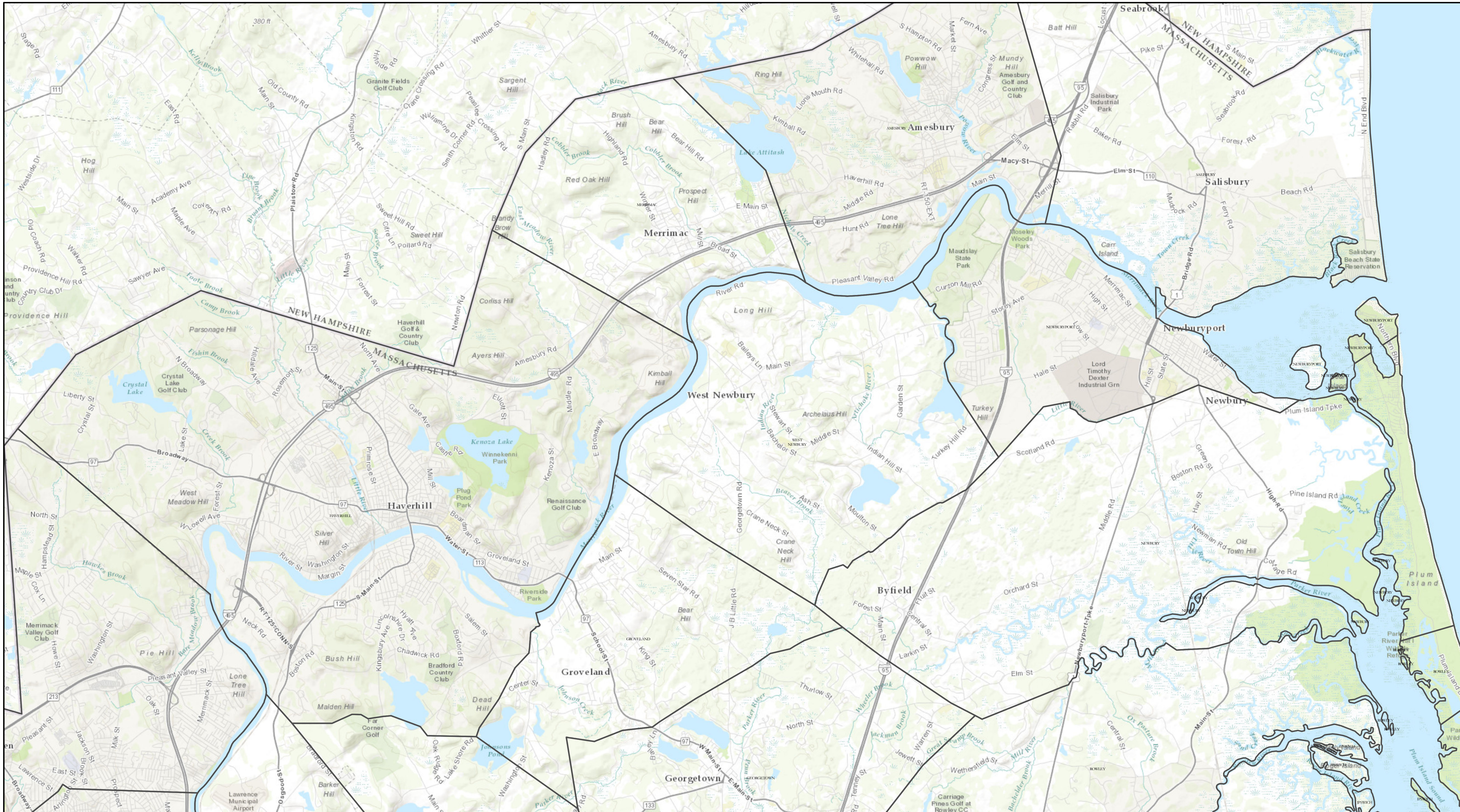
The Merrimack River from the Route 495 bridge to the Atlantic Ocean at Salisbury and the lower segment of the Little River, from the state line, are the receiving waters for this study, see Figure 5-2.

The lower segment of the Little River is Class B defined as:

> *Class B - These waters are designated as a habitat for fish, other aquatic life, and wildlife, including for their reproduction, migration, growth and other critical functions, and for primary and secondary contact recreation. Where designated in 314 CMR 4.06, they shall be suitable as a source of public water supply with appropriate treatment ("Treated Water Supply"). Class B waters shall be suitable for irrigation and other agricultural uses and for compatible industrial cooling and process uses. These waters shall have consistently good aesthetic value.*

The Little River uses are qualified as warm water fisheries.

The Merrimack River is Class B from the Haverhill city line to the Little River. From the Little River to the coast, the Merrimack River is Class SB. The SB designation is for marine waters; the lower segment of the Merrimack is influenced by ocean tides. Uses designated for Class SB waters in the state include:



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City of Haverhill, Massachusetts
Integrated Final CSO Long-Term Control Plan
February 2017

Haverhill CSO Receiving Waters
Figure 5-2

Class SB - These waters are designated as a habitat for fish, other aquatic life and wildlife, including for their reproduction, migration, growth and other critical functions, and for primary and secondary contact recreation. In certain waters, habitat for fish, other aquatic life and wildlife may include, but is not limited to, seagrass. Where designated in the tables to 314 CMR 4.00 for shellfishing, these waters shall be suitable for shellfish harvesting with depuration (Restricted and Conditionally Restricted Shellfish Areas). These waters shall have consistently good aesthetic value.

The Merrimack River uses are qualified as warm water fisheries in the Class B portion of the river and for shellfishing in the SB portion of the River. However, the Merrimack River from Haverhill to Amesbury has very low salinity and does not support existing or potential shellfishing use in the Haverhill reach under Class SB.

5.4.2 Uses and Supporting WQS

There are four major categories of potential uses of the Class B and SB rivers in Haverhill – aesthetics; habitat for fish, wildlife, and aquatic life; primary (swimming) and secondary (boating) contact recreation; and water supply.

Aesthetics

The aesthetics of the river are an important asset to Haverhill. The city has urban renewal projects that focus on land adjacent to the river bank. The riverfront is also the setting for several city parks, and a future river walk and trail system that will be incorporated in the Heritage Trail system.

These state WQS indicate that the waters should be free from color and turbidity and floating, suspended, and settleable solids in concentrations or combinations that are aesthetically objectionable or would impair any use assigned to this class. Oil, grease and petrochemicals that produce a visible film on the surface of the water or impact aquatic life are also prohibited.

Fishing

State and local parks provide public access for fishing. The Haverhill City River Park and Maudslay State Park (in Newbury) provide access for fishing. Additionally, numerous direct access points to the river bank and boat fishing is available. Freshwater species caught include Smallmouth Bass, Bullhead Catfish, and White Perch. The Merrimack River is also an anadromous fish run. The fish include River Herring, American Shad, and Atlantic salmon as the three main species, but also the Sea Lamprey, American Eel, and Stripe Bass. For the most recent reported year, in 2016, 417,240 River Herring, 67,528 American Shad, and 6 Atlantic salmon passed the fish lift at the Essex Dam in Lawrence. (Fish and Wildlife Service, 2016)

WQS indicate that waters shall have a temperature not to exceed 68^{o} F (20^{o} C) for cold-water fisheries and 83^{o} F (28.3^{o} C) for warm-water fisheries. Dissolved oxygen levels must also be maintained at 6.0 milligrams per liter (mg/l) for cold-water fisheries and at 5.0 mg/l for warm-water fisheries. Solids and oils and grease should be minimized to avoid benthic loadings along the river bottom, deleterious effects to aquatic organisms, and tainting or undesirable taste in edible portions of fish.

The Massachusetts Department of Public Health has issued a Freshwater Fish Advisory for mercury for the Merrimack River from above the Essex Dam in Lawrence to the state line in Tyngsborough. However, there are no reported issues based on these standards affecting fish and there are no fish advisories that exist in this project's study area, which is below the Route 495 bridge upstream of Haverhill to the ocean. The Merrimack River meets the fishing use for the section in Haverhill.

Fishing is not possible on the downstream portion of the Little River because the stream is shallow, narrow and enclosed in a concrete culvert.

Shellfishing

The Merrimack River below the Route 95 Bridge in Newburyport and Salisbury is a designated shellfish area, but the area has been closed for more than 20 years because of high bacteria counts. In March 2006, the Massachusetts Division of Marine Fisheries announced the re-classification and re-opening of the Merrimack River shellfish flats in Newburyport and Salisbury to the conditional harvesting of soft-shell clams.

Water quality testing by Marine Fisheries confirmed the river meets moderately contaminated criteria during dry weather, for a Conditionally Restricted classification. Marine Fisheries sampling also demonstrated that rainfall causes intermittent and predictable periods of bacteria counts above thresholds levels.

Consequently, only specially licensed Master and Subordinate diggers may harvest soft-shell clams for depuration (purification) at Marine Fisheries' Shellfish Purification Plant at Plum Island Point, Newburyport. At the Shellfish Plant, clams are purged of bacteria in clean seawater in a controlled, strictly monitored, process for two to three days until safe to eat. No recreational harvesting is allowed in these areas.

The sources of the bacteria are thought to be upstream untreated river discharges (CSOs, stormwater and non-point sources) and local non-point sources. Also, the area within the influence of the Newburyport wastewater treatment facility and Amesbury wastewater treatment facility remains closed to shellfishing.

Swimming

Currently, there are no designated swimming areas on the lower Little River or along the Merrimack River within and downstream of Haverhill. Swimming is not possible on the lower segment of the Little River because the stream is narrow and shallow and, in its last reach, enclosed in a concrete culvert. The Salisbury Beach State Reservation and beaches on Plum Island are located on the ocean at the mouth of the Merrimack River. Public access to the Merrimack River is available through several state and local parks.

Bacteria are used as an indicator to identify the potential health risks to swimmers. Under the WQS, no single E. coli sample shall exceed 235 colonies per 100 milliliters.

Boating

Boating, kayaking, canoeing, jet skiing, water skiing, and sail boarding are popular activities on the lower Merrimack River. Boat launches are available at Haverhill City River Park and numerous marinas in Amesbury, Newbury, and Newburyport. Boating is not possible on the Little River because the stream is shallow, narrow and enclosed in a concrete culvert. Bacteria in the river can impact secondary recreation.

Water Supply

There are no municipal water withdrawals for drinking water along the Little River or the Merrimack River through and below Haverhill. The city of Haverhill is in the initial stages of considering a new supply, which may include a new water withdrawal from the Merrimack River but, would not be a direct intake from the Merrimack River. Haverhill does not have a definite plan at this current time.

5.4.3 Status of River Water Quality

Section 303(d) of the CWA requires each state to periodically review and identify those waterbodies that are not expected to meet surface water quality standards after the implementation of technology-based controls. Water bodies and uses that are impaired by water quality issues are included on the 303(d) list, which is also referred to as the Integrated List of Waters. The CWA requires that states develop a total maximum daily loads (TMDL) assessment to determine what pollutant loads are acceptable to maintain water quality standards and/or receiving water uses.

Both the Little River and the Merrimack River are on the 2014 303(d) list, the latest list available. Table 5-1 presents the information from the state's 303(d) list. The list does not identify the source of the impairment.

Table 5-1 Water Quality Impaired Segments

River	River Segment	Size	Impairment Cause
Little River	New Hampshire state line, Haverhill to confluence with Merrimack River, Haverhill.	4.6 Miles	(Debris/Floatables/Trash*), (Habitat Assessment (Streams)*) and Escherichia coli
Merrimack River	Essex Dam, Lawrence to confluence with Little River, Haverhill.	10 Miles	Escherichia coli, PCB in Fish Tissue and Phosphorus (Total)
Merrimack River	Confluence Little River, Haverhill to confluence Indian River, West Newbury/Amesbury.	1.83 Sq. Miles	Enterococcus and PCB in Fish Tissue
Merrimack River	Confluence Indian River, West Newbury/Amesbury to mouth at Atlantic Ocean, Newburyport/Salisbury	4.46 Sq. Miles	Enterococcus, Fecal Coliform and PCB in Fish Tissue
Merrimack River	The Basin in the Merrimack River Estuary, Newbury/Newburyport.	0.17 Sq. Miles	Fecal Coliform

* TMDL not required (Non-Pollutant)
Source: Massachusetts Year 2014 Integrated List of Waters

In 2005, MassDEP completed a draft TMDL for pathogens for the Merrimack River and Little River. The draft TMDL found the sources of bacteria in the Merrimack River watershed were many and varied. Most of the bacteria sources are believed to be stormwater related, but also included failing septic systems, CSOs, sanitary sewer overflows (SSO), sewer pipes connected to storm drains, certain recreational activities, wildlife including birds along with domestic pets and animals and direct overland storm water runoff.

The draft TMDL could not accurately estimate the existing sources to determine the control approach. For the illicit connections to the stormwater system and/or direct discharges to the river, the goal is complete elimination (100 percent reduction). This should be accomplished through the Phase II NPDES Stormwater program for the municipal separate storm sewer system (MS4s) permittees along the river. The city completed dry-weather stormwater outfall inspections and flow sampling in 2014/2015 in compliance with the 2003 NPDES MS4 Stormwater Permit and is now working to identify any potential illicit connections in the stormwater system.

For wet weather conditions, target bacteria load reductions were estimated using typical storm water bacteria concentrations. This analysis indicated that a pollutant load reduction of two to three orders of magnitude (i.e., greater than 90 percent) of stormwater fecal coliform loading would be required to meet the bacteria standard. The draft TMDL determined that the goal should be accomplished through implementation of best management practices, such as those associated with the nine minimum controls and Phase II control program for stormwater.

The draft TMDL proposed a Waste Load Allocation (Limit) for CSO discharges to meet the state WQS. The TMDL targets a discharge with a bacterial level not to exceed a geometric mean of 200 organisms in any set of representative samples and shall not have more than 10 percent of the samples exceed 400 organisms. The state has not issued a final TMDL for the Merrimack River.

5.5 Existing Water Quality Data – Merrimack River Watershed Assessment

General

A comprehensive watershed-based study was undertaken by the CSO communities on the Merrimack River starting in 2002. The effort was jointly funded by the CSO communities and the federal government, through the United States Army Corps of Engineers (USACE) New England District. The five local-community sponsors are Manchester and Nashua, New Hampshire; Lowell and Haverhill, Massachusetts; and the Greater Lawrence Sanitary District (GLSD), Massachusetts. Collectively, these communities formed the Merrimack River Basin CSO Coalition (MRBC).

The overall purpose of the watershed assessment was to develop a comprehensive watershed management plan for the Merrimack River watershed. The plan could be used to guide investments in local environmental resources and infrastructure, with the goal of achieving water quality and flow conditions to support uses such as drinking water supply, recreation, fisheries and aquatic life support.

Water quality and streamflow data were collected for this study and used in the calibration and validation of water quality and hydrologic/hydraulic models. The water quality models were used to determine whether segments of the mainstem of the Merrimack River are likely to meet state water quality standards with discharge improvements.

Additional phases of the Merrimack River Watershed Assessment continue. Several phases of water quality sampling and modeling have been completed. Water quality sampling was completed in August 2016, and water quality modeling of the Lower Merrimack basin is currently in progress and will be completed in fall 2017. The data report for the 2016 sampling and current modeling results are anticipated for submittal later this year. Thus far, no more significant findings or conclusions have been made.

Sampling Program

The monitoring area for Phases I and III of the watershed assessment encompassed the lower portion of the mainstem Merrimack River from Concord, New Hampshire to its estuary in Newburyport, Massachusetts, and also included the mouths of eleven major tributaries adjoining the mainstem. Additional sampling further upstream along three of those major tributaries was also conducted in Phase III to assess any potential nonpoint source impacts to water quality. In total, over sixty mainstem sampling locations and over thirty tributary sampling locations were strategically located in-stream to measure streamflow and/or concentration of dissolved oxygen and pollutants such as bacteria and nutrients. Additionally, locations upstream and downstream of numerous storm drain outfalls and combined sewer overflow (CSO) outfalls were sampled during wet and dry-weather events to monitor contributing pollutant loads from urbanized areas. Note that Phase II of the watershed assessment focused on the Upper Merrimack River in New Hampshire, including the mainstem Merrimack and Pemigewasset Rivers from Lincoln, NH, close to the headwaters and as far south as the Massachusetts state line.

From 2003–2005, three dry-weather surveys and four wet-weather surveys were conducted in the Lower Merrimack. A continuous survey of dissolved oxygen and temperature was also conducted at two locations for a one-month period during low-flow conditions in August and September 2003. Between 2014 and 2016, one dry-weather mainstem survey, one wet-weather mainstem survey, one hybrid dry/wet-weather mainstem survey, and one dry-weather tributary survey were conducted in the Lower Merrimack.

The following conclusions were drawn from the water-quality surveys (2016 results pending):

- The mainstem of the Merrimack River from Manchester to the Atlantic Ocean is impaired with respect to bacteria standards, although many reaches exhibit satisfactory bacteria levels during dry weather.
- Many of the tributaries are impaired with respect to bacteria standards during wet weather, as measured upstream of combined sewer outfalls.
- The mainstem of the Merrimack River from Manchester to the Atlantic Ocean is not impaired with respect to dissolved oxygen standards. Measured and simulated concentrations of dissolved oxygen were always well above the regulatory threshold of 5 mg/l.
- While currently there are no regulatory requirements for nutrient levels in the river waters, levels of nutrients (phosphorus and nitrogen) in rivers can be indicative of the likelihood of excessive in-stream organic production, which can deplete oxygen levels in the water and degrade aquatic habitat quality. Mainstem concentrations of nitrogen and phosphorus exhibited a wide range that is generally thought to be acceptable.
- Levels of chlorophyll-a, another indicator of organic productivity in the water, were generally not excessive in the New Hampshire reaches of the river. Levels in the mainstem

downstream of Lowell ranged as high as 42 μg/L under 7Q10 conditions. Despite these high levels of chlorophyll-a, no impairment of dissolved oxygen was found, indicating that the river can support high levels of algae growth.

Receiving Water Quality Evaluation

One of the objectives of the Merrimack River Watershed Assessment was to complete a comprehensive analysis, using computer models, of the impacts of CSO discharges and point and non-point stormwater discharges to assess the incremental benefits that would be achieved by the complete elimination of all CSO discharges along the Merrimack River.

Model Development

A suite of hydrologic, hydraulic, and water quality models were developed as tools to assist in evaluating and comparing watershed management strategies and in prioritizing potential improvements in the watershed. The goals of the modeling effort were to:

- Simulate the generation of pollutant loads (primarily bacteria and nutrients) throughout the watershed, both from point sources and nonpoint sources.
- Simulate the water quality and flow regimes in the mainstem Merrimack River under dry weather and wet weather conditions.
- Simulate the dynamic nature of storm events as well as seasonal patterns and their effect on water quality and hydraulic conditions in the mainstem Merrimack River.

These goals were achieved by combining the strengths of several different public domain models. Existing models of combined sewer systems developed in USEPA Stormwater Management Model (SWMM) and Modeling of Urban Sewers (MOUSE) for each of the five major CSO communities in the basin were incorporated. Hydrological Simulation Program—Fortran (HSPF) was used to model watershed hydrology and nonpoint source water quality. The HSPF model represents all major tributaries to the Merrimack River, as well as non-point source loads for the basin. The CSO and HSPF flow inputs were entered into a SWMM hydraulic model of the mainstem Merrimack River. The Water Quality Simulation Program (WASP) was used to simulate dynamic concentrations of bacteria, nutrients, dissolved oxygen, chlorophyll-a, and BOD in the river.

Model Simulations

Using the hydrologic and hydraulic models, a series of discharge abatement strategies were evaluated throughout the watershed to determine the water quality benefits and river improvements that could be achieved by these options.

Figure 5-3 shows a summary of the compliance status for bacteria along the Merrimack River under each scenario from the Phase I assessment. The bacteria compliance was assessed using the older version of the Massachusetts Water Quality Standards that was in effect when the Phase I assessment was completed. These criteria require that the geometric mean of any representative set of samples must be less than 200 org/100 ml and less than 10% of the samples can exceed 400 org/100 ml. For this assessment the geometric mean and 10% daily maximum bacteria criteria were evaluated using all daily fecal coliform values over the 180-day simulation period. Subsequent updates to the Massachusetts Surface Water Quality Standards use *E. coli* as the indicator pathogen for freshwater and Enterococcus as the indicator pathogen for saltwater; the Phase III modeling assessment will evaluate compliance with respect to the revised water quality standard.

The status of each of the 140 river segments represented in the simulation model is shown as "Baseline: Existing Conditions" in Figure 5-3. This figure illustrates that the entire reach from Haverhill to the ocean exceeded bacteria limits under the existing conditions at the time of the report (2006). Under current conditions, "Phase I CSO" (as Phase I controls have been implemented by all CSO communities along the river), a portion of the river, downstream of Haverhill and all the way to the ocean, should be in compliance with bacteria standards (in Massachusetts) and should support primary and secondary contact recreation under most conditions.

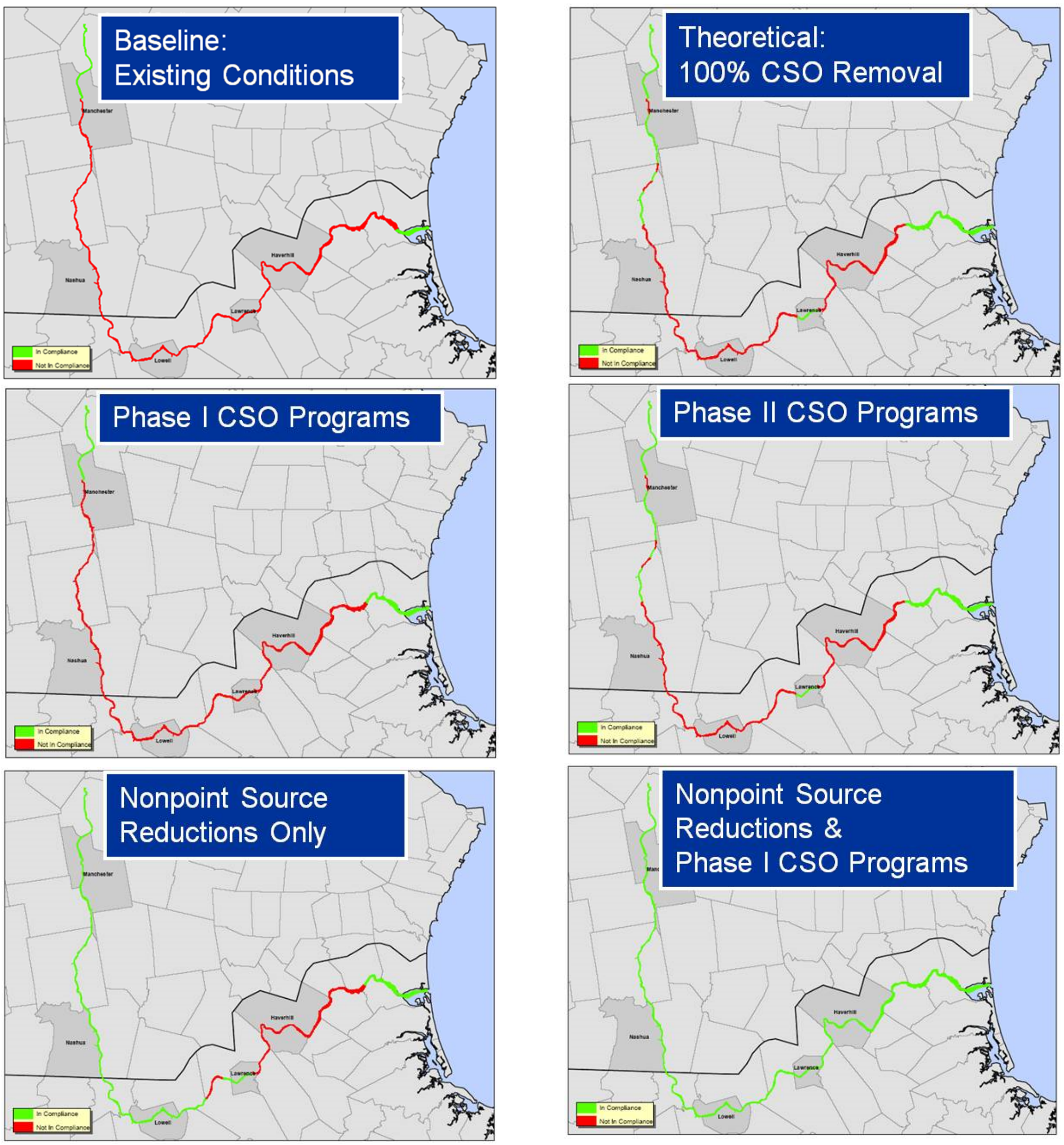

Figure 5-3
Compliance Summary for Watershed-Wide Abatement

The following conclusions were drawn from the analysis of the alternative discharge abatement strategies:

- An alternative strategy is to reduce nonpoint source control to reasonable levels, as defined by approximately 20 percent reduction of all runoff concentrations and reduction of background concentrations in highly polluted tributaries to 5,000 organisms/100ml (still well above standard). This is shown in "Nonpoint Source Reductions Only." This strategy will offer significant improvements in compliance with bacteria standards upstream of Haverhill but does not significantly change the downstream compliance status.

- Full separation of combined sewers, in all communities, shown as "Theoretical 100% CSO" would offer very little improvement in river water quality downstream of Haverhill. This condition exists because overflow events, taken together, occur for a very small percentage of the time in any given year. The remainder of the time, the river system is dominated by stormwater and background concentrations that often exceed bacteria standards.

- Long-Term phased CSO abatement programs (including partial separation, storage, increased treatment capacity, etc.), beyond the Phase 1 programs, offer very little additional improvement in compliance when compared to Phase I abatement alone for the river reaches downstream of Haverhill. As shown in "Phase II CSO Programs," there are very few appreciable instream benefits of Long-Term CSO control plans beyond the Phase I programs (that are almost completed). The impact of future Phase II CSO programs was also evaluated coupled with nonpoint source abatement. However, while the future Phase II long-term alternatives will reduce the occurrence of very high bacteria levels in the river, these occur during a total of just a few days during each year. Again, stormwater dominates as an impact to the water quality compliance status of the river during rainfall events based on this analysis.

- The analysis does show that Nonpoint Source (NPS) controls coupled with Phase I CSO controls implemented by the Merrimack River CSO communities will be sufficient to achieve compliance as shown in "Nonpoint Source Reductions & Phase I CSO Programs." In fact, the implementation of the nonpoint source reductions described above would actually increase the effectiveness of Phase I CSO controls by bringing the river closer to compliance and closing the gap that CSO abatement would need to bridge. Model results suggest that under normal hydrologic conditions, the river would be fully compliant with bacteria standards with the suggested nonpoint source reductions and Phase I CSO abatement. During abnormally dry and wet years, there may still be small isolated reaches that do not fully comply.

By far, the greatest value in abatement dollars can be realized with nonpoint source abatement and Phase I CSO controls implemented by all of the CSO communities. Since this report, the upstream CSO communities have continued to invest in very costly system improvements to continue to address the water quality impacts from the CSO discharges. Haverhill has already implemented its Phase II CSO measures and significantly decreased its CSO volumes by more than

25 percent. Continued implementation of system improvement results in much lower value, with regard to the benefits achieved compared to implementation costs.

In this case, value is measured in terms of river miles or days of compliance that can be achieved for every million dollars spent. Study results suggest that a balanced watershed management plan that includes modest CSO abatement coupled with reasonable levels of nonpoint source reduction should form the basis of watershed management decisions in the Merrimack Basin.

Results also suggest that such a balanced strategy would be eight times more cost-effective than full CSO separation using this same metric. In addition to being more cost-effective, the balanced approach would offer significantly more benefits than continuing with the implementation of Phase II CSO abatement improvements alone, and would result in a river that would comply with water quality standards under most conditions. Haverhill still is considering CSO work beyond Phase II, despite its very small CSO volumes. However, these future expenditures do not make holistic sense compared to other city and collection system spending priorities.

5.6 Summary

The principal receiving water for Haverhill's CSO discharges is the Merrimack River. CSO discharges are point source discharges and subject to the requirements of USEPA's CSO Policy, the state's CSO Control Strategy, and the Massachusetts WQS. The Merrimack River through Haverhill is on the 303(d) list of impaired waters based on concentrations of bacteria in the waterway. The city's CSO discharges do not meet the water quality criteria for Class B and SB waters for bacteria but the river will likely continue to exceed the bacteria standard, even with full elimination of CSO discharges, because of background point and non-point source stormwater discharges. It is important to note that there are no designated swimming areas along the river, downstream of Haverhill.

The river below Haverhill to the ocean at Salisbury/Newburyport has a multitude of uses. The river supports both fresh water fisheries and anadromous fish. Although no public swimming beaches exist on the Merrimack River in this segment, the river is used for boating and canoeing. A shellfish resource exists on the Merrimack River below the I-95 bridge in Salisbury. This shellfish area is conditionally harvested but may never be fully reopened unconditionally because of the upstream bacteria contamination and the proximity of the Newburyport and Amesbury WWTP discharges, regardless of Haverhill's CSO discharges.

CSO discharges to the Little River do not impact the designated uses of the Little River as significant portions of the river downstream of the discharges are enclosed within conduits and, thus, are not accessible for recreational or fisheries uses.

Haverhill's CSO planning is complicated by several factors, as discussed above, including a regulatory strategy that differentiates between pollutant sources within the watershed instead of a watershed-based plan. TMDLs, including a comprehensive assessment of river uses, have not yet been formally approved for the Merrimack River. Because of these complicating factors, the specific applicability of these CSO policies (and their intended water quality goals) to the city is unclear and appears to warrant a variance or reclassification of the river. What is clear is that the city must comply with EPA's Nine Minimum Controls, as these are the technology-based control requirements applicable to all CSO communities.

Beyond the nine minimum controls, the application of the CSO policies is complicated by the following factors:

- No final TMDL has been approved for the Merrimack River. Although control of CSOs in Haverhill could lead to some improved water quality downstream of the city, it has not been reasonably demonstrated that CSO control alone would serve to protect existing or future uses, or that these uses can even be achieved given reasonable assumptions concerning the impact of nonpoint sources.
- There are four CSO communities on the main stem of the Merrimack upstream of Haverhill, two in New Hampshire and two in Massachusetts. The CSO control planning and implementation for these communities continues. Most of the upstream communities are discharging significantly more frequent and larger volumes of CSO to the river (10 times the volume). Even with the continued implementation of the CSO plans for these upstream communities, it may take decades for them to provide a similar level of control of the CSO discharges that has already been achieved by the city of Haverhill.

In the following sections of this report, a range of CSO alternatives will be developed to identify the costs of incremental CSO discharge control. Haverhill's average annual CSO discharge volumes are small relative to the other CSO communities on the Merrimack River, but Haverhill will still propose additional CSO abatement improvements.

Further discussion of these CSO alternative costs will be compared to the proposed small and incremental benefits of continuing to reduce Haverhill's discharges both in volume and frequency, and the attainability of river uses. Accordingly, it is likely, given the complicating factors, that a variance, and/or reclassification of the river is warranted until a more holistic, watershed-based, program is approved.

The development of Haverhill's long-term control plan should consider the needs and concerns of their residents, including both environmental and economic concerns, while considering the results of the Merrimack River Assessment study and its conclusions regarding the overall goal of meeting water quality standards, enhancing the attainability of river uses, and improving the quality of the environment.

Massachusetts WQS recognizes that full compliance with all Class B/SB criterion may be difficult or impossible for CSO impacted waters. However, the regulators provide several options for a temporary variance and permanent changes to designated received water uses (reclassification to B_{CSO} or SB_{CSO}). Given the existing conditions along the river, this may be the appropriate approach for the city.

APPENDIX F

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APPENDIX G

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APPENDIX H

COMMITMENT & INTEGRITY
DRIVE RESULTS

41 Hutchins Drive
Portland, Maine 04102
www.woodardcurran.com

T 800.426.4262
T 207.774.2112
F 207.774.6635

MEMORANDUM

TO: City of Haverhill Wastewater Division

FROM: Woodard & Curran

DATE: January 20, 2016

RE: High Flow Management Plan

Haverhill's wastewater treatment plant is designed for a maximum wet-weather flow of 65 mgd. Operators are required to pass as much flow as possible through secondary treatment (estimated to be 20 to 25 mgd per the 2006 O&M manual), and the rest must be bypassed.

Wet weather operations present a challenging, dynamic situation. Operators must keep an eye on changing flows and SST blanket levels and make a decision on when and if to bypass. Waiting too long to bypass can result in failure of the secondary clarifiers and a permit violation. Bypassing too soon or too much flow can also result in a permit violation.

This High Flow Management Plan describes the standard operating procedures for dealing with wet weather. Operators should be familiar with this plan and use it as a decision making tool during wet weather events.

Step 1: Good Dry Weather Operations

High flow management begins well before the storm with good dry weather operation and maintenance practices. In order to maximize wet weather capacity, the secondary system should be running well, with a reasonable MLSS concentration, low SVIs, and minimum blanket levels in the secondary settling tanks.

Equipment maintenance issues should be addressed promptly to minimize down time of critical liquid-treatment processes. Pay attention to the forecast so that planned maintenance can be performed in dry weather, and any unplanned maintenance on critical processes can be prioritized before the rain arrives. All grit chambers, bar screens, primary settling tanks, aeration basins, secondary settling tanks, and RAS pumps should be operational at the start of a wet weather event.

Check bypass equipment (chlorination, weir gates) during prolonged dry periods to insure it will be operational when needed.

Instrumentation that is critical for wet-weather operations should also be checked. On-line sludge blanket monitors are particularly critical. The current practice of routinely checking them with a sludge judge is excellent for ensuring that they are functioning correctly and that staff are comfortable with their readings. It is also critical that all flow meters (influent, bypass, and RAS) are operational.

Step 2: Maximum Stable Secondary Operations

The 2006 O&M manual suggests a maximum secondary flow of 20 to 25 mgd, though depending on SVI and MLSS the clarifiers may be able to handle higher flows. For example, state-point analysis predicts a critical (peak instantaneous) flow of 40 mgd for the current maximum RAS rate of 10 mgd, an SVI of 200 mL/g, and a MLSS of 2,000 mg/L. Plant staff have observed similar values in practice.

During wet weather, use the plant's state point flux graphs to estimate the critical flow based on the latest lab results. Use a new chart and file it with the daily log. Post the critical flow with the date updated in a place where operators can refer to it during the storm event.

The critical capacity from the state point flux is only a guide. At higher blanket depths in particular, operator experience has shown that the state point flux graphs overestimate critical capacity. When operating near critical capacity, monitor blanket depth on SCADA frequently and periodically perform visual checks using the sludge judge and/or observing the launders for any signs of solids loss.

Step 3: Rising Blankets

If flows exceed the clarifier's critical loading, clarifier blankets will rise. If blankets begin to rise:

1) Ensure that the RAS rate is maximum. 10.5 mgd is the maximum RAS rate that can be set and sustained. Increasing the RAS rate will shift solids out of the clarifier and back to the aeration tanks.

2) Ensure that the bypass system is in Auto (in SCADA), the bypass isolation gate is open, and the Secondary Flow Setpoint is set to the estimated critical capacity of the clarifiers. For more details on bypass operation, refer to Chapter 3 of the *Supplementary O&M Manual* (CDM, c.2006).

Maintaining low blankets at the start of a wet weather event provides a buffer between exceeding critical capacity, and needing to initiate a bypass. This buffer may provide enough time to ride through short peaks in flow without bypassing.

If other options are exhausted, and blankets rise to 10 feet of clarifier depth or there are visual signs of solids loss into the launders, begin bypassing immediately.

Step 4: Bypass

Bypassing is only to be used as a last resort. In automatic mode, the bypass gate will automatically open when flow to the plant exceeds the Secondary Flow Setpoint. The bypass can also be initiated manually. The weir gate will modulate to maintain the Secondary Flow Setpoint. Refer to Chapter 3 the 2006 O&M manual supplement for additional detailed information on bypass operations.

In addition to blanket depth, operators rely on their experience and consider factors such as storm duration, storm intensity, and plant operating conditions when deciding when and how long to bypass.

When a bypass is started, note the start time in the log as well as the reason for the decision (blankets at 10 feet, visible solids loss, etc.) and other pertinent information (Secondary Flow Setpoint, deviations from the state point graphs or this plan, etc.). When bypassing, continue to monitor blanket depth on SCADA frequently and periodically perform visual checks using the sludge judge and/or observing the launders for any signs of solids loss. Good notes help to justify the bypass and to continuously improve high flow management.

APPENDIX I

Hanna Dustin Recreation Area

N
W E
S

City Of Haverhill, MA
Engineering --- Division
Date produced: 1/27/2022

0 85 170 340 Feet

1 inch = 127 feet

HAVERHILL PENTUCKET SETTLED 1640, INSTITUTED A CITY, 1870.

Riverrest Park 2

N
W E
S

City Of Haverhill, MA
Engineering --- Division
Date produced: 1/27/2022

0 85 170 340 Feet

1 inch = 127 feet

HAVERHILL PENTUCKET SETTLED 1640, INSTITUTED A CITY, 1870.

Riverside Park 3

N
W E
S

City Of Haverhill, MA
Engineering --- Division
Date produced: 1/27/2022

0 | 85 | 170 | 340 Feet

1 inch = 127 feet

HAVERHILL PENTUCKET SETTLED 1640, INSTITUTED A CITY, 1870.

Crescent Yacht Club 4

N
W E
S

City Of Haverhill, MA
Engineering --- Division
Date produced: 1/27/2022

Feet	0	85	170	340

1 inch = 127 feet

Riveredge Park 5

N W E S

0 85 170 340 Feet

1 inch = 127 feet

City Of Haverhill, MA
Engineering --- Division
Date produced: 1/27/2022

HAVERHILL PENTUCKET SETTLED 1640, INSTITUTED A CITY, 1870.

Kazmiera Marina 6

N
W E
S

City Of Haverhill, MA
Engineering --- Division
Date produced: 1/27/2022

Feet
0 85 170 340
1 inch = 127 feet

This map was produced from the City Of Haverhill's Geographic Information System. The City expressly disclaims any liability that may result from use of this map.

Abbotts Marina 7

City Of Haverhill, MA
Engineering --- Division
Date produced: 1/27/2022

Feet: 0, 85, 170, 340
1 inch = 127 feet

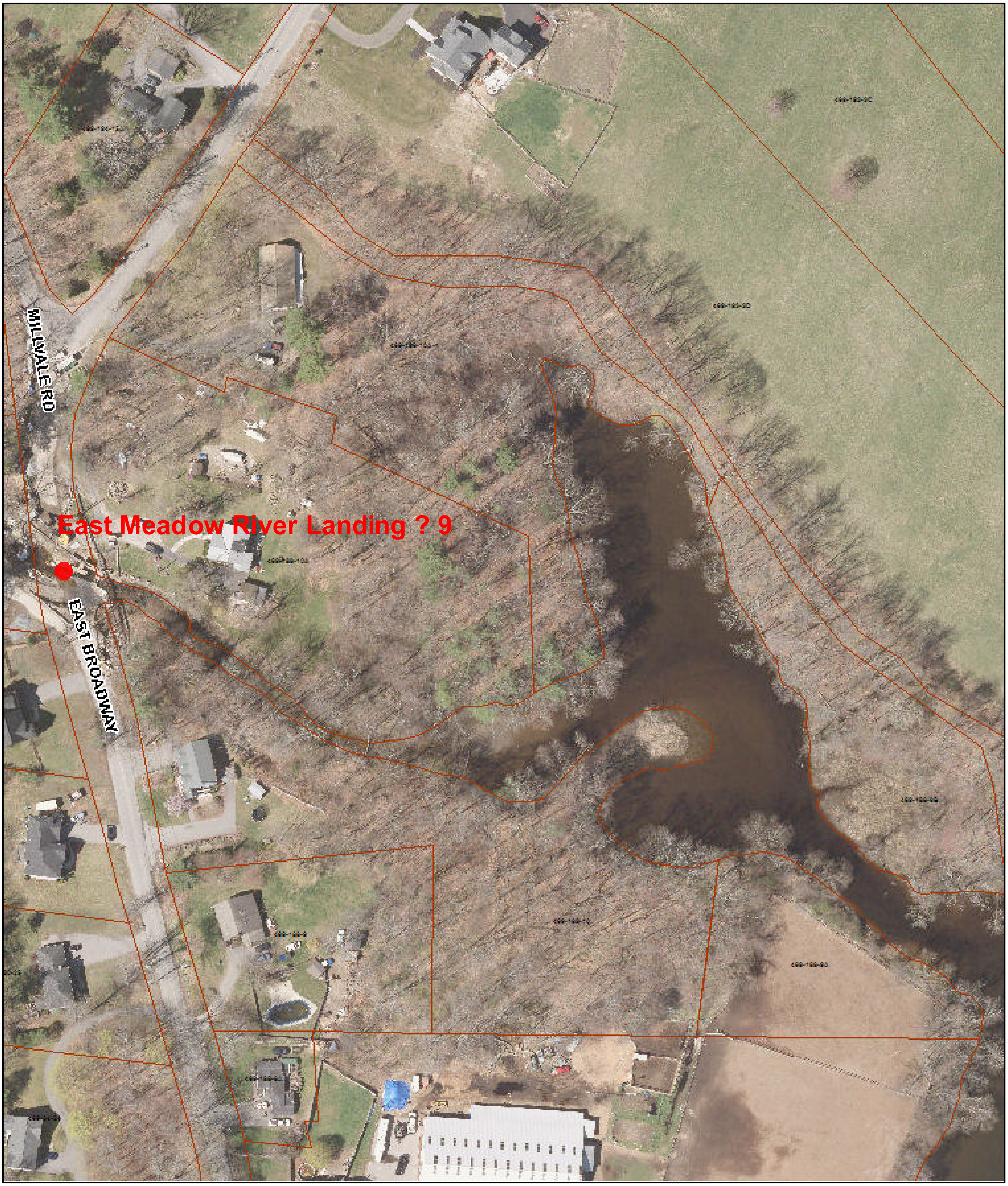
Lighthouse Landing marina 8

N
W E
S

City Of Haverhill, MA
Engineering --- Division
Date produced: 1/27/2022

0 85 170 340 Feet

1 inch = 127 feet



East Meadow River Landing 9

N
W E
S

City Of Haverhill, MA
Engineering --- Division
Date produced: 1/28/2022

0 85 170 340 Feet

1 inch = 127 feet

Appendix J CSO Downstream Signage Template

perma-line

PERMA-LINE CORP. OF N.E.

Date	Product	Customer Name
9 21 23	Custom Signs	Town of Haverhill

Color	Sizes	Total #	File Name:
Blue	12x18	15 Signs	Haverhill Water Advisory

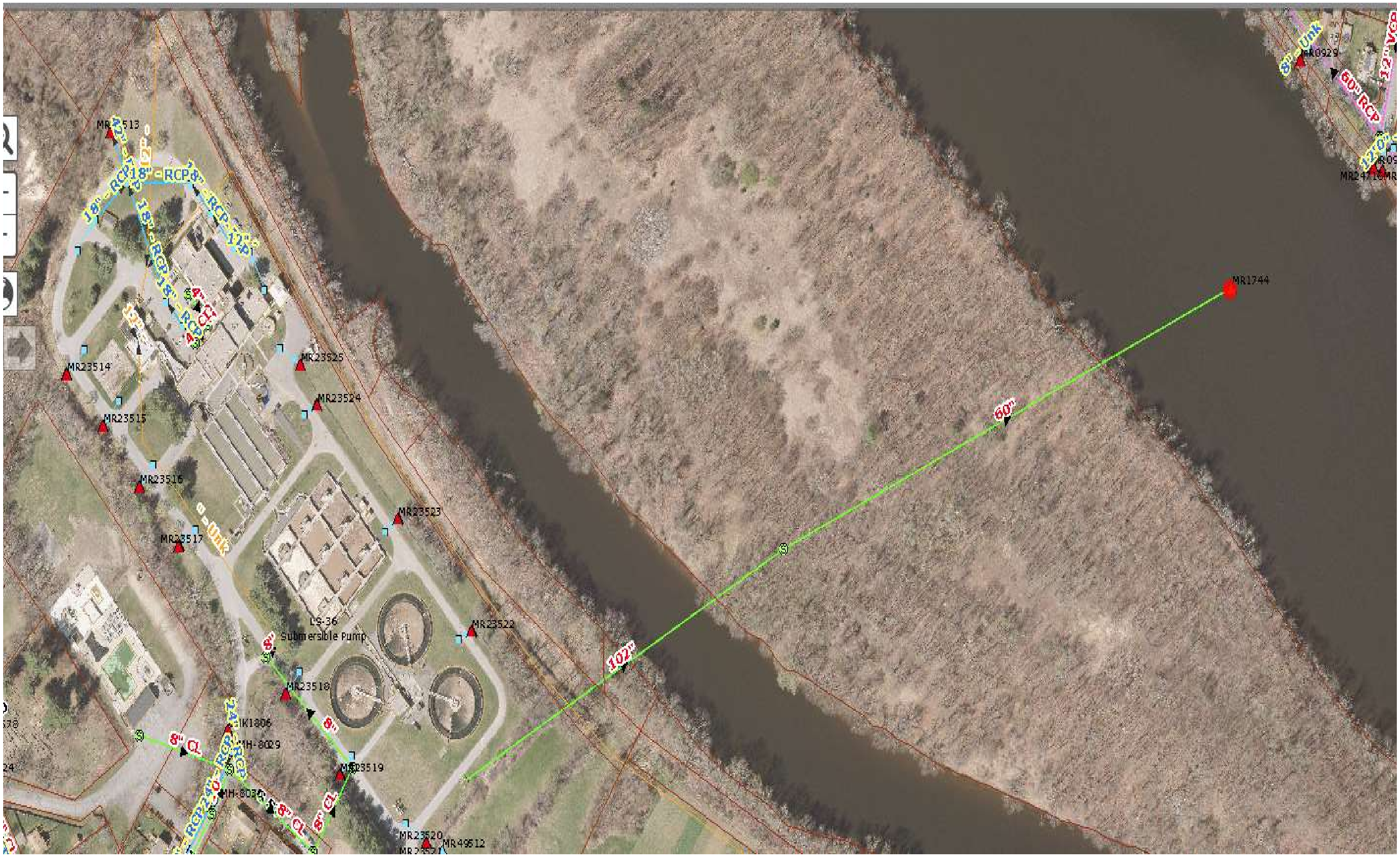
Appendix K CSO Public Comments

The City of Haverhill has prepared and submitted a Final Combined Sewer Overflow (CSO) Public Notification Plan to the Massachusetts Department of Environmental Protection (MassDEP). Any interested party can view the plan at the following website: https://www.cityofhaverhill.com/departments/public_works_department/water_wastewater/wastewater/wastewater_collection_system/cso_public_notification.php

Written comments can be submitted until February 24, 2023. This is a period of 30 days after the date of publication in the Environmental Monitor. Submit written comments to MassDEP by email (preferred) to massdep.sewagenotification@mass.gov or by mail to 100 Cambridge St, Suite 900 Boston, MA 02114. Submit written comments to the City of Haverhill by email to ilewis@haverhillwater.com or by mail to City of Haverhill WWTP, 40 South Porter Street, Haverhill MA, 01835.

This Public Notice is published in the Environmental Monitor and The Eagle Tribune.

Appendix L Blended Flow Location Map



Memorandum

To: *City of Haverhill*

From: *CDM Smith*

Date: *1/31/2024*

Subject: *City of Haverhill CSO Overflow Impacted Area Analysis*

Introduction

The City of Haverhill's Combined Sewer Overflow (CSO) Notification Plan requires the City to post signage at public recreational facilities that could be potentially impacted by CSO events taking place in Haverhill. Haverhill CSO events may lead to higher E. Coli or Enterococcus concentrations in the river and may contribute to these concentrations exceeding federal standards. This study identifies the distance downstream within which facilities are likely to encounter pathogen concentrations above the standards following a Haverhill CSO event. The estimated distance downstream does not consider pollutants resulting from CSO events occurring in adjacent municipalities, nor does it consider concentration impacts resulting from stormwater and tributary inflows.

This memorandum presents the calculations and recommendation that the City post signage a distance of 9.1 miles downstream from the downstream edge of the Haverhill CSOs. This distance corresponds with 99% of the events evaluated in this study.

Methodology

Several factors influence the extent of a CSO event's downstream impact. These factors include event characteristics such as the total volume of overflow, the initial mixing of the overflow into the receiving water, the natural die-off of pathogens within the receiving water, and pathogen transport rate downstream. All of these event characteristics are included in this study.

Overview

The analysis steps for each recorded historical CSO events from 2016-2022 included:

1. Characterize event based on the following:
    a. Duration
    b. Total volume
    c. Corresponding Merrimac River flow during events.

2. Calculate initial E. coli and Enterococcus concentrations in the river based on CSO volume, duration, and corresponding river flow.
3. Calculate impact time (time in-river required for die-off to reduce concentrations below standards).
4. Calculate the impact distance travelled during impact time.

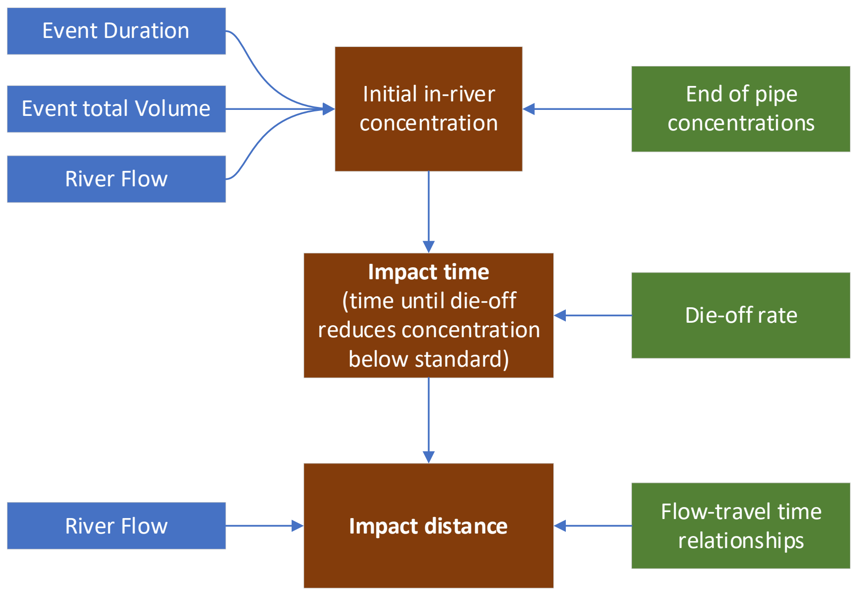


Figure 1. CSO analysis approach.

The workflow depicted in Figure 1 was carried out for all events on record, resulting in over 200 unique downstream distance estimates. These estimates were used determine a reasonable distance within which to post signage.

Two key conservative assumptions included in the analysis were as follows:

- The corresponding river flow in the Merrimack River was assumed to be equal to the flow recorded at the USGS gaging station in Lowell (Station ID 01100000) downstream of the Concord River.
- Pollutant dispersion along the length of the river is not included in this analysis. Dispersion accounts for variations in water currents, and would spread a CSO's discharged mass out along the length of the river. This spreading occurs in addition to the natural decay and transport downstream that is incorporated into this analysis. The dispersion effect could significantly reduce peak concentrations earlier than predicted and lead to a shorter downstream impact distance than determined in this analysis. This is especially conservative in the reach downstream of Haverhill, which experiences tidal mixing and is inherently subject to significant dispersion of pollutants.

Calculations

Event Characteristics

The City provided data summarizing all recorded CSO events between 2016 and 2022, which amounted to over 200 events and data points for this analysis (City of Haverhill, 2023). Because the downstream impact is affected by CSO volume, CSO duration, and river flow, this analysis did not select just one event as representative, since no single event can be known beforehand to represent the worst-case combination of all three of these conditions. Rather, this analysis considers all 231 events and presents results statistically. The data provided by the City for each event included:

- The ID of each CSO that was active during an event,
- The start and stop time of each CSO's overflow,
- The total volume of flow associated with each CSO, and
- Rain gage information for the event.

Corresponding Merrimack River flow on the day of the CSO event was added to the event database in order to calculate corresponding volume and downstream impact distance.

Between January 7th, 2016 and December 23rd, 2022, 231 CSO events were recorded by the City. Four events had very short durations that were listed as instantaneous overflows. For the purposes of CDM Smith's analysis, these events were assigned a duration of 10 minutes. Two of the 231 events were also combined into a single event, as they occurred one minute apart from each other. No other events were combined for this analysis. A spot check of the other events provided by the City indicated that all other events had at minimum several hours between them.

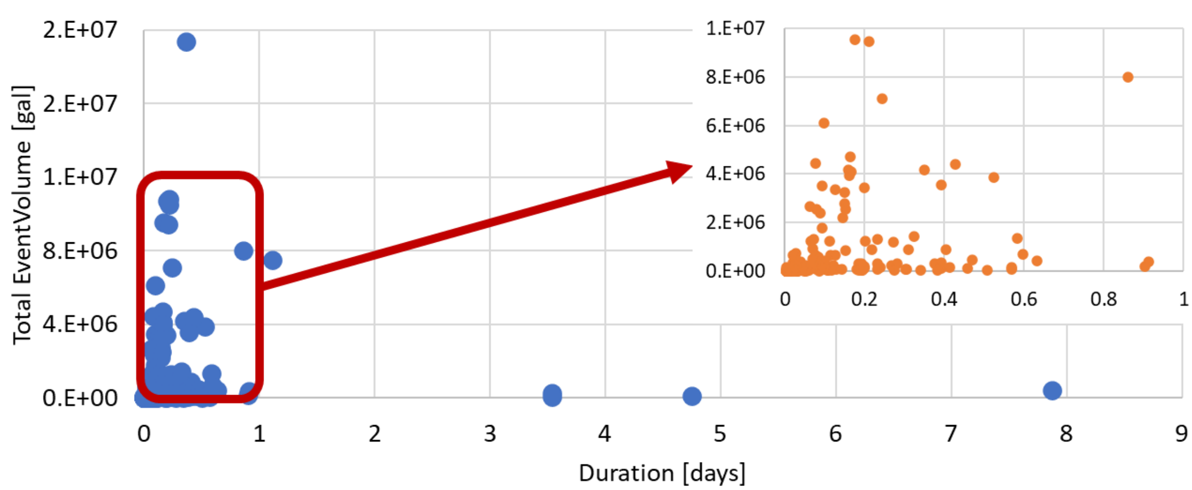


Figure 2. CSO event duration and total volume.

Figure 2 shows the event duration and total volume associated with each overflow event. All events, with the exception of a handful of outliers, are less than 10 million gallons of total volume and shorter than 1 day duration. The callout plot in Figure 2 details the distribution of these smaller, shorter events. Most are less than 200,000 gallons in total volume.

River Flow

The flow rate of the Merrimack River was taken from USGS Gauge 01100000 in Lowell, MA (USGS, 2023). Figure 1 shows the distribution of flows in the Merrimack River compared to total overflow volume during CSO events. The median flow in the river between 2016 and 2022 was 6,620 cubic feet per second (cfs). The median flow during an event was slightly higher at 7,220 cfs.

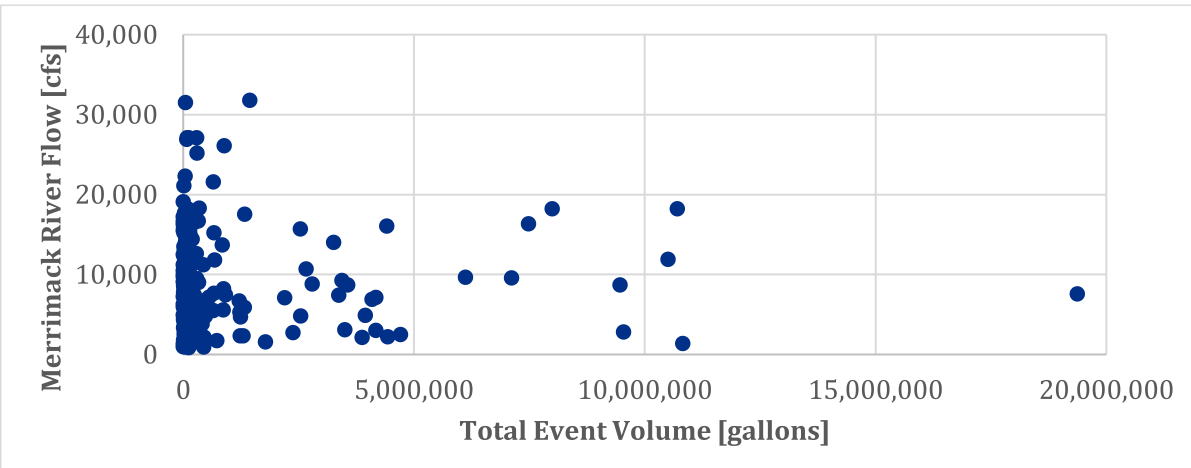


Figure 1: Histogram of Merrimack River Flow Rate During CSO Events

End-of-Pipe Concentrations and Initial Mixing

The initial concentration in the river was calculated as the total event loading represented by CSO flow and end of pipe concentrations, mixed evenly over the duration of overflow with the corresponding flow in the Merrimack River during the event. For the purposes of this study, full mixing across the river is assumed on initial overflow discharge.

All CSO events were assigned the same end of pipe concentration of 1.245×10^5 counts/100ml for E. coli and 3.9×10^4 counts/100ml for Enterococcus. The E. coli end of pipe concentration was determined based on the Merrimack River Watershed Assessment Study (CDM Smith, 2004). The Enterococcus end of pipe concentration was determined based on the Greater Lawrence Sanitary District (GLSD) Combined Sewer Overflow Affected Area Calculation Methodology (Kleinfelder, 2023).

Initially mixed concentrations are summarized in Table 1. A majority of CSO events (81%) had initial concentrations below the EPA standard of 410 ct/100mL for E. Coli and 130 ct/100mL for Enterococcus. This finding is consistent with the small CSO event discharge volumes shown in

Figure 2, and demonstrates that the majority of the recorded CSO events do not significantly degrade water quality downstream of Haverhill.

Table 1. Initial concentrations in-river

Quantity	Initial Concentration for E. coli (ct/100mL)	Initial Concentration for Enterococcus (ct/100mL)
Minimum	0.25	0.08
Mean	305	96
Median	56	18
Maximum	6,600	2,100
Standard	410	130

Impacted Travel Time

The impacted travel time is the time between a CSO event's discharge and when the concentration of the discharge mass to decrease below water quality standards. The initially mixed CSO concentration decays in the river as it travels downstream. Eventually enough bacteria die off that concentrations are below the standards for E. coli and Enterococcus. The travel time for an overflow mass to achieve the standard concentration was calculated using the initially mixed concentration as outlined above and a first order decay rate. A previous modeling study of the Merrimack River (CDM Smith, 2005) determined that pathogen loss can be calculated using a first order decay rate of 1.5 and 1.0 per day for E. Coli and Enterococcus respectively. These decay rates account for loss from die-off, settling, and any other sources of loss in-stream. The decay rates used for the 2005 modeling study were calibrated and validated, and are used in this present study for Haverhill as well. Figures 4 and 5 show the distribution of impact time for E. Coli and Enterococcus respectively. As the figures demonstrate, most events reached concentrations below the standards within 6 hours (0.25 days). Events with initial in-river concentrations below the standard were assigned distances of 0 miles.

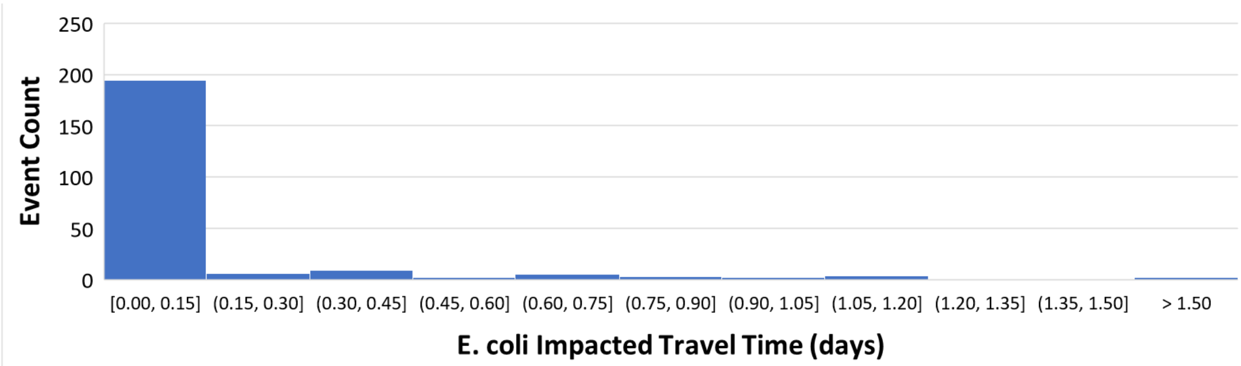


Figure 4: Histogram of Time to Achieve E. Coli Standard.

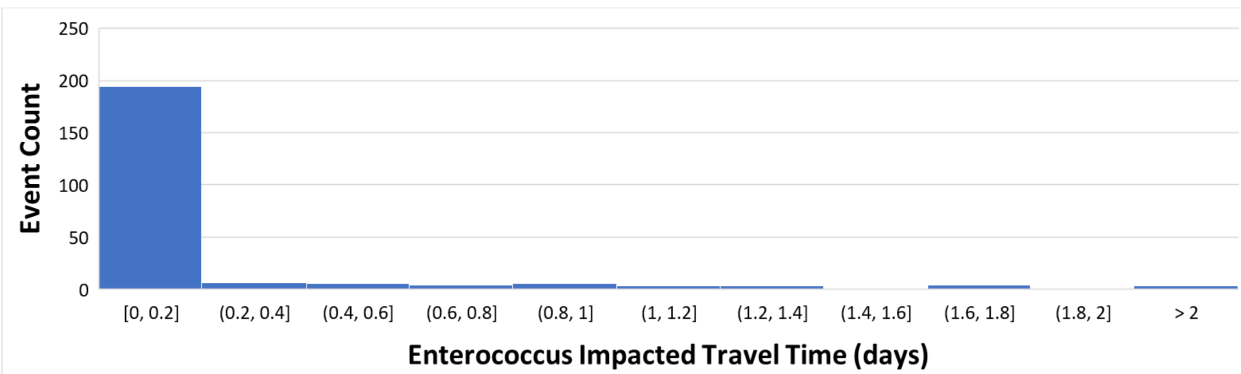


Figure 5: Histogram of Time to Achieve Enterococcus Standard.

Impact Distance

The distance traveled during the impacted travel time as defined above was determined for each event using the results from the 1966 report by the US Department of Interior (1966). As part of the CDM Smith modeling study (CDM Smith 2005), dye studies in the river generally validated the travel times and distance reported in the 1966 report.

The impact distances for Enterococcus calculated in this study are shown in Figure 6. Enterococcus impact distances were consistently longer than E. coli distances. This was because of the higher decay rate used for E. coli (1.5 per day) versus Enterococcus (1.0 per day). The sensitivity of E.Coli impact distance to decay rate was evaluated by assessing travel distances with a 1.0 per day decay rate for E. Coli. Reducing the decay rate to 1.0 for E. Coli (the same as Enterococcus) results in more closely agreeing impact distances between the two pathogens, but does not result in E. Coli impact distances that exceed those for Enterococcus.

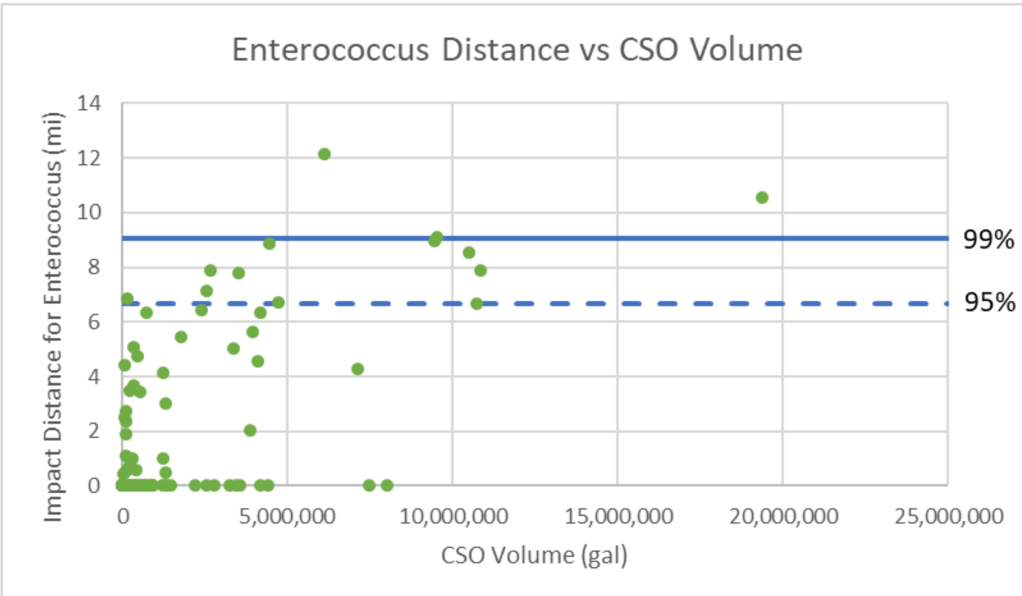


Figure 6. Enterococcus impact distance with CSO volume.

Travel distances required for E. coli and Enterococcus concentrations to drop below standards are summarized in Table 2. As seen in both Figure 6 and Table 2, a majority of events have a distance of 0 miles. This is because a majority of Haverhill's events were small enough in volume that initial in-river concentrations were approximately below standards on initial mixing after discharge. The analysis indicates that ninety percent of events also resolve themselves within 5 miles of discharge.

Table 2. Summary statistics for impacted distances from all CSO events.

Statistic	Miles Downstream for E. Coli	Miles Downstream for Enterococcus
Mean	0.66	0.9
90% Percentile	3.1	4.5
95% Percentile	4.8	6.7
99% Percentile	6.4	9.1

Recommendations

Figure 7 shows the locations of the 95% and 99% impact distances along the Merrimack River. **CDM Smith recommends using the 99% impact distance as a threshold for signage**. This is more reasonable than taking a "worst case" event alone, such as the largest CSO event on record, and is in accordance with established precedence by regulators for discharge permitting in most states. The distribution of event data demonstrates that the largest event in Haverhill's record, which totaled 19 million gallons, is an outlier that is nearly two times larger than any other event on record. Relying on statistical extremes like the 95% and 99% distances is much more reasonable, as it safe-guards from extreme outliers, which could be the result of reporting errors, measurement errors, or even the absence of recent system improvements, as discussed below. The majority of events in Haverhill's record do not result in in-river concentrations above the standards anywhere in the Merrimack River downstream of initial cross sectional mixing. The 95% distance for Enterococcus is 6.7 miles downstream. The 99% distance is 9.1 miles. These distances are shown on the map in Figure 7.

Maximum Event

Earlier figures in this memorandum depict a peak event occurring on September 18, 2018, with a magnitude of 19 million gallons. Rainfall accumulation at the Middle Siphon (identified by NPDES Number 21A) measured 3.29 inches for this event, accompanied by a peak intensity of 3.36 inches per hour.

In approximately 2016, the City introduced modulating gates for both the Upper Siphon (NPDES Number 24) and Lower Siphon (NPDES Number 13), which became operational. The initial Programmable Logic Controller (PLC) encompassed a complex ten-step program, challenging to comprehend for those not involved in its design. This intricate program has since been substituted with a streamlined and modified version, implemented around 2020. During the aforementioned storm event, the Upper and Lower Siphons contributed a combined 10 million gallons of the total 19 million gallons in 2018.

During a later a storm event on July 29, 2023, total rainfall accumulation was 4.73 inches with a peak intensity of 12.36 inches per hour. This storm event was larger and more intense than the peak CSO event recorded in 2018. Despite this, the cumulative volume of CSOs attributed to the Upper and Lower Siphons during this event was 0.9 million gallons, much lower than the CSO volume of 19 million gallons. This indicates that adjustment in the PLC programming resulted in a reduction in CSO volume.

The analyses presented in this memorandum intentionally included the recorded events between 2016 and the operational change in 2020 in order to provide a longer record for statistical analysis. Ultimately, this results in more conservative estimates of downstream impact area and supports a higher degree of confidence in using the results of this analysis for public notification protocols.

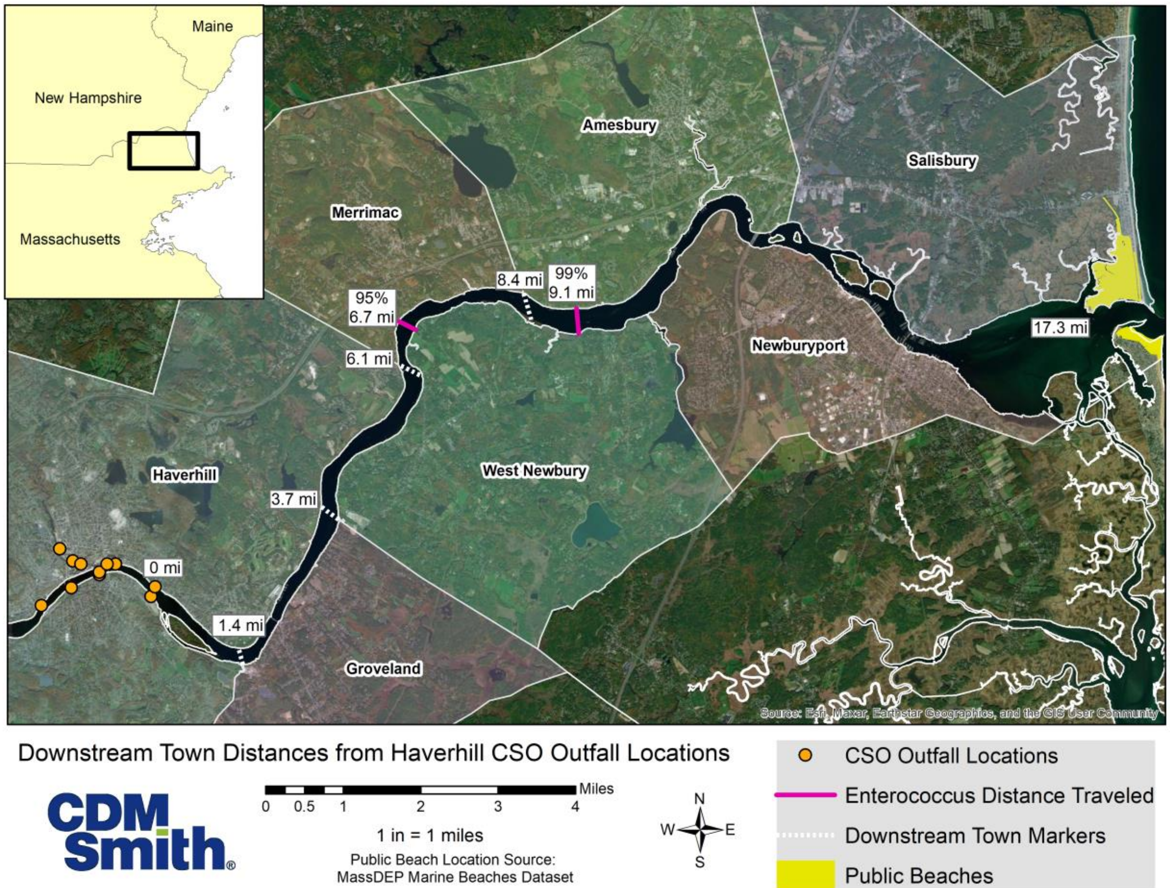


Figure 7. Mapped impact distances and distances to municipal boundaries downstream of Haverhill.

Distances plotted in Figure 7 are measured using the most downstream CSO in the City of Haverhill as a starting point. While many events in Haverhill only involve CSOs upstream of these downstream outfalls, using the downstream edge of the CSOs as a reference is a conservative approach.

Two-Day Travel Time Analysis

For the purposes of comparison and overall understanding, this section compares the transport analysis discussed above with a two-day travel distance.

Figure 8 shows a scatter plot of all events between 2016 and 2022, with the 2-day travel distance for each event plotted against the days needed for each event's concentration to reduce below the criteria. The figure has red lines included to indicate the recommended signage distance of 9.1 miles, and also the 2-day threshold.

The figure shows that, by the analysis presented in this memorandum, 3 out of the 230 events included in the analysis (less than 1%) require more than 2 days to decay below the criteria. Of these three events, all of them have a 2-day travel distance of less than 9.1 miles.

Similarly, all events with 2-day travel distances above the recommended notification threshold of 9.1 miles have enough initial dilution that subsequent decay reduces the concentration in the river below the criteria within less than 1.5 days.

Events with higher 2-day travel times occur when Merrimack River flows are high. While river velocities are high under these conditions and can carry CSO plumes downstream quickly, the high flows also provide significant mixing and dilution. This prevents CSO events from falling in the grey region of the plot, where events would have the combination of high travel distances and a long time requirement to decay. This evaluation indicates that the methods discussed in this memorandum do not inadvertently under-estimate an appropriate signage distance.

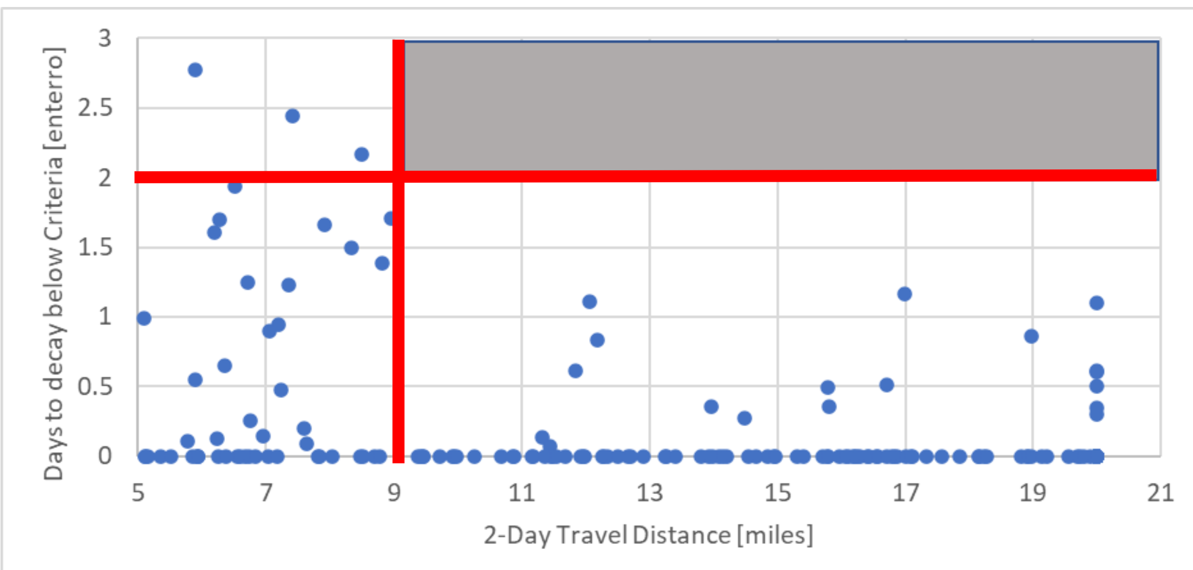


Figure 8. Event time for enterococcus concentrations to decay below the criteria, compared with the River's 2-day travel distance at the time of each recorded event.

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