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New Bedford Inner Harbor Embayment System, Total Maximum Daily Load for Total Nitrogen

Commonwealth of Massachusetts
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MassDEP

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Cover Photo

Ariel photograph of New Bedford Inner Harbor

Notice of Availability

This report is available on the Massachusetts Department of Environmental Protection website:
https://www.mass.gov/lists/total-maximum-daily-loads-by-watershed

Massachusetts Department of Environmental Protection

MassDEP's mission is to protect and enhance the Commonwealth's natural resources – air, water, and land – to provide for the health, safety, and welfare of all people, and to ensure a clean and safe environment for future generations. In carrying out this mission MassDEP commits to address and advance environmental justice and equity for all people of the Commonwealth; provide meaningful, inclusive opportunities for people to participate in agency decisions that affect their lives; and ensure a diverse workforce that reflects the communities we serve.

Watershed Planning Program

The Watershed Planning Program is a statewide program in the Division of Watershed Management, Bureau of Water Resources, at MassDEP. We are stewards of the water resources of Massachusetts. Together with other state environmental agencies, we share in the duty and responsibility to protect, enhance, and restore the quality and value of the waters of the Commonwealth. We are guided by the federal Clean Water Act and work to secure the environmental, recreational, and public health benefits of clean water for the residents of Massachusetts. The Watershed Planning Program is organized into five Sections that each have a different technical focus under the Clean Water Act: (1) Surface Water Quality Standards; (2) Surface Water Quality Monitoring; (3) Data Management and Water Quality Assessment; (4) Total Maximum Daily Load; and (5) Nonpoint Source Pollution.

Acknowledgements

The New Bedford Inner Harbor TMDL for Total Nitrogen was developed with data collected, compiled, and analyzed by the University of Massachusetts Dartmouth's School of Marine Science and Technology (SMAST), US Geological Survey; Applied Coastal Research and Engineering, Inc, the Buzzards Bay Coalition (BBC) BayWatchers Water Quality Monitoring Program, and the City of New Bedford, Town of Fairhaven and Town of Acushnet, as part of the Massachusetts Estuaries Project (MEP).

Disclaimer

References to trade names, commercial products, manufacturers, or distributors in this report constituted neither endorsement nor recommendation by MassDEP.

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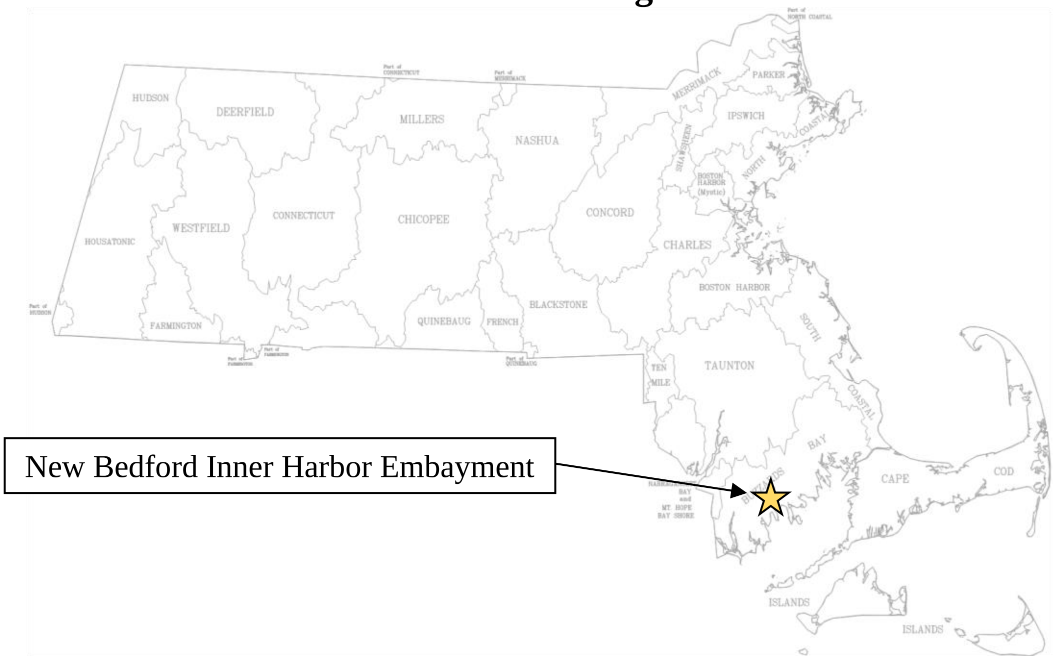
New Bedford Inner Harbor Embayment
Total Maximum Daily Load
For Total Nitrogen



Key Feature:	Total Nitrogen TMDLs for New Bedford Inner Harbor
Location:	EPA Region 1, Towns of New Bedford and Fairhaven with watersheds in Acushnet, Freetown, Rochester and Lakeville.
Land Type:	New England Coastal
2022 Integrated List of Waters Category 5 303d Listings:	New Bedford Inner Harbor (MA95-42) - *Total Nitrogen* - *Dissolved Oxygen* - *Nutrient/Eutrophication Biological Indicators* Acushnet River (MA95-33) - *Total Nitrogen* - *Dissolved Oxygen* - *Nutrient/Eutrophication Biological Indicators*
Data Sources:	University of Massachusetts – Dartmouth/School for Marine Science and Technology; US Geological Survey; Applied Coastal Research and Engineering, Inc.; Buzzards Bay Coalition, City of New Bedford, Town of Fairhaven, Town of Acushnet.
Data Mechanism:	Massachusetts Surface Water Quality Standards, Ambient Data, and Linked Watershed-Embayment Nitrogen Model
Monitoring Plan:	Buzzards Bay Coalition, Baywatcher Program; City of New Bedford & Town of Fairhaven monitoring program with technical assistance from SMAST
Control Measures:	Sewering, Stormwater Management, Attenuation by Impoundments and Wetlands, Fertilizer Use By-laws

Executive Summary

The Massachusetts Department of Environmental Protection (MassDEP) is responsible for monitoring the waters of the Commonwealth, identifying those waters that are impaired, and developing a plan to bring them back into compliance with the Massachusetts Surface Water Quality Standards. The list of impaired waters, also referred to as Category 5 of the State Integrated List of Waters or the "303d list", identifies river, lake, and coastal waters and the cause for impairment. All impaired waters listed in Category 5 require the development of a Total Maximum Daily Load (TMDL).

Once a waterbody is identified as impaired (i.e., not supporting designated uses as established in the Massachusetts Surface Water Quality Standards), MassDEP is required by the federal Clean Water Act (CWA) to essentially develop a "pollution budget" designed to restore the health of the impaired waterbody. The process of developing this pollution budget, generally referred to as a TMDL, includes identifying the source(s) of the pollutant from direct discharges (point sources) and indirect discharges (nonpoint sources), determining the maximum amount of the pollutant that can be discharged to a specific waterbody to meet water quality standards, and developing a plan to meet that goal.

This report develops total nitrogen TMDLs for an interconnected set of waterbodies within the and its upstream waters, hereinafter referred to as the "New Bedford Inner Harbor Embayment System".

Problem Statement

Excessive nitrogen (N) originating from a wide range of sources, has impaired the Acushnet River and the Inner New Bedford Harbor System. In general, excessive N in these waters are indicated by:

- Reductions in the diversity of benthic animal populations;
- Periodic decreases in dissolved oxygen concentrations that threaten aquatic life;
- Undesirable increases in macroalgae; and
- Periodic algae blooms

With proper management of nitrogen inputs these trends can be reversed. Without proper management more severe problems might develop, including:

- Periodic fish kills;
- Unpleasant odors and scum; and
- Benthic communities reduced to the most stress-tolerant species, or in the worst cases, near loss of the benthic animal communities.

The communities surrounding the New Bedford Inner Harbor Embayment System rely on clean, productive, and aesthetically pleasing marine and estuarine waters for recreational boating and swimming, as well as fishing and shellfishing. Failure to reduce and control N loadings will result in complete replacement of eelgrass by macroalgae, a higher frequency of decreases in dissolved oxygen concentrations and fish kills, widespread occurrence of unpleasant odors and visible scum, and a complete loss of benthic macroinvertebrates throughout most of the embayment. As a result of these environmental impacts, commercial and recreational uses of the New Bedford Inner Harbor Embayment System coastal waters will be greatly reduced.

Sources of Nitrogen

Nitrogen enters the waters of coastal embayments/ponds from the following sources:

- The watershed
  - on-site subsurface wastewater disposal (septic) systems
  - natural background
  - runoff from impervious surfaces
  - fertilizers
  - wastewater treatment facilities (WWTF)
  - Combined sewer overflows (CSO)
  - agricultural activities
- Atmospheric deposition
- Nutrient-rich bottom sediments in the embayments/ponds

Figure ES-A below indicates the percent contributions of the various sources of N in the watershed to New Bedford Inner Harbor. Values are based on Figure IV-4 from the Massachusetts Estuaries Project (MEP) Technical Report (Howes *et al*. 2015). In Figure ES-A "Overall Load" is the total nitrogen input within the watershed, while the "Controllable Load" represents only those nitrogen sources that could be under local regulatory control. WWTF and CSO nitrogen loads are exclusively in the southern portion of the watershed while farm animal loads are almost exclusively in the northern portion of the watershed. As evident from this figure, most of the present *controllable* N load to New Bedford Inner Harbor originates from wastewater (WWTF and septic systems).

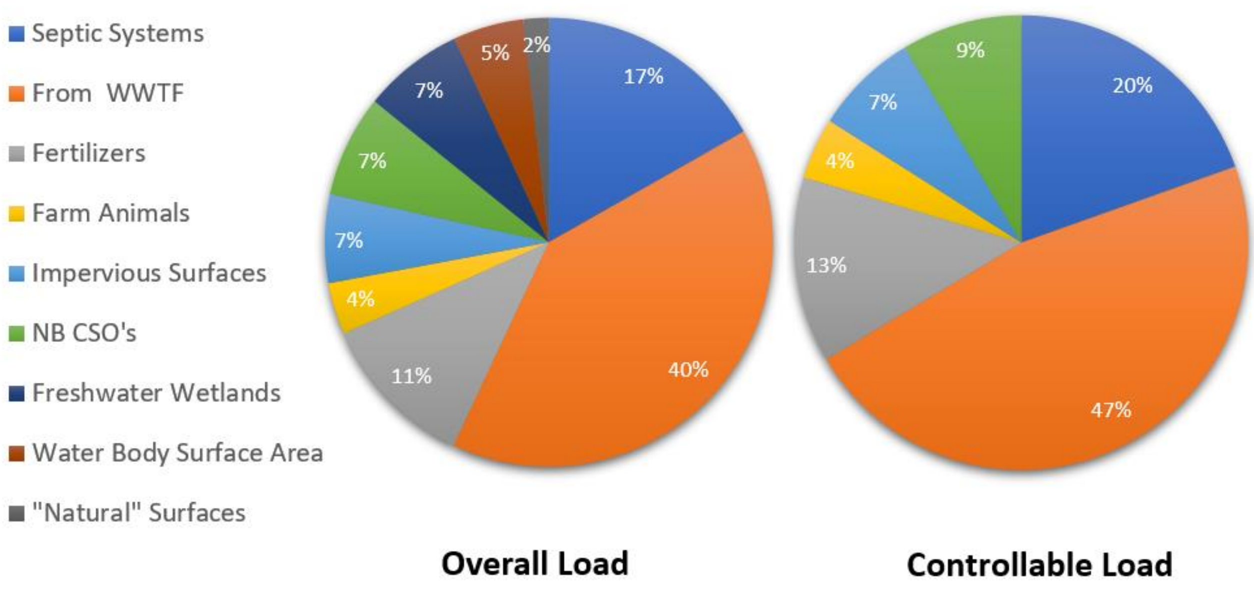


Figure ES-A: Percent Contributions of All Watershed Nitrogen Sources and Percent Contributions of Controllable Nitrogen Sources to New Bedford Inner Harbor System

Target Threshold Nitrogen Concentrations and Loadings

The N loadings (the quantity of nitrogen) to this embayment system varies between sub-embayments. The present total attenuated watershed nitrogen load that enters the estuary each day (N load) is 330.46 kg/day from the combined sub-watersheds (Table ES-1, MEP Technical Report, Howes *et al.* 2015). The resultant N concentrations in this embayment range from 0.48 mg/L (milligrams per liter of N) at the downstream-most station (at the Hurricane Barrier, station MEP-9) to 0.79 mg/L in the upper basin (station MEP-2), as reported in Table VI-1 and shown in Figure VI-1of the MEP Technical Report (Howes *et al.* 2015) and included in Appendix B of this report.

To restore and protect this embayment system, N loadings, and subsequently N concentrations in the water, must be reduced to levels below the thresholds that cause the observed environmental impacts. This concentration will be referred to as the *target threshold nitrogen concentration*. It is the goal of the TMDL to reach this target threshold N concentration, as it has been determined for each impaired waterbody segment. The Massachusetts Estuaries Project (MEP) has determined through multiple years of sampling and modeling that, for this embayment system, an N concentration of 0.50 mg/L, achieved at the "sentinel" station located in the mid basin (Figure 5), will restore benthic infauna habitat and be protective of water quality standards throughout the estuary.

Based on the MEP and resulting Technical Report, MassDEP has determined that the Total Maximum Daily Load (TMDL) that will meet the target threshold N concentration ranges from 70.70 kg/day in the Acushnet River(MA95-33, MEP sub-embayment Upper Basin) to 137.11 kg/day in New Bedford Inner Harbor (MA95-42, includes MEP sub-embayments Mid Basin and Lower Basin). This document presents the TMDL for each waterbody segment and provides general guidance to New Bedford, Fairhaven, Acushnet, Freetown, Rochester and Lakeville on possible ways to reduce the N loadings to within the recommended TMDL and protect the waters for this embayment. The N TMDL to meet the target threshold N concentration of 0.50 mg/L is 276.6 kg N/day (with negative benthic flux set to zero) for the entire system. The mechanism for achieving this target threshold N concentration is to reduce the N loadings to the New Bedford Inner Harbor system. To meet the TMDL, this report suggests that a 49.6 % reduction of the total watershed nitrogen load for the entire system will be required.

This document presents the TMDL for this waterbody and provides guidance to the communities of New Bedford, Fairhaven, Acushnet, Freetown, Rochester, and Lakeville on possible ways to reduce the N loadings to within the recommended TMDL and protect the waters of this estuarine system.

Implementation

The primary goal of implementation is to lower N concentrations by greatly reducing the loadings from controllable sources through a variety of methods, such as expanded sewering, long-term CSO control measures, advanced wastewater treatment, and implementation of best management practices for the control of nonpoint sources.

Local officials can explore other load reduction scenarios through additional modeling as part of their Comprehensive Wastewater Management Plan (CWMP). Implementing best management practices (BMPs) to reduce N loadings from fertilizers and runoff where possible will also help to lower the total N load to the system. Methodologies for reducing N loading from septic systems, stormwater runoff, and fertilizers are provided in detail in the "MEP Embayment Restoration and Guidance for Implementation Strategies" (MassDEP 2003). The appropriateness of any of the alternatives will depend on local conditions and will need to be determined on a case-by-case basis, using an adaptive management approach. Finally, growth within the communities of New Bedford Inner Harbor Embayment System, which would exacerbate the problems associated with N loading, should be guided by considerations of water quality-associated impacts.

Table of Contents

List of Tables

List of Figures

Introduction

Section 303(d) of the federal Clean Water Act requires each state (1) to identify waters that are not meeting water quality standards, and (2) to establish Total Maximum Daily Loads (TMDLs) for such waters for the pollutants of concern. The TMDL allocation establishes the maximum loadings of these pollutants of concern, taking into consideration all contributing sources to that waterbody, while allowing the system to meet and maintain applicable water quality standards and designated uses, including compliance with numeric and narrative standards. The TMDL development process may be described in four steps, as follows:

1. Determination and documentation of whether a waterbody is presently meeting applicable water quality standards and designated uses.

2. Assessment of present water quality conditions in the waterbody, including estimation of present loadings of pollutants of concern from both point sources (discernable, confined, and concrete sources such as pipes) and nonpoint sources (diffuse sources that carry pollutants to surface waters through runoff or groundwater).

3. Determination of the loading capacity of the waterbody. EPA regulations define the loading capacity as the greatest amount of loading that a waterbody can receive without violating water quality standards. If the waterbody is not presently attaining its designated uses, then the loading capacity will represent a reduction relative to present loadings.

4. Specification of load allocations, based on the loading capacity determination, for nonpoint sources and point sources that will ensure that the waterbody will not violate water quality standards.

After public comment and final approval by EPA, the TMDL will serve as a guide for future implementation activities. MassDEP will work with the towns of New Bedford, Fairhaven, Acushnet, Freetown, Rochester, and Lakeville to develop specific implementation strategies to reduce N loadings and will assist in developing a monitoring plan for assessing the success of the nutrient reduction strategies.

In the New Bedford Inner Harbor Embayment System, the pollutant of concern for this TMDL (based on observations of eutrophication) is nitrogen (N) because it is the limiting nutrient in coastal and marine waters, which means that plant productivity increases as the N concentration increases. Increased plant productivity leads to nuisance populations of macroalgae, increased phytoplankton and epiphyton abundance and impairment of the affected waterbodies.

The total N TMDL for the New Bedford Inner Harbor Embayment System is based primarily on data collected, compiled, and analyzed by University of Massachusetts Dartmouth's School of Marine Science and Technology (SMAST), Buzzards Bay Coalition, the City of New Bedford and the Town of Fairhaven, as part of the Massachusetts Estuaries Project (MEP). The data were collected over a study period from 2000 through 2006, additional data was re-evaluated as part of efforts to update the original 2008 MEP report which includes data through 2012. The 2000-2006 data were used for the modeling, with the 2006-2012 data available for key stations supporting the contention that this was appropriate for the 2000-2012 period. The reason for this approach was to allow better spatial coverage of the Harbor basins to produce a more accurate calibration and verification of the water quality model (Howes *et al.* 2015, pg. 114). This study period will be referred to as the "Present Conditions" in the TMDL since it contains the most recent data available. The MEP Technical

Report (Howes *et al*. 2015) can be found on the MassDEP website (https://www.mass.gov/guides/the-massachusetts-estuaries-project-and-reports). The MEP Technical Report presents the results of the analyses of this coastal embayment system using the MEP Linked Watershed-Embayment Nitrogen Management Model (Linked Model).

Although New Bedford and Fairhaven are the primary stakeholders to the inner harbor, the watershed also includes Acushnet, Rochester, Freetown, and Lakeville. The analyses that were performed can assist all the municipalities in the watershed make decisions on current and future wastewater planning, wetland restoration, anadromous fish runs, shellfisheries, open-space, and harbor maintenance programs. Critical elements of this approach are the assessment of water quality monitoring data, time-series water column oxygen and chlorophyll measurements, and benthic community structure that were conducted on this embayment. These assessments served as the basis for generating an N loading threshold for use as a goal for watershed N management. The TMDL is based on the site-specific threshold generated for this embayment. Thus, the MEP offers a science-based management approach to support the wastewater management planning and decision-making process in New Bedford and Fairhaven.

Description of Waterbodies and Priority Ranking

Watershed Characterization

The New Bedford Inner Harbor Embayment System is located along the western coastline of Buzzards Bay in New Bedford and Fairhaven, Massachusetts (Figure 1). The Acushnet River flowing seaward from the Towns of Lakeville and Freetown in the upper portions of the Acushnet River watershed provides steady freshwater flow to the headwaters of New Bedford Harbor, which is the estuarine reach of the Acushnet River.

Sub-watersheds were delineated for the New Bedford Inner Harbor Embayment System, as outlined in the MEP Technical Report, shown in Figure 2. The MEP team used the United States Geological Survey (USGS) groundwater model as the basis for delineating the New Bedford Inner Harbor Embayment System. The watershed area is approximately 18,499 acres (28.9 square miles). The watersheds include contributing areas to the freshwater portions of the Acushnet River (Howes *et al.* 2015). The watershed area includes six towns, Acushnet (50%), New Bedford (27%), Freetown (11%), Fairhaven (9%), Rochester (3%), and Lakeville (1%).

The MEP project assessed land use in the New Bedford Inner Harbor Embayment System using municipal assessor data from City of New Bedford and the towns of Fairhaven, Acushnet, Rochester and Freetown. Land use was summarized into nine categories including residential, commercial, industrial, mixed use, undeveloped, agricultural, recreational, forest, public service/government, including road rights-of-way, and freshwater features (e.g., ponds and streams). These land use categories, except the freshwater features, are aggregations derived from the major categories in the Massachusetts Assessors land uses classifications (MassDOR, 2012). The most common land use categories in the overall watershed are residential (39%) and public service (24%) (Howes *et al.* 2015, pg. 32).

The nature of enclosed embayments in populous regions exposes an inherent challenge: as protected marine shoreline they are popular regions for boating, recreation, and land development; as enclosed waterbodies, they may not be readily flushed of the pollutants that they receive due to the proximity and density of development near and along their shores. In particular, the New Bedford Inner Harbor

Embayment System, like many other embayment systems in the region, is at risk of eutrophication from high N loads in the groundwater and runoff from their watersheds.

Description of Waterbodies

The estuary currently has relatively good tidal flushing, due to its relatively large tide range. There are no significant tributary sub-embayments within this system. The estuary can be partitioned into an upper (north of the constriction at Rt. 195), middle (the constriction at Rt. 195 to the area of the harbor constricted by Popes, Fish, and Crow Islands) and the lower region (the island constriction down to the Hurricane Barrier).

Together, the estuary and the associated port are a complex coastal marine environment that forms the basis for numerous natural, social, cultural, and economic resources of the region. This embayment system constitutes an important component of the region's natural and cultural resources. New Bedford Inner Harbor Embayment System is at risk of further eutrophication from high nutrient loads in the groundwater and runoff from the watershed. This TMDL report applies to four waterbody segments listed as requiring a TMDL (Category 5) in the MA 2022 Integrated List of Waters (MassDEP 2023), as summarized in Table 1.

All of the available information on eelgrass relative to New Bedford Inner Harbor indicates that this embayment has not supported eelgrass over the past two decades and likely has not supported eelgrass for over a century. No eelgrass was detected in the 1985 survey and subsequent field surveys. As eelgrass habitat could not be documented to exist either historically or presently within New Bedford Inner Harbor, the thresholds analysis for this system should focus on restoration of the impaired infaunal habitats. However, it is likely that N management within the Inner Harbor will improve eelgrass and infaunal habitat within the down-gradient basins of the Outer Harbor. (Howes *et al.* 2015)

Table 1 provides information from the 2022 Integrated List of Waters (MassDEP 2023), and the impairments observed during the preparation of the MEP Technical Report. A more complete description of this estuarine system is presented in Chapters I and IV of the MEP Technical Report (Howes *et al.* 2015). The information presented here on this estuarine system is primarily drawn from the Technical Report. Chapters VI and VII of the MEP Technical Report provide assessment data that show that portions of the New Bedford Harbor embayment system are impaired because of nutrients, low dissolved oxygen levels, elevated chlorophyll *a* levels, and benthic fauna habitat degradation.

Figure 1: Overview of New Bedford Inner Harbor

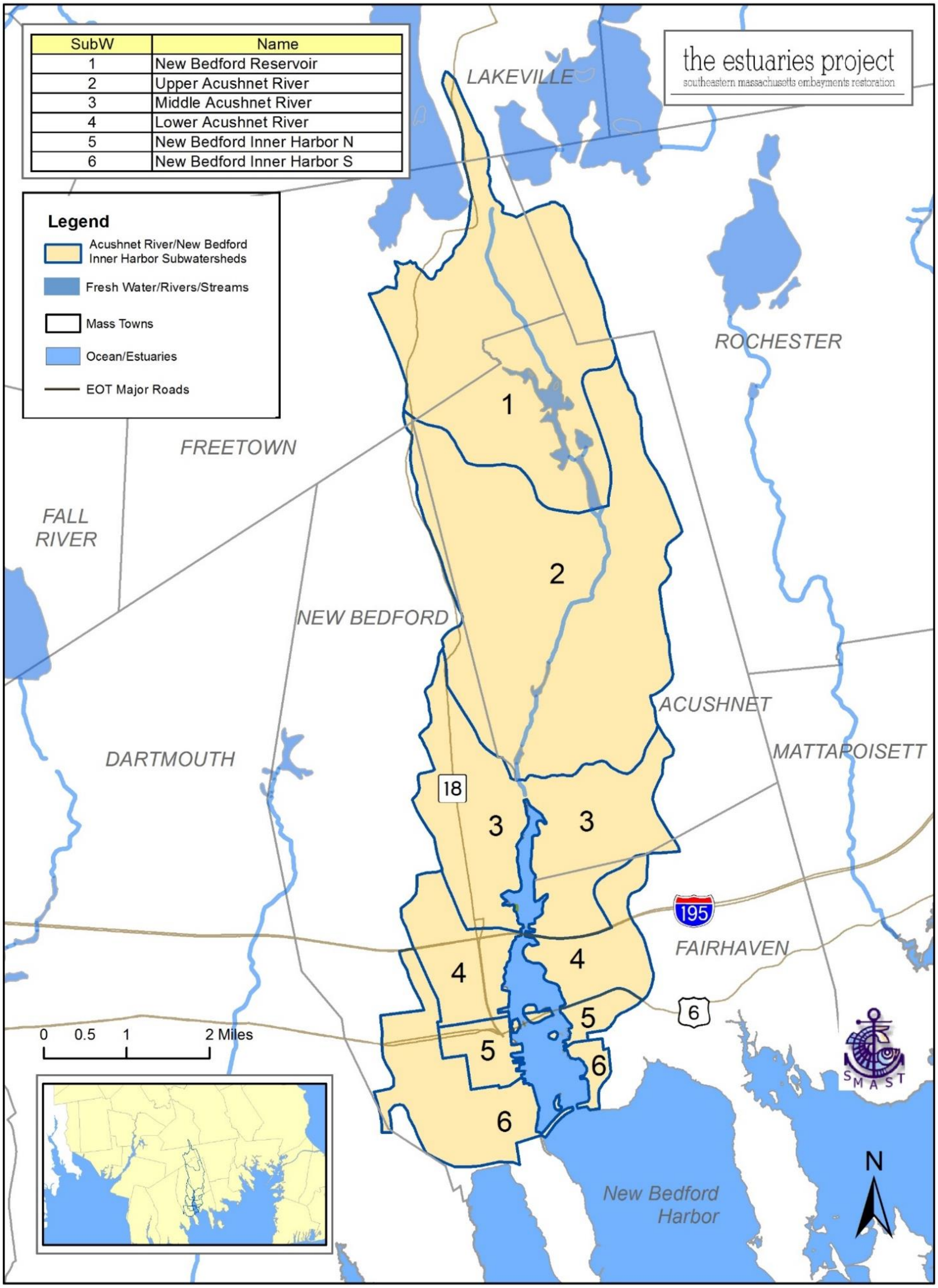


Figure 2: Map of Sub-watersheds for New Bedford Inner Harbor/Acushnet System used in MEP Tech Report Linked Model (Howes *et al.* 2015, p. 24)

Table 1: Comparison of DEP and SMAST Impaired Parameters for New Bedford Inner Harbor Embayment System

Waterbody	MassDEP Waterbody Segment ID (Class)	MassDEP Segment Description	2022 Integrated List (Category)	SMAST Impaired Parameter	Size
Acushnet River	MA95-31 (B)	Outlet New Bedford Reservoir, Acushnet to Hamlin Street culvert, Acushnet.	-Dissolved Oxygen (5) -Enterococcus, Escherichia Coli (E. Coli), Fecal Coliform (4A) [TMDL CN 251.1]	Not Assessed	2.9 miles
Acushnet River	MA95-32 (B)	Hamlin Street culvert, Acushnet to culvert at Main Street, Acushnet.	-Benthic Macroinvertebrates(5) -Dissolved Oxygen (5) -Enterococcus, Escherichia Coli (E. Coli), Fecal Coliform (4A) [TMDL CN 251.1]	Not Assessed	1.1 miles
Acushnet River	MA95-33 (SB)	Outlet Main Street culvert, Acushnet to Coggeshall Street bridge, New Bedford/Fairhaven.	-Color (5) -Dissolved Oxygen (5) -Enterococcus, Fecal Coliform (4A) [TMDL CN 251.1] -Metals (5) -Nitrogen, Total (5) -Nutrient/Eutrophication Biological Indicators (5) -Odor (5) -Oil and Grease (5) -Polychlorinated Biphenyls (PCBs) (5) -Trash (5) -(Debris*)	Low DO Chlorophyll *a* Macroalgae Infaunal animals	0.31 sq mi
New Bedford Inner Harbor	MA95-42 (SB)	Coggeshall Street Bridge to hurricane barrier, Fairhaven/ New Bedford	-Dissolved Oxygen (5) -Enterococcus, Fecal Coliform (4A) [CN 251.1] -Metals (5) -Nitrogen, Total (5) -Nutrient/Eutrophication Biological Indicators (5) -Odor (5) -Oil and Grease (5) -PCBs In Fish Tissue (5) -Polychlorinated Biphenyls (PCBs) (5) -Trash (5) -(Debris*)	Low DO Chlorophyll *a* Macroalgae Infaunal animals	1.25 sq mi

* Non-pollutant, does not require TMDL

Description of Hydrodynamics of the New Bedford Inner Harbor Embayment System

Circulation in the Acushnet River is dominated by tidal exchange with Buzzards Bay. From measurements made during the MEP study, the average tide range at the entrance to New Bedford Harbor is approximately 3.1 feet.

The embayment system has been divided into smaller embayments with the construction of bridges to Popes Island, the Interstate 195 bridge, and hurricane barrier at the head of the harbor. In general, flow between Buzzards Bay and the system is restricted by the hurricane barrier at the entrance of New Bedford Harbor. Although the narrowing of channels, bridge abutments, restrictions, and frictions losses restrict tidal flow, they do not significantly hinder flow to the upper reaches of the estuary. The tide range in upper Acushnet River is only slightly smaller (approximately 3.0 feet) due to flow restrictions.

Located within the estuary system is a small overall area of salt marsh (approximately 230 acres), which accounts for 37 percent of the estuary surface area (Howes *et al.* 2015, pg. 79). The system is generally a shallow tidal estuary, with mean water depth of only 2.5 feet and deeper sections resulting from navigational dredging and scour through the hurricane barrier.

The MEP project has evaluated the tidal circulation and flushing characteristics of this embayment system using both direct measurements and the RMA-2 model, a well-established model for estuaries (Norton et al., 1973). The MEP project deployed four gaging stations throughout the New Bedford Inner Harbor system to evaluate tidal characteristics. Residence times run for the model calibration period are listed in Table V-8 of the MEP Tech Report (Howes *et al.* 2015). The computed flushing rate for the entire system (1.504 days) shows that the system flushes well with water resident in the system for approximately a day and a half. The system residence time for the upper portions of the harbor lags behind with a residence time of approximately a week. However, the local residence times show that the water passes rather quickly into the lower portions of the harbor from the Acushnet River and then past Popes Island into the outer harbor (Howes *et al.* 2015, pg. 111).

Priority Ranking

The embayment addressed by this TMDL was determined to be a high priority based on three significant factors:

1) the initiative that the towns have taken to assess the conditions of the estuarine system
2) the commitment made by the towns to restore and preserve the embayment
3) the extent of impairment in the embayment

This embayment is at risk of further degradation from increased N loads entering through groundwater and surface water runoff from the increasingly developed watershed. In both marine and freshwater systems, an excess of nutrients results in degraded water quality, adverse impacts to ecosystems, and reduced use of water resources. Observations are summarized in Table 2 and in the Problem Assessment section below and are detailed in Chapter VII, Assessment of Embayment Nutrient Related Ecological Health, of the MEP Technical Report (Howes *et al.* 2015).

Problem Assessment

The elevated nutrient levels are primarily related to the land use impacts associated with the population within the coastal zone over the past half-century. Although population rates in the towns of New Bedford, Fairhaven, and Acushnet (Figure 3) have stayed relatively steady, the population density results in significant water quality impacts to the estuary and harbor system.

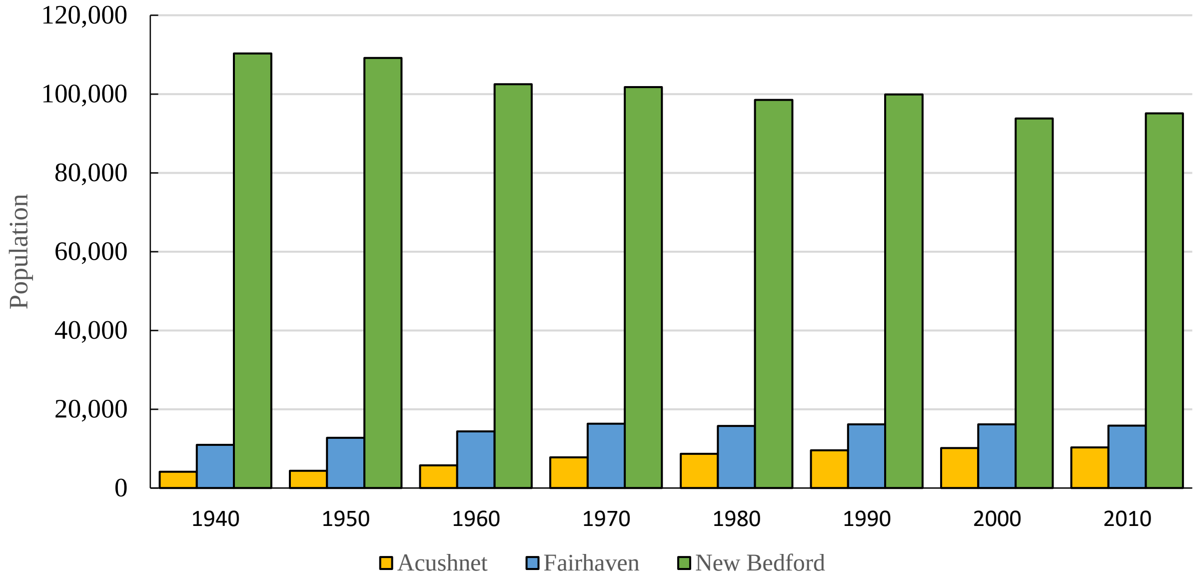


Figure 3: Historic Population of Acushnet, Fairhaven, and New Bedford (US Census)

Habitat and water quality assessments were conducted on this embayment system based upon water quality monitoring data, time-series water column oxygen measurements, and benthic community structure. The New Bedford Inner Harbor System is a riverine estuary composed of an upper tidal river with fringing wetlands, a middle depositional basin and a lower reach bounded by the New Bedford Hurricane Barrier. Each of these functional components has different natural sensitivities to nitrogen enrichment and organic matter loading. Evaluation of infaunal habitat quality must consider the natural structure of each system and the ability of the system to support specific types of infaunal communities.

At present, the New Bedford Inner Harbor Embayment System is showing variations in nitrogen enrichment and habitat quality among its various component basins. Overall, the habitat quality of the nitrogen enriched upper basin (with TN concentrations greater than 0.7 mg N/L) was found to be moderately impacted due to elevated chlorophyll *a*, low dissolved oxygen, an impacted benthic faunal community and sparse patches of drift algae. The MEP project found chlorophyll *a* levels >15 ug/L for 39% of the 34-day record. The upper basin, a wetland-dominated basin, has a moderately impacted benthic infaunal community with a limited diversity, a preponderance of stress tolerant species while also having a moderate number of individuals. The MEP project also noted that the benthic community while reflective of nutrient enrichment was also structed in response to the salinity and wetland influences.

The middle basin, between Popes Island the Route 195 bridge, is relatively deep and narrow, with tidal influence. The depth and depositional nature of the basin make the middle basin more sensitive to organic matter nitrogen enrichment and nitrogen loading than the upper and lower basins. It was found to have moderate to high levels of phytoplankton, periodic dissolved oxygen depletion, an infaunal community representative of a moderate level of impairment and sparce or absent macro-algae. Dissolved oxygen was found to be below 5 mg/L for approximately 33% of the dissolved oxygen probe deployment time. The MEP project found chlorophyll *a* levels >15 ug/L for 14% of the 33.9-day record. The elevated nitrogen (0.5-0.62 mg/L) concentrations correspond to moderately high nutrient enrichment in the middle reach. The middle basin was considered more typical of an open water embayment with greater sensitivity to nitrogen enrichment and as such was the targeted basin for the setting of a nitrogen threshold. However, the MEP Technical Report indicates that attainment of the nitrogen threshold in the middle basin will result in habitat restoration in the upper and lower basins.

The lower basin demonstrates the least nitrogen enrichment of the three estuarine basins in the overall system, with tidally averaged nitrogen ranging from 0.47 to 0.51 mg/L. Moderate oxygen depletion, elevated chlorophyll *a*, predominately moderately impaired benthic community and generally absent drift algae are indicative of a healthy to moderately impaired system overall. Dissolved oxygen was found to be below 5 mg/L for approximately 11-15 % of the dissolved oxygen probe deployment time at the Lower Basin - Pope's Island and Lower Basin West stations respectively. The MEP project found chlorophyll *a* levels >15 ug/L for 17% of the 34.5-day record at the Lower Basin - Pope's Island station and chlorophyll *a* levels >15 ug/L for 6% of the 41.9-day record at the Lower Basin West station. The MEP project found at some locations the benthic community was responding to the physical structure of the basin. Few organisms found near the dredged channel. A benthic community structured in response to the organic rich sediments in the depositional area of an artificial cove between Palmers Island and the Hurricane Barrier was also found. In this location low diversity and a community with the disturbance indicator species, *Capitella capitata*, was found. While these localized areas of impacted benthic communities were found, the MEP project found the main basin to have a "moderate to high numbers of species (20) and moderate numbers of individuals (~250), with high diversity (H'>3.0) and Evenness (E>0.7)", noted a lack of organic enrichment indicator species found in other parts of the basin and characterized the benthic community in the central region as only slightly impaired consistent with its nutrient concentrations (Howes *et. al* 2015, pg. 149).

Table 2: General Summary of Conditions Related to the Major Indicators of Habitat Impairment Observed in the New Bedford Inner Harbor Embayment System (Howes *et al*. 2015, Table VIII-1)

MassDEP Waterbody	Embayment	Overall Health[1]	Dissolved Oxygen Depletion	Chlorophyll *a*[2]	Macroalgae	Benthic Infauna[3]
Acushnet River (MA95-33)	Upper Basin	Moderate to significant impairment based upon patches of drift macroalgae and moderate-high chlorophyll levels, community dominated by organic enrichment indicators **MI**	Frequent depletions to 4-4.5 mg/L <5 mg/L for 27% of record **MI**[1]	generally 7-20 µg/L frequently >15 µg/L (39% of record) **MI-SI**	drift algae (Ulva, Gracillaria) in patches, indicative of nitrogen enrichment **MI**	Moderate number of individuals, low number of species, moderate diversity and evenness **MI**
New Bedford Inner Harbor (MA95-42)	Mid Basin	Moderate impairment of infaunal habitat, with moderate chlorophyll levels resulting in soft organic sediments in this depositional basin and basin-wide periodic oxygen depletion. **MI**	Frequent depletions to 4.5 mg/L Periodic declines to 3.5-4.0 mg/L <5 mg/L for 33% of record **MI-SI**	generally 4-18 µg/L occasionally >15 µg/L (14% of record) **MI**	drift algae absent or sparse	Moderate number of individuals, moderate-low number of species, moderate-high diversity and evenness, Dominant species (*Mediomastus*, *Streblospio*, *Leitoscolopios*) indicative of moderate organic enrichment **MI**
New Bedford Inner Harbor (MA95-42)	Lower Basin	Based mainly upon nitrogen related impairment to main basin, rather than localized areas of moderate to significant impairment of infaunal habitat, (e.g. Popes Island and Palmers Island depositional areas) and basin-wide periodic oxygen depletion. **H-MI**	Generally >5 mg/L <5 mg/L for 11-15% of record Rare depletions to 4 mg/L **MI**	Generally 4-18 µg/L, occasionally >15 µg/L (6-17 of record) **MI**	drift algae sparse/absent, some attached (Codium), patches of surface microphyte mat **H-MI**	Spatially variable, habitat ranging from moderate impairment in areas of organic enrichment, to significant impairment due to localized dredging disturbance, marina activities, depositional areas. Main Basin: moderate to high quality infaunal habitat, moderate # individuals & species, moderate diversity & evenness Channel: depleted community indicative of recent disturbance, Palmer Cove: moderate number of individuals,low number of species, dominated by organic enrichment/disturbance species (*Capitella capitata*) **MI-SI**

H - Healthy Habitat Conditions*, MI-Moderate Impairment*, SI-Significant Impairment*

1. No historical evidence this basin supported eelgrass since ~1950’s.
2. Algal blooms are consistent with chlorophyll *a* levels above 20 µg/l
3. Based on observations of the types of species, number of species, and number of individuals

** These terms are more fully described in MEP report “Site-Specific Nitrogen Thresholds for Southeastern Massachusetts Embayments: Critical Indicators” December 22, 2003. (https://www.mass.gov/doc/massachusetts-estuaries-project-interim-report-on-site-specific-nitrogen-thresholds-for/download)*

Pollutant of Concern, Sources, and Controllability

In the coastal embayments of the City of New Bedford and Town of Fairhaven, as in most marine and coastal waters, the limiting nutrient is nitrogen. Nitrogen concentrations beyond those expected naturally contribute to undesirable conditions, including the severe impacts described above, through the promotion of excessive plant and algal growth, including nuisance vegetation.

The embayment covered in this TMDL has had extensive data collected and analyzed through the Massachusetts Estuaries Program (MEP) and with the cooperation and assistance from the USGS, Buzzards Bay Coalition, the City of New Bedford, and Towns of Fairhaven, Acushnet, Freetown, Rochester and Lakeville. Data collection included both water quality and hydrodynamics as described in Chapters I, IV, V, and VII of the MEP Technical Report. These investigations revealed that nutrient loading, especially for N, are much larger than they would be under natural conditions, and as a result the water quality has deteriorated.

Figures below illustrate the sources of nitrogen to the harbor. “Overall Load” is the total nitrogen input within the watershed, while the “Controllable Load” represents only those nitrogen sources that could potentially be under local regulatory control. Most of the watershed loading of nitrogen to Inner New Bedford Harbor is from wastewater treatment facilities (WWTF, 40%), on-site subsurface wastewater disposal systems (septic systems, 17%) and fertilizers (11%), with less N originating from CSOs, impervious surface, farm animal and natural surfaces (Figure 4A). The nitrogen loading that is considered controllable affecting this system originates predominately from wastewater treatment facilities (WWTF, 47%), on-site subsurface wastewater disposal systems (septic systems, 20%) fertilizers (13%), CSOs (9%), impervious surfaces (7%) and farm animals (4%) (Figure 4B). WWTF and CSO nitrogen loads are exclusively in the southern portion of the watershed. Farm animal loads are almost exclusively in the northern portion of the watershed (Howes *et al.* 2015).

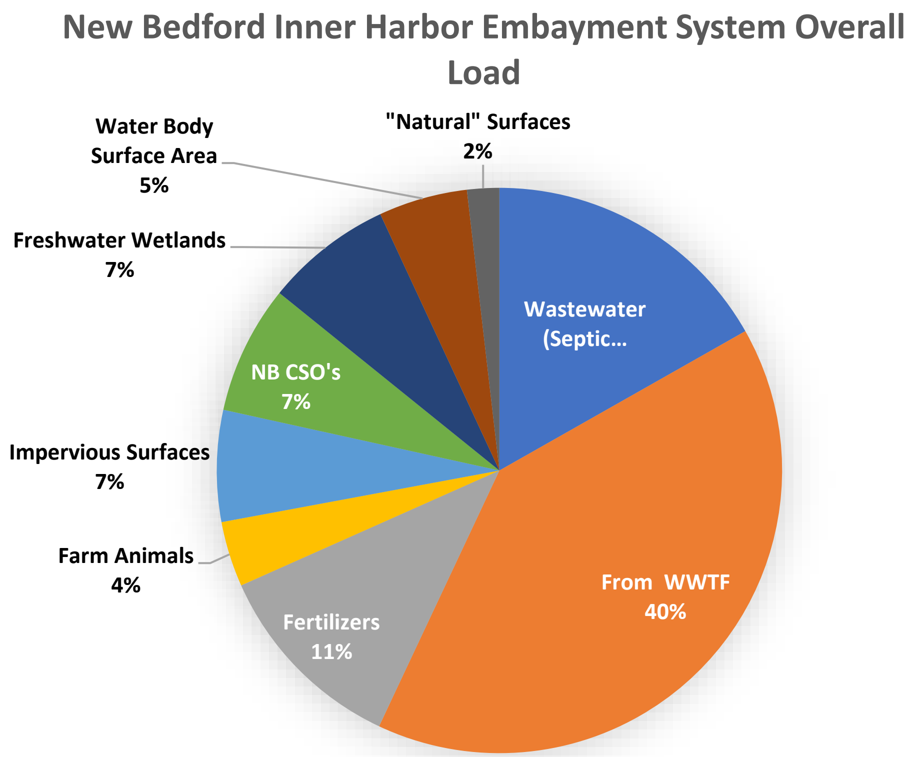


Figure 4A: Percent Contributions of All Watershed Nitrogen Sources to the New Bedford Inner Harbor Embayment System Watershed

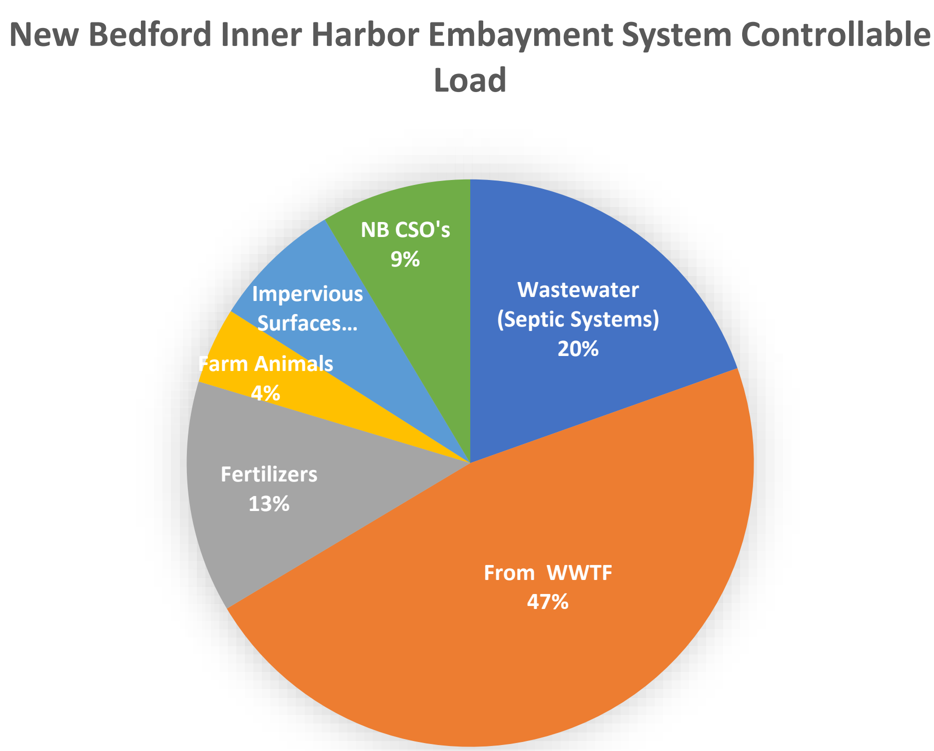


Figure 4B: Percent Contributions of Controllable Watershed Nitrogen Sources to the New Bedford Inner Harbor Embayment System

The level of "controllability" of each source, however, varies widely as shown in Table 3 below. Cost/benefit analyses will have to be conducted for all possible N loading reduction methodologies in order to select the optimal control strategies, priorities, and schedules.

Nitrogen Source	Degree of Controllability at Local Level	Reasoning
Agricultural fertilizer and animal wastes	Moderate	These nitrogen loadings can be controlled through appropriate agricultural Best Management Practices (BMPs).
Atmospheric deposition to the estuary surface	Low	It is only through region- and nation-wide air pollution control initiatives that significant reductions are feasible. Local control although helpful is not adequate.
Atmospheric deposition to natural surfaces (forests, fields, freshwater bodies) in the watershed	Low	Atmospheric deposition (loadings) to these areas cannot adequately be controlled locally. However, the N from these sources might be subjected to enhanced natural attenuation as it moves toward the estuary.
Combined Sewer Overflows (CSO)	Moderate	CSO permittee must implement "Nine Minimum Controls" to maximize the efficiency of existing facilities in order to limit the duration and impact of CSO discharges. Facilities must also develop and implement a Long-Term CSO Control Plan, which must demonstrate compliance with SWQS.
Fertilizer	Moderate	Lawn and golf course fertilizer and related N loadings can be reduced through BMPs, bylaws and public education.
Septic system	High	Sources of N can be controlled by a variety of case-specific methods including: sewering and treatment at centralized or decentralized locations, transporting and treating septage at treatment facilities with N removal technology either in or out of the watershed, or installing N-reducing on-site wastewater treatment systems.
Sediment	Low	N loadings are not feasibly controlled on a large scale by such measures as dredging. However, the concentrations of N in sediments, and thus the loadings from the sediments, will decline over time if sources in the watershed are removed, or reduced to the target levels discussed later in this document. In addition, increased dissolved oxygen will help keep N from fluxing.
Stormwater runoff from impervious surfaces	Moderate	This nitrogen source can be controlled by BMPs, bylaws and stormwater infrastructure improvements and public education. Stormwater NPDES permit requirements help control stormwater related N loadings in designated communities.
Wastewater treatment facility (WWTF)	High	Wastewater treatment facilities as point sources of pollution to surface water are permitted under the National Pollution Discharge Elimination System. Treated wastewater effluent discharged to groundwater disposal systems are permitted by MassDEP. There is a high degree of regulatory certainty that within the limits of technology, nutrient sources at these facilities can be controlled.

Table 3: Sources of Nitrogen and their Controllability

Description of the Applicable Water Quality Standards

The estuarine portion of Acushnet River and New Bedford Inner Harbor are classified as SB in the Massachusetts Surface Water Quality Standards (MassDEP, 2021). The standards of particular interest to the issues of cultural eutrophication are dissolved oxygen, nutrients, aesthetics, excess plant biomass, and nuisance vegetation. Ponds and tributaries associated with public water supplies are classified as Class A surface waters. All other freshwater portions are classified as Class B.

Massachusetts currently has narrative standards for nutrients (nitrogen and phosphorus) for waters of the Commonwealth such that "*all surface waters shall be free of nutrients in concentrations that would cause or contribute to impairment of existing or designated uses and shall not exceed site specific criteria developed in a TMDL or otherwise, established by the department*" (MassDEP, 2021). A more thorough explanation of applicable standards can be found in Appendix A.

Thus, the assessment of eutrophication is based on site-specific information within a general framework that emphasizes impairment of uses and preservation of a balanced indigenous flora and fauna. This approach is recommended by the U.S. Environmental Protection Agency in their Nutrient Criteria Technical Guidance Manual for Estuarine and Coastal Marine Waters (EPA, 2001). The guidance manual notes that lakes, reservoirs, streams, and rivers may be subdivided by classes, allowing reference conditions for each class and facilitating cost-effective criteria development for nutrient management. However, individual estuarine and coastal marine waters tend to have unique characteristics, and development of individual waterbody criteria is typically required.

Methodology - Linking Water Quality and Pollutant Sources

Extensive data collection and analyses have been described in detail in the MEP Technical Report. Those data were used by SMAST to assess the loading capacity of each sub-embayment. Physical (Chapter V), chemical, and biological (Chapters IV, VII, and VIII**)** data were collected and evaluated. The primary water quality objective was represented by conditions that:

1) Prevent algal blooms;
2) Restore and protect benthic communities; and
3) Maintain dissolved oxygen concentrations that protect estuarine communities.

The details of the data collection, modeling and evaluation are presented and discussed in Chapters IV, V, VI, VII and VIII of the MEP Technical Report. The main aspects of the data evaluation and modeling approach are summarized below.

The core analytical method of the MEP is the Linked Watershed-Embayment Management Modeling Approach. It fully links watershed inputs with embayment circulation and N characteristics, and is characterized as follows:

- Requires site-specific measurements within the watershed and each sub-embayment;
- Uses realistic "best-estimates" of N loads from each land-use (as opposed to loads with built-in "safety factors" like Title 5 design loads);
- Spatially distributes the watershed N loading to the embayment;
- Accounts for N attenuation during transport to the embayment;

- Includes a 2D or 3D embayment circulation model depending on embayment structure;
- Accounts for basin structure, tidal variations, and dispersion within the embayment;
- Includes N regenerated within the embayment;
- Is validated by both independent hydrodynamic, N concentration, and ecological data;
- Is calibrated and validated with field data prior to generation of "what if" scenarios.

The Linked Model has previously been applied to watershed N management in over 65 embayments throughout Southeastern Massachusetts. In these applications it became clear that the model can be calibrated and validated and has use as a management tool for evaluating watershed N management options.

The Linked Model, when properly calibrated and validated for a given embayment, becomes an N management planning tool as described in the model overview below. The model can assess solutions for the protection or restoration of nutrient-related water quality and allows testing of management scenarios to support cost/benefit evaluations. In addition, once a model is fully functional it can be refined for changes in land-use or embayment characteristics at minimal cost. Also, since the Linked Model uses a holistic approach that incorporates the entire watershed, embayment, and tidal source waters, it can be used to evaluate all projects as they relate directly or indirectly to water quality conditions within its geographic boundaries. This approach includes high-order, watershed and sub-watershed scale modeling necessary to develop critical nitrogen targets for each major sub-embayment. The models, data and assumptions used in this process are specifically intended for the purposes stated in the MEP Technical Report, upon which this TMDL is based. As such, the Linked Model process does not contain the type of data or level and scale of analysis necessary to predict the fate and transport of nitrogen through groundwater from specific sources. In addition, any determinations related to direct and immediate hydrologic connection to surface waters are beyond the scope of the MEP's Linked Model process.

The Linked Model provides a quantitative approach for determining an embayment's: (1) N sensitivity; (2) N threshold loading levels (TMDL); and (3) response to changes in loading rate. The approach is fully field validated and unlike many approaches, accounts for nutrient sources, attenuation, and recycling and variations in tidal hydrodynamics (Figure I-2 of the MEP Technical Report). This methodology integrates a variety of field data and models, specifically:

- Monitoring - multi-year embayment nutrient sampling

- Hydrodynamics -
  - Embayment bathymetry (depth contours throughout the embayment)
  - Site-specific tidal record (timing and height of tides)
  - Water velocity records (in complex systems only)
  - Hydrodynamic model

- Watershed Nitrogen Loading
  - Watershed delineation
  - Stream flow (Q) and N load
  - Land-use analysis (GIS)
  - Watershed N model

- Embayment TMDL - Synthesis
  - Linked Watershed-Embayment Nitrogen Model

- Salinity surveys (for linked model validation)
- Rate of N recycling within embayment
- Dissolved oxygen record
- Chlorophyll *a* record
- Eelgrass and Infaunal surveys

Application of the Linked Watershed-Embayment Model

The approach developed by the MEP for applying the linked model to specific embayments, for the purpose of developing target N loading rates, includes:

1) Selecting one or two sub-embayments within the embayment system, located close to the inland-most reach or reaches, that typically has the poorest water quality within the system. These are called "sentinel" stations.

2) Using site-specific information and a minimum of three years of sub-embayment-specific data to select target threshold N concentrations for each sub-embayment. This is done by refining the draft target threshold N concentrations that were developed as the initial step of the MEP process. The target threshold N concentrations that were selected generally occur in higher quality waters near the mouth of the embayment system.

3) Running the calibrated water quality model using different watershed N loading rates, to determine the loading rate, that will achieve the target threshold nitrogen concentration at the sentinel station. Differences between the modeled N load required to achieve the target threshold nitrogen concentration, and the present watershed N load, represent N management goals for restoration and protection of the embayment system.

Previous sampling and data analyses, and the modeling activities described above, resulted in four major outputs that were critical to the development of the TMDL.

Two outputs are related to N **concentration**:
- The present N concentrations in the sub-embayments
- Site-specific target threshold N concentrations

Two outputs are related to N **loadings:**
- The present N loads to the sub-embayments
- Load reductions necessary to meet the site-specific target threshold N concentrations

In summary, by reducing the nitrogen concentration (and thus the nitrogen load) at the sentinel stations(s) to meet applicable water quality standards, the water quality goals will be met throughout the entire system. A brief overview of each outputs is listed below.

Nitrogen concentrations in the embayment

1) <u>Observed "present" conditions:</u>

Table 4 presents the average concentrations of N measured in this embayment from six years of data collection (during the period 2000 through 2006). Concentrations of N ranged from 0.48-0.1.20 mg/L. The overall means and standard deviations of the averages are presented in Appendix A (reprinted from Table VI-1 of the accompanying MEP Technical Report). The locations of the water quality monitoring stations referenced in Table 4 and Appendix A are shown in Figure 5.

Table 4: Observed Present Nitrogen Concentrations and Sentinel Station Target Threshold Nitrogen Concentrations for the New Bedford Inner Harbor System

Sub-embayment	Station(s)	Observed Nitrogen Concentration [1] (mg/L)	Sentinel Station Target Threshold Nitrogen Concentration (mg/L)
Acushnet River (freshwater)		0.70-1.38	
Upper Basin	MEP2, MEP3	0.62 - 0.79 [2]	
Mid Basin		~0.6	**0.50**[3]
Lower Basin	MEP6, MEP7, MEP8, MEP9, MEP12	0.48 - 1.20 [2]	
Outer Harbor - Boundary Condition	PT1, NB5, NB3,11	0.39	

[1] Calculated as the average of the separate yearly means of 2000-2006 data. Overall means and standard deviations of the average are presented in Appendix A
[2] Listed as a range since it was sampled at several stations (see Appendix A)
[3] The location of the sentinel station is shown on the map below, head of mid basin, near benthic station NB13. Target concentration established to restore benthic habitat.

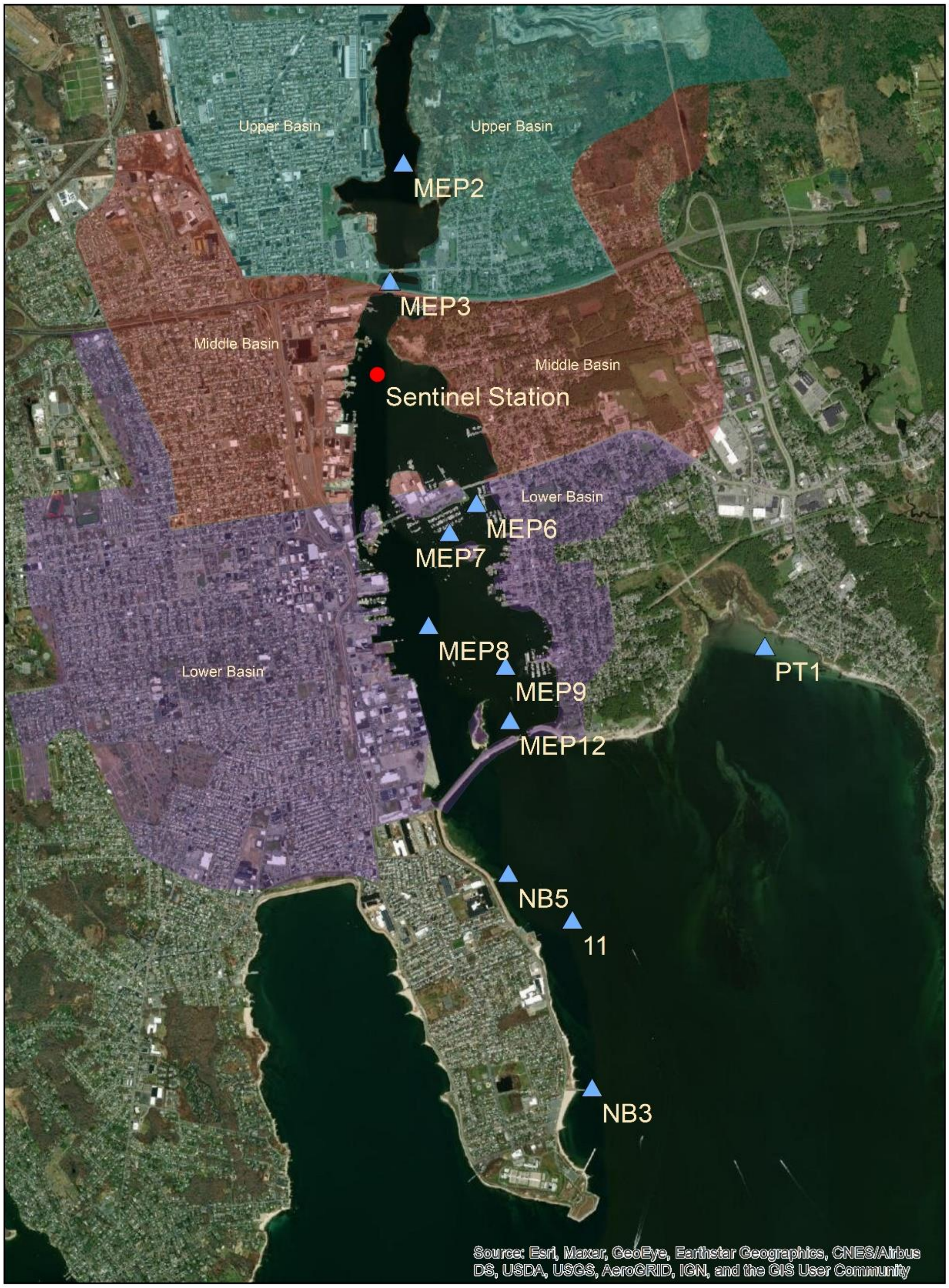


Figure 5: Location of Sentinel Threshold Station (red) and Monitoring Stations

2) Modeled site-specific target threshold N concentrations:

A major component of TMDL development is the determination of the maximum N concentrations (based on field data) that can occur without causing unacceptable impacts to the aquatic environment. This is called the *target threshold nitrogen concentration*. Prior to conducting the analytical and modeling activities described above, SMAST selected appropriate nutrient-related environmental indicators and tested the qualitative and quantitative relationship between those indicators and N concentrations. The Linked Model was then used to determine site-specific threshold N concentrations by using the specific physical, chemical, and biological characteristics of each sub-embayment.

The approach for determining nitrogen loading rates, which will maintain acceptable habitat quality throughout an embayment system, is to first identify a sentinel location within the embayment and second to determine the nitrogen concentration within the water column that will restore the location to the desired habitat quality. The sentinel location is selected such that the restoration of that one site will necessarily bring the other regions of the system to acceptable habitat quality levels. Once the sentinel site and its target threshold nitrogen concentration are determined, the MEP study modeled nitrogen loads from the watershed until the targeted nitrogen concentration was achieved.

The threshold N level for an embayment represents the average water column concentration of N that will support the habitat quality being sought. The water column N level is ultimately controlled by the integration of the watershed N load, the N concentration in the inflowing tidal waters (boundary condition) and dilution and flushing via tidal flows. The water column N concentration is modified by the extent of sediment uptake and/or regeneration and by direct atmospheric deposition.

Target threshold nitrogen concentrations in this study were developed to restore or maintain SB waters or high habitat quality. In this system, high habitat quality was defined as diverse benthic animal communities and dissolved oxygen levels that would support Class SB waters. As listed in Table 4, the site-specific target threshold nitrogen concentration is 0.50 mg/L, to be assessed at the head of the middle basin, 0.6 kilometers downstream of highway 195 bridge (approximately 41°38'57"N, 70°55'8"W).

For the New Bedford Inner Harbor Estuary, determination of the critical nitrogen threshold for maintaining high quality habitat is based primarily upon the nutrient and oxygen levels, current benthic community indicators and macroalgal accumulations. The N threshold is based upon the primary goal of restoring these impaired habitats. In general, the level of impairment increases as from the tidal inlet into the upper basin. The middle basin of New Bedford Inner Harbor shows nitrogen enrichment, with tidally averaged total nitrogen levels 0.51-0.62 mg/L N. Nitrogen management focused on the middle basin will improve the upper basin and will also result in lowering the enrichment in the lower basin (Howes *et al*. 2015).

Based upon data that the MEP collected from similar estuary systems in the Buzzards Bay region, an upper concentration limit of 0.50 mg/L tidally averaged TN would support healthy infaunal habitat in this system. Healthy infaunal habitats have been documented as part of MEP with corresponding level of nitrogen less than 0.5 mg/L. This includes Perch Pond, Bournes Pond and Popponesset Bay located along Nantucket Sound. Conversely, in the Centerville River system, moderate impairment was found at nitrogen levels of 0.543 mg/L (tidally averaged). Similarly, the Wareham River had TN levels ranging 0.535-0.600 mg/L demonstrating moderate impairment. The range in nitrogen levels in the Wareham River are comparable to those found during the MEP project in middle reach of New Bedford Inner Harbor Embayment System.

Nitrogen loadings to the embayment

1) <u>Present loading rates:</u>

In the New Bedford Inner Harbor System, the highest overall N loading from controllable sources is from Fairhaven Wastewater Pollution Control Facility (NPDES Permit No. MA0100765). The MEP Technical Report calculates that the facility accounts for 47% of the controllable N load to the system. Other controllable sources include on-site wastewater treatment (septic) systems (20%), fertilizers (13%), CSOs (9%) and runoff from impervious surface (7%). A further breakdown of N loading by source is presented in Table 5, the data on which the table is based can be found in Table ES-1 of the MEP Technical Report.

2) <u>Nitrogen loads necessary for meeting the site-specific target threshold N concentrations</u>:

The nitrogen threshold developed by SMAST and summarized above was used to determine the amount of total nitrogen mass loading reduction required for restoration of infauna habitats in the New Bedford Inner Harbor system. Tidally averaged total nitrogen concentrations were used to calibrate the water quality model). Modeled watershed nitrogen loads were sequentially lowered until the nitrogen levels reached the threshold level at the sentinel station chosen for New Bedford Inner Harbor (located at the head of the middle basin just below the entrance to the channel to the upper basin). Threshold nitrogen levels for this embayment system were developed to restore or maintain SB waters. In this system, habitat quality consistent with the system's structure was defined as supportive of diverse benthic animal communities. Dissolved oxygen and chlorophyll *a* were also considered in the assessment (Howes *et al.* 2015, ES pg.9).

Table 6 lists the present watershed N loadings to the New Bedford Inner Harbor embayment system, and one scenario of the reduced loads and percentage reductions that could achieve the target threshold N concentration at the sentinel station (see following section). In the scenario presented, the percentage reductions in N loadings to meet target threshold N concentration ranged by sub-watershed from approximately 30% in Acushnet River (freshwater) to 60% in the Lower Basin. It is important to note that load reductions can be produced by reduction of any or all sources of N and/or by increasing the natural attenuation of nitrogen within the freshwater systems to the embayment. The load reductions presented here represent only one of a suite of potential reduction approaches that need to be evaluated by the community.

Two model runs were made under the MEP to assess the impact of removing loads to the harbor system: (1) changes in water quality from continued Combined Sewer Outflows (CSOs) improvements and (2) from the modification of the Fairhaven wastewater treatment facility outfall. The focus of the model runs was whether change to TN loads to the harbor system would achieve the requirements of the threshold. An 8.3% reduction in the total watershed load to the harbor system is possible by removing all CSO inputs. A 49.2% reduction in total watershed load is possible by removing both CSO and Fairhaven Wastewater Pollution Control Facility discharges to the harbor (see Figure 6). Based on the results from the Linked Watershed-Embayment Model, neither of these scenarios alone will meet the threshold requirements of a 0.50 mg/L TN concentration at the upper 1/3 of the mid Harbor basin. Therefore, additional loads (e.g., septic load) would need to be removed to meet the threshold (Howes *et al.* 2015, ES pg.10).

Table 5: Present Attenuated Nitrogen Loading from New Bedford Inner Harbor System (Howes *et al.* 2015)

Sub-embayment	Present Land Use Load[1] (kg/day)	Present Attenuated Septic System Load (kg/day)	Present WWTF Load[2] (kg/day)	Present Total Attenuated Watershed Load[3] (kg/day)	Direct Atmospheric Deposition[4] (kg/day)	Present Net Benthic Flux (kg/day)	Total N Load from All Sources[5] (kg/day)
Upper Basin	40.337	7.562		47.899	2.836	45.081	95.816
Mid Basin	15.463	2.137		17.6	3.614	-28.561	-7.347
Lower Basin	159.54	5.973	145.32	165.512	7.011	52.147	224.671
Acushnet River (freshwater)	61.164	38.279		99.444			99.443
System Total	**276.504**	**53.951**	**145.32**	**330.455**	**13.461**	**68.667**	**412.583**

1 composed of non-wastewater loads, e.g., fertilizer and runoff from natural surfaces and atmospheric deposition to lakes, as well as wastewater treatment facility discharges and combined sewer overflows

2 existing unattenuated wastewater treatment facility discharges, Fairhaven Wastewater Pollution Control Facility (NPDES MA0100765), included in present land use load but also shown separately for emphasis

3 composed of combined natural background, fertilizer, runoff, atmospheric deposition to lakes, septic system loadings and wastewater treatment facility discharges and combined sewer overflows as applicable

4 atmospheric deposition to embayment surface only.

5 composed of total attenuated watershed load, atmospheric deposition, and benthic flux loadings

As part of the 2015 MEP Technical Report, model runs were made to investigate the effect of proposed modifications to the hurricane barrier, and separately, different N loading scenarios. The objective of evaluating modifications to the New Bedford Harbor Hurricane Barrier was to assess potential improvements to the water quality within the harbor. The modeling results focused on quantifying the effects of installing additional openings in the Hurricane Barrier to both tidal circulation and water quality in Inner New Bedford Harbor. The overall conclusion relating to the modeling effort is that the Hurricane Barrier is currently presenting only a very minor restriction to tidal exchange between the Inner New Bedford and Outer New Bedford Harbor waters (Howes *et al.* 2015, Tables ES-3, 4, 5). Therefore, installing a 24' box culvert would have negligible effect on volumetric exchange and tidal flushing, hence water or habitat quality within the Inner Harbor (Howes *et al*. 2015, ES pg.11).

Table 6: Present Watershed Nitrogen Loads, Thresholds Loads, and the Percent Reductions Necessary to Achieve the Thresholds Loads.

Sub-watershed	Present Attenuated Watershed Load [1] (kg/day)	Target Threshold Watershed Load [2] (kg/day)	Percent watershed reductions needed to achieve threshold loads
Upper Basin	47.899	22.948	-52.1%
Mid Basin	17.600	12.219	-30.6%
Lower Basin	165.512	62.668	-62.1%
Acushnet River (fresh water)	99.444	68.820	-30.8%
System Total	330.455	166.656	-49.6%

[1] Composed of combined natural background, fertilizer, runoff, WWTF, CSOs, and septic system loadings.

[2] Target threshold watershed load is the load from the watershed needed to meet the embayment threshold concentration identified in Table ES-1.

The approach presented in Table 6 is only one scenario that will meet the target N concentrations in the sentinel systems, which is the goal of the TMDL. There can be variations depending on the chosen sub-watershed and which controllable source is selected for reduction. Alternate scenarios will result in different amounts of nitrogen being reduced in different sub-watersheds. For example, removing additional nitrogen upstream will impact how much nitrogen must be removed downstream. The towns should take any reasonable effort to reduce the controllable nitrogen sources.

Total Maximum Daily Loads

A total maximum daily load (TMDL) identifies the loading capacity of a waterbody for a pollutant. EPA regulations define loading capacity as the greatest amount of loading that a waterbody can receive without violating water quality standards. The TMDLs are established to protect and/or restore the estuarine ecosystem, thus meeting water quality goals for aquatic life support. There are site-specific numeric nutrient criteria for certain waterbodies in the Massachusetts Surface Water Quality Standards. However, because there are not generally applicable or site specific criteria for the New Bedford Inner Harbor Embayment System in the Massachusetts Surface Water Quality Standards, the TMDL for the embayment system is aimed at determining the loads that would correspond to the target threshold N concentration at the sentinel station, thus protecting the water quality and ecosystems of the entire estuary system.

The development of a TMDL requires detailed analyses and mathematical modeling of land use, nutrient loads, water quality indicators, and hydrodynamic variables (including residence time) for each waterbody system. The results of the mathematical model are correlated with estimates of impacts on water quality including negative impacts on benthic infauna, as well as dissolved oxygen and chlorophyll.

The TMDL can be defined by the equation:

$$TMDL = WLAs + LAs + MOS$$

Where

TMDL = loading capacity of receiving water
WLAs = portion allotted to point sources
LAs = portion allotted to (cultural) nonpoint sources
MOS = margin of safety

Background Loading

Natural background N loading is included in the loading estimates but is not quantified or presented separately. Background loading was calculated on the assumption that the entire watershed is forested with no anthropogenic sources of N. It is accounted for in this TMDL but not defined as a separate component. The MEP Technical Report includes estimated loading due to natural conditions.

Waste Load Allocations

Waste load allocations (WLA) identify the portion of the loading capacity allocated to existing and future wastewater point sources. A TMDL may establish a specific WLA for an identified source or, as in the case of stormwater, may establish an aggregate WLA that applies to numerous sources. EPA interprets 40 CFR 130.2(h) to require that allocations for NPDES regulated discharges of stormwater also be included in the waste load component of the TMDL.

In the New Bedford Harbor Embayment System, this Waste Load Allocation includes the Fairhaven Wastewater Pollution Control Facility discharge, City of New Bedford CSO discharge, and runoff from impervious surfaces. Currently, these three sources account for 194.95 kg/day of the total nitrogen load, or about 59% of the approximately 330.5 kg of the total present nitrogen load entering this system each day. The data used to make these calculations are taken directly from Table ES-1 and Table IV-4 of the accompanying MEP Technical Report. The future allocation of loads from these sources will depend on additional scenario runs to be conducted as part of the CWMP.

In addition to stormwater, there are two permitted surface water discharges in the watershed, New Bedford Wastewater Pollution Control Facility (New Bedford WPCF) and Combined Sewer Overflows (CSO) and Fairhaven Wastewater Pollution Control Facility (Fairhaven WPCF).

The New Bedford WPCF is located at the end of Clarks Point and discharges treated effluent into Buzzards Bay through an outfall pipe located off the end of the point and outside of the New Bedford Inner Harbor MEP study area. The annual existing MEP CSO nitrogen load to the New Bedford Inner Harbor system is 9,706 kg. Since nearly all of the New Bedford parcels in the Harbor watershed are connected to the sewer system and the New Bedford WPCF discharges through an outfall pipe outside of the Harbor study area, only wastewater nitrogen loads from the New Bedford portion of the watershed are included in the CSO nitrogen loads (Howes *et al.* 2015, Table IV-2).

The Fairhaven WPCF is located on Arsene Street in Fairhaven. The WPCF has a National Pollutant Discharge Elimination System (NPDES) permit from US Environmental Protection Agency (USEPA) and MassDEP that allows direct discharge into New Bedford Harbor (Figure 1) and limits total flow to 5 million gallons per day (MGD). The sewer collection system connected to the Fairhaven WPCF receives wastewater flow from the Towns of Fairhaven and Mattapoisett (approximately 0.25-0.30 MGD). Using flow and concentration data, MEP staff determined monthly loads and summed these to determine an annual load for each of the three years. The average of the three years is 53,043 kg (145.32 kg N/day).

EPA concluded that the MEP modeling approach as applied to New Bedford Inner Harbor is scientifically credible and used it as basis for setting permit limits. Nitrogen limits are included in the most recent discharge permit issued in 2017 (EPA 2017). With the WPCF load set at 57 kg/day (the equivalent of 3 mg/L TN at design flow), then there will also need to be an approximate 72% reduction in the overall combined septic, fertilizer, and impervious surface loads within the Lower Basin watershed.

The City of New Bedford and the Towns of Fairhaven, Acushnet, Freetown, and Lakeville are subject to the NPDES Phase II General Permit for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems (MS4s). Most of this watershed within the City of New Bedford and the Town of Fairhaven is within the designated MS4 areas of these communities. Following the watershed upstream into the Towns of Acushnet, Freetown, Rochester, and ending in Lakeville, the area of this watershed within the EPA designated regulated urbanized area for these towns continues to decrease. In addition, there are directly connected impervious areas (DCIAs) that discharge stormwater directly to waterbodies via a conveyance system such as a swale, pipe or ditch throughout the entire watershed as identified by the EPA in: https://www.epa.gov/npdes-permits/regulated-ms4-massachusetts-communities . This TMDL treats stormwater discharge from all DCIAs (even those outside of regulated urbanized areas) as part of a waste load allocation.

The Linked Model accounts for stormwater and groundwater loadings in one aggregate allocation as a nonpoint source – combining the assessments of wastewater and stormwater (including stormwater that infiltrates into the soil and direct discharge pipes into waterbodies) for the purpose of developing control strategies. Based on land use, the Linked Model accounts for loading from stormwater, but does not differentiate stormwater into a load and waste load allocation. In order to distinguish the point source or waste load allocation of stormwater originating from DCIAs from the nonpoint source stormwater contribution (LA or load allocation), the percent of the impervious area that was identified as DCIA was determined and multiplied by the impervious surface N load (in kg N/day) as reported by the MEP in Table IV-5 of the Technical Report.

Table 7 shows the existing WLA and LA from stormwater runoff from impervious surfaces in the New Bedford Inner Harbor (NBIH) watershed. The WLAs for stormwater nitrogen contribution (kg N/day) was determined using the DCIA for each sub-embayment divided by total impervious area in the sub-embayment, then multiplying the total impervious surfaces runoff N load for the sub-watershed (from Table IV-5 in the MEP Technical Report) per EPA methodology (EPA, 2010). The remaining impervious surfaces loads were assigned as the LA.

Table 7. Existing Stormwater WLA and LA as determined by Percentage of Directly Connected Impervious Area (DCIA) in the NBIH watershed

Sub-watershed	Percent DCIA[1] (%)	Watershed Impervious Surface N Load[2] (kg N/day)	Stormwater WLA[3] (kg N/day)	Stormwater LA (kg N/day)
Upper Basin	86%	8.895	7.612	1.283
Middle Basin	83%	1.927	1.598	0.329
Lower Basin	89%	3.344	2.967	0.377
Acushnet River (freshwater)	46%	8.871	4.053	4.818
System Total		**23.04**	**16.23**	**6.81**

[1] DCIA (Directly connected impervious area in acres) divided by Total Impervious Area (acres) X 100.
[2] from the MEP Technical Report, Table IV-4, kg/yr divided by 365
[3] Percent DCIA multiplied by Watershed Impervious Surface N Load

Load Allocations

Load allocations identify the portion of loading capacity allocated to existing and future nonpoint sources. In the case of the New Bedford Inner Harbor Embayment System, the nonpoint source loadings are primarily from septic systems (wastewater) and fertilizer. Nonpoint source loading contributions from farm animals and stormwater runoff from impervious surfaces determined to be load allocations, make up a much smaller percentage of the controllable load. In addition, there are nonpoint sources of N from wetlands, sediments, natural background and atmospheric deposition that are not feasibly controllable.

Stormwater that is subject to the EPA Phase II Program is considered a part of the waste load allocation, rather than the load allocation. As presented in Chapter IV, V, and VI, of the MEP Technical Report, the majority of stormwater percolates into the aquifer and enters the embayment system through groundwater, thus defining the stormwater in pervious areas to be a component of the nonpoint source load allocation. Nitrogen from stormwater runoff attributed to impervious surfaces not directly connected to a waterbody was determined to be 6.81 kg N/day for the entire system (see Table 7), which when compared to the total impervious surface N watershed load of 23.0 kg N.day, accounts for approximately 29.5% of the impervious surface N load for the entire watershed.

Locally controllable sources of N within this embayment system's watersheds are CSOs, the Fairhaven WWTF effluent, on-site septic system wastes, stormwater runoff from impervious surfaces, and fertilizers. Figure 6 emphasizes the fact that the overwhelming majority of locally controllable N comes from the Fairhaven WWTF and on-site septic systems.

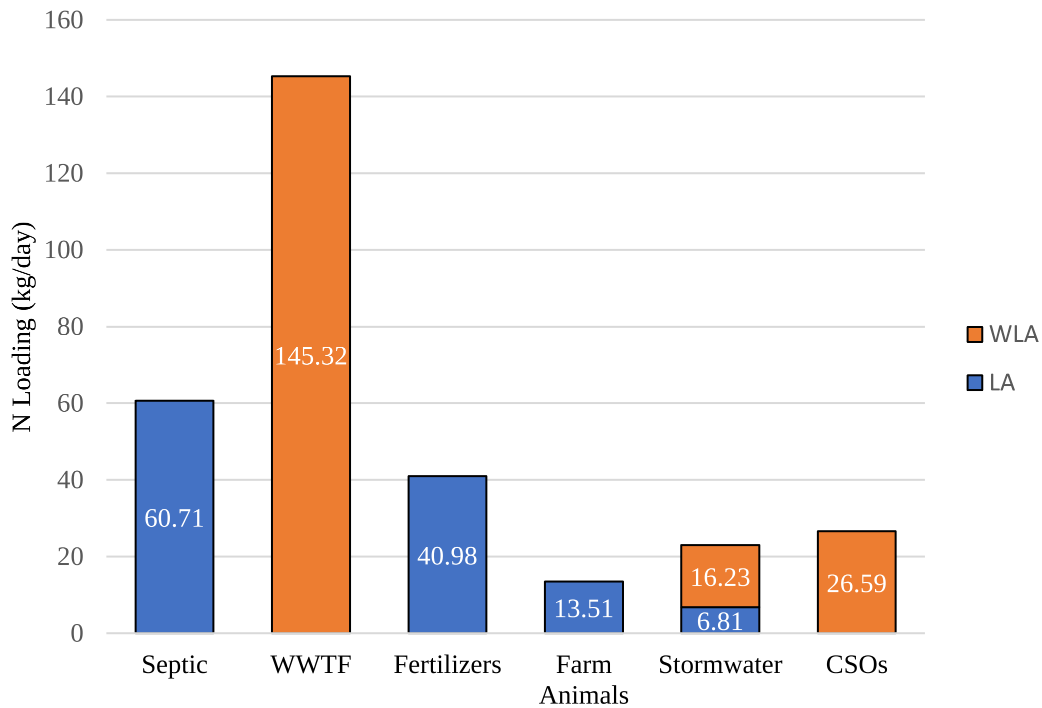


Figure 6: Controllable Nitrogen Loads (kg/day) into New Bedford Inner Harbor Embayment System

Benthic Flux and Atmospheric Deposition

Sediment loading rates incorporated into the TMDL are different than the existing sediment flux rates because projected reductions of N loadings from the watershed will result in reductions of nutrient concentrations in the sediments, and therefore, over time, reductions in loadings from the sediments will occur. Benthic flux of nitrogen from bottom sediments is a critical (but often overlooked) component of nitrogen loading to the shallow estuarine systems, therefore determination of the site-specific magnitude of this component was also performed (see Sections IV.3 and VI of the MEP Report).

Benthic N flux is a function of N loading and particulate organic N (PON). Projected benthic fluxes are based upon projected PON concentrations and watershed N loads and are calculated by multiplying the present N flux by the ratio of projected PON to present PON using the following formulae:

Projected N flux = (present N flux) (PON projected / PON present)

When: $PON\ projected = (R_{load})\ (D_{PON}) + PON_{present\ offshore}$

When R_{load} = (projected N load) / (Present N load)

And D_{PON} is the PON concentration above background determined by:

$D_{PON} = (PON_{present\ embayment} - PON_{present\ offshore})$

The benthic flux modeled for the New Bedford Inner Harbor Embayment System is reduced from existing conditions based on the load reduction and the observed PON concentrations within each sub-embayment relative to Buzzards Bay (boundary condition). A net negative benthic flux was recorded in the middle basin under present conditions. This indicates nitrogen uptake from bottom sediments. A conservative approach was applied by assuming zero benthic flux in this basin.

The loadings from atmospheric sources incorporated into the TMDL are the same rates presently occurring because, as discussed above, significant control of atmospheric loadings at the local level is not considered feasible.

Margin of Safety

Statutes and regulations require that a TMDL include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and waste load allocations and water quality [CWA para 303 (d)(20C, 40C.G.R. para 130.7C(1)]. The MOS must be designed to ensure that any uncertainties in the data or calculations used to link pollutant sources to water quality impairment modeling will be accounted for in the TMDL and ensure protection of the beneficial uses. The EPA's 1991 TMDL Guidance explains that the MOS may be implicit, i.e., incorporated into the TMDL through conservative assumptions in the analysis, or explicit, i.e., expressed in the TMDL as loadings set aside for the MOS. An explicit MOS quantifies an allocation amount separate from other Load and Waste Load Allocations. An explicit MOS can incorporate reserve capacity for future unknowns, such as population growth or effects of climate change on water quality. An implicit MOS is not specifically quantified but consists of statements of the conservative assumptions used in the analysis. The MOS for the New Bedford Inner Harbor Embayment System TMDL is implicit. MassDEP used conservative assumptions to develop numeric model applications that account for the MOS. These assumptions are described below, and they account for all sources of uncertainty, including the potential impacts of changes in climate.

While the general vulnerabilities of coastal areas to climate change can be identified, specific impacts and effects of changing estuarine conditions are not well known at this time (https://www.mass.gov/adapting-to-climate-change). Because the science is not yet available, MassDEP is unable to analyze climate change impacts on streamflow, precipitation, and nutrient loading with any degree of certainty for TMDL development. Considering these uncertainties and informational gaps, MassDEP has opted to address all sources of uncertainty through an implicit MOS. MassDEP does not believe that an explicit MOS approach is appropriate under the circumstances or will provide a more protective or accurate MOS than the implicit MOS approach, as the available data simply does not lend itself to characterizing and estimating loadings to derive numeric allocations within confidence limits. Although the implicit MOS approach does not expressly set aside a specific portion of the load to account for potential impacts of climate change, MassDEP has no basis to conclude that the conservative assumptions that were used to develop the numeric model applications are insufficient to account for the lack of knowledge regarding climate change.

Conservative assumptions that support an implicit MOS:

1. Use of conservative data in the linked model

The watershed N model provides conservative estimates of N loads to the embayment. Nitrogen transfer through direct groundwater discharge to estuarine waters is based upon studies indicating negligible aquifer attenuation and dilution, i.e. 100% of load enters embayment. This is a conservative estimate of loading because studies have also shown that in some areas less than 100% of the load enters the estuary. Nitrogen from the upper watershed regions, which travel through ponds or wetlands, almost always enter the embayment via stream flow, are directly measured (over 12-16 months) to determine attenuation. In these cases, the land-use model has shown a slightly higher predicted N load than the measured discharges in the streams/rivers that have been assessed to date. Therefore, the watershed model as applied to the surface water watershed areas again presents a conservative estimate of N loads because the actual measured N in streams was lower than the modeled concentrations.

The hydrodynamic and water quality models have been assessed directly. In the many instances where the hydrodynamic model predictions of volumetric exchange (flushing) have also been directly measured by field measurements of instantaneous discharge, the agreement between modeled and observed values has been $R^2 \geq 93\%$. Field measurement of instantaneous discharge was performed using acoustic doppler current profilers (ADCP) at key locations within the embayment (with regards to the water quality model, it was possible to conduct a quantitative assessment of the model results as fitted to a baseline dataset - a least squares fit of the modeled versus observed data showed an $R^2>0.93$, indicating that the model accounted for 93% of the variation in the field data). The hydrodynamic modeling showed strong agreement between measured and modeled tides. The error associated with tidal height was less than the accuracy of the tidal gage (+/-0.32 ft). Since the water quality model incorporates all the outputs from the other models, this excellent fit indicates a high degree of certainty in the final result. The high level of accuracy of the model provides a high degree of confidence in the output; therefore, less of a margin of safety is required.

With regards to the water quality model, it is possible to conduct a quantitative assessment of the model outputs as fitted to the measured nitrogen concentrations. The computed root mean square error for this modeling effort is 0.03 mg/L and indicates a good fit between measured and modeled data (Howes *et al*. 2015, pg. 117). Since the water quality model incorporates all of the outputs from the other models, this good fit indicates a high degree of certainty in the final result.

Similarly, the water column N validation dataset was also conservative. The model is calibrated to measured water column N and validated to salinity. However, the model predicts average summer N concentrations. The very high or low measurements are marked as outliers. The effect is to make the N threshold more accurate and scientifically defensible. If a single measurement two times higher than the next highest data point in the series, raises the average 0.05 mg N/L, this would allow for a higher "acceptable" load to the embayment. Marking the very high outlier is a way of preventing a single and rare bloom event from changing the N threshold for a system. This effectively strengthens the data set so that a higher margin of safety is not required.

Finally, the predicted reductions of the amount of N released from the sediments are most likely underestimates, i.e. conservative. The reduction is based solely on a reduced deposition of particulate organic nitrogen (PON) due to lower primary production rates under the reduced N loading in these systems. As the N loading decreases and organic inputs are reduced it is likely that rates of coupled remineralization-nitrification, denitrification and sediment oxidation will increase.

Benthic regeneration of N is dependent upon the amount of PON deposited to the sediments and the percentage that is regenerated to the water column as opposed to being denitrified or buried. The regeneration rate projected under reduced N loading conditions was based upon two assumptions:(1) PON in the embayment exceeding that of inflowing tidal water (boundary condition) results from production supported by watershed N inputs; and (2) presently enhanced production will decrease in proportion to the reduction in the sum of watershed N inputs and direct atmospheric N input. The latter condition would result in equal embayment versus boundary condition production and PON concentrations if watershed N loading and direct atmospheric deposition could be reduced to zero, which is impossible. This proportional reduction assumes that the proportion of remineralized N will be the same as under present conditions, which is almost certainly an underestimate. Future N regeneration rates are therefore overestimated, which adds to the margin of safety.

Finally, decreases in air deposition through continuing air pollution control efforts are unaccounted for this TMDL and provide another component of the margin of safety.

2. Conservative sentinel station/target threshold nitrogen concentration

Conservatism was used in the selection of the sentinel station and target threshold nitrogen concentration. The site was chosen that had stable benthic animal (infaunal) communities, and not those just starting to show impairment, which would have slightly higher N concentration. Meeting the target threshold N concentration at the sentinel station will result in reductions of N concentrations in the rest of the system.

3. Conservative approach

The target loads were based on tidally averaged N concentrations on the outgoing tide which is the worst-case condition because that is when the N concentrations are the highest. The N concentrations will be lower on the flood tides; therefore, this approach is conservative.

In addition to the margin of safety within the context of setting the N threshold levels described above, a programmatic margin of safety also derives from continued monitoring of this embayment to support adaptive management. This continuous monitoring effort provides the ongoing data to evaluate the improvements that occur over the multi-year implementation of the N management plan. This will allow refinements to the plan to ensure that the desired level of restoration is achieved.

Seasonal Variation

The TMDLs for the waterbody segments are protective for all seasons because they are based on the most critical time period, i.e., the summer growing season.. The daily loads can be converted to annual loads by multiplying by 365 (the number of days in a year). Nutrient loads to the embayment are based on annual loads for two reasons. The first is that primary production in coastal waters can peak in both the late winter-early spring and in the late summer-early fall periods. Second, as a practical matter, the types of management necessary to control the N load do not lend themselves to intra-annual manipulation since a considerable portion of the N is from nonpoint sources. Thus, calculating annual loads is most appropriate since it is difficult to control nonpoint sources of N on a seasonal basis and N sources can take considerable time to migrate to impacted waters.

TMDL Values for the New Bedford Inner Harbor Embayment System

As outlined above, the total maximum daily N loadings that would provide for the restoration and protection of the embayment were calculated by considering all N sources grouped by natural background, point sources, and nonpoint sources. A more meaningful way of presenting the loads from an implementation perspective, is presented in Table 8 and Appendix D.

Table 8: The Total Maximum Daily Load (TMDL) for New Bedford Inner Harbor Embayment System

Sub-embayments	**Present Watershed Load [1] (kg/day)**	**Target Threshold Watershed Load [2] (kg/day)**	**Direct Atmospheric Deposition (kg/day)**	**Load from Sediments [3] (kg/day)**	**TMDL [4] (kg/day)**
Upper Basin	47.899	22.948	2.668	45.081	70.70
Mid Basin	17.600	12.219	3.403	0	15.62
Lower Basin	165.512	62.668	6.674	52.147	121.49
Acushnet River (fresh water)	99.444	68.820	-	-	68.82
System Total	**330.455**	**166.656**	**12.745**	**97.228**	**276.63**

1 Composed of combined natural background, WWTF, septic systems, fertilizer, CSOs, stormwater runoff, and farm animal loadings.
2 Target threshold watershed load is the load from the watershed needed to meet the embayment threshold concentration identified in Table 4.
3 Projected future flux (present rates reduced approximately proportional to watershed load reductions). Negative benthic flux was set to zero for Mid Basin
4 Sum of target threshold watershed load, atmospheric deposition load, and benthic flux load.
(Table ES-2 Howes *et al.* 2015)

In this table the N loadings from the atmosphere and from nutrient rich sediments are listed separately from the target watershed threshold loads, which are composed of natural background N along with locally controllable N from WWTF, on-site subsurface wastewater disposal systems (septic systems), fertilizer, CSOs, stormwater runoff, and farm animal sources. In the case of the

New Bedford Inner Harbor Embayment System the TMDL was calculated by projecting reductions in locally controllable on-site subsurface wastewater disposal system, Fairhaven Wastewater Treatment Plant and CSO load to the harbor.

Watershed nitrogen loads were sequentially lowered, using reductions in septic effluent discharges as specified in Table 9 below, lowering of load from the Fairhaven Wastewater Treatment Plant and complete elimination of the CSO load to the harbor, until the nitrogen levels approached the threshold level at the sentinel station chosen for New Bedford Harbor. In addition to these load reductions, a reduction in the watershed load from other sources (fertilizers, agriculture and impervious surfaces) is also necessary to meet the target threshold concentration. The target load identified in this table represents one alternative loading scenario to achieve that goal, but other scenarios may be possible and approvable as well. It must be demonstrated however, that any alternative implementation strategies will be protective of the entire embayment system. Once again, the goal of this TMDL is to achieve the identified target threshold N concentration at the identified sentinel station. These waterbody segment TMDLs are also presented in more detail in Appendix D.

Implementation Plans

The critical element of this TMDL process is achieving the target threshold N concentration at the sentinel station, as presented in Table 4 above, that is necessary for the restoration and protection of water quality and benthic habitat within the New Bedford Inner Harbor Embayment System. To achieve this target threshold N concentration, N loading rates must be reduced throughout this embayment. Table 8, above, lists the target watershed threshold loads.

As previously noted, this loading reduction scenario is not the only way to achieve the target threshold N concentrations. New Bedford and Fairhaven might find it beneficial to explore other loading reduction scenarios through additional modeling as part of the Comprehensive Wastewater Management Plan (CWMP). It must be demonstrated, however, that alternative implementation strategies will be protective of the entire New Bedford Inner Harbor system. To this end, additional linked model runs can be performed by the MEP at a nominal cost to assist the planning efforts of the municipalities in achieving target N loads that will result in the desired target threshold N concentration.

The following list provides possible solutions that could be implemented to achieve water quality standards:

- Modifications to the Fairhaven Treatment Plant
    - Advanced treatment
    - Altering location of outfall
- Long-term control of CSO discharges
- Additional sewering within the watersheds
- Control and treatment of stormwater
- Fertilizer use reduction

WWTF and Outfall

In the development of the threshold loading scenario presented in the MEP report (Howes *et al.* 2015, pg. 157), all CSO loads were removed (9,706 kg/yr) as was approximately 70% of the Fairhaven

Wastewater Pollution Control Facility load. This percentage reduction is based on the maximum likely achievable by upgrading the plant to tertiary treatment with a 5 mg/l discharge TN concentration at a buildout flow of 3.17 MGD. Additional load throughout the watershed, beyond the WWTF (in the lower basin) and CSOs, must be removed to meet the threshold requirements of a 0.50 mg/L TN concentration at the upper 1/3 of the mid Harbor basin. Accordingly, EPA and MassDEP applied the principles of the MEP analysis to the discharge permit for Fairhaven WPCF and included a monthly average limitation of 57 kg/day (125 lbs/day), which corresponds to treatment plant flow of 5.0 MGD and effluent concentration of 3 mg/L TN (EPA 2017, pg 129).

Septic Systems

Nitrogen loading from septic systems is considered a controllable source. The load from individual septic systems for private residences need to be addressed, in addition to other source reductions, to meet the target threshold established in the TMDL. The Comprehensive Wastewater Management Plan (CWMP) should assess the most cost-effective options for achieving the target threshold N watershed loads, including but not limited to, sewering and treatment for N control of sewage and septage at either centralized or de-centralized locations, and denitrifying systems for all private residences. The CWMP should include a schedule of the selected strategies and estimated timelines for achieving those targets. However, MassDEP realizes that an adaptive management approach may be used to observe implementation results over time and allow for adjustments based on those results. The appropriateness of any of the alternatives will depend on local conditions and will have to be determined on a case-by-case basis, using an adaptive management approach.

Table 9 (from Table VIII-2 of the MEP Technical Report) summarizes the present loadings from septic systems and the reduced loads that would be necessary to achieve the target threshold N concentration in the New Bedford Inner Harbor system under the TN reduction scenario modeled here (inclusive of CSO elimination, wastewater treatment plant reductions, and additional watershed load reduction). A 77% reduction in present septic loading achieved the target threshold N concentration of 0.50 mg/L at the sentinel station (Station NBH), time averaged over the summer period.

Table 9: Summary of the Present Septic System Loads and the Loading Reductions Necessary to Achieve the TMDL

Sub-embayment	Present Septic Load (kg/day)	Threshold Septic Load (kg/day)	Threshold Septic Load % Change
Upper Basin	7.562	2.268	-70.0%
Mid Basin	2.137	0.641	-70.0%
Lower Basin	5.973	1.792	-70.0%
Acushnet River – fresh water	38.279	7.656	-80.0%
System Total	**53.951**	**12.357**	**-77.1%**

The above modeling results provide one scenario of achieving the threshold level for the sentinel site within the estuarine system. This example does not represent the only method for achieving this goal. The Towns of New Bedford and Fairhaven and other towns (Acushnet, Freetown, Rochester and Lakeville) within the New Bedford Inner Harbor Embayment System watershed are encouraged to evaluate other load reduction scenarios and take any reasonable steps to reduce the controllable N sources.

CSOs

While modern systems transport rainwater and sewage through separate pipes, some older systems, including New Bedford, "combined" sewers that carry both flows together. During normal conditions flows are delivered to treatment plants. During very heavy rains, when flows sometimes double and even triple, these systems become overloaded. Built-in overflows (called combined sewer overflows or "CSOs") must then act as relief points by releasing excess flows into New Bedford Inner Harbor. This prevents sewage backups, but it impacts the quality of the receiving waters.

Each CSO permittee must implement the following “Nine Minimum Controls” to maximize the efficiency of existing facilities in order to limit the duration and impact of CSO discharges:

1) Proper operation and regular maintenance programs for the sewer system and CSO outfalls.
2) Maximum use of the collection system for storage.
3) Review and modification of pretreatment requirements to ensure that CSO impacts are minimized.
4) Maximization of flow to the POTW for treatment.
5) Elimination of CSOs during dry weather.
6) Control of solid and floatable materials in CSOs.
7) Pollution prevention programs to reduce containments in CSOs.
8) Public notification to ensure that the public receives adequate notification of CSO occurrences and CSO impacts.
9) Monitoring to effectively characterize CSO impacts and the efficacy of CSO controls.

Facilities must also develop and implement a Long-Term CSO Control Plan (LTCP), which must demonstrate compliance with the SWQS.

In 2012, EPA issued an administrative order (AO) for New Bedford requiring the city to develop an approach and schedule in updating its LTCP for managing CSOs. New Bedford complied with the order and proposed an integrated planning approach to prioritize projects addressing multiple issues included WWTP, CSO, and stormwater discharges. The plan identifies projects from eight categories over a 20-year time frame (2017-2036). The schedule focused first on infrastructure repair and renewal to eliminate illicit connections to the storm sewer system, reduce infiltration and inflow into the combined sewer system, and eliminate a CSO outfall. New Bedford submitted its Long Term CSO Control and Integrated Capital Improvements Plan (Integrated Plan) to EPA in 2017. A 2019 consent order formally implemented the first phase of the plan that included projects for the first seven years. The city started several integrated plan projects before the 2019 order, including equipment upgrades at the wastewater treatment facility, two sewer separation projects, two pumping station upgrades, and a flow monitoring program. The implementation of the Integrated Plan addresses CSO, MS4, SSO and WWTF discharges and is a holistic approach, supported by EPA (EPA 2021), to address goals in the previously approved pathogen TMDL (MassDEP 2009) as well as the goals in this total nitrogen TMDL. In the last 27 years approximately $357 million (in 2021 dollars) has been spent via State Revolving Funds projects in New Bedford on CSO planning and construction projects.

Stormwater

EPA and MassDEP authorized the watershed communities within the New Bedford Inner Harbor watershed for coverage under the NPDES Phase II General Permit for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems (MS4s) in 2003. EPA and MassDEP reissued the MS4 permit effective July 1, 2018 with modification effective January 6, 2021 (EPA, 2016). The NPDES permits issued in Massachusetts do not establish numeric effluent limitations for stormwater discharges; rather, they establish narrative requirements, including best management practices, to meet the following six minimum control measures and to meet the Massachusetts Surface Water Quality Standards.

1) Public education and outreach particularly on the proper disposal of pet waste,
2) Public participation/involvement,
3) Illicit discharge detection and elimination,
4) Construction site runoff control,
5) Post construction runoff control, and
6) Pollution prevention/good housekeeping.

As part of their applications for Phase II permit coverage, communities must identify the best management practices they will use to comply with each of these six minimum control measures and the measurable goals they have set for each measure. Therefore, compliance with the requirements of the Phase II stormwater permit in the New Bedford Inner Harbor watershed towns will contribute to the goal of reducing the nitrogen load as prescribed in this TMDL for the New Bedford Inner Harbor Embayment System watershed.

Climate Change

MassDEP recognizes that long-term (25+ years) climate change impacts to southeastern Massachusetts, including the area of this TMDL, are occurring based on known science. Massachusetts Executive Office of Energy and Environmental Affairs 2011 Climate Change Adaptation Report: https://www.mass.gov/service-details/2011-massachusetts-climate-change-adaptation-report, predicts that by 2100 the sea level could be from 1 to 6 feet higher than the current position and precipitation rates in the Northeast could increase by as much as 20 percent. However, the details of how climate change will affect sea level rise, precipitation, streamflow, sediment and nutrient loading in specific locations are generally unknown. The ongoing debate is not about whether climate change will occur, but the rate at and the extent to which it will occur, and the adjustments needed to address its impacts. EPA's 2012 Climate Change Strategy (http://water.epa.gov/scitech/climatechange/upload/epa_2012_climate_water_strategy_full_report_final.pdf) states: "Despite increasing understanding of climate change, there still remain questions about the scope and timing of climate change impacts, especially at the local scale where most water-related decisions are made." For estuarine TMDLs in southeastern Massachusetts, MassDEP recognizes that this is particularly true, where water quality management decisions and implementation actions are generally made and conducted at the municipal level on a sub-watershed scale.

EPA's Climate Change Strategy identifies the types of research needed to support the goals and strategic actions to respond to climate change. EPA acknowledges that data are missing or not available for making water resource management decisions under changing climate conditions. In addition, EPA recognizes the limitation of current modeling in predicting the pace and magnitude of localized climate change impacts and recommends further exploration of the use of tools, such as atmospheric, precipitation and climate change models, to help states evaluate pollutant load impacts under a range of projected climatic shifts.

In 2013, EPA released a study entitled, “Watershed modeling to assess the sensitivity of streamflow, nutrient, and sediment loads to potential climate change and urban development in 20 U.S. watersheds.” (National Center for Environmental Assessment, Washington D.C.; EPA/600/R-12/058F). The closest watershed to southeastern Massachusetts that was examined in this study is a New England coastal basin located between Southern Maine and Central Coastal Massachusetts. These watersheds do not encompass any of the watersheds in the Massachusetts Estuary Project (MEP) region, and it has vastly different watershed characteristics, including soils, geography, hydrology and land use – key components used in a modeling analysis. The initial “first order” conclusion of this study is that, in many locations, future conditions, including water quality, are likely to be different from experience. However, most significantly, this study did not demonstrate that changes to TMDLs (the water quality restoration targets) would be necessary for the region. EPA’s 2012 Climate Change Strategy also acknowledges that the Northeast, including New England, needs to develop standardized regional assumptions regarding future climate change impacts. EPA’s 2013 modeling study does not provide the scientific methods and robust datasets needed to predict specific long-term climate change impacts in the MEP region to inform TMDL development.

MassDEP believes that impacts of climate change should be addressed through TMDL implementation with an adaptive management approach in mind. Adjustments can be made as environmental conditions, pollutant sources, or other factors change over time. Massachusetts Coastal Zone Management (CZM) has developed a StormSmart Coasts Program (2008) to help coastal communities address impacts and effects of erosion, storm surge and flooding which are increasing due to climate change. The program, www.mass.gov/czm/stormsmart offers technical information, planning strategies, legal and regulatory tools to communities to adapt to climate change impacts.

As more information and tools become available, there may be opportunities to make adjustments in TMDLs in the future to address predictable climate change impacts. When the science can support assumptions about the effects of climate change on the nitrogen loadings to New Bedford Inner Harbor Embayment System the TMDL can be reopened, if warranted.

Implementation Guidance

The watershed communities of New Bedford Inner Harbor Embayment System are urged to meet the target threshold N concentrations by reducing N loadings from any and all sources, through whatever means are available and practical, including reductions in on-site subsurface wastewater disposal system loadings as well as reductions in stormwater runoff and/or fertilizer use within the watershed through the establishment of local by-laws and/or the implementation of stormwater Best Management Practices (BMPs).

MassDEP’s MEP Implementation Guidance report (MassDEP 2003) provides N loading reduction strategies that are available to New Bedford, Fairhaven, Acushnet, Rochester, Freetown and Lakeville that could be incorporated into the implementation plans. The following topics related to N reduction are discussed in the Guidance:

- Wastewater Treatment;
    - On-Site Treatment and Disposal Systems

    - Cluster Systems with Enhanced Treatment
    - Community Treatment Plants
    - Municipal Treatment Plants and Sewers
- Tidal Flushing;
    - Channel Dredging
    - Inlet Alteration
    - Culvert Design and Improvements
- Stormwater Control and Treatment*;
    - Source Control and Pollution Prevention
    - Stormwater Treatment
- Attenuation via Wetlands and Ponds;
- Water Conservation and Water Reuse;
- Management Districts;
- Land Use Planning and Controls;
    - Smart Growth
    - Open Space Acquisition
    - Zoning and Related Tools
- Nutrient Trading.

* New Bedford, Fairhaven, Acushnet Rochester, Freetown, and Lakeville are six of the 237 communities in Massachusetts covered by the Phase II stormwater program requirements.

Monitoring Plan

There are two forms of monitoring that are useful to determine progress towards achieving compliance with the TMDL. The two forms of monitoring include: 1) tracking implementation progress as approved in the town CWMP plan (as appropriate); and 2) monitoring ambient water quality conditions, including but not limited to, the sentinel station identified in the MEP Technical Report.

Implementation will be conducted through an iterative process to accommodate future adjustments as warranted. If necessary, to achieve the TMDL, the CWMP will evaluate various options to achieve the goals set out in the TMDL and Technical Report. It will also make a final recommendation based on existing or additional modeling runs, set out required activities and identify a schedule to achieve the most cost-effective solution that will result in compliance with the TMDL. Once approved by MassDEP, tracking progress on the agreed-upon plan will, in effect, also be tracking progress towards water quality improvements in conformance with the TMDL.

Relative to water quality, MassDEP believes that an ambient monitoring program, much reduced from the data collection activities needed to properly assess conditions and to populate the model, will be important to determine actual compliance with water quality standards. Through discussions amongst MEP project partners, it is generally agreed that existing monitoring programs which were designed to thoroughly assess conditions and populate water quality models can be substantially reduced for compliance monitoring purposes. Although more specific details need to be developed on a case-by-case basis, MassDEP’s current thinking is that about half the current effort (using the same data collection procedures) would be sufficient to monitor compliance over time and to observe trends in water quality changes. In addition, the benthic habitat and communities would require periodic monitoring on a frequency of about every 5+ years. Finally, in addition to the above, existing monitoring conducted by MassDEP for eelgrass should continue to observe any changes that may occur to eelgrass populations resulting from restoration efforts.

MassDEP will continue working with the watershed communities to develop and refine monitoring plans that remain consistent with the goals of the TMDL. Through the adaptive management approach, ongoing monitoring will be conducted and will indicate if water quality standards are being met. If this does not occur, other management activities would have to be identified and considered to reach the goals outlined in this TMDL. However, development and implementation of a monitoring plan will take some time; it is more important at this point to focus efforts on reducing existing watershed loads to achieve water quality goals.

Reasonable Assurances

MassDEP possesses the statutory and regulatory authority, under the Massachusetts Clean Waters Act and Massachusetts Surface Water Quality Standards, to implement and enforce the provisions of the TMDL through its many permitting programs, including requirements for N loading reductions from on-site subsurface wastewater disposal systems. However, because most nonpoint source controls are voluntary, reasonable assurance is based on the commitment of the locality involved. The City of New Bedford has demonstrated this commitment through the comprehensive wastewater planning initiated well before the generation of the TMDL. The towns expect to use the information in this TMDL to generate support from their citizens to take the necessary steps to remedy existing problems related to N loading from on-site subsurface wastewater disposal systems, stormwater, and runoff (including fertilizers) and to prevent any future degradation of these valuable resources.

Moreover, reasonable assurances that the TMDL will be implemented include enforcement of regulations, availability of financial incentives and local, state, and federal programs for pollution control. Stormwater NPDES permit coverage will address discharges from municipally owned stormwater drainage systems. Enforcement of regulations controlling nonpoint discharges include local implementation of the Commonwealth’s Wetlands Protection Act and Rivers Protection Act; Title 5 regulations for on-site subsurface wastewater disposal systems and other local regulations such as the Town of Rehoboth’s stable regulations.

Financial incentives include federal funds available under Sections 319, 604 and 104(b) programs of the CWA, which are provided as part of the Performance Partnership Agreement between MassDEP and EPA. Other potential funds and assistance are available through Massachusetts’ Department of Agriculture’s Enhancement Program and the United States Department of Agriculture’s Natural Resources Conservation Services. The Massachusetts Coastal Zone Management also provides grants through its Coastal Pollutant Remediation (CPR) Grant Program. Additional financial incentives include income tax credits for Title 5 upgrades and low interest loans for Title 5 on-site subsurface wastewater disposal system upgrades available through municipalities participating in this portion of the state revolving fund program.

As the town implements this TMDL, the TMDL values (kg/day of N) will be used by MassDEP as guidelines for permitting activities and should be used by local communities as a management tool.

Public Participation

To be completed.

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Appendix A: Overview of Applicable Surface Water Quality Standards

Water quality standards that govern surface water conditions that may result from cultural eutrophication are dissolved oxygen, nutrients, bottom pollutants or alterations, aesthetics, excess plant biomass, and nuisance vegetation. The Massachusetts Surface Water Quality Standards (SWQS, 314 CMR 4.00) contain both numeric and narrative criteria for a variety of parameters, such as numeric criteria for dissolved oxygen and site-specific numeric and narrative standards for nutrients. This brief summary does not supersede or replace information contained in 314 CMR 4.00. A complete version of the SWQS is available online (MassDEP 2021).

Applicable Narrative Standards

The following narrative standards are excerpted from the SWQS:

> 314 CMR 4.05(5)(a): *Aesthetics*. All surface waters shall be free from pollutants in concentrations that settle to form objectionable deposits; float as debris, scum, or other matter to form nuisances, produce objectionable odor, color, taste, or turbidity, or produce undesirable or nuisance species of aquatic life.
>
> 314 CMR 4.05(5)(b): *Bottom Pollutants or Alterations*. All surface waters shall be free from pollutants in concentrations or combinations or from alterations that adversely affect the physical or chemical nature of the bottom, interfere with the propagation of fish or shellfish, or adversely affect populations of non-mobile or sessile benthic organisms.
>
> 314 CMR 4.05(5)(c): *Nutrients*. Unless naturally occurring, all surface waters shall be free from nutrients in concentrations that would cause or contribute to impairment of existing or designated uses and shall not exceed the site-specific criteria developed in a TMDL or as otherwise established by the Department pursuant to 314 CMR 4.00 including, but not limited to, those established in 314 CMR 4.06(6)(c): *Table 28: Site-specific Criteria*. Any existing point source discharge containing nutrients in concentrations that would cause or contribute to cultural eutrophication, including the excessive growth of aquatic plants or algae, in any surface water shall be provided with the most appropriate treatment as determined by the Department, including, where necessary, highest and best practical treatment (HBPT) for POTWs and BAT for non POTWs, to remove such nutrients to ensure protection of existing and designated uses. Human activities that result in the nonpoint source discharge of nutrients to any surface water may be required to be provided with cost effective and reasonable best management practices for nonpoint source control.

Description of Coastal and Marine Classes and Numeric Dissolved Oxygen Standards

The following class descriptions and numeric standards are excerpted from the SWQS:

> 314 CMR 4.05(4)(a): *Class SA*. Those Coastal and Marine Waters so designated pursuant to 314 CMR 4.06; including, without limitation, 314 CMR 4.06(2) and (5), and certain qualified waters designated in 314 CMR 4.06(6)(b). These waters are designated as an excellent 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, excellent habitat for fish, other aquatic life and wildlife may include, but is not limited to, seagrass. Where designated for shellfishing in 314 CMR 4.06(6)(b), these waters shall be suitable for shellfish harvesting without depuration (Approved and Conditionally Approved Shellfish Areas). These waters shall have excellent aesthetic value.

314 CMR 4.05(4)(a)1.: *Dissolved Oxygen*. Shall not be less than 6.0 mg/l. Where natural background conditions are lower, DO shall not be less than natural background. Natural seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained.

314 CMR 4.05(4)(b): *Class SB*. Those Coastal and Marine Waters so designated pursuant to 314 CMR 4.06; including, without limitation, 314 CMR 4.06(2) and certain surface waters designated in 314 CMR 4.06(6)(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. In certain waters, habitat for fish, other aquatic life and wildlife may include, but is not limited to, seagrass. Where designated for shellfishing in 314 CMR 4.06(6)(b), these waters shall be suitable for shellfish harvesting with depuration (Restricted and Conditionally Restricted Shellfish Areas). These waters shall have consistently good aesthetic value.

314 CMR 4.05(4)(b)1.: *Dissolved Oxygen*. Shall not be less than 5.0 mg/l. Where natural background conditions are lower, DO shall not be less than natural background. Natural seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained.

Surface Waters Not Specifically Designated in 314 CMR 4.06

Note that many waterbodies do not have a specific water quality classification in 314 CMR 4.06: *Classification, Figures, and Tables***.** Waterbodies that are not listed in the classification tables have default classifications. The default classification for coastal and marine surface waters is Class SA; these waters are presumed to be High Quality Waters as described in 314 CMR 4.06 (5).

314 CMR 4.06(5): *Other Waters*. Unless otherwise designated in 314 CMR 4.06: *Classification, Figures, and Tables*, other waters are Class B, and presumed High Quality Waters for inland waters and Class SA, and presumed High Quality Waters for coastal and marine waters. Inland fisheries designations and coastal and marine shellfishing designations for unlisted waters shall be made on a case-by-case basis as necessary.

Applicable Antidegradation Provisions

Applicable antidegradation provisions are detailed in 314 CMR 4.04: *Antidegradation Provisions*, from which an excerpt is provided:

314 CMR 4.04(1): *Protection of Existing Uses*. In all cases existing uses and the level of water quality necessary to protect the existing uses shall be maintained and protected.

314 CMR 4.04(2): *Protection of High Quality Waters*. High Quality waters are waters whose quality exceeds minimum levels necessary to support the national goal uses, low flow waters, and other waters whose character cannot be adequately described or protected by traditional criteria. These waters shall be protected and maintained for their existing level of quality unless limited degradation by a new or increased discharge is authorized by the Department pursuant to 314 CMR 4.04(5). Limited degradation also may be allowed by the Department where it determines that a new or increased discharge is insignificant because it does not have the potential to impair any existing or designated water use and does not have the potential to cause any significant lowering of water quality.

314 CMR 4.04(3): *Protection of Outstanding Resource Waters*. Certain waters are designated for protection under this provision in 314 CMR 4.06. These waters include Class A Public Water

Supplies (314 CMR 4.06(1)(d)1.) and their tributaries, certain wetlands as specified in 314 CMR 4.06(2) and other waters as determined by the Department based on their outstanding socio-economic, recreational, ecological and/or aesthetic values. The quality of these waters shall be protected and maintained.

(a) Any person having an existing discharge to these waters shall cease said discharge and connect to a Publicly Owned Treatment Works (POTW) unless it is shown by said person that such a connection is not reasonably available or feasible. Existing discharges not connected to a POTW shall be provided with the highest and best practical method of waste treatment determined by the Department as necessary to protect and maintain the outstanding resource water.

(b) A new or increased discharge to an Outstanding Resource Water is prohibited unless:

1. the discharge is determined by the Department to be for the express purpose and intent of maintaining or enhancing the resource for its designated use and an authorization is granted as provided in 314 CMR 4.04(5). The Department's determination to allow a new or increased discharge shall be made in agreement with the federal, state, local or private entity recognized by the Department as having direct control of the water resource or governing water use; or

2. the discharge is dredged or fill material for qualifying activities in limited circumstances, after an alternatives analysis which considers the Outstanding Resource Water designation and further minimization of any adverse impacts. Specifically, a discharge of dredged or fill material is allowed only to the limited extent specified in 314 CMR 9.00: *401 Water Quality Certification for Discharge of Dredged or Fill Material, Dredging, and Dredged Material Disposal in Waters of the United States within the Commonwealth* and 314 CMR 4.06(1)(d). The Department retains the authority to deny discharges which meet the criteria of 314 CMR 9.00 but will result in substantial adverse impacts to the physical, chemical, or biological integrity of surface waters of the Commonwealth

314 CMR 4.04(4) *Protection of Special Resource Waters*. The quality of Special Resource Waters shall be protected and maintained. No new or increased discharge to an SRW, and no new or increased discharge to a tributary to an SRW that would result in lower water quality in the SRW, may be allowed, except where:

(a) the discharge results in temporary and short term changes in the quality of the SRW, provided that the discharge does not permanently lower water quality or result in water quality lower than necessary to protect uses; and

(b) an authorization is granted pursuant to 314 CMR 4.04(5).

314 CMR 4.04(5): *Authorizations*.

(a) An authorization to discharge to waters designated for protection under 314 CMR 4.04(2) may be issued by the Department where the applicant demonstrates that:

1. The discharge is necessary to accommodate important economic or social development in the area in which the waters are located;

2. No less environmentally damaging alternative site for the activity, receptor for the disposal, or method of elimination of the discharge is reasonably available or feasible;

3. To the maximum extent feasible, the discharge and activity are designed and conducted to minimize adverse impacts on water quality, including implementation of source reduction practices; and

4. The discharge will not impair existing water uses and will not result in a level of water quality less than that specified for the Class.

(b) An authorization to discharge to the narrow extent allowed in 314 CMR 4.04(3) or

314 CMR 4.04(4) may be granted by the Department where the applicant demonstrates compliance with 314 CMR 4.04(5)(a)2. through 314 CMR 4.04(5)(a)4.

(c) Where an authorization is at issue, the Department shall circulate a public notice in accordance with 314 CMR 2.06: *Public Notice and Comment*. Said notice shall state an authorization is under consideration by the Department and indicate the Department's tentative determination. The applicant shall have the burden of justifying the authorization. Any authorization granted pursuant to 314 CMR 4.04 shall not extend beyond the expiration date of the permit.

(d) A discharge exempted from the permit requirement by 314 CMR 3.05(4) (discharge necessary to abate an imminent hazard) may be exempted from 314 CMR 4.04(5) by decision of the Department.

(e) A new or increased discharge specifically required as part of an enforcement order issued by the Department in order to improve existing water quality or prevent existing water quality from deteriorating may be exempted from 314 CMR 4.04(5) by decision of the Department.

314 CMR 4.04(6): The Department applies its Antidegradation Implementation Procedures to point source discharges subject to 314 CMR 4.00.

314 CMR 4.04(7): ***Discharge Criteria***. In addition to the other provisions of 314 CMR 4.00, any authorized Discharge shall be provided with a level of treatment equal to or exceeding the requirements of 314 CMR 3.00: *Surface Water Discharge Permit Program*. Before authorizing a discharge, all appropriate public participation and intergovernmental coordination shall be conducted in accordance with 314 CMR 2.00: *Permit Procedures*.

Appendix B: Summary of the Nitrogen Concentrations in New Bedford Inner Harbor Embayment System

Table B-1: Summary of the Nitrogen Concentrations for the New Bedford Inner Harbor Embayment System (Reprinted from Table VI-1 of the MEP Technical Report, Howes *et al*. 2015)

Table VI-1. Measured data and modeled Nitrogen concentrations for the New Bedford Harbor estuarine system used in the model calibration plots of Figures VI-2 and VI-3. All concentrations are given in mg/L N. "Data mean" values are calculated as the average of the separate yearly means. Data represented in this table were collected in the summers of 2000 through 2006.

Sub-Embayment	MEP monitoring station	data mean	s.d. all data	N	model min	model max	model average
Estuary Upper Basin	2	0.789	0.128	14	0.629	1.060	0.754
Coggeshall Bridge	3	0.624	0.155	50	0.549	0.764	0.621
Popes Island East Bridge	6	0.553	0.110	27	0.499	0.515	0.505
Lower Basin (North)	7	0.544	0.127	19	0.490	0.506	0.496
Lower Basin (Mid)	8	0.493	0.083	29	0.475	0.493	0.485
Low Basin South of FTP	12	0.519	0.129	27	0.452	0.488	0.474
FTP - Fairhaven WWTF	FTP	1.200	0.320	23	-	-	-
Low Basin-Inside Inlet	9	0.484	0.084	17	0.429	0.482	0.458
Outer Harbor - Boundary	PT1, NB5, NB3,11	0.388	0.017	108	-	-	-

Appendix C: Stormwater Loading Information

Impervious surfaces such as roadways, parking lots, rooftops, sidewalks, driveways, and other pavements impede stormwater infiltration and generate surface runoff. It is widely known that the amount of impervious area (IA) in a watershed is correlated with a decrease in water and habitat quality including increased flood peaks and frequency, increased sediment, nutrient, and other pollutant levels, channel erosion, impairments to aquatic biota, and reduced recharge to groundwater. Directly connected impervious area (DCIA) is defined as the portion of IA with a direct hydraulic connection to the waterbody via continuous paved surfaces, gutters, drain pipes, or other conventional conveyance and detention structures that do not reduce runoff volume (EPA 2010).

DCIA does not include:

- Impervious area draining to stormwater practices designed to meet recharge and other volume reduction criteria.
- Isolated impervious area with an indirect hydraulic connection to the MS4, or that otherwise drain to a pervious area.
- Swimming pools or man-made impoundments, unless drained to an MS4.
- The surface area of natural waterbodies (e.g., wetlands, ponds, lakes, streams, rivers).

When determining the TMDL for a pollutant, MassDEP has decided that stormwater from all areas defined as DCIA's should be considered part of the stormwater waste load allocation (WLA) regardless of whether the area is part of an EPA designated "urbanized area" and as such subject to the NPDES Phase II General Permit for stormwater discharges from Small Municipal Separate Storm Sewer Systems (MS4s). The WLA is the stormwater DCIA contribution, and the Fairhaven WPCF Outfall point source.

DCIA was calculated in accordance with EPA methodology (EPA 2010) using the "Sutherland Equations" (Sutherland 2000). As outlined in the methodology: the IA of each sub-watershed was determined using the MassGIS 2005 Impervious Surface data layer (MassGIS 2007), the land use categories in the MassGIS Land Use 2005 datalayer (MassGIS 2009) were reclassified into commonly used land use categories that correspond with the Sutherland watershed selection criteria, and the "Sutherland Equations" were applied to the IA to calculate DCIA as a percentage of IA in each sub-watershed.

The WLAs for stormwater nitrogen contribution (kg N/day) was determined using the DCIA for each sub-embayment divided by total IA in the sub-embayment, then multiplying the total impervious surfaces runoff N load for the sub-watershed (Table IV-2 of the MEP Technical Report) per EPA methodology. The remaining impervious surfaces loads were assigned as the LA. Table 7 shows the existing WLA and LA from stormwater runoff from impervious surfaces in the New Bedford Inner Harbor Embayment System watershed.

To complete the WLA calculation, the total stormwater load from impervious surfaces as determined by the MEP study (23.0 kg N/day from Table IV-2 in the MEP Technical Report) was multiplied by 0.77 (the percentage of IA that was determined to be DCIA in the watershed - see Table C-1). The resulting value of 16.2 kg N/day is the WLA and the remaining 6.8 kg N/day is assigned to the nonpoint source contribution to the load allocation (LA).

Appendix C: Stormwater Loading Information

Table C-1: Directly Connected Impervious Area (DCIA) and Stormwater WLA for the New Bedford Inner Harbor Embayment System

Sub-watersheds	Total Watershed Land Area (acres)	Total Impervious Area in Watershed[1] (acres)	Impervious Area as % of Total Watershed Area	DCIA Area[2] (acres)	DCIA as % of Total Impervious Area	Watershed Impervious Load[3] (kg N/day)	MEP Total Unattenuated Watershed Load[3,4] (kg N/day)	WLA[5] (kg N/day)	WLA as % of MEP Total Unattenuated Watershed Load[6]
Upper Basin	3,286	1,468	45%	1,256	86%	8.895	50.733	7.612	15.00%
Middle Basin	1,821	809	44%	671	83%	1.927	21.212	1.598	7.53%
Lower Basin	2,280	1,430	63%	1,269	89%	3.344	172.521	2.967	1.72%
Acushnet River (freshwater)	11,149	1,071	10%	489	46%	8.871	116.992	4.053	3.46%
System Total:	***18,536***	**4,778**	**26%**	**3,686**	***77%***	***23.037***	***361.458***	***16.230***	***4.49%***

[1] Total Impervious Area calculated using GIS using 2005 Impervious cover datalayer (MassGIS 2007).
[2] DCIA calculated per MEP sub-embayment using GIS and EPA methodology (EPA 2010).
[3] From MEP Technical Report, Table IV-2.
[4] This includes the unattenuated nitrogen loads from wastewater from septic systems, landfills, fertilizer, agriculture, runoff from both natural and impervious surfaces, and atmospheric deposition to freshwater waterbodies.
[5] The DCIA Area as % of Total Impervious Area multiplied by the MEP Total Unattenuated Watershed Impervious Load (kg N/day).
[6] The WLA (kg N/day) divided by the total unattenuated watershed load (kg N/day) then multiplied by 100.

Appendix D: New Bedford Inner Harbor Total Nitrogen TMDLs

Table D-1: TMDLs for New Bedford Inner Harbor Embayment System – Two Restoration and Two Protection TMDLs

Waterbody Name	**MassDEP Waterbody Segment ID (class)**	**Impairment[1]**	**TMDL Type**	**TMDL (kg N/day)**
Acushnet River (Upper Basin)	MA95-33 (SB)	Dissolved Oxygen Nitrogen, Total Nutrient/Eutrophication Biological Indicators	Restoration	70.70
New Bedford Inner Harbor (Mid and Lower)	MA95-42 (SB)	Dissolved Oxygen Nitrogen, Total Nutrient/Eutrophication Biological Indicators	Restoration	137.11[2]
Freshwater				
Acushnet River	MA95-31 (B)		Protection[3]	62.46[4]
Acushnet River	MA95-32 (B)		Protection[3]	6.36[4]
New Bedford Inner Harbor (total system)				**276.6**

1 MassDEP 2022 Integrated Report impairments asso
2 Total N load for the New Bedford Inner Harbor (MA95-42) is a combination of SMAST Middle and Lower sub-embayment loading
3 Protective TMDL assigned to freshwater segments based on hydraulic connection to New Bedford Inner Harbor
4 The load for SMAST Acushnet River freshwater sub-embayment was split between the two MassDEP segments (MA95-31 and MA95-32)