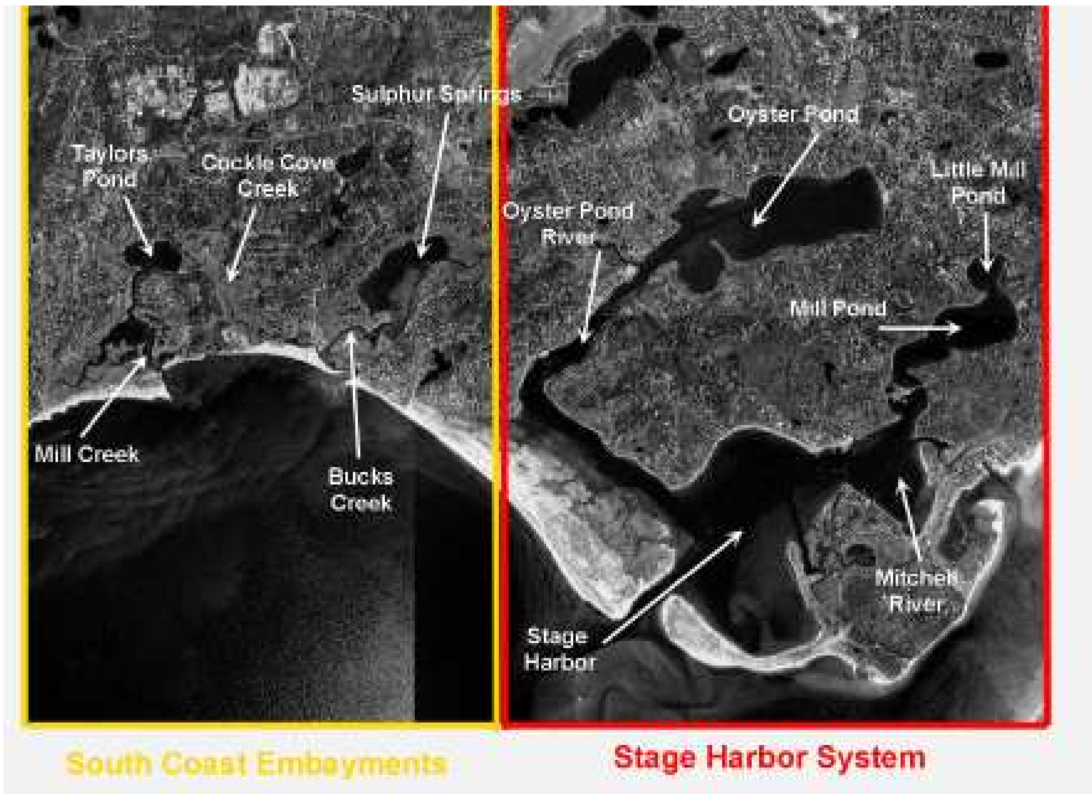
Stage Harbor/Oyster Pond, Sulphur Springs/Bucks Creek, Taylors Pond/Mill Creek Total Maximum Daily Load Re-Evaluations For Total Nitrogen

(Control # CN 206.1)



COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS
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December 31, 2008

NOTICE OF AVAILABILITY

Limited copies of this report are available at no cost by written request to:

Massachusetts Department of Environmental Protection
Division of Watershed Management
627 Main Street, 2nd Floor
Worcester, MA 01608

Please request Report Number: MA96-TMDL-3; Control Number CN 206.1

This report is also available from DEP's home page on the World Wide Web at:

http://www.mass.gov/dep/water/resources/tmdls.htm#cape

A complete list of reports published since 1963 is updated annually and printed in July. The report, titled, "Publications of the Massachusetts Division of Watershed Management – Watershed Planning Program, 1963-(current year)" can be found on the MassDEP website at www.mass.gov/dep/about/priorities/dwmpub06.pdf. It is also available by writing to the DWM in Worcester and on the DEP Web site identified above.

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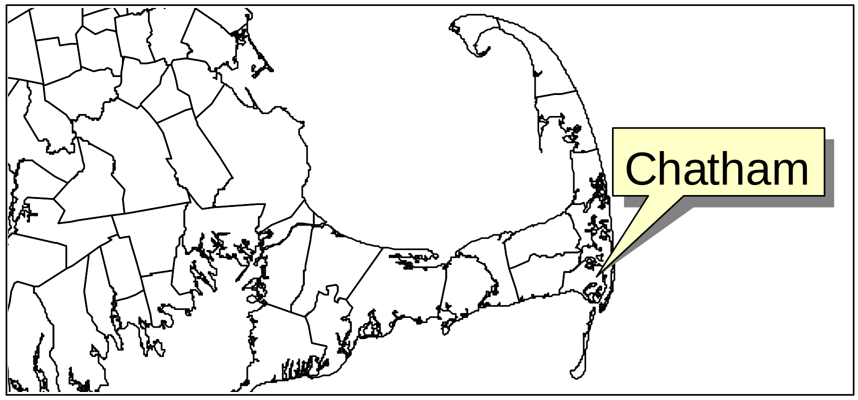
Front Cover

Town of Chatham Major Embayment Systems

Chatham Embayments Total Maximum Daily Loads For Total Nitrogen



Key Feature: Total Nitrogen TMDL for Chatham Embayments
Location: EPA Region 1
Land Type: New England Coastal
303d Listing in the proposed Massachusetts 2008 Integrated List[1]:

Oyster Pond	MA96-45_2008	0.21 sq mi	Nutrients & Pathogens
Oyster Pond R	MA96-46_2008	0.14 sq mi	Nutrients & Pathogens
Stage Harbor	MA96-11_2008	0.58 sq mi	Nutrients & Pathogens
Mill Pond	MA96-52_2008	0.06 sq mi	Nutrients
Harding Beach Pd	MA96-43_2008	0.07 sq mi	Nutrients &Pathogens
Bucks Creek	MA96-44_2008	0.02 sq mi	Nutrients & Pathogens
Mill Creek	MA96-41_2008	0.03 sq mi	Nutrients & Pathogens
Taylors Pond	MA96-42_2008	0.02 sq mi	Nutrients & Pathogens

[1] All segments are in category 5 with the exception of Mill Pd, which is in category 4a

Data Sources: University of Massachusetts – Dartmouth/School for Marine Science and Technology; US Geological Survey; Applied Coastal Research and Engineering, Inc.; Cape Cod Commission, Town of Chatham
Data Mechanism: Massachusetts Surface Water Quality Standards, Ambient Data, and Linked Watershed Model
Monitoring Plan: Town of Chatham monitoring program (possible assistance from SMAST)
Control Measures: Comprehensive Wastewater Management Plan, Sewering, Storm Water Management, Attenuation by Impoundments and Wetlands, Fertilizer Use By-laws

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EXECUTIVE SUMMARY

On June 21, 2006 the U.S. Environmental Protection Agency approved the original Total Maximum Daily Load (document control #206.0) for the Chatham embayments. The development of the original TMDL was based on the availability of three quarters of water use data provided by the Town. Subsequent to that analysis, data for a full year was collected and was provided by the Town. In addition, the monitoring program was extended, adding to the database. Also, the USGS refined the delineation of the ground watershed. As a result, the Town requested that the TMDL be reevaluated using the additional data and re-delineated ground watershed information. This TMDL report serves to update the 2006 TMDL for the southern embayments - Sulphur Springs, Taylor's Pond, and Stage Harbor Systems. The northern embayments were previously updated and are contained in the Pleasant Bay TMDL, which was approved by the U.S. EPA on 10/24/07 (document control #244.0).

The target threshold N concentrations for the southern embayments are the same in both the original and re-evaluated technical reports. However, the original TMDL N loading values were 9% lower than the N TMDL values that resulted from the re-evaluation. (Appendix C).

Subsequent to the development of the initial TMDL the TMDL writing team determined that negative losses in the system, such as those sometimes encountered with the uptake of N in the sediment, should not be credited towards the need for future load reductions. As a result, negative flux values have been entered as 0.

The data for determining the total maximum daily load of nitrogen to the southern Chatham embayments were collected, primarily, over a study period from 1997 to 2005. The results of these studies were published in the 2003 and 2007 MEP Technical Reports. The revised analyses of these three coastal embayments, using the MEP Linked Watershed-Embayment N Management Model (Linked Model), are presented in the 2007 Report which can be downloaded from the SMAST web site at http://www.oceanscience.net/estuaries/Chatham.htm .

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Problem Statement

Excessive nitrogen (N) originating primarily from septic systems has led to significant decreases in the "environmental quality" of coastal rivers, ponds, and harbors in many communities in southeastern Massachusetts. In Chatham the problems in coastal waters include:

- Partial loss of eelgrass beds, which are critical habitats for macroinvertebrates and fish
- Undesirable increases in macro algae, which are much less beneficial than eelgrass
- Periodic extreme decreases in dissolved oxygen concentrations that threaten aquatic life
- Reductions in the diversity of benthic animal populations
- 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, scum, and benthic communities reduced to the most stress-tolerant species.

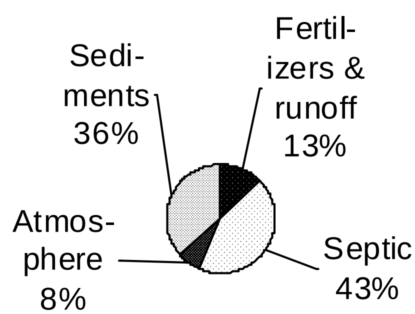
Coastal communities, including Chatham, rely on clean, productive, and aesthetically pleasing marine and estuarine waters for tourism, recreational swimming, fishing, and boating, as well as for commercial fin fishing and shell fishing. Failure to reduce and control N loadings could result in complete replacement of eelgrass by macro-algae, a higher frequency of extreme decreases in dissolved oxygen concentrations, fish kills, widespread occurrence of unpleasant odors and visible scum, and a loss of benthic macroinvertebrates throughout most of the embayments. As a result of these environmental impacts, commercial and recreational uses of Chatham's coastal waters could be greatly reduced, or cease altogether.

Sources of Nitrogen

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

- The watershed
    - Wastewater (Septic systems and Wastewater treatment plants)
    - Natural background
    - Runoff
    - Fertilizers
- Atmospheric deposition
- Nutrient-rich bottom sediments in the embayments

Most of the present N load, in the southern embayments (combined), originates from individual subsurface wastewater disposal (septic) systems, primarily serving individual residences, as seen in the following figure:



Target "Threshold" Nitrogen Concentrations and Loadings

The N loadings (the quantity of nitrogen) to Chatham's southern embayments presently range from 3.4 kg/day in Little Mill Pond, to 34.4 kg/day in Oyster Pond. The concentrations of N in the embayments range from 0.39 mg/L (milligrams of nitrogen per liter) in Stage Harbor to 1.86 mg/L in Cockle Cove Cr.

In order to restore and protect Chatham's embayments, N loadings, and subsequently the concentrations of N in the water, must be reduced to levels below the "thresholds" that cause the observed environmental impacts. The MEP has determined that, for the three southern Chatham estuary systems, a target "system" N concentration of 0.38 mg/L is protective. The mechanism for achieving the target N concentrations is to reduce the N loadings to the embayments. The MEP has determined through mathematical modeling that the total maximum daily loads (TMDL) of N that would result in the "safe" target concentrations in the various embayments range from 1 to 18 kg/day.

The purpose of this document is to present updated TMDLs for each embayment and to provide guidance to the Town on possible ways to reduce the N loadings to meet, or "implement", these proposed TMDLs.

Implementation

The primary vehicle for developing strategies to implement the TMDL is the Town's Comprehensive Wastewater Management Plan (CWMP). The CWMP evaluates alternative ways to significantly reduce the N loadings from septic systems through a variety of centralized or decentralized methods such as sewering with N removal technology, advanced treatment of septage, upgrading to nitrogen-removing on-site systems, and/or N-reducing on-site systems. Guidance on these strategies, plus ways to reduce N loadings from storm water runoff and fertilizers, are explained in detail in the "MEP Embayment Restoration Guidance for Implementation Strategies", available on the DEP website at http://www.mass.gov/dep/water/resources/coastalr.htm . 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.

There is presently only one municipal wastewater treatment facility in Chatham, which discharges approximately 3 kg N/day into the groundwater adjacent to Cockle Cove Creek. Recent studies indicated that as long as the existing concentrations of N in the marsh system are not exceeded, the well- functioning salt marshes along Cockle Cove Creek, as well as the rest of the Sulphur Springs embayment system, would be protected.

Finally, growth within Chatham, which would exacerbate the problems associated with N loadings, should be guided by considerations of water quality-associated impacts.

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Introduction

Section 303(d) of the Federal Clean Water Act requires each state (1) to identify waters for which effluent limitations normally required are not stringent enough to attain 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 pollutants of concern), from all contributing sources, that a water body may receive and still meet and maintain its 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. Description of water bodies and priority ranking: determination and documentation of whether or not a water body is presently meeting its water quality standards and designated uses.

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

3. Linking water quality and pollutant sources: determination of the loading capacity of the water body. EPA regulations define the loading capacity as the greatest amount of loading that a water body can receive without violating water quality standards. If the water body is not presently meeting its designated uses, then the loading capacity will represent a reduction relative to present loadings.

4. Total maximum daily loads: specification of load allocations, based on the loading capacity determination, for non-point sources and point sources, that will ensure that the water body will not violate water quality standards.

After public comment and final approval by the EPA, the TMDL will serve as a guide for future implementation activities. The DEP will continue to work with Chatham 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 Chatham embayments, the pollutant of concern, for this TMDL (based on observations of eutrophication), is the nutrient nitrogen. Nitrogen is the limiting nutrient in coastal and marine waters, which means that as its concentration is increased, so is the amount of plant matter. This can lead to nuisance populations of macro-algae, increased concentrations of phytoplankton and epiphyton (which impair eelgrass beds) - all of which combine to imperil the ecological health of the affected water bodies.

The TMDLs for total N for the three southern Chatham estuaries are based primarily on data collected, compiled, and analyzed by the University of Massachusetts Dartmouth's School of Marine Science and Technology (SMAST), the Cape Cod Commission, and others, as part of the Massachusetts Estuaries Program (MEP). The original TMDL was developed based on the availability of three quarters of water use data provided by the Town. Since that time a full year of

data has been collected and was provided by the Town. In addition, the USGS refined the delineation of the ground watershed, and the monitoring program was continued, thus providing a few years of additional water quality data. As a result the Town requested that the TMDL be reevaluated using all of the additional data and information. This TMDL report serves to update the 2006 TMDL for the embayments including the Sulphur Springs, Taylor's Pond, and Stage Harbor Systems.
The target threshold concentrations are the same in both the original and re-evaluated technical reports. However, the re-evaluation resulted in slightly different watershed target loads.

Subsequent to the development of the initial TMDL the TMDL writing team determined that negative losses in the system, such as those sometimes encountered with the uptake of N in the sediment, should not be credited towards the need for future load reductions. As a result, negative flux values have been entered as 0. This will provide an additional margin of safety to the required load reductions to meet water quality standards.

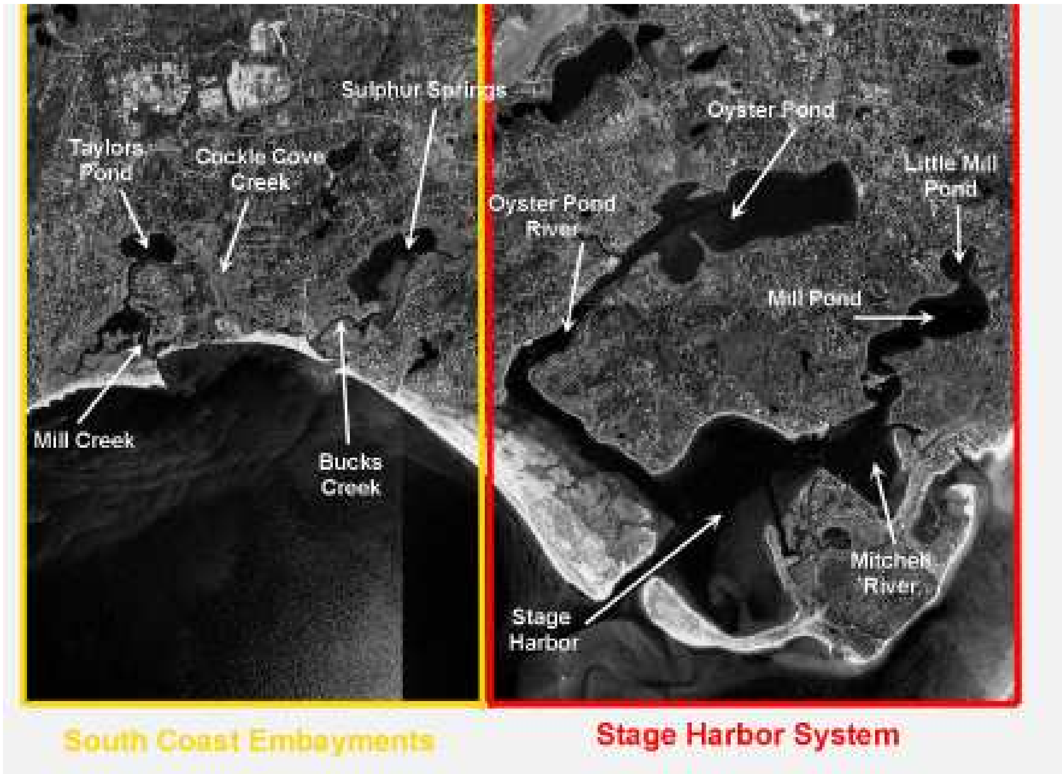
The target threshold N concentrations for the southern embayments are the same in both the original and re-evaluated technical reports. However, the original recommended N loading values were 9% lower than the N TMDL values that resulted from the re-evaluation. (Appendix C)

The northern embayments were previously updated and are contained in the Pleasant Bay TMDL, which was approved by the U.S. EPA on 10/24/07 (document control #244.0) which can be downloaded from the SMAST web site at http://www.oceanscience.net/estuaries .

The data were collected, primarily, over a study period from 1997 to 2005. This study period will be referred to as the "present conditions" in the TMDL because it is generally the most recent data available. The revised analyses of these three coastal embayments, using the MEP Linked Watershed-Embayment N Management Model (Linked Model), are presented in the 2007 Re-evaluated Report. The analyses were performed to assist the Town with decisions on current and future wastewater planning, wetlands restoration, anadromous fish runs, shell-fisheries, open-space, and harbor maintenance programs. A critical element of this approach is the assessment of water quality monitoring data, historical changes in eelgrass distribution, time-series water column oxygen measurements, and benthic community structure that were conducted on each embayment. These assessments served as the basis for generating N loading thresholds for use as goals for watershed N management. The TMDLs are based on the site-specific thresholds generated for each embayment. Thus, the MEP offers a science-based management approach to support the Town of Chatham's wastewater management planning and decision-making process.

Description of Water Bodies and Priority Ranking

Chatham Massachusetts, at the eastern end of Cape Cod, is surrounded by water on three sides, with Nantucket Sound to the south, the Atlantic Ocean and Chatham Harbor to the east, and Pleasant Bay to the north. Much of the shoreline, especially in Chatham's southern three estuaries, consists of a number of small embayments of varying size and hydraulic complexity, characterized by limited rates of flushing, shallow depths and heavily developed watersheds. The estuaries that are subject to this report are indicated on the following figure:



These embayments constitute important components of the Town's natural and cultural resources. The nature of enclosed embayments in populous regions brings two opposing elements to bear: 1) as protected marine shoreline they are popular regions for boating, recreation, and land development, and 2) as enclosed bodies of water, 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 embayments along Chatham's shore are at risk of further eutrophication from high nutrient loads in the groundwater and runoff from their watersheds. Because of excessive nutrients many embayments or sub-embayments are already listed as waters requiring TMDLs (Category 5) in the MA 2006 Integrated List of Waters, as summarized in Table 1 a.

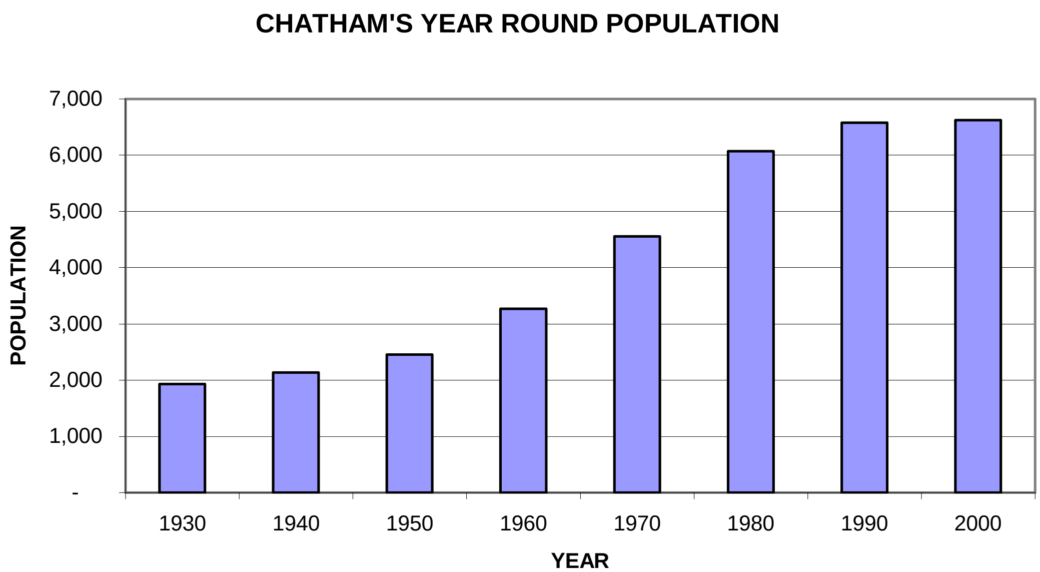
A complete description of the water bodies is presented in Chapter I of the 2003 Technical Report from which the majority of the following information is drawn. TMDLs were prepared for 11 ponds, rivers, creeks, and harbors. Analytical and modeling efforts were conducted by grouping these 11 "sub-embayments" into three embayment systems, each of which flow into Nantucket Sound to the south.

The embayments addressed by this document are determined to be high priorities based on three significant factors: 1) the initiative that the Town has taken to assess the conditions of embayments, 2) the commitment made to restoring and preserving their embayments, and 3) because of the extent of eutrophication in the embayments. In particular, the embayments within the Town of Chatham are at risk of further degradation from increased N loads entering through groundwater and surface water from their increasingly developed watersheds. In both marine and freshwater systems, an excess of nutrients results in degraded water quality, adverse impacts to ecosystems, and limits on the use of water resources.

The general conditions related to the major indicators of habitat impairment, due to excess nutrient loadings, are tabulated in Table 1b. Observations are summarized in the Problem Assessment section below, and detailed in Chapter VII, Assessment of Embayment Nutrient Related Ecological Health, of the accompanying 2003 Technical Report.

Problem Assessment

The watersheds of Chatham's estuaries have all had rapid and extensive development of single-family homes and the conversion of seasonal into full time residences. This is reflected in a substantial transformation of land from forest to suburban use between the years 1951 to 2000. Water quality problems associated with this development result primarily from on-site wastewater treatment systems, and to a lesser extent, from runoff - including fertilizers - from these developed areas. The population of Chatham, as shown in the following graph, increased markedly between 1950 and 1990.



Septic system effluents discharge to the ground, enter the groundwater system and eventually enter the surface water bodies. In the sandy soils of Cape Cod, effluent that has entered the groundwater travels towards the coastal waters at an average rate of one foot per day. The nutrient load to the groundwater system is directly related to the number of subsurface wastewater disposal systems, which in turn are related to the population.

In the particular case of the Town of Chatham, the increase in population is on the order of 250% since 1950. In addition, summertime residents and visitors swell the population of the entire Cape by about 300% according to the Cape Cod Commission (http://www.capecodcommission.org/data/trends98.htm#population).

Based on current local zoning, the populations in the various embayments discussed here could increase from a low of about 4 % to a high of 20% depending on the particular water body.

TABLE 1 a. Chatham Embayments Listed in the Proposed Massachusetts 2008 Integrated List[1]

Name	Segment ID	Description	Size	Pollutant Listed
Stage Harbor				
Oyster Pond	MA96-45_2008	Including Stetson Cove	0.21 sq mi	Nutrients & Pathogens
Oyster Pond River	MA96-46_2008	Outlet of Oyster Pd to confluence with Stage harbor, Chatham	0.14 sq mi	Nutrients & Pathogens
Stage Harbor	MA96-11_2008	From the outlet of Mill Pd (including Mitchell River) to the Confluence with Nantucket Sound at a line from the southernmost point of Harding Beach southeast to the Harding Beach Point, Chatham	0.58 sq mi	Nutrients & Pathogens
Mill Pond	MA96-52_2008	Including Little Mill Pond (PALIS #96174), Chatham	0.06 sq mi	Nutrients
Sulphur Springs				
Harding Beach Pond	MA96-43_2008	Locally known as Sulphur Springs (northeast of Bucks Cr), Chatham	0.07 sq mi	Pathogens & Nutrients
Bucks Creek	MA96-44_2008	Outlet from Harding Beach Pond (locally known as Sulphur Springs) to confluence with Cockle Cove, Chatham	0.02 sq mi	Pathogens & Nutrients
Taylors Pond				
Mill Creek	MA96-41_2008	Outlet of Taylors Pond to confluence with Cockle Cove, Chatham	0.03 sq mi	Pathogens & Nutrients
Taylors Pond	MA96-42_2008	Chatham	0.02 sq mi	Pathogens & Nutrients

[1] All segments are in Category 5, with the exception of Mill Pond, which is in Category 4 a.

TABLE 1 b. General Summary of Conditions Related to the Major Indicators of Nutrient Over-Enrichment/Habitat Impairment Observed in Chatham Embayments

The table does not include the salt marsh habitats of Cockle Cove, or Mill Creek because, unlike embayments listed below, they are highly tolerant of watershed N loading. The examples of Chlorophyll and dissolved oxygen conditions are based on data from continuous DO and Chlorophyll monitoring during summer, 2002.

Embayments	Eel Grass Loss (1951 – 2000)	Dissolved Oxygen Depletion	Chlorophyll *a* [2]
Stage Hbr			
Oyster Pond	Complete loss	Insignificant [1]	Generally 5 – 15 µg/L
Oyster Pond R.	Half lost	Insignificant	Generally 5 – 15 µg/L
Stage Harbor	Slight decline	Insignificant	Generally 5 – 15 µg/L
Mitchell river	Beds declining	Insignificant	No blooms reported
Mill Pond	Complete loss	<4 mg/L 30 % of study period <3 mg/L 16% of study period	Generally 5 – 20 µg/L occasionally > 20 µg/L
Little Mill Pd	Complete loss	Presumed same as Mill Pond	Generally 5 – 20 µg/L occasionally > 20 µg/L
Sulphur Spr			
Sulphur Springs	Complete loss	< 4 mg/L 12% of study period < 3 mg/L 6% of study period	Frequently > 20 µg/L Occasionally > 25 µg/L
Taylors Pd			
Taylors Pond	Complete loss	< 4 mg/L 2% of study period	Frequently 10 – 20 µg/L

[1] Insignificant defined as a slight lowering of DO, but no observations of ecologically significant reductions (below 4 mg/L)

[2] Nuisance algal blooms: chlor a = 15 – 20 µg/L; significant algal blooms = chlor *a* > 20µg/L)

Dramatic declines in water quality, and the quality of the estuarine habitats, throughout Chatham, have paralleled the population growth of the Town. The problems in these embayments generally include periodic decreases of dissolved oxygen, decreased diversity of benthic animals, and periodic algal blooms. Eelgrass beds, which are critical habitats for macroinvertebrates and fish, have significantly declined in these waters. This is a result of nutrient loads causing excessive growth of algae in the water (phytoplankton) and algae growing on eelgrass (epiphyton), both of which result in the loss of eelgrass through the reduction of available light levels. Furthermore, eelgrass is being replaced by macro algae, which are undesirable, because they do not provide high quality habitat for fish and invertebrates. In the most severe cases there would be periodic fish kills, unpleasant odors and scum, and near loss of the benthic community and/or presence of only the most stress-tolerant species of benthic animals.

Coastal communities, including Chatham, rely on clean, productive, and aesthetically pleasing marine and estuarine waters for tourism, recreational swimming, fishing, and boating, as well as commercial fin fishing and shell fishing. The continued degradation of Chatham's coastal embayments, as described above, will significantly reduce the recreational and commercial value and use of these important environmental resources.

Habitat and water quality assessments were conducted on each embayment based upon available water quality monitoring data, historical changes in eelgrass distribution, time-series water column oxygen measurements, and benthic community structure. The three-embayment systems in this study display a range of habitat quality, both between systems and along the longitudinal axis of the larger systems. In general, the habitat quality of the sub-embayments is highest near their mouths and poorest in the inland-most tidal reaches. Eelgrass abundance is highest near the mouths of the embayments. Infaunal communities are more stressed in the inland reaches.

The following is a brief synopsis of the present habitat quality within each of the three-embayment systems:

Stage Harbor System – Little Mill Pond, Mill Pond, and Oyster Pond have elevated nitrogen levels and have lost historic eelgrass beds, which once covered most of their respective basins, although eelgrass beds within Oyster Pond appear to have been restricted to its lower ~1/3 with only fringing beds in the shallow areas of the upper portion and oxygen depletion is observed during summer in each system with Mill Pond (and presumably Little Mill Pond) having ecologically significant declines (<3 mg/L). Oyster Pond had less oxygen depletion possibly due to its greater fetch for ventilation with the atmosphere. Chlorophyll *a* levels were consistent with the observed oxygen depletion. The lower reaches of the Oyster Pond River and Upper Stage Harbor show good habitat quality as evidenced by their persistent eelgrass beds, infaunal community structure, and oxygen and chlorophyll a levels. The innermost high quality habitat is found in the lower Mitchell River/upper Stage Harbor.

Sulphur Springs System – Cockle Cove consists primarily of a salt marsh and a central tidal creek. This system contains little water at low tide and has a high assimilative capacity for nitrogen, as do other New England salt marshes. The Cockle Cove tidal creek, along with its associated marsh area, is functioning well as a salt marsh ecosystem. The nitrogen threshold established for the open water areas of the Sulphur Springs system is not applicable to the Cockle Cove salt marsh area. Based upon a detailed MEP site-specific investigation of the Cockle Cove salt marsh, it appears that the N load can be increased to this tidal creek as long as the nitrogen concentration does not increase significantly (see MEP Cockle Cove Creek Threshold Report 2006). However potential negative effects of increased loading to Cockle Cove Creek on down-gradient Bucks Creek is a concern. This concern is addressed in a Town-requested modeling scenario detailed in Section IX of re-evaluated

Technical Report. Sulphur Springs is a shallow basin containing significant macroalgal accumulations, no eelgrass, and appears to be transitioning to salt marsh. However, Sulphur Springs basin is still functioning as an embayment, but a eutrophic one. Nitrogen levels are high (Section VI), oxygen levels become significantly depleted (6% of time <3 mg/L) and phytoplankton blooms are common (chlorophyll a levels >20 µg/L). Eelgrass has not been observed for over a decade.

Taylors Pond System – Taylors Pond represents the inland-most sub-embayment and is a drowned kettle pond. The lower portion of this system is comprised of a tidal salt marsh, Mill Creek. Like the Sulphur Springs System, the inner basin functions as an embayment and the tidal creek as a salt marsh with low sensitivity to nitrogen inputs. Taylors Pond is currently showing poor habitat quality. There is currently no eelgrass community and no record of eelgrass for over a decade. Water column nitrogen levels are enriched over incoming tidal waters (Section VI) and dissolved oxygen depletion to ~4 mg/L is common. Chlorophyll a levels of 10-15 µg/L are common during summer. The benthic infaunal community is impoverished, with only a mean of 43 individuals collected in the grab samples, compared to several hundred in the high quality sub-embayments.

Pollutant of Concern, Sources, and Controllability

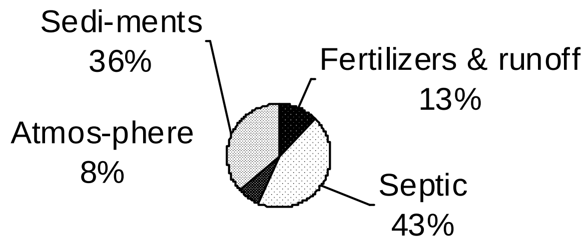
In the coastal embayments in the Town of Chatham, as in most marine and coastal waters, the limiting nutrient is nitrogen. Nitrogen concentrations beyond those expected naturally contribute to undesirable conditions, including the severe impacts described above, through the promotion of excessive growth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

Research has shown that the presently the degraded environmental conditions, including the loss of eelgrass, is a result of excess nitrogen entering the estuaries. The expectation is that the eelgrass will recover following the recommended reductions in N loadings. It should be noted that eelgrass loss can be attributed to other causes, including wasting disease, suspended sediments, boat traffic, and poor seed germination, however, these factors have not been shown to be significant contributors to the decline of eelgrass that has led to the current conditions in Chatham.

Each of the embayments 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 Town of Chatham, the USGS, and the Cape Cod Commission. Data collection included both water quality and hydrodynamics as described in Chapters I, V, and VII of the 2003 Technical Report and Chapter IV of the 2007 re-evaluated Technical Report.

The following figure, illustrating the N sources of Chatham's combined southern embayments, indicates that most of the N originates from septic systems and nutrient-rich benthic sediments, with considerably less N originating from runoff, fertilizers, and atmospheric deposition.

Relative Contribution of Various Sources of Nitrogen in the Combined Southern Chatam Embayments



The level of "controllability" of each source, however, varies widely:

Atmospheric N cannot be adequately controlled locally – it is through region- and nation-wide air pollution control initiatives that significant reductions are feasible;

Sediment N control by such measures as dredging is not feasible on a large scale. 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;

Fertilizer – related N loadings can be reduced through bylaws and public education;

Storm water sources of N can be controlled by best management practices (BMPs), by-laws, and storm water infrastructure improvements;

Septic system sources of N are the largest controllable sources. These can be controlled by a variety of case-specific methods including: sewering and treatment at centralized or decentralized locations, upgrading to nitrogen-removing systems, transporting and treating septage at treatment facilities with N removal technology either in or out of the watershed, or installing N-reducing septic systems.

Cost/benefit analyses will have to be conducted on all of the possible N loading reduction methodologies in order to select the optimal control strategies, priorities, and schedules.

Description of the Applicable Water Quality Standards

The Coastal waters in the Stage Harbor/Oyster Pd, Sulphur Springs/Bucks Cr, and Taylors Pd/Mill Cr systems in Chatham are classified as SA. Water quality standards of particular interest to the issues of cultural eutrophication are dissolved oxygen, nutrients, aesthetics, excess plant biomass, and nuisance vegetation. The Massachusetts water quality standards (314 CMR 4.0) contain numeric criteria for dissolved oxygen, but have only narrative standards that relate to the other variables, as described below:

314 CMR 4.05(5)(a) states "Aesthetics – All surface waters shall be free from pollutants in concentrations or combinations 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)(c) states, "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…"

314 CMR 4.05(b) 1:

(a) Class SA

1. Dissolved Oxygen -
a. Shall not be less than 6.0 mg/L unless background conditions are lower;
b. Natural seasonal and daily variations above this level shall be maintained.

(b) Class SB

1. Dissolved Oxygen -
a. Shall not be less than 5.0 mg/L unless background conditions are lower;
b. Natural seasonal and daily variations above this level shall be maintained.

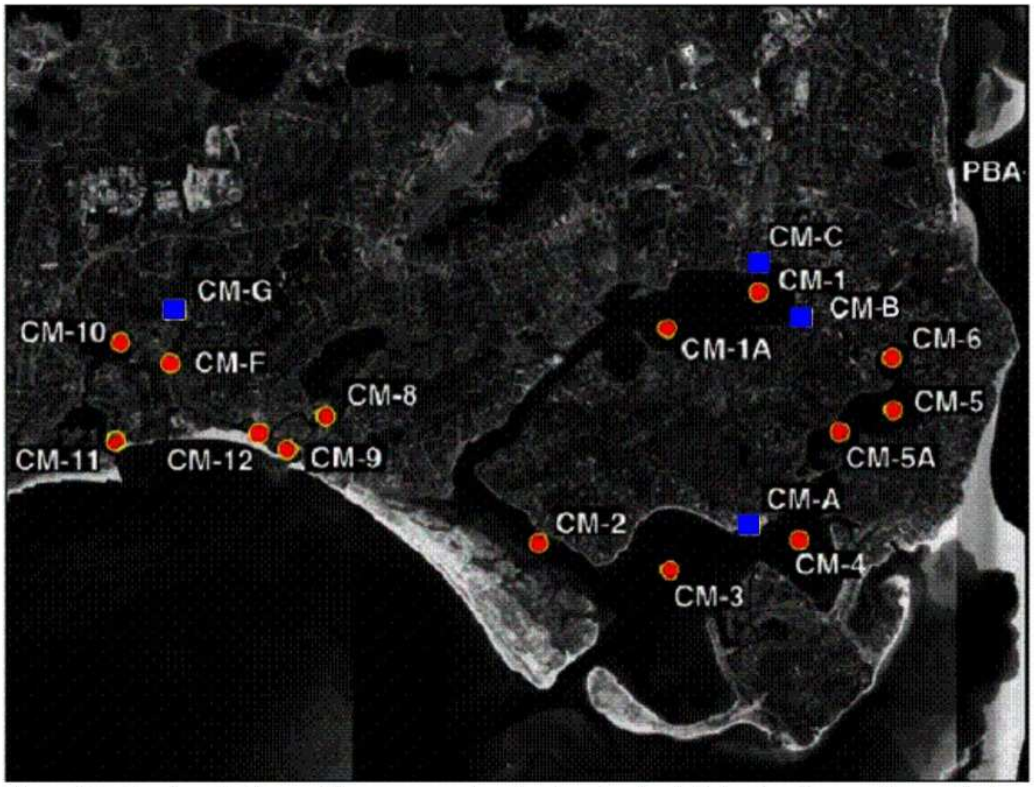
Thus, the assessment of eutrophication is based on site-specific information within a general framework that emphasizes impairment of uses and preservation of a balanced indigenous flora and fauna. This approach is recommended by the US Environmental Protection Agency in their draft Nutrient Criteria Technical Guidance Manual for Estuarine and Coastal Marine Waters (EPA-822-B-01-003, Oct 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 water body criteria is typically required.

It is this framework, coupled with an extensive outreach effort that the Department, with the technical support of SMAST, is employing to develop nutrient TMDLs for coastal waters.

Methodology - Linking Water Quality and Pollutant Sources

Extensive data collection and analyses have been described in detail in the Technical Report. Those data were used by SMAST to assess the loading capacity of each embayment.

Sampling station locations are indicated in the following figure:



Map of freshwater discharge (blue squares) and estuarine (red circles) water quality monitoring stations within the Town of Chatam's southern three estuaries.

The primary water quality objective was represented by conditions that: 1) preserve the natural distribution of eelgrass because it provides valuable habitat for shellfish and finfish, 2) prevent algal blooms, 3) protect benthic communities from impairment or loss, and 4) maintain dissolved oxygen concentrations that are protective of the estuarine communities.

The core of the Massachusetts Estuaries Project analytical method 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 each watershed and 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 additional scenarios.

The Linked Model has been applied previously to watershed N management in 15 embayments throughout Southeastern Massachusetts. In these applications it became clear that the Linked Model can be calibrated and validated, and has use as a management tool for evaluating watershed N management options.

The Linked Model, when properly parameterized (values assigned for each variable), calibrated, and validated, for a given embayment, becomes a N-management planning tool as described below. The Linked 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 the Linked Model is fully functional it can be refined for changes in land-use or embayment characteristics at minimal cost. In addition, 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.

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 2003 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 N Loading

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

• Embayment TMDL - Synthesis

- Linked Watershed-Embayment N Model
- Salinity surveys (for Linked Model validation)
- Rate of N recycling within embayment
- Dissolved oxygen record
- Macrophyte survey
- Infaunal survey (benthic animals) in complex systems

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 each embayment system, located close to the inland-most reach or reaches, which typically has the poorest water quality within the system. These are called "sentinel" sub-embayments;

2) Using site-specific information and 3 years of embayment-specific data to select target/threshold N concentrations for each embayment system. This is done by refining the draft or "threshold" N concentrations that were developed as the initial step of the MEP process. The target concentrations that were selected generally occur in higher quality waters near the mouths of the embayment systems;

3) Running the calibrated water quality model using different watershed N loading rates, to determine the loading rate, which would result in achieving the target N concentration <u>within the sentinel system</u>. Differences between the modeled N load required to achieve the target N concentration, and the present watershed N load, represent N management goals for restoration and protection of the embayment system as a whole.

Previous sampling and data analyses, and the modeling activities described above, resulted in four major outputs that were critical to the development of the TMDLs. Two outputs are related to nitrogen **concentration**:

- The present N concentrations in the embayments
- Site-specific target (threshold) concentrations

And, two outputs are related N **loadings** in each of the Chatham embayment systems:

- The present N loads to the sub-embayments
- Load reductions necessary to meet the site-specific target N concentrations

A brief overview of each of the outputs follows:

<u>Total Nitrogen concentrations in the embayment systems</u>

a) Observed "present" conditions:

Table 2 presents the average concentrations of total N (TN), modeled from measurements in the sub-embayments from 1999 through 2005. Concentrations of N are the highest in Cockle Cove Cr (1.86 mg/L), which is a functioning salt marsh habitat where assimilative capacity is naturally high. Nitrogen in the other embayments ranges in concentration from 0.39 to 0.74 mg/L, resulting in overall ecological habitat quality ranging from moderately high to poor. The individual yearly means and standard deviations of the averages are presented in Table A of Appendix A.

b) Modeled site-specific target (threshold) N concentrations:

A major component of TMDL development is the determination of the maximum concentrations of N (based on field data) that can occur without causing unacceptable impacts to the aquatic environment. 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 embayment.

As listed in Table 2, the site-specific target (threshold) N concentration is 0.38 mg/L for the sentinel stations in each of the embayment systems (Oyster Pond, between CM1-A and Oyster Pond River inlet at 41º 40' 43.5" N, 69º 58'39" W; Mitchell River CM5-A at 41º40'19" N, 69º57'35"W;

Sulphur Springs CM-8 at 41º40’25”N, 70º0’0”W; and Taylors Pond CM-10 at 41º40’40”N, 70º1’1”W.

TABLE 2. “Existing” Total Nitrogen Concentrations (Observed and Modeled) and Calculated Target Threshold Nitrogen Concentrations Derived for the Southern Chatham Embayment Systems. Concentrations appear as ranges when two or more segments of the water body were sampled.

Embayment Systems and Sub-Embayments	Observed Total Nitrogen Concentration [1] (mg/L)	System Threshold Nitrogen Concentration (mg/L)
Stage Harbor		
Oyster Pond	0.51-0.74	0.38 (near sta CM1-A)
Oyster Pond River	0.49	
Stage Harbor	0.39-0.50	
Mitchell River	0.46	0.38 (near sta CM5-A)
Mill Pond	0.49	
Little Mill Pond	0.74	
Sulphur Springs		
Sulphur Springs	0.58	0.38 (sta CM 8)
Bucks Cr	0.52	
Cockle Cove Cr	0.73-1.86	
Taylors Pond		
Mill Cr	0.52	
Taylors Pond	0.53	0.38 (sta CM 10)

[1] Based on annual means from 1999 – 2005. Individual yearly means and standard deviations of the average are presented in Tables A of Appendix A

The findings of the analytical and modeling investigations for each embayment system are discussed and explained below:

Stage Harbor System – This embayment system has two upper reaches. Therefore, two sentinel sub-embayments were selected, lower Oyster Pond and Mitchell River/Mill Pond. Little Mill Pond could not be used because it is small and has steep horizontal nitrogen gradients (see Section VI). Within the Stage Harbor System, the uppermost sub-embayment supportive of high quality habitat was upper Stage Harbor (Section VII, VIII-1). Water column total nitrogen levels within this embayment region vary with the tidal stage due to high nitrogen out-flowing waters and low nitrogen inflowing waters (Section VI). The calibrated water quality model for this system indicates an average total nitrogen level in the upper Stage Harbor of about 0.40 mg/L is most representative of the conditions within this sub-embayment. However, upper Stage Harbor does not appear to be stable based upon changes in eelgrass distribution. Therefore, a nitrogen level reflective of conditions closer to the inlet should achieve the stability required. The lower nitrogen level is equivalent to the tidally averaged total nitrogen concentration mid-way between upper Stage Harbor and Stage Harbor or 0.38 mg/L. This threshold selection is supported by the fact that the high quality and stable habitat near the mouth of the Oyster Pond River is also at a tidally averaged total nitrogen concentration of 0.37 mg N. The 0.38 mg/L was used to develop watershed nitrogen loads required to reduce the average nitrogen concentrations in each sentinel system to this level. Tidal waters inflowing from Nantucket Sound have an average concentration of total nitrogen of 0.285 mg/L. For the development of the Stage

Harbor total nitrogen threshold, two sentinel stations were selected, one for each branch of the system. For the Mitchell River/Mill Pond branch, the existing CM5-A monitoring station was selected. For the Oyster Pond branch, the area between station CM1-A and the inlet to Oyster Pond was selected. In order for any loading scenario to meet the requirements of the threshold set for Stage Harbor, the TN concentration must be no more than 0.38 mg/L at both of these stations.

Sulphur Springs System – The Sulphur Springs basin is both the inland-most sub-embayment and also represents the largest component of the Sulphur Springs System (which also includes Cockle Cove Creek and Bucks Creek). Since this System exchanges tidal waters with Nantucket Sound (0.285 mg/L), as does Stage Harbor, and since there is currently no high quality habitat within this system, Stage Harbor habitat quality information was used to support the Sulphur Springs thresholds analysis. The tidally averaged nitrogen threshold concentration for this system was determined to be the same as for the sentinel sub-embayments to the Stage Harbor System (0.38 mg/L). The 0.38 mg/L was used to develop watershed nitrogen loads required to reduce the average nitrogen concentrations in the Sulphur Springs sentinel system to this level (station CM8). It should be noted that the total nitrogen concentration in Bucks Creek should not be elevated above 0.38 mg/L. This 0.38 mg/L threshold concentration was developed for the open water portions of the system and as previously mentioned above is not applicable to the Cockle Cove subsystem as it is functioning well as a salt marsh. As such, the Cockle Cove Creek sub-system received its own nitrogen threshold analysis, which was provided previously to the Town of Chatham by the MEP (Howes, White & Samimy 2006) and which was supported by an appended companion habitat study by MCZM (Carlisle, Smith, Callahan 2005).

Taylors Pond System – This system was approached in a similar manner to the Sulphur Springs System and for the same reasons. Taylors Pond represents the innermost and functional embayment within this system. This system also exchanges tidal waters with Nantucket Sound (0.285 mg/L), as does the Stage Harbor System and there is no high quality stable embayment habitat within this system. Therefore, the tidally averaged nitrogen threshold concentration for this system was determined to be the same as for the sentinel sub-embayments to the Stage Harbor System or 0.38 mg/L. The 0.38 mg/L was used to develop watershed nitrogen loads required to reduce the average nitrogen concentrations in Taylors Pond to this level.

<u>Nitrogen loadings to the sub-embayments</u>

a) Present loading rates:

In Chatham's southern systems, the highest N loading from controllable sources is from septic systems. Septic system loadings range from 0.9 kg/day to as high as 8.1 kg/day. Nitrogen loading from the nutrient-rich sediments (sometimes referred to as benthic flux) exceeds the N loading from septic systems in five out the six Stage Harbor sub-embayments. As discussed previously, however, the "direct" control of N from sediments is not considered feasible. However, the magnitude of the benthic contribution is related to the watershed load. Therefore, reducing the incoming load will reduce the loading from sediments. The TN loading from all sources ranges from 3.4 kg/day in Little Mill Pond, to 34.4 kg/day in Oyster Pond. A further breakdown of N loading, by source, is presented in Table 3.

TABLE 3. Nitrogen Loadings to the Chatham Sub-Embayments from Within the Watersheds (Land Use-Related Runoff, and Septic Systems), from the Atmosphere, and from Nutrient-rich Sediments Within the Embayments

Embayment Systems and Sub-embayments	Present Non-Wastewater Watershed Load[1] (kg/day)	Present wastewater (septic and WWTP) Load (kg/day)	Present Atmospheric Deposition[2] (kg/day)	Present Load from Nutrient Rich Sediments (kg/day)	Total nitrogen load from all sources (kg/day)
Stage Harbor					
Oyster Pond	1.9	8.1	1.8	22.6	34.4
Oyster Pond River	2.3	7.1	1.1	1.0	11.5
Stage Harbor	0.5	1.5	3.2	4.1	9.3
Mitchell river	0.4	2.2	0.9	4.0	7.5
Mill Pond	0.6	3.0	0.6	3.5	7.7
Little Mill Pond	0.4	0.9	0.1	1.8	3.4
Sulphur Springs					
Sulphur Springs	1.7	7.9	0.4	0	10.0
Bucks Cr	0.6	2.8	0.1	2.9	6.4
Cockle Cove Cr	4.1	4.3[3]	0.1	0	8.5 [3]
Taylors Pond					
Mill Cr	1.0	3.6	0.2	0	4.8
Taylors Pond	1.2	5.0	0.2	1.4	7.8
Total all systems	14.7	49.6	8.7	41.3	114.4
Percentage	13%	43%	8%	36%	

[1] Composed of fertilizer and runoff. Includes a small amount (3%-10%) of atmospheric deposition to "natural surfaces."

[2] Atmospheric deposition directly to the estuary surface only

[3] Includes the 3.2 kg/day from the wastewater treatment facility

b) Nitrogen loads necessary for meeting the site-specific target N concentrations.

As previously indicated, the present N loadings to the Chatham embayments must be reduced in order to restore the impaired conditions and to avoid further nutrient-related adverse environmental impacts. The critical final step in the development of the TMDL is modeling and analysis to determine the loadings required to achieve the target N concentrations. Table 4 a lists the present controllable watershed N loadings and reduced watershed loadings that are necessary to achieve target concentrations (which will be described more fully in the following section). It should be noted once again that the goal of this TMDL is to achieve the target N concentration in the designated sentinel system. The loadings presented in Table 4a represent one, but not the only, loading reduction scenario that can meet the TMDL goal. In this scenario the percentage reductions to meet threshold concentrations range from 0 % at Bucks Creeks up to 81% at Oyster Pond.
Table 4b summarizes the present loadings from septic systems, and the reduced loads that would be necessary to achieve the threshold N concentrations in each embayment if septic loads alone were targeted. It is important to note that completely different reduction scenarios result from strategies that focus on all watershed sources, as opposed to focusing only on reducing septic system N loads.

TABLE 4 a. Present Watershed Nitrogen Loading Rates, Calculated "Target" Loading Rates, and the Percent Reductions Necessary to Achieve the Target Threshold Loadings

Embayment Systems and Sub-embayments	Present Watershed Load [1] (kg/day)	Target Watershed Load[1, 2] (kg/day)	Percent Load Reductions Needed to Achieve Target Loads
Stage Harbor			
Oyster Pond	10.0	1.9	81%
Oyster River	9.4	2.3	76%
Stage Harbor	2.0	.5	75%
Mitchell river	2.6	1.5	42%
Mill Pond	3.6	2.1	42%
Little Mill Pond	1.3	0.8	38%
Sulphur Springs			
Sulphur Springs	9.5	4.6	52%
Bucks Cr	3.4	3.4	0%
Taylors Pond			
Mill Cr	4.6	1.0	78%
Taylors Pond	6.2	4.2	32%

[1] Composed of combined fertilizer, runoff, and septic system loadings. Does not include direct atmospheric deposition to estuarine surfaces, but does include a small amount (3%-10%) of atmospheric deposition to "natural surfaces."

[2] Target threshold watershed load is the load from the watershed needed to meet the embayment threshold concentrations identified in Table 2 above.

TABLE 4 b. Present Septic System Nitrogen Loading Rates and Target Septic Loading Rates Needed to Meet Threshold N Concentrations in the Estuaries if Only Septic Loads were Reduced, Ignoring All Other Sources

Embayment Systems and Sub-embayments	Present Septic Load (kg/day)	Target Septic Load (kg/day)	Percent Load Reductions Needed to Achieve Target Loads
Stage Harbor			
Oyster Pond	8.099	0	100 %
Oyster River	7.052	0	100 %
Stage Harbor	1.523	0	100 %
Mitchell river	2.170	1.085	50 %
Mill Pond	2.956	1.478	50 %
Little Mill Pond	0.904	0.452	50 %
Sulphur Springs			
Sulphur Springs	7.863	2.971	62.2 %
Bucks Cr	2.767	2.767	0 %
Taylors Pond			
Mill Cr	3.584	0	100 %
Taylors Pond	5.019	3.012	40 %

Total Maximum Daily Loads

As described in EPA guidance, a total maximum daily load (TMDL) identifies the loading capacity of a water body for a particular pollutant. EPA regulations define loading capacity as the greatest amount of loading that a water body can receive without violating water quality standards. Because there are no “numerical” water quality standards for N, the TMDLs for the Chatham embayments are aimed at determining the loads that would correspond to embayment-specific N concentrations determined to be protective of the water quality and ecosystems. The effort includes detailed analyses and mathematical modeling of land use, nutrient loads, water quality indicators, and hydrodynamic variables (including residence time), for each embayment. The results of the mathematical model are correlated with estimates of impacts on water quality, including negative impacts on eelgrass (the primary indicator), as well as dissolved oxygen, chlorophyll, and benthic infauna. The TMDLs are established to protect and/or restore the estuarine ecosystem, including eelgrass, the leading indicator of ecological health, thus meeting water quality goals for aquatic life support.

The TMDL can be defined by the equation:

$$TMDL = BG + WLAs + LAs + MOS$$

Where

TMDL = loading capacity of receiving water
BG = natural background
WLAs = portion allotted to point sources
LAs = portion allotted to (cultural) non-point sources
MOS = margin of safety

Background Loading

Natural background N loading is included in watershed loads, but is not quantified or presented separately.

Waste Load Allocations

Waste load allocations identify the portion of the loading capacity allocated to existing and future point sources of wastewater. EPA interprets 40 CFR 130.2(h) to require that allocations for NPDES regulated discharges of storm water be included in the waste load component of the TMDL. On Cape Cod the vast majority of storm water percolates into the ground and aquifer and proceeds into the embayment systems through groundwater migration. The Linked Model accounts for storm water loadings and groundwater loading in one aggregate allocation as a non-point source – combining the assessments of waste water and storm water (including storm water that infiltrates into the soil and direct discharge pipes into water bodies) for the purpose of developing control strategies. Although the vast majority of storm water percolates into the ground, there are a few storm water pipes that discharge directly to water bodies that are subject to the requirements of the Phase II Storm Water NPDES Program. Therefore, any storm water discharges subject to the requirements of storm water Phase II NPDES permit must be treated as a waste load allocation. Since the majority of the nitrogen loading comes from septic systems, fertilizer and storm water that infiltrates into the groundwater, the allocation of nitrogen for any storm water pipes that discharge directly to any of the embayments is insignificant as compared to the overall groundwater load. Based on land use, the Linked Model accounts for loading for storm water, but does not differentiate storm water into a load and waste load allocation. Nonetheless, based on the fact that there are few storm water discharge pipes within NPDES Phase II communities that discharge directly to embayments or waters that are connected to the embayments, the waste load allocation for these sources is estimated to be 0.28% of the total nitrogen load from the watershed to the embayments. The percentage for individual sub-embayments ranged from 0.09% - 0.55% (Appendix B). This is based on the percent of impervious surface within 200 feet of the water bodies and the relative load from this area compared to the overall load (Table IV-4 of the 2007 MEP Re-evaluated Technical Report). Although most storm water infiltrates into the ground on Cape Cod, some impervious areas within approximately 200 feet of the shoreline may discharge storm water via pipes directly to the water body. For the purposes of waste load allocation it was assumed that all impervious surfaces within 200 feet of the shoreline discharge directly to the water body. This load is negligible when compared to other sources.

Load Allocations

Load allocations identify the portion the loading capacity allocated to existing and future nonpoint sources. In the case of the Chatham embayments, the nonpoint source loadings are primarily from septic systems. Additional N sources include: natural background, storm water runoff (including N from fertilizers), the Chatham wastewater treatment facility (WWTF) groundwater discharge, atmospheric deposition, and nutrient-rich sediments.

Generally, storm water that is subject to the EPA Phase II Program would be considered a part of the "waste load allocation", rather than the "load allocation". On Cape Cod however the vast majority of storm water percolates into the aquifer and enters the embayment system through groundwater. Given this, the TMDL accounts for storm water loadings and groundwater loadings in one aggregate allocation as a non-point source, thus combining the assessments of wastewater and storm water for the purpose of developing control strategies. Ultimately, when the Phase II Program is implemented in Chatham, new studies, and possibly further modeling, will identify what portion of the storm water load may be controllable through the application of Best Management Practices (BMPs).

The WWTF currently discharges about 3 kg N/day into the groundwater adjacent to the extensive salt marshes of Cockle Cove Creek. This marsh system is functioning well and there are no observed indications that it is impaired by the current N loadings. The results of a study conducted on Cockle Cove Cr and the surrounding marsh (MEP Technical Memorandum, Nov 30, 2006) indicate that as long as the existing concentrations of N are maintained in the marsh system, the marsh will be protected.

The sediment loading rates incorporated into the TMDL are lower than the existing loading rates from the sediments listed in Table 3 above 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 N flux is a function of N loading and particulate organic nitrogen (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:

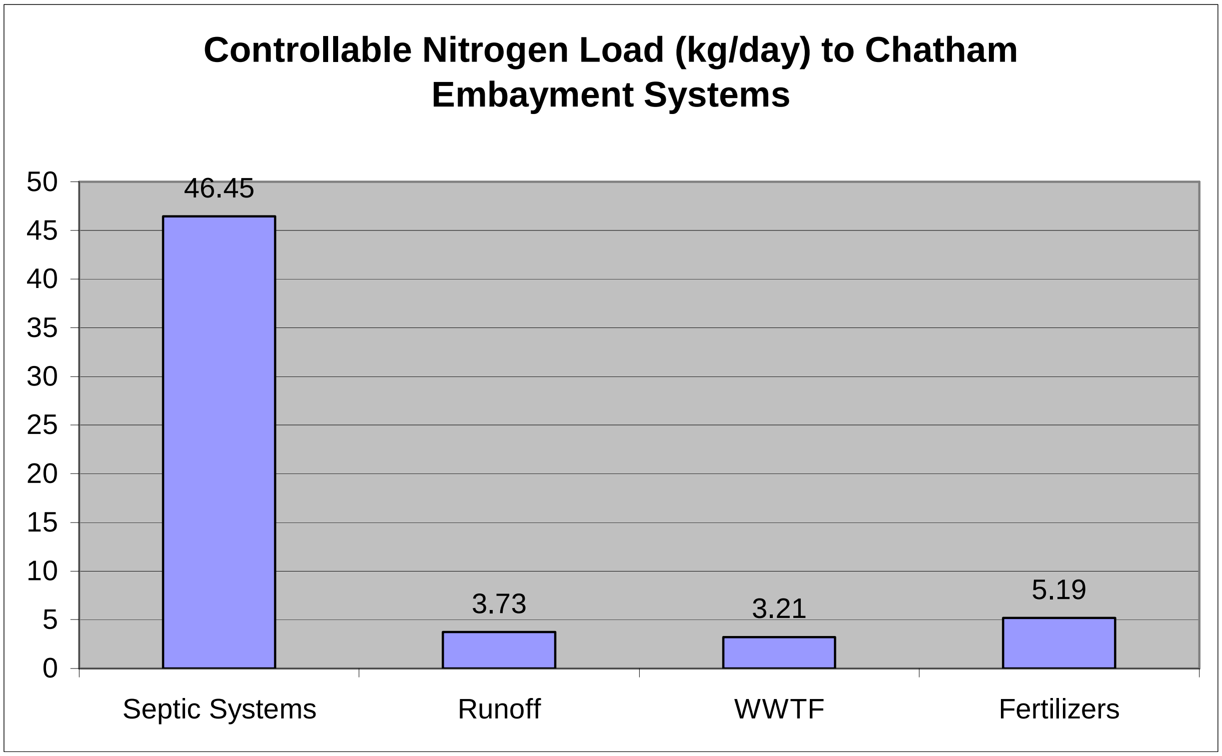
D_{PON} is the PON concentration above background determined by:

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

Since benthic loading varies throughout the year and the values shown represent ‘worst-case’ summertime conditions, loading rates are presented in kilograms per day (Table VIII-3 of the accompanying Technical Report). The benthic flux for the MEP modeling effort is reduced from existing conditions based on the load reduction and the observed PON concentrations within each sub-embayment relative to Nantucket Sound (boundary condition). The loading from sediments (benthic flux) to each embayment was reduced based on the reduction of N in the watershed load.

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

The following figure, showing the primary sources of locally controllable N, emphasizes the fact that the overwhelming majority of locally controllable N comes from septic systems.



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)(20©, 40C.G.R. para 130.7©(1)]. 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. The MOS for the Chatham TMDL is implicit, and the conservative assumptions in the analyses that account for the MOS are described below.

1. Use of conservative data in the Linked Model

In the Chatham embayments, where most of the current N load does not pass through surface water features, which reduce N concentrations, the attenuation factor becomes important only when the loads are greatly reduced, as they will be when the recommended TMDL values are achieved. At present loads, attenuation represents only a small fraction of the entire load and has little if any influence on the current water column concentrations. The load model uses attenuation factors for ground water passing through surface water features lower than those actually measured. Attenuation factors of 50% are used in the model when measured factors are in the vicinity of 60%. However, for the TMDL, a smaller than expected attenuation factor makes the allowable loading lower than it would otherwise be and constitutes a portion of the factor of safety.

In addition, using sub-embayments that are at, or near, the inland-most tidal reaches as sentinels for establishing the acceptable nitrogen load (i.e., the TMDL) provides a major margin of safety for "downstream" embayments, which are closer to the mouths. Finally, decreases in air deposition through continuing air pollution control efforts, are uncounted in this TMDL, and are thus another component of the margin of safety.

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 $\geq$95%. 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 $R^2>0.95$, indicating that the model accounted for 95% of the variation in the field data). Since the water quality model incorporates all of 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 and therefore, less of a margin of safety is required.

Similarly, the water column N validation dataset was also conservative. The Linked Model is validated to measured water column N. 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 2 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, it is important to note that the reductions in benthic regeneration of N are most likely underestimates, i.e. conservative. The reduction is based solely on a reduced deposition of 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 dependant upon the amount of PON deposited to the sediments and the percentage that is regenerated to the water column versus denitrified or buried. The regeneration rate projected under reduced N loading conditions was based upon two assumptions:

a) The PON in the embayment in excess of that of inflowing tidal water (boundary condition) results from production supported by watershed N inputs and

b) The presently enhanced production would decrease in proportion to the reduction in the sum of watershed N inputs + plus direct atmospheric N input. The latter condition would result in equal embayment versus boundary condition production and PON levels if watershed N loading + direct atmospheric deposition could be reduced to zero (an impossibility of course).

This proportional reduction assumes that the proportion of remineralized N will be the same as under present conditions, which is almost certainly an underestimate. As a result future N regeneration rates are overestimated, which adds to the margin of safety.

2. Conservative threshold sites/nitrogen concentrations

Conservatism was used in the selection of the threshold sites and N concentrations. Sites were chosen that had stable eelgrass or benthic animal (infaunal) communities, and not those just starting to show impairment, which would have slightly higher N concentrations. Meeting the target thresholds in the sentinel sub-embayments will result in reductions of N concentrations in the rest of the systems, which is very conservative, thus adding to the margin of safety for those embayments as a whole.

3. Conservative approach

Cockle Cove Creek marsh - the area in which the Chatham WWTF groundwater discharge plume enters marine waters - was given a threshold concentration only slightly higher than its current concentration. The reason is that the system is a salt marsh, which appears to be functioning well. Based upon a detailed MEP site-specific investigation of the Cockle Cove salt marsh, it appears that the N load can be increased to this tidal creek as long as the N concentration does not increase significantly (see MEP Cockle Cove Creek Threshold Report 2006).

In addition, the target loads were based on tidal averaged N concentrations on the outgoing tide, which is the "worst case" because that is when the N concentrations are the highest. The N concentrations will be lower on the flood tides, due to dilution by incoming sea water, therefore this approach is conservative, and adds to the margin of safety.

Seasonal Variation

Nutrient loads to embayments 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. Thus, nutrient loads must be controlled on an annual basis. Second, as a practical matter, the types of controls necessary to control the N load, the nutrient of primary concern, by their very nature do not lend themselves to intra-annual manipulation since the majority of the N is from non-point sources.

TMDL Values for Chatham Embayments

As outlined above, the total maximum daily loadings of N that would provide for the restoration and protection of each embayment can be calculated by considering all sources of N grouped by natural background, point sources, and non-point sources. A more meaningful way of presenting the loadings data, from an implementation perspective, is presented in Table 5. In this table the N loadings from the atmosphere and 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 the WWTF, septic systems, storm water runoff, and fertilizers. In the case of Chatham, the TMDLs were calculated by projecting reductions in locally controllable septic system, storm water runoff, and fertilizer sources.

Implementation Plans

The critical element of this TMDL process is achieving the embayment-specific nitrogen concentrations presented in Table 2 above, that are necessary for the restoration and protection of water quality and eelgrass habitat within the Chatham embayments. In order to achieve those "target" concentrations, N loading rates must be reduced throughout the embayment systems. Table 5, above, lists target watershed threshold loads for each sub-embayment. If those threshold loads are achieved, the overall embayment will be protected. This loading reduction scenario is not the only way to achieve the target N concentrations. The Town is free to explore other loading reduction scenarios through additional modeling as part of the Comprehensive Wastewater Management Plan (CWMP). It must be demonstrated, however, that any alternative implementation strategies will be protective of the overall embayment systems, and that none of the sub-embayments will be negatively impacted. To this end, additional Linked Model runs can be performed by the MEP at a nominal cost to assist the Town planning effort in achieving target N loads that will result in the desired threshold concentrations. The CWMP should include a schedule of the selected strategies and estimated timelines for achieving those targets. However, the DEP realizes that an adaptive management approach may be used to observe implementation results over time and allow for adjustments based on those results.

Because the vast majority of controllable N load is from individual septic systems for private residences, the CWMP should assess the most cost-effective options for achieving the target 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 Town, however, is 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 storm water runoff, controls of fertilizer use within the watershed through the establishment of local by-laws, wetlands restoration or other hydraulic alterations to reduce N loadings or mitigate the impacts of loading, implementation of storm water BMPs, in addition to reductions in septic system loadings.

The EPA and the MassDEP recognize that effluent trading may provide a cost-effective means for the Town of Chatham to achieve the overall TMDL objectives. The EPA Water Quality Trading Policy Statement (http://www.epa.gov/owow/watershed/trading.htm) encourages trading programs that facilitate implementation of TMDLs, reduce the costs of compliance with the Clean Water Act regulations, establish incentives for voluntary reductions, and promote watershed-based nutrient load reduction initiatives.

TABLE 5. The Total Maximum Daily Loads (TMDL) for the Chatham Embayment Systems, Represented as the Sum of the Calculated Target Thresholds Loads, Atmospheric Deposition, and Sediment Sources (Benthic Flux)

Embayment Systems and Sub-embayments:	Target Watershed Threshold Load [1] (kg/day)	Atmospheric Deposition[2] (kg/day)	Benthic Flux [3] (kg/day)	TMDL [4] (kg/day)
Stage Harbor				
Oyster Pond	1.9	1.8	14.1	18
Oyster River	2.3	1.1	0.7	4
Stage Harbor	0.5	3.2	2.3	6
Mitchell river	1.5	0.9	3.4	6
Mill Pond	2.1	0.6	2.9	6
Little Mill Pond	0.8	0.1	1.4	2
Sulphur Springs				
Sulphur Springs	4.6	0.4	0	5
Bucks Cr	3.4	0.1	2.5	6
Taylors Pond				
Mill Cr	0.9	0.2	0	1
Taylors Pond	4.2	0.2	1.1	6

[1] Target watershed threshold load is the load from the watershed needed to meet the embayment threshold concentrations identified in Table 2. Loads are made up of all sources in the watershed and consist of both controllable and a small percentage of non-controllable sources. 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.

[2] Atmospheric Deposition is deposition directly to the estuary surface only

[3] Projected sediment N loadings obtained by reducing the present loading rates (Table 3) proportional to proposed watershed load reductions and factoring in the existing and projected future concentrations of PON.

[4] Rounded off Sum of target threshold watershed load, atmospheric deposition load, and sediment sources (benthic flux).

The MEP Implementation Guidance report provides N loading reduction strategies that are available to the Town of Chatham, and could be incorporated into the Town's implementation plans. The following topics related to N reduction are discussed in the Guidance report:

- 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
- Storm water Control and Treatment *
    - Source Control and Pollution Prevention

        - Storm water 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

* The Town of Chatham is one of 237 communities in Massachusetts covered by the phase II storm water program requirements.

Monitoring Plan for TMDL Developed Under the Phased Approach

MassDEP is of the opinion that there are two forms of monitoring that are useful to determine progress towards achieving compliance with the TMDL keeping in mind that implementation will be conducted through an iterative process where adjustments may be needed along the way. The two forms of monitoring include 1) tracking implementation progress as approved in the Town CWMP plan and 2) monitoring ambient water quality conditions at the sentinel stations identified in the MEP Technical Report and listed in Table 2 and the related discussion in this report.

The CWMP will evaluate various options to achieve the goals set out in the Technical Report and TMDL. 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 the Department 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 that were needed to develop the TMDL, will be important to determine actual compliance with water quality standards. Although the TMDL load values are not fixed, the target threshold nitrogen concentrations at the sentinel stations are fixed. In addition, there are target threshold N concentrations that are provided for many other non-sentinel locations in sub-embayments to protect near-shore benthic habitat. These are the water quality targets, and a monitoring program should encompass these stations at a minimum. Through discussions amongst the MEP 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 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 3-5 years. Finally, in addition to the above, existing monitoring conducted by MassDEP for eelgrass will continue into the future to observe any changes that may occur to eelgrass populations as a result of restoration efforts.

The MEP will continue working with the Towns to develop and refine monitoring plans that remain consistent with the goals of the TMDL. It must be recognized however that development and implementation of a monitoring plan will take some time, but it is more important at this point to focus efforts on reducing existing watershed N loads to achieve water quality goals.

Reasonable Assurances

MassDEP possesses the statutory and regulatory authority, under the water quality standards and/or the State Clean Water Act (CWA), 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 non-point source controls are voluntary, reasonable assurance is based on the commitment of the locality involved. Chatham has demonstrated this commitment 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, storm water, 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. Storm water NPDES permit coverage will address discharges from municipally owned storm water drainage systems. Enforcement of regulations controlling non-point 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. 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. 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.

Appendix A

TABLE A: Summaries of Nitrogen Concentrations for Stage Harbor, Sulphur Springs, and Taylors Pond Systems (from Chapter VI of the 2007 MEP Re-Evaluation Tech Report)

Table VI-1. Measured and modeled Nitrogen concentrations for Stage Harbor, Sulphur Springs, and Taylors Pond, used in the model calibration plots of Figures VI-6 (Stage Harbor total N), VI-7 (Sulphur Springs), and VI-8 (Taylors Pond). All concentrations are given in mg/L N. "Data mean" values are calculated as the average of all measurements.

System	Embayment	1999 Mean	2000 Mean	2001 Mean	2002 Mean	2003 Mean	2004 Mean	2005 Mean	Data Mean	s.d	N	Model Min	Model Average	Model Max
Stage Harbor	Oyster Pond	0.597	0.786	0.708	0.604	0.770	0.671	0.761	0.735	0.227	45	0.708	0.714	0.721
	Lower Oyster Pond	-	-	0.552	0.498	0.482	0.580	0.447	0.513	0.135	27	0.372	0.534	0.652
	Oyster River	0.451	0.457	0.386	0.536	0.458	0.609	0.491	0.489	0.121	39	0.287	0.367	0.546
	Stage Harbor	-	-	-	-	-	-	0.385	0.385	0.062	29	0.288	0.336	0.415
	Upper Stage Harbor	0.418	0.457	0.503	0.548	0.500	0.500	0.467	0.503	0.136	103	0.381	0.403	0.425
	Mitchell River	-	-	0.429	0.487	0.477	0.494	0.400	0.459	0.087	29	0.406	0.435	0.463
	Mill Pond	0.471	0.503	0.418	0.507	0.520	0.390	0.553	0.485	0.123	96	0.458	0.466	0.474
	Little Mill Pond	0.792	0.690	0.742	0.741	0.805	0.764	0.554	0.736	0.232	97	0.653	0.666	0.675
Sulphur Springs	Mid Cockle Cove Cr.	-	1.492	2.043	1.613	2.115	1.499	1.901	1.857	0.531	36	0.606	1.373	2.482
	Cockle C. Cr. Mouth	-	0.890	0.687	0.636	0.973	0.620	0.536	0.730	0.242	38	0.275	0.410	0.813
	Bucks Creek	-	0.401	0.479	0.576	0.561	0.573	0.621	0.516	0.149	38	0.282	0.347	0.684
	Sulphur Springs	-	0.360	0.453	0.584	0.623	0.643	0.768	0.584	0.179	39	0.270	0.452	0.906
Taylors Pond	Mill Creek	-	0.491	0.508	0.530	0.546	0.484	0.534	0.516	0.124	75	0.284	0.329	0.630
	Taylors Pond	-	0.509	0.487	0.530	0.575	0.568	0.528	0.525	0.099	37	0.414	0.455	0.502

Appendix B

TABLE B: Estimated Waste Load Allocation (WLA) from Runoff of all Impervious Areas within 200 Feet of Water Bodies in the Chatham Southern Estuaries

Subwatershed Name	Impervious Surface area in 200' buffer[1]		Impervious area in Total Subwatershed		Total Impervious Subwatershed load	Total Subwatershed load	Impervious Subwatershed buffer area WLA	
	Acres[2]	%[3]	Acres[2]	%[3]	Kg/year[4]	Kg/year[4]	Kg/year[5]	%[6]
Oyster Pond	5.9	9.7	150.4	18	248	4465	9.7	0.22
Oyster River	5.3	7.6	99.9	11.8	223	3901	11.8	0.30
Stage Harbor	5.8	8.2	28.3	5.1	51	1914	10.5	0.55
Mill Pond	4.9	11.4	65.3	19.2	135	2045	10.1	0.50
Harding Beach Pond	2.7	6.7	99.7	15.4	206	3667	5.6	0.15
Bucks Creek	1.8	9.2	45.2	8.1	63	1334	2.5	0.19
Mill Creek	0.5	1.3	35.5	13	113	1786	1.6	0.09
Taylors Pond	3.4	14.6	61.4	18.2	151	2446	8.4	0.34
TOTAL						21558	60.2	0.28

[1] The entire impervious area within a 200-foot buffer zone around all water bodies as calculated from GIS. Due to the soils and geology of Cape Cod it is unlikely that runoff would be channeled as a point source directly to a water body from areas more than 200 feet away. Some impervious areas within approximately 200 feet of the shoreline may discharge storm water via pipes directly to the water body. For the purposes of the waste load allocation it was assumed that all impervious surfaces within 200ft of the shoreline discharge directly to the water body.

[2] Based on GIS data received from the Cape Cod Commission

[3] Taken from the GIS printed report for this estimated waste load allocation.

[4] Taken from Table IV-4 of the accompanying MEP Technical Report

[5] Calculated by dividing the impervious surface area in 200' buffer (acres) by impervious area in total subwatershed (acres) and then multiplying that by the total impervious subwatershed load.

[6] Calculated by dividing the impervious subwatershed buffer area WLA (Kg/year) by the total watershed load (Kg/year) and then multiplying by 100.

Appendix C

TABLE C: Comparison of Original and Re-Evaluated TMDLs

Embayment	Original TMDL (kg/day)	Revised TMDL (kg/day)
Oyster Pond	14	18
Oyster Pond River	4	4
Stage Harbor	9	6
Mitchell River	4	6
Mill Pond	3	6
Little Mill Pond	2	2
Sulphur Springs	9	5
Bucks Creek	4	6
Mill Creek	3	1
Taylors Pond	4	6
Total	63	69

Response to Comments

Town of Chatham Comments:

1. What is the source of the data used to generate the pie chart shown at the top of page v of the Executive Summary? Same question for pie chart on page 7.

Response: The charts were developed using the data presented in Table 3.

2. Page 4, 2nd para: "…the town of Chatham, the increase <u>in population</u> is on the order of…"

Response: The suggested clarifying phrase was added to the text.

3. Page 5, Table 1 b.: No data is shown for Mill Creek, last line of table.

Response: No data were provided for Mill Creek, the table has been modified accordingly.

4. Page 5, 2nd para from the bottom: The following statement is made *"Eelgrass beds, which are critical habitats for macroinvertebrates and fish, have significantly declined in these waters."* The implication is that this decline is due to increased nutrient levels, however, it is well know that there are a variety of causes for the ongoing decline in the presence of eelgrass. It should be clarified that decline in eelgrass is not due solely to increased nutrient levels and that mitigation of nitrogen may not be sufficient for eelgrass restoration in the face of other causes of decline (wasting disease, poor seed germination, etc.).

Response: Although it is true that wasting disease, and other conditions have been known to cause reductions in eelgrass, the weight-of-evidence indicates that nitrogen enrichment is a significant contributor to the loss of eelgrass in the Chatham estuaries.

5. Page 8, <u>Sediment N</u>: What rate of decrease in sediment N can be expected as watershed N load is decreased?

Response: The rate will be very site specific, based on the size of the area of the nitrogen-rich sediments, the velocity of water over the sediments, the magnitude of the benthic flux of nitrogen, the magnitude of the nitrogen reductions to be made in the water body, and the rate at which the nitrogen in the watershed is reduced. The approach used in the report is based on the final loads, after all the required reductions have been made. But in reality, as the watershed loads are reduced over time, benthic flux reductions will track reductions in water column nitrogen. It might take a few years (as opposed to decades) for the system to come into equilibrium after the target watershed nitrogen reductions are achieved in the water bodies themselves.

6. Page 6, 1st para: At the end of this paragraph general statements are made that *"DO concentrations are lowest inland…" and "Chlorophyll a concentrations are highest in the inland reaches."* These general statements are not supported by the data shown in Table 1 b. (page 5) for the western reach of the Stage Harbor system (Oyster River/Oyster Pond). This table shows that DO depletion in Oyster River and Oyster Pond is "insignificant" and chlorophyll a levels are below the range considered to produce nuisance algal blooms.

Response: The paragraph cited was meant to be a generalization, typical of most estuarine systems, however, because it does not apply to the data presented in Table 1b, it may be confusing, and therefore, the statements were deleted from the text. MEP staff appreciates the reviewer pointing out this confusion.

7. Page 8: Need space between Fertilizer and Storm water categories.

Response: The space was added.

8. Page 8: The section under Septic Systems states that *"These can be controlled by….upgrading/repairing failed systems…"*. Under current inspection protocols a system will usually only be classified as failed based on hydraulic conditions, not on whether or not it is reducing nitrogen. A system classified as "failed" is most likely still achieving the 20-25% nitrogen removal attributed to functioning septic system as this removal occurs primarily in the leach field and surrounding soil. As a result while upgrading or repairing "failed" septic systems can address potential public health issues (i.e. surfacing effluent, etc.) it will have minimal impact on nitrogen removal. Upgrading or repairing failed systems should only be considered as addressing nitrogen if it includes N-reducing technology, not simply upgrading/repairing to Title 5 standards. A similar concern over this wording was expressed during review of the Pleasant Bay Total Nitrogen TMDL and revisions made.

Response: The statement was changed to read: " … upgrading to nitrogen removing systems…"

9. Page 9 Figure: The freshwater discharge station labeled as "CM-5" in the SE corner of Oyster Pond should be labeled as "CM-B".

Response: The figure has been corrected.

10. Page 12, para a): The last sentence references tables A-1 and A-2 in Appendix A, there is only a single table shown in Appendix A.

Response: The error was corrected.

11. Page 13, Table 2: The data contained in Table 2 is unclear. The values shown in column 2 look like the "model average" values shown in the 14th column of the Table A in Appendix A, not observed "existing" concentrations. The exception is the values shown for Oyster Pond, Oyster River and Stage Harbor, which do not appear to be from Table A.

Response: Table 2 has been modified to include actual observed data.

   a. In the footnote to Table 2 it is indicated that only years 1999 – 2002 were used, why was the entire available data set, 1999 – 2005, not used?

Response: The modeling was performed on data from 1999 to 2005, the footnote has been corrected.

   b. The footnote also indicates Tables A-1 and A-2 of Appendix A, there is only one table in Appendix A.

Response: The footnote has been corrected.

12. Page 14, 1st para: "…Sulphur Springs System (which also includes ~~Mill Creek~~ <u>Cockle Cove Creek</u> and Bucks Creek)."

Response: The error has been corrected.

13. Page 16, Table 3:

    a. What is the source of the data presented in each column of Table 3?

Response:

<u>Natural Background</u> was derived from Table VI-4, page 55 of the "re-evaluated" Tech Report, under the assumption that the "no load" values were the same as "natural background". Subsequent discussions with SMAST personnel have indicated that the "no load" value is not actually an estimate of background, and is not additive regarding the other quantified sources. Therefore the Natural Background column of Table 3 has been eliminated.

<u>Present land use load</u> data are derived from Table IV-4, by adding the values from the columns for "fertilizers", "impervious surfaces", and "natural surfaces".

<u>Present Septic system Loads</u> were taken from Table VIII-2 of the "re-evaluated" tech report.

<u>Present Atmospheric Deposition</u> and <u>Present loadings from sediments (Benthic Flux)</u> were taken from Table VI-2 of the "re-evaluated technical report.

    b. What accounts for the significant differences in the Natural Background Watershed Load (kg/day), column 2, between this TMDL and Table 3 of the original 2004 TMDL? In some cases the background loads in the 2008 TMDL are 2-3 xs higher than the 2004 values.

Response: As stated above the "background" value was reconsidered and dropped from the analyses.

    c. Why is there a 6x increase in the Present Atmospheric Deposition (kg/day) (column 5) for Oyster Pond between this TMDL and original 2004 TMDL? (This question also applies to Table 5 on page 22.)

Response: According to SMAST staff, there was a typo in the original Tech Report, that was inadvertently transcribed into the original TMDL. It was not caught until the re-evaluated Tech report was reviewed, and the error was corrected.

    d. Why are values in column 6 (Benthic Flux) for Sulphur Springs, Cockle Cove Creek and Mill Creek shown as 0? In Table VI-2 of the 2007 Tech report the values are reported as -3.756, -0.578, and -0.061 respectively.

Response: Subsequent to the development of the initial TMDL the TMDL writing team determined that negative losses in the system, such as those sometimes encountered with the uptake of N in the sediment, should not be credited towards the need for future load reductions.

As a result, negative flux values have been entered as 0. This will provide an additional margin of safety to the required load reductions to meet water quality standards.

e. The Header and/or footnotes for this table need clarification for the following:

1. It should be clearly indicated that column 2, *"Natural Background Watershed Load (kg/day)"*, includes atmospheric deposition onto non-estuary water bodies within the watershed and atmospheric deposition onto natural surfaces.

Response: As described above, this column has been removed from the table.

2. It should be clearly indicated that column 5, *"Present Atmospheric Deposition (kg/day)"*, is atmospheric deposition directly to the estuary surface area only.

Response: A footnote with this clarification has been added.

14. Page 19, 5th para: The next to the last sentence indicates a value of 40% is used in the MEP model for attenuation; however, on page 22 of the 2007 MEP Tech Report (2nd paragraph) it is stated that a value of 50% is used.

Response: The commenter is correct, and the value on page 19 has been changed to "50%"

15. Page 21, 2nd para: This paragraph contains the statement *"While this system might take additional N Load without significant impairment, the evidence is not yet available to support increased loadings."* This statement appears to be a holdover from the 2004 TMDL and does not reflect the new findings of the Cockle Cove Salt Marsh study. This statement is also inconsistent with the text on page 6, middle of paragraph 3.

Response: The text on page 6 is correct, and has been repeated on page 21, replacing the original text.

16. Page 22, Table 5: The Header and/or footnotes for this table need clarification for the following:

    a. It should be clearly indicated that column 2, *"Target Watershed Threshold Load (kg/day)"*, includes atmospheric deposition onto non-estuary water bodies within the watershed and atmospheric deposition onto natural surfaces, both of which are <u>non-locally controllable</u>. The table header indicates that the target threshold loads are from "controllable" sources, this is inaccurate.

    b. It should be clearly indicated that column 3, *"Atmospheric Deposition (kg/day)"*, is atmospheric deposition directly to the estuary surface area only.

Response: The table, including the header and footnotes, has been edited to clarify the issues raised by the reviewer.

17. Page 22 Table 5: The kg/day figures shown for Benthic Flux are zero for Sulphur Springs and Cockle Cove Ck. This differs from the figures given in the MEP report dated Feb 2007, which are -2.8 and -0.6 respectively for these two estuaries. What is the reason for this difference?

Response: following the preparation of the original Chatham tech report and TMDL, it was determined by MEP staff that because TMDLs reflect sources of nitrogen, that negative flux values would not be included in the TMDL values. Therefore, any negative flux values were entered as 0.

18. Page 22 Table 5: In footnote 1, it's not clear why there are alternative loading scenarios, given the atmospheric deposition and the benthic flux?

Response: Alternative scenarios may be investigated with additional model runs, which may result in slightly different loading rates to the different sub-embayments within each of the major systems.

19. Page 27 Appendix B: I suggest that this key Table VIII-2 be included and discussed in the main portion of this report. Also, change the column heading "New Septic Load" to "Threshold Septic Load".

Response: The recommended changes have been made. Table VIII-2 in Appendix B is now Table 4b in the body of the TMDL document.

20. Page 28 Appendix C: This Table needs explaining.

Response: Additional footnotes have been added to clarify values in the table. (Note: In the revised version of the report, Appendix C, referred to here, is now Appendix B.)

21. Page 30 Attachment 1: Tell the reader the source of these questions.

Response: The commenters are identified.

22. The reductions required in Sulphur Springs do not make sense if the sentinel station is located in Bucks Creek.

Response: You are correct. The sentinel station was inadvertently indicated to be in Bucks Creek. It is actually in Sulphur Springs. All the calculations and modeling were done based on it being in Sulphur Springs, so the results are accurate, and the resultant TMDL is appropriate.

John Payson, West Chatham, Comments:

1. The MEP Report of February 2007 for the three southern estuary systems in Chatham did not include re-evaluated TMDLs. However, TMDLs are shown in Table 5 in the subject Report dated January 3, 2008.

Response: Even though TMDL values themselves were not presented, the information, on which the revised TMDLs were based, was presented in various tables in the MEP Report of February 2007 for the three southern estuary systems in Chatham.

2. Table 5 calculates TMDLs as "the sum of the calculated Target Threshold N Loads from controllable watershed sources (plus) Atmospheric Deposition and Benthic flux."

This says that the greater the input of atmospheric deposition and/or benthic flux, the greater will be the amount of total nitrogen that a water body can accept and still meet water quality standards.

This brings into serious question the advisability of TMDLs being used by local communities as a management tool, or referencing them in any way, in preparing proposed Comprehensive Wastewater Management Plans.

Response: The assumption that the greater the input from atmospheric deposition and sediments (benthic flux), the greater will be the amount of nitrogen that the water body can accept is false. The amount of "allowable" nitrogen loading from the watershed is carefully modeled, taking into consideration the atmospheric and sediment sources, and is based on the threshold concentration(s) within the water bodies. The Technical Reports and the loading values that they provide are the best management tools and should serve as the basis for the CWMPs.

3. The probable expenditure of hundreds of millions of dollars by the town of Chatham is being projected for sewering, and it is imperative that extremely stringent quality control measures must be instituted to ensure that the water samples taken at the sentinel stations will result in the reliable generation of very accurate water quality data.

Response: MEP agrees with this statement. The same level of QA/QC that went into the data collection used to set the TMDL will have to go in to future monitoring efforts to track the implementation of the TMDL.

4. There are many differences in the original Technical Report and the re-evaluated Technical Report.

Response: This observation is correct. The reason that loading rates and TMDLs changed from the original Tech Report and the original TMDL to the revised Tech Report and the revised TMDL is that more field data were included in the analyses, more water use data were used in the loading estimates, and the watersheds were re-delineated. All of these efforts contributed to varying degrees, the differences in the loading estimates and projected, allowable, loading rates.

5. Stipulating a need for any reduction in the septic N load, much less the 100% shown in the February 2007 MEP Report for the Mill Creek sub-embayment, does not appear supportable, when the observed N concentration is 0.33 mg/L and the target N concentration is 0.38 mg/L.

Response: The 0.38 mg/L is the target for Taylors Pond, not Mill Creek. The particular strategy, to meet the site-specific water quality standards, that was presented in the SMAST Tech report, may not be the final strategy chosen by the Town. That is why additional model runs will be conducted by SMAST. However, based on the hydrology, including incoming tide water, carrying nitrogen from downstream in Mill Creek up into Taylors Pd, the linked modeling effort indicates that one "solution" is to remove 100% of the septic systems in the Mill Creek watershed. If the reality of the situation is that the Town chooses not to do so, but chooses to remove more in the Taylors Pond watershed, then the strategy will be tested by re-running the models with a different nitrogen-loading scheme.