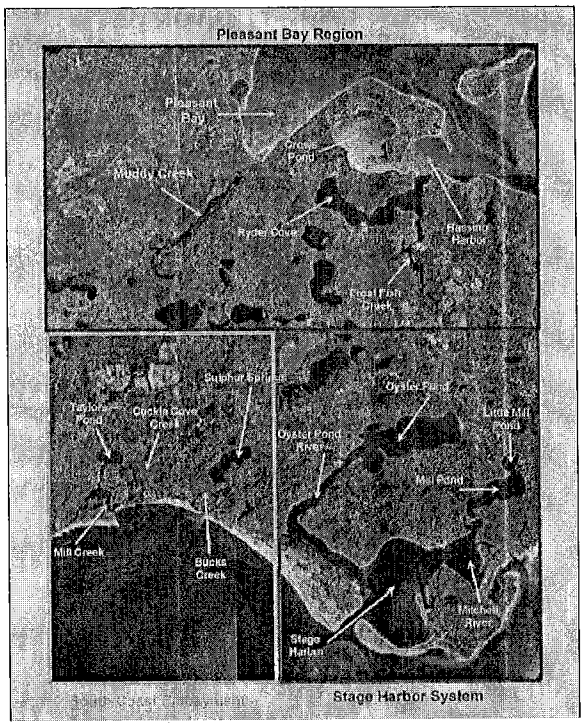
Stage Harbor, Sulphur Springs, Taylors Pond, Bassing Harbor and Muddy Creek Total Maximum Daily Loads For Total Nitrogen

(Report # MA96-TMDL-3
Control # CN206.0)



COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
ELLEN ROY HERZFELDER, SECRETARY
MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION
ROBERT W. GOLLEDGE, JR., COMMISSIONER
BUREAU OF RESOURCE PROTECTION
CYNTHIA GILES, ASSISTANT COMMISSIONER
DIVISION OF WATERSHED MANAGEMENT
GLENN HAAS, DIRECTOR

November 17, 2004

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 206.0

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

http://www.state.ma.us/dep/brp/wm/wmpubs.htm

or, more specifically, http://www.state.ma.us/dep/brp/wm/tmdls.htm.

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)", is also available by writing to the DWM in Worcester and on the DEP Web site identified above.

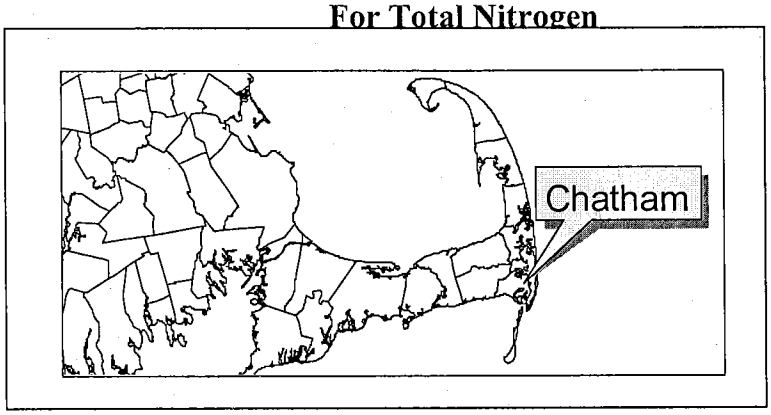
DISCLAIMER

References to trade names, commercial products, manufacturers, or distributors in this report constitute neither endorsements nor recommendations by the Division of Watershed Management for use.

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
Current 303d Listing:

Oyster Pond	MA96-45_2002	0.21 sq mi	Nutrients & Pathogens
Oyster Pond R	MA96-46_2002	0.14 sq mi	Nutrients & Pathogens
Stage Harbor	MA96-11_2002	0.58 sq mi	Nutrients & Pathogens
Mill Pond	MA96-52_2002	0.06 sq mi	Nutrients
Harding Beach Pd	MA96-43_2002	0.07 sq mi	Pathogens
Bucks Creek	MA96-44_2002	0.02 sq mi	Pathogens
Mill Creek	MA96-41_2002	0.03 sq mi	Pathogens
Taylors Pond	MA96-42_2002	0.02 sq mi	Pathogens
Crows Pond	MA96-47_2002	0.19 sq mi	Nutrients
Ryder Cove	MA96-50_2002	0.17 sq mi	Nutrients & Pathogens
Frost Fish Creek	MA96-49_2002	0.02 sq mi	Nutrients & Pathogens
Muddy Creek	MA96-51_2002	0.05 sq mi	Pathogens

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

This page left blank intentionally

EXECUTIVE SUMMARY

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:

- Loss of some 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 and scum
- Benthic communities reduced to the most stress-tolerant species, or in the worst cases, near loss of the benthic animal communities

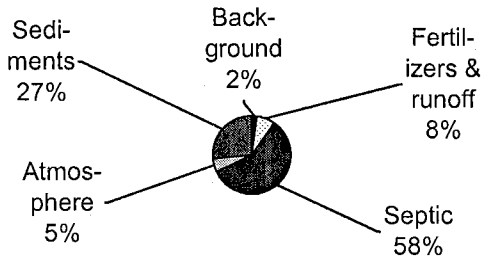
Coastal communities, including Chatham, rely on clean, productive, and aesthetically pleasing marine and estuarine waters for tourism, recreational swimming, fishing, and boating, as well as for commercial fin fishing and shellfishing. Failure to reduce and control N loadings will result in complete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

Sources of nitrogen

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

- The watershed
  - Septic systems
  - Natural background
  - Runoff
  - Fertilizers
- Atmospheric deposition
- Nutrient-rich bottom sediments in the embayments

Most of the present N load 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 embayments presently range from 3.45 kg/day in Frost Fish Creek, to 39.9 kg/day in Oyster Pond. The resultant concentrations of N in the embayments range from 0.42 mg/L (milligrams of nitrogen per liter) in Ryder Cove to 1.69 mg/L in the Sulphur Springs system.

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 Department has determined that, for Chatham, N concentrations in the range from 0.38 to 0.552 mg/L are protective. The mechanism for achieving these target N concentrations is to reduce the N loadings to the embayments. The Department has determined through mathematical modeling that the total maximum daily loads (TMDL) of N that would result in the "safe" target concentrations range from 1.85 to 13.82 kg/day. The purpose of this document is to present 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 Watewater Management Plan (CWMP). The CWMP will evaluate 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, upgrade/repairs of failed on-site systems, and/or N-reducing on-site systems. Guidance on these strategies, plus ways to reduce N loadings from stormwater runoff and fertilizers, are explained in detail in the "MEP Embayment Restoration Guidance for Implementation Strategies", available on the DEP website at http://www.mas.gov/dep/smerp/smerp.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. Indications are that maintaining the present loading rates from the treatment facility will protect the well- functioning salt marshes along Cockle Cove Creek, as well as the rest of the Sulphur Springs embayment system. The Department will, however, allow additional loading if data indicate that there would be no negative impacts to the adjacent salt marshes or groundwater supplies in the area.

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

Table of Contents

List of Tables

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 work with Towns 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 five coastal embayments within the Town of Chatham, Massachusetts 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 data were collected, primarily, over a study period from 1997 to 2003. This study period will be referred to as the "present conditions" in the TMDL because it is generally the most recent data available. The accompanying MEP Technical Report presents the results of the analyses of these five coastal embayments using the MEP Linked Watershed-Embayment N Management Model (Linked Model). 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 to the north and south, 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. 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 2002 Integrated List of Waters, as summarized in Table 1a.

A complete description of the water bodies is presented in Chapters I and IV of the Technical Report from which the majority of the following information is drawn. TMDLs were prepared for 17 ponds, rivers, creeks, and harbors listed below. Analytical and modeling efforts were conducted by grouping these 17 "sub-embayments", where appropriate, into embayment systems in which all the sub-embayments of an individual watershed combine to flow into either Nantucket Sound to the south or Pleasant Bay to the North.

- Stage Harbor System:
  - Oyster Pond
  - Oyster Pond River
  - Stage Harbor
  - Mitchell River
  - Mill Pond
  - Little Mill Pond
- Sulphur Springs System:
  - Sulphur Springs
  - Bucks Cr
  - Cockle Cove Cr
- Taylors Pond System:
  - Mill Cr
  - Taylors Pond
- Bassing Harbor System:
  - Crows Pond
  - Ryder Cove
  - Frost Fish Cr
  - Bassing Harbor
- Muddy Creek
  - Lower Muddy Cr
  - Upper Muddy Cr

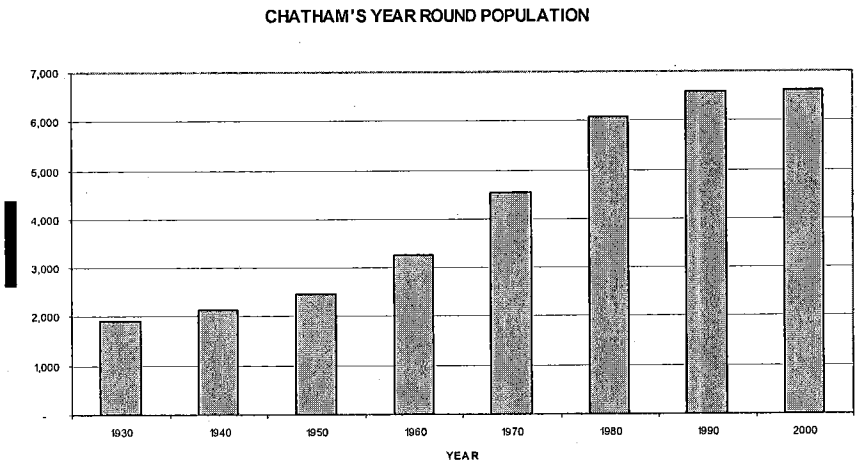
The embayments addressed by this document are determined to be high priorities based on three significant factors: 1) the initiative that the Town has taken to assess the conditions of embayments, 2) the commitment made to restoring and preserving their embayments, and 3) because of the extent of eutrophication 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 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.

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. The population of Chatham, as with all of Cape Cod, has increased markedly since 1950. In the particular case of the Town of Chatham, the increase 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). The increase in year round residents is illustrated in the following graph:



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 in Category 5 of the Massachusetts 2002 Integrated List[1]

NAME	SEGMENT ID	DESCRIPTION	SIZE	Pollutant Listed
Stage Harbor				
Oyster Pond	MA96-45_2002	Including Stetson Cove	0.21 sq mi	Nutrients & Pathogens
Oyster Pond River	MA96-46_2002	Outlet of Oyster Pd to confluence with Stage harbor, Chatham	0.14 sq mi	Nutrients & Pathogens
Stage Harbor	MA96-11_2002	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_2002	Including Little Mill Pond (PALIS #96174), Chatham	0.06 sq mi	Nutrients
Sulphur Springs				
Harding Beach Pond	MA96-43_2002	Locally known as Sulphur Springs (northeast of Bucks Cr), Chatham	0.07 sq mi	Pathogens
Bucks Creek	MA96-44_2002	Outlet from Harding Beach Pond (locally known as Sulphur Springs) to confluence with Cockle Cove, Chatham	0.02 sq mi	Pathogens
Taylors Pond				
Mill Creek	MA96-41_2002	Outlet of Taylors Pond to confluence with Cockle Cove, Chatham	0.03 sq mi	Pathogens
Taylors Pond	MA96-42_2002	Chatham	0.02 sq mi	Pathogens
Bassing Harbor				
Crows Pond	MA96-47_2002	To Bassing Harbor, Chatham	0.19 sq mi	Nutrients
Ryder Cove	MA96-50_2002	Chatham	0.17 sq mi	Nutrients & Pathogens
Frost Fish Creek	MA96-49_2002	Outlet from cranberry bog northwest of Stony Hill Road to Confluence with Ryder Cove, Chatham	0.02 sq mi	Nutrients & Pathogens
Muddy Creek	MA96-51_2002	Outlet of small unnamed pond south of Countryside Drive and north-northeast of Old Queen Anne Road to mouth at Pleasant Bay, Chatham	0.05 sq mi	Pathogens

[1] This list was developed prior to the completion of data collection activities and will be reassessed based on the data and information collected during this project.

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, Mill, or Frost Fish Creeks 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 ug/L
Oyster River	Half lost	Insignificant	Generally 5 – 15 ug/L
Stage Harbor	Slight decline	Insignificant	Generally 5 – 15 ug/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 ug/L occasionally > 20 ug/L
Little Mill Pd	Complete loss	Presumed same as Mill Pond	Generally 5 – 20 ug/L occasionally > 20 ug/L
Sulphur Spr			
Sulphur Springs	Complete loss	< 4 mg/L 12% of study period < 3 mg/L 6% of study period	Frequently > 20 ug/L Occasionally > 25 ug/L
Bucks Cr	Complete loss	< 4 mg/L 12% of study period < 3 mg/L 6% of study period	Frequently > 20 ug/L Occasionally > 25 ug/L
Taylors Pd			
Taylors Pond	Complete loss	< 4 mg/L 2% of study period	Frequently 10 – 20 ug/L
Bassing Hbr			
Crows Pd	moderate loss, density sparse	Consistently > 5 mg/L	Generally 10 – 15 ug/L
Ryder Cove, U	75% lost	< 4 mg/L 7% of study period <3 mg/L 1% of study period	Frequently > 20 ug/L Occasionally > 25 ug/L
Ryder Cove, L	Slight loss	Insignificant	Generally 10 – 20 ug/L
Bassing Harbor	No loss	Insignificant	Typically 5 – 10 ug/L
Muddy Cr.			
Lower Muddy Cr.	Near- complete loss	<4 mg/L 60 % of study period < 3 mg/L 49 % of study period	Frequently > 50 ug/L
Upper Muddy Cr.	Unknown	< 4 mg/L 76 % of study period < 3 mg/L 69% of study period	Frequently > 50 ug/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 ug/L; significant algal blooms = chlor *a* > 20ug/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. 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 scums, 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 shellfishing. 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 five-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. This is indicated by longitudinal gradients of the various indicators. N concentrations are highest inland and lowest near the mouths. Eelgrass abundance is highest near the mouths of the embayments. Infaunal communities are more stressed in the inland reaches. Dissolved oxygen concentrations are lowest inland and highest near the mouths of the embayments. Chlorophyll *a* concentrations are the highest in the inland reaches.

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

Stage Harbor System – Little Mill Pond, Mill Pond, and Oyster Pond have elevated N concentrations and have lost historic eelgrass beds that once covered most of their respective basins. Oxygen depletion is observed during summer in each system with Mill Pond (and presumably Little Mill Pond) having ecologically significant declines (to less than 3 mg/L). Oyster Pond had less oxygen depletion possibly due to its greater fetch for ventilation from the atmosphere. Chlorophyll *a* concentrations were consistent with the observed oxygen depletion. The lower reaches of the Oyster River and Upper Stage Harbor show good habitat quality as evidenced by their persistent eelgrass beds, infaunal community structure and oxygen and chlorophyll *a* concentrations. 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 central tidal creek. Both types of habitat are not expected to support eelgrass even under natural conditions. This system contains little water at low tide. Even though the assimilative capacity of salt marsh is unknown, it appears to be higher than that of eelgrass habitats. Sulphur Springs is a shallow basin containing significant macro algal 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 concentrations are high, oxygen concentrations become significantly depleted (6% of time <3 mg/L) and phytoplankton blooms are common and large (chlorophyll *a* concentrations >20 ug/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 tidal salt marshes along 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 N 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 N levels are enriched over incoming tidal waters and severe dissolved oxygen depletion to ~4 mg/L is common. Very high chlorophyll *a* concentrations of 10-15 ug/L are common during summer. The benthic infaunal community is impoverished, with a mean of only 43 individuals collected in the grab samples, compared to several hundred in the high quality sub-embayments.

Bassing Harbor System – The innermost sub-embayments to this system contain high quality habitat that is currently becoming impaired by N enrichment. Ryder Cove receives the greatest watershed N load of the Bassing Harbor sub-systems. This sub-embayment has been losing its eelgrass over at least the last decade. In 1951 the full basin appears to have supported eelgrass beds, many of which do not exist today. Infaunal communities indicate a moderate quality system with relatively low diversity and evenness. This is consistent with a system whose habitat is in transition from high to moderate level of quality. Upper Ryder Cove is currently showing bottom water oxygen depletion, frequently to <4 mg/L and occasionally to < 3 mg/L. The periodic oxygen declines, loss of eelgrass, and watershed N loading is consistent with the observed phytoplankton blooms, which generally (>40% of time) are >15 ug/L and frequently >20 ug/L. In contrast, the outer reach of Ryder Cove still supports relatively high habitat quality with dissolved oxygen concentrations almost always above 5 mg/L (99%) and moderate chlorophyll *a* concentrations (<15 ug/L). These water column parameters are consistent with the high eelgrass coverage. Crows Pond is the other inland-most sub-embayment in this Y-shaped estuary. However, Crows Pond has a significantly lower watershed N load than that to Ryder Cove. Crows Pond currently supports a high level of habitat quality, with eelgrass beds surrounding the central basin and sparse coverage throughout. Infaunal diversity and evenness is consistent with a high quality habitat. Dissolved oxygen concentrations are consistently above 5 mg/L and chlorophyll *a* concentrations also are moderate (generally 10-15 ug/L). However, it appears that habitat quality currently is declining. Eelgrass coverage is less than in the 1951 and 1995 records. At present it appears the Crows Pond is slightly beyond its threshold N level and is beginning to decline in habitat quality. In addition, Frost Fish Creek is a tributary system to outer Ryder Cove, which functions primarily as a salt marsh with a central basin. The outer-most basin is Bassing Harbor, which receives tidal exchanges with Pleasant Bay. Bassing Harbor currently supports high habitat quality and based upon the eelgrass records has been relatively constant since 1951. The infaunal community is consistent with high habitat quality, the maintenance of "protective" dissolved oxygen concentrations, and moderate to low chlorophyll *a* concentrations (typically 5-10 ug/L). The Bassing Harbor sub-embayment appears to be a relatively stable high habitat quality system, with demonstrated good eelgrass and infaunal communities.

Muddy Creek – Muddy Creek, like Bassing Harbor, exchanges tidal waters with the greater Pleasant Bay System. However, unlike Bassing Harbor, Muddy Creek is a highly eutrophic embayment. Muddy Creek does not support significant eelgrass beds; however, a small sparse bed has persisted adjacent to the inlet. Muddy Creek is divided into an upper and lower portion by a dike whose weir has been removed or washed away. Massachusetts Water Quality Standards designates the saltwater tributaries of Pleasant Bay, which includes Upper and Lower Muddy Creek, as SA waters designated for open shellfishing, and Outstanding Resource Waters. Presently both portions are highly eutrophic with frequent anoxia in bottom waters and large algal blooms (chlorophyll a frequently >50 ug/L). The upper portion has poorer habitat quality than the lower portion, most likely as a result of access to the better quality waters entering the lower portion from Pleasant Bay. An infaunal community persists but it is dominated by species tolerant of organic enrichment. Species diversity and evenness are low. The whole of Muddy Creek currently supports N-impaired habitat of poor quality.

Pollutant of Concern, Sources, and Controllability

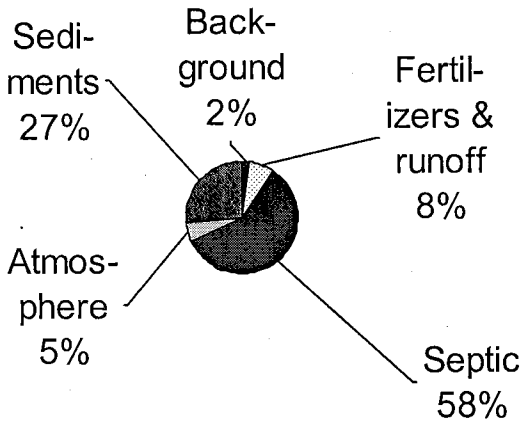
In the coastal embayments in the Town of Chatham, as in most marine and coastal waters, the limiting nutrient is nitrogen. Nitrogen concentrations beyond those expected naturally contribute to undesirable conditions, including the severe impacts described above, through the promotion of excessive growth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

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, IV, V, and VII of the Technical Report.

These investigations revealed that loadings of nutrients, especially N, are much larger than they would be under natural conditions, and as a result the water quality has deteriorated. A principal indicator of decline in water quality is the disappearance of eelgrass from much of its natural habitat in these embayments. This is a result of nutrient loads causing excessive growth of algae in the water (phytoplankton) and algae growing on eel grass (epiphyton), both of which result in the loss of eelgrass through the reduction of available light levels.

As is illustrated by the following figure, most of the N affecting Chatham's embayments originate from septic systems and nutrient-rich benthic sediments, with considerably less N originating from natural background sources, runoff, fertilizers, and atmospheric deposition.

Percent contribution of various sources of nitrogen in Chatham's embayments



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

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

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