Inter-municipal Watershed Planning and TMDL Implementation to Restore Embayment Water Quality on Cape Cod:

Three Case Studies of Towns Sharing Coastal Watersheds

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Disclaimer

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Front Cover: A view of Shoestring Bay, Mashpee, Massachusetts
Photograph by George Zoto

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Preface

This report presents the findings and recommendations from three Pilot Projects on Cape Cod; each addressing the watershed nitrogen load conditions affecting water quality impairment for three estuaries: Popponesset Bay (Mashpee, Barnstable, and Sandwich, MA); Three Bays (Barnstable, Sandwich, and Mashpee, MA), and Pleasant Bay (Chatham, Orleans, Brewster, and Harwich, MA). The outcome of these case studies, including what was learned, and the actions taken and/or recommended for follow-up, represent several years of dialogue among the towns sharing land use jurisdiction of the affected watersheds.

Each estuary had been designated by the Commonwealth as a nitrogen impaired estuary - in violation of the state water quality numerical standards and its designated uses (recreational fishing, swimming and boating and as habitat for sustaining eelgrass meadows as a breeding and nursery ground for important commercial marine fisheries and shellfish).

Past wastewater planning elsewhere in the US and in New England are typically focused on end of pipe point (NPDES) discharges to receiving surface waters. These case studies on Cape Cod address the fact that wastewater impacts to coastal embayments are not from typical NPDES discharges but from nonpoint source discharges to the ground from septic systems, stormwater runoff, large and small wastewater treatment plants, and use of fertilizers by the towns sharing the watershed. These case studies utilized a holistic, scientific approach by evaluating all nitrogen sources in the watershed for use in integrating a broad range of infrastructure and management solutions into existing state permitting programs.

For an electronic version, please visit: <www.mass.gov/DEP>.

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MassDEP does not necessarily agree with all the recommendations expressed in this document by persons or groups that have participated in the project. Nor is MassDEP committing at this time to implement any of the recommendations made by others.

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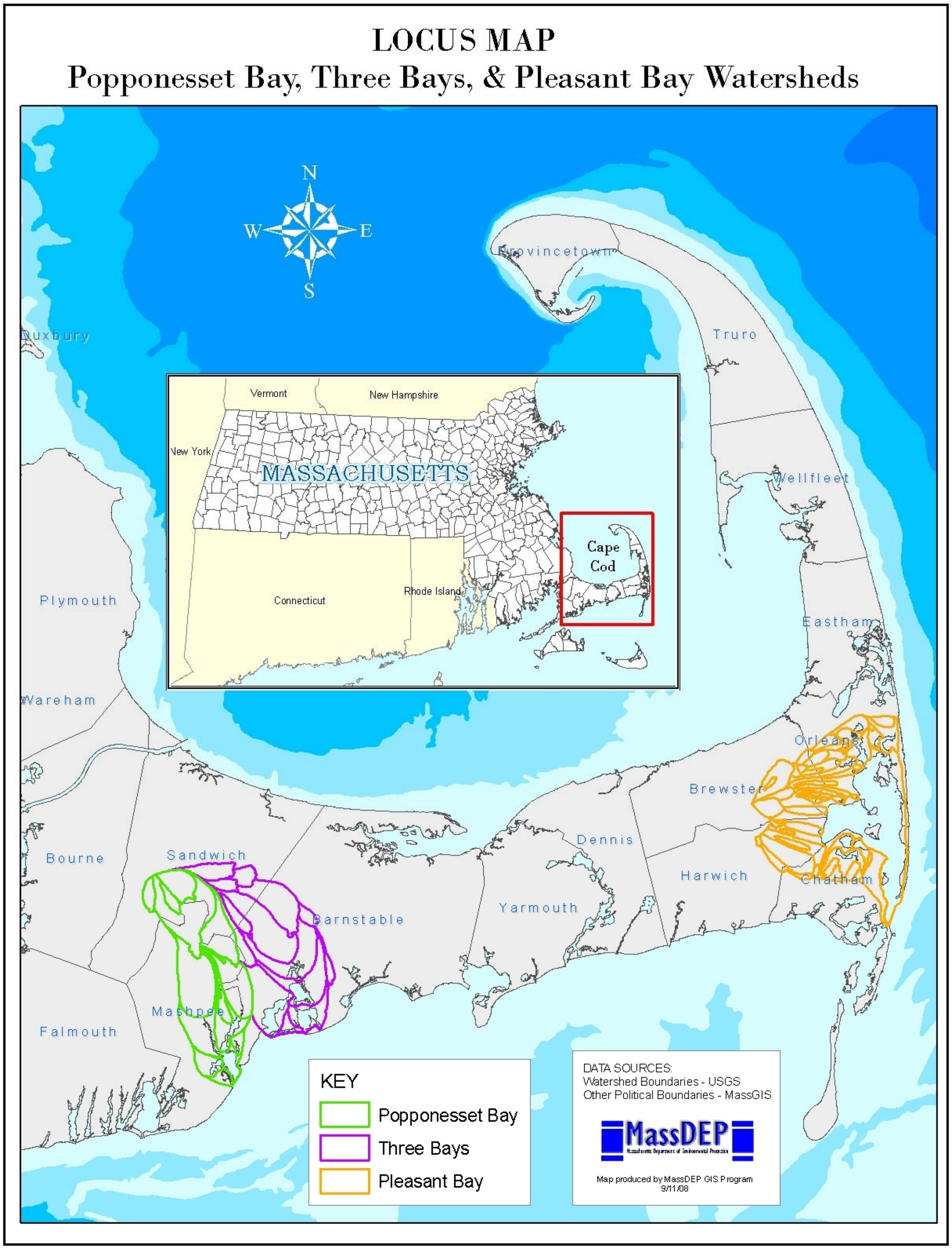


Chapter 1: Introduction

The significance of protecting estuaries is clear. Estuaries, as the boundary between land and sea, are also the mixing zones where the freshwaters of the land and the salt waters of the ocean meet. This mixing/transition zone, or ecotone, promotes the environmental conditions that make estuaries among the earth's richest and most productive ecosystems. Healthy, biologically diverse estuarine ecosystems are able to sustain habitat, spawning grounds and nursery conditions to at least two-thirds of the Nation's commercial fisheries, while providing for the recreational and aesthetic enjoyment of the public.

Ironically, as the winter and summer coastal population grows, the estuaries that once attracted these people as visitors are now under increased assault, as they are now attracted to live there year-round. According to the National Oceanic and Atmospheric Administration (NOAA) "the coastal zone has become the most developed in the nation. This narrow fringe–comprising 17% of the contiguous U.S. land area is home to more than 53% of the nation's population. Furthermore, the coastal population is increasing by 3,600 people per day, giving a projected total increase of 27 million people between now and 2015".

As a result of these growth pressures, ambient water quality at estuarine locations has been increasingly under assault and at risk from human dominated land use changes within the coastal watershed. The water quality impacts were primarily from:

- Expansion of urbanization and wastewater collection and disposal systems discharges that collectively contribute 75-85% of the nitrogen load to southeastern Massachusetts' coastal estuaries;
- Loss of open space and the proliferation of impervious pavement (roof tops, sidewalks, parking lots, and roadways) that contributed to the loss of groundwater recharge from rainfall events and the increase in stormwater runoff discharges to coastal waters;
- Expansion of stormwater collection and disposal systems that discharge untreated to inland and coastal waters and the excess nutrient contamination from its many sources;
- Higher volumes of urban nonpoint runoff;
- Noticeable increases in nitrate levels in drinking water

The accompanying decline in water quality, primarily from nitrogen discharges from residential on-site septic disposal systems, residential lawn fertilizer use, and stormwater discharges has detrimentally affected the biological richness and productivity of these ecosystems that once supported spawning grounds and nursery for a vast array of shellfish and commercially important fisheries. This decline has also affected tourism, property values, and the economy of affected coastal areas.

1.1 Nitrogen Pollution

It is well established that nitrogen is essential to living organisms and its availability is critical to functioning estuarine ecosystems. However, unlike freshwater ecosystems where phosphate is the limiting nutrient, marine ecosystems are limited by nitrogen. This means that freshwater and marine ecosystems have all the nutrients needed for growth – except for phosphate and nitrogen. When either nitrogen or phosphate concentrations exceed natural background levels, the affected marine or freshwater ecosystems undergo eutrophication, with an explosive growth of undesired phytoplankton (blooms) and algal mats that overwhelm and degrade the ecological functioning of these inland and coastal waters. However, it must also be understood that eutrophication is a natural process that occurs over a long period while cultural eutrophication, the dynamic affecting this and other coastal embayments, is a human influenced acceleration of this natural process.

The collapse of the affected coastal ecosystems soon follows. During the day the algal blooms supersaturate the water column with oxygen and at night, this oxygen is depleted by biological respiration.

Finally, when the algal bloom undergoes decay and microbial decomposition most of the dissolved oxygen in the water column is consumed leaving very little for the affected ecosystem to sustain itself.

Figure 1.2 A view of Shoestring Bay from the Santuit River with algal mats throughout much of the surface waters of the Bay (Photo by Ed Baker)

Eutrophication also results in the buildup of carbon rich bottom sediments resulting from the fallout of this algal and plant biomass from the water column. This bottom settlement buildup can have long-term changes in benthic habitat, animal populations, and community structure has the potential to affect biogeochemical cycles, living resources, and biodiversity.

It is important to understand the connection between nitrogen pollution and the decline of eelgrass beds. When the water column is overwhelmed by an algal bloom, it is no longer transparent to sunlight penetration. The shading that results from these algal blooms and the attached epiphytic algae is such that the eelgrass beds are no longer receiving sufficient sunlight to fuel their photosynthetic needs on the seafloor (Kemp et al., 1983). The subsequent loss of these eelgrass beds soon has a domino effect on the ecosystem it had sustained, with the loss of its dependent plant and animal community; including habitat, breeding ground, and nursery to its dependent commercial fisheries and shellfish.

Increases in estuarine nitrogen levels have also affected the health and functioning of the saltwater marshes that had been dominated by *Spartina alternafolia* (seagrass). The introduction of nitrogen to these ecosystems will over time result in a community dominated by *Phragmites australis*. Phragmites thrives in nitrogen enriched estuaries and easily out competes *Spartina* for both sunlight and nutrients as it spreads its dense growth of underground stems (rhizomes). Collectively, this dense growth pattern and slow rate of winter decomposition of its rhizomes and leaves, results in a degraded habitat that no longer sustains preexisting wetlands function when these thick stands become elevated and fill in the previous open waters.

Nitrogen enrichment from groundwater and stormwater can have a profound affect on the functioning of estuarine ecosystems. When present at levels that exceed its capacity to function, it will have a damaging and catastrophic effect on its dependent plant and animal communities. This report focuses on three tidally restricted coastal embayment systems on Cape Cod that have been affected by elevated nitrogen concentrations due to increases in housing, population densities, and the impacts of septic system discharges.

1.2 Case Studies on Watershed-Based Permitting: Massachusetts Roadmap for Regulatory Change

The need for these case studies is clear. The discharge of untreated, nonpoint source discharges of wastewater continues unchecked from population growth and land use development from many of the communities on the south shore of Massachusetts. Seasonal homes have become year-round, undeveloped land has continued to be lost with the development of year-round residences, road networks, businesses and municipal buildings. The loss of open space with each new development has collectively contributed to the decline in water quality; primarily from the discharges of nitrogen from septic systems, lawn fertilizers, and stormwater runoff. This decline in water quality is especially noticeable in the small upper sub-embayments where septic system load discharges have increased steadily with land development in a small sub-embayment system that has a limited capacity to exchange its nutrient laden waters with clean seawater during each tidal cycle.

At some point, the untreated wastewater discharges will need to be managed to reduce the impacts to these nitrogen impaired embayments. The degradation of water quality to these embayments has frequently been from more than one community sharing this resource. The driving force for this study has been how towns sharing a resource would address the watershed load reductions. Would they do it alone or in collaboration? It is clear that the resolution of these questions will not be easy as the priorities may not be the same for all towns sharing the watershed to an impaired embayment. MassDEP faces the difficult challenge of promoting watershed wide, inter-municipal planning and coordination to achieve these reductions while integrating the management of town-specific and watershed-wide, inter-municipal CWMPs into the existing NPDES and groundwater discharge permitting framework.

Unlike past wastewater facilities planning that historically focused on the mitigation of NPDES point discharges within a community or within one of its villages, a watershed-wide, inter-municipal approach is being pursued to promote shared planning and responsibility for reducing nonpoint source loads of nitrogen to a nitrogen sensitive estuary. The goal of this project is to identify the issues that would define each study and how they would be addressed.

It was for this reason, with funding provided by an US Environmental Protection Agency (EPA) Water Quality Cooperative Agreement that this project was undertaken to address the pathways the towns and the state would take when two or more municipalities share responsibility for restoring water quality to a nitrogen impaired embayment. Also of interest was how the towns, county, and the MassDEP would resolve any zoning, regulatory or permitting issues that address the watershed-wide nitrogen load reductions. Other issues addressed are: (1) inter-municipal strategies towns could engage in for the restoration of water quality from the land use impacts they collectively share responsibility for its restoration and (2) identifying barriers in local zoning, regulations, state statutes, regulation or policies and recommending ways these barriers could be overcome.

In sum, the major nutrient management issues of concern pertain to inter-municipal collaboration and allocation of responsibility, including actions taken and recommendations for the future. This project also focuses on identifying barriers in local zoning, regulations, state statutes, regulations and polices and to recommend ways they could be overcome.

1.2.1 Selection of Coastal Watersheds

The coastal watersheds were selected on the following criteria: a) at least two or more communities sharing jurisdiction of a coastal watershed; and b) a signed agreement with a commitment to attend and participate at regular scheduled meetings. Case study participants, referred to as the Pilot Project Team, would use the findings of the MEP Technical Report and the EPA approved TMDL to define the watershed nitrogen loads and load reductions needed to restore eelgrass or the shellfish benthic habitat - the ultimate compliance criterion for deciding if water quality restoration had been achieved; even if the nitrogen water quality standard had not been met.

In addition, the team was also tasked to identify and develop creative decision-making, nutrient management solutions. Ultimately, this information would be shared with other coastal communities. The three coastal watersheds from Cape Cod selected and the towns sharing land use jurisdiction for these case studies are:

- Popponesset Bay – Towns of Mashpee, Sandwich and Barnstable
- Three Bays – Towns of Barnstable and Sandwich
- Pleasant Bay – Towns of Chatham, Harwich, Orleans, and Brewster

Each of three selected watersheds has been designated by the Commonwealth of Massachusetts as nitrogen impaired - a violation of the state's surface water quality standards for its designated uses (recreational fishing, swimming, boating and a habitat for sustaining eelgrass meadows as a breeding and nursery ground for important marine fisheries and shellfish).

This project was initiated with the goal of promoting watershed-based, inter-municipal planning and coordination. However, this would need to overcome the Commonwealth's history of strong local home rule and municipal authority. Few examples exist in the Commonwealth for guiding inter-municipal wastewater management planning and implementation. It was the hope that these case studies would define some of the issues of concern and how they would be resolved when two or more towns share responsibility for reducing nitrogen throughout a watershed to a nitrogen-impaired embayment. The lessons learned and the recommendations presented in these case studies are, at best, a first step to a lengthy, deliberative planning and implementation process that encompass the steps that have been defined in Figure 1.2.

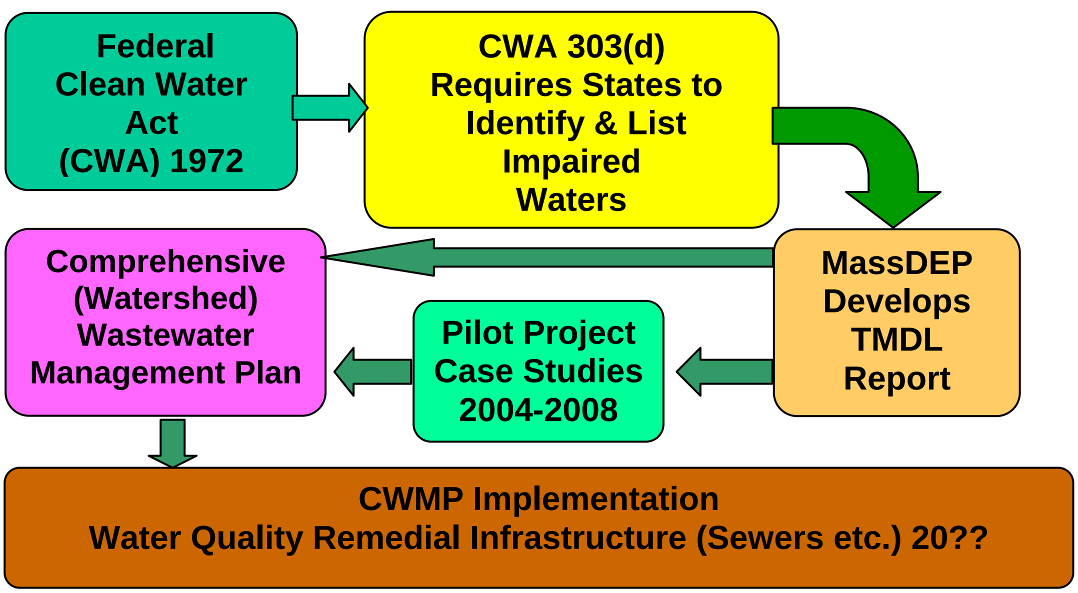


Figure 1.3 Diagram Defining the Pilot Project Case Studies Role in the Implementation of a TMDL

1.2.2 Watershed and Embayment Characteristics

The estuaries and ground-watersheds that defined each of the three case studies are dissimilar in land use, population/housing density, proximity of discharges to the coast, the role of natural attenuation to denitrify nitrogen loads, the number of towns sharing the watershed, and it's tidal flushing cycle (the embayment inlet's capacity to exchange its waters within a tidal cycle). Any one or more of these characteristics define the uniqueness of these embayment systems and the mitigations required for reducing nitrogen loads.

As a result, an understanding of these watershed/subembayment differences is critical to the management decisions affecting the selection of any nitrogen load reduction scenario that achieves the threshold concentration at a sentinel station. Further discussion on Cape Cod's embayments can be found at: http://www.capecodgroundwater.org/groundwateredpage/embayment.pdf

1.2.3 Pilot Study Team Recruitment

Recruitment of communities for the project required:

- A strong lead town – a commitment to participate in advance, prior to any particular outcomes.
- Each town designate a primary contact or "point person" who would solicit input from a broad range of municipal and nongovernmental citizen groups. However, the work of the Pilot Team required a commitment to attend meetings and contribute to the ongoing dialogue.
- Participation in and support of an inter-municipal team through informal meetings, problem solving, and the shared responsibility to reduce nitrogen loads either jointly or alone through the formal CWMP planning process.
- Interest in promoting inter-municipal watershed-wide cooperative planning.

MassDEP also enticed participation by covering the cost of the Linked Model runs to evaluate the effect of proposed nitrogen reductions by the Pilot Study Team on the threshold concentration at the sentinel station(s).

MassDEP's Case Study Project Manager, as team leader, was responsible for team recruitment; the scheduling/coordination of team meetings; educating stakeholders about the MEP process and the applicable state and federal regulatory rules; presenting/discussing wastewater treatment options; and defining/resolving issues of concern for follow-up by local, regional, and state policy makers.

1.2.4 Pilot Project Team Guiding Principles

Participating Pilot communities understood that the lessons learned would guide them with the planning and implementation of their Comprehensive Wastewater Management Plans. Likewise, MassDEP would evaluate how its policies and regulations could be enhanced to promote a state regulatory framework that facilitates local and regional watershed efforts that are consistent with the restoration of estuarine water quality.

The following facts guided case study meeting discussions:

- Wastewater discharges to the watershed are the dominant sources of nitrogen pollution affecting estuarine water quality;
- Most estuaries require nitrogen load removals of nearly 75% to achieve water quality restoration at their designated embayment sentinel station;
- Identify the most cost-effective and environmentally appropriate restoration scenario
- Sewering is key, but towns must first evaluate the many technical and institutional options;
- Solutions will cost many millions of dollars and take many years;
- Towns sharing a coastal watershed should work together to define optimal solutions that are:
    - Watershed-wide
    - Environmentally-sound

- Cost effective

Equally important, the towns understood the importance of examining all nitrogen reduction options, including:

- Land use alternatives that reduce the need for sewering,
- Evaluating creative, nontraditional ways to solve the nitrogen problem beyond the typical wastewater treatment focus of Comprehensive Wastewater Management Planning,
- Aquaculture that provides habitat, water quality, and community benefits.

Team meetings also discussed wastewater infrastructure, management and regulatory practices for reducing nitrogen loading from existing and proposed land uses at build-out, including the following:

- Better wastewater treatment: sewers, small systems, onsite septic disposal
- Stormwater runoff and fertilizer use controls
- Embayment flushing improvements
- Natural attenuation
- Water reuse
- Wastewater management districts
- Watershed-wide cooperative arrangements
- Land use controls
- Nitrogen offsets and trading

1.2.5 Team Meetings

The Pilot Project Team consisted of officials and representatives of environmental organizations from the participating towns and environmental organizations sharing the watershed, with support from the Cape Cod Commission, MassDEP, and SMAST. Team meetings varied but on average were held monthly.

Each Case Study involved the following:

- An in-depth understanding of the Technical Report and use of the Linked Model;
- A review of the nitrogen reduction scenario described in the MEP Technical Report (Chapter 8.3);
- Team proposals for three model runs by SMAST, based on nitrogen reduction options to determine if the threshold concentration at the sentinel station is achieved; and
- Discussion of local and state management and regulatory issues.

The lessons learned from the Pilot Projects are combined and presented in detail in Chapter 7, under the heading “Recommendations”. Case study meetings identified a number of issues for improving the CWMP and TMDL implementation process and the recommendations for the adoption of a broad range of infrastructure and management practices by local, county, and state polices and regulations.

1.3 The Massachusetts Estuaries Project (MEP)

1.3.1 MEP History

In 2000, the Massachusetts Executive Office of Environmental Affairs and the University of Massachusetts signed a cooperative agreement to collaborate on environmental projects. The idea was to give the Commonwealth access to the talent pool at UMass campuses, while giving students the opportunity for hands-on study. This agreement led to the launching of the Massachusetts Estuaries Project (MEP) in 2002 with partial funding provided by the Massachusetts Legislature to address the pollution from excess nitrogen loading in 89 estuaries in southeastern Massachusetts. As a multiyear $13 million dollar project, financed by federal, state, municipal, and private funds, this project involved the collaboration of the University of Massachusetts at Dartmouth's School Marine Science and Technology (SMAST), the Massachusetts Department of Environmental Protection (MassDEP), the Executive Office of Energy and Environmental Affairs (EOEEA), the MEP coastal communities in southeastern Massachusetts, the Cape Cod Commission, the US Environmental Protection Agency (EPA), Applied Coastal Research and Engineering, and the U.S. Geological Survey.

The estuaries and embayments of southeastern Massachusetts, ranging from the Town of Duxbury to the City of Fall River, encompass all of Cape Cod and the Islands, Buzzards Bay and Mt. Hope Bay. Many of these estuaries are at risk of, or are experiencing degraded water quality and habitat loss from watershed-based nitrogen loading impacts. With local communities dependent on the preservation of water quality for sustaining their fishing, shellfishing, and tourism industries, the degradation of these estuarine water resources has serious economic consequences; including reductions in property values, local commerce, and tax revenues. Given the synergy among these interests, embayment protection and restoration is of paramount importance to the Commonwealth and its coastal communities.

1.3.2 MEP Linked Watershed Embayment Model

The MEP uses a model developed at the University of Massachusetts Dartmouth School of Marine Science and Technology (SMAST). Input parameters required for modeling include physical, chemical and biological data. Collectively these model inputs calculate the capacity of an embayment to assimilate nitrogen and run predictive scenarios for use in planning water quality restoration through nitrogen reductions throughout an impacted subwatershed.

The complexity of the nitrogen flows to the estuary from subwatershed discharges (septic systems, fertilizer use, stormwater runoff, atmospheric deposition, and benthic flux) and its interaction with the environment (natural attenuation, tidal flushing, and benthic regeneration) is reflected in the results generated by the MEP Linked Watershed Embayment Model (Appendix A). At best, the model is a quantitative estimate of an embayment's: (1) N sensitivity, (2) N threshold loading levels (TMDL) and (3) response to changes in nitrogen loading. The Linked Model approach, after it is fully field validated, accounts for all sources of nitrogen loads, the reduction by natural attenuation, nutrient recycling, and the variations in an embayment's water quality resulting from a bay's hydrodynamics (current, tidal range, bathymetry) (Figure I-2 of each Technical Report). In short, the Linked Model approach integrates the water quality monitoring results from the field with the data collected on its hydrodynamics, as listed below:

- Water Quality Monitoring - multi-year, 3-year minimum, 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 Threshold Development - Synthesis
  - Linked Watershed-Embayment N Model
  - Salinity surveys (for Linked Model validation)
  - Rate of N recycling within embayment

- o Dissolved oxygen record
- o Macrophyte (eelgrass and other plants living on the bottom of an embayment))
- o Infaunal survey (benthic/bottom dwelling animals) in complex systems

1.3.3 Sentinel Stations

Prior to initiating the water quality studies, the MEP team first identified for each impaired embayment representative sampling location(s) within the system and at its headwater sub-embayments. Following three years of water quality sampling, testing, and data collection, the MEP technical team was able to analyze this data for use in identifying sentinel station(s) that are representative of current water quality throughout a nitrogen-impaired embayment. Usually, the sentinel station is the furthest from the ocean inlet with the best potential for restoring water quality and habitat throughout the embayment to its headwaters when the threshold concentration has been met at that location. Some systems, such as Pleasant Bay, have more than one impaired embayment and as such have several sentinel stations. Once the model has been calibrated and validated with this input data, it is possible to run the model to determine if one or more proposed subwatershed-load reductions for each nitrogen impaired embayment has the potential to restore water quality at its sentinel station. This information is then used by the towns for CWMP planning and implementation.

The target concentration of total nitrogen (TN) that is restorative of water quality and eelgrass habitat at any sentinel station is site specific and dependent on the restoration of eelgrass and/or benthic animal habitat. Since Popponesset Bay was without an established eelgrass bed, the establishment of a threshold concentration required site visits to similar habitat where eelgrass exists such as those at Stage Harbor (Chatham) and Waquoit Bay, near the inlet (measured TN of 0.39 mg TN/liter, tidally corrected <0.38 mg N/Liter) and a similar finding in West Falmouth Harbor. However, with this said, the use of a threshold concentration for all embayments in setting the TMDL is not the ultimate test for compliance with water quality standards; its will always be the restoration of eelgrass and/or benthic habitat even if water quality exceeds the 0.38 mg/L TN standard. The secondary standard for the establishment of benthic infaunal species is between 0.400 and 0.500 mg/L TN

Determining the acceptable maximum level of TN without causing unacceptable harm to habitat is a major part of threshold development. Prior to conducting model runs, SMAST selected appropriate nutrient-related environmental indicators and tested the qualitative and quantitative relationship between those indicators (eelgrass and benthic infaunal species) and the TN concentrations. The Linked Model was then applied to determine the site-specific threshold TN concentrations of each sampling location by using the specific physical, chemical and biological characteristics of each embayment, corrected for tidally driven variation in TN concentration at each site within an embayment. As a result, the calibrated and validated water quality model for a chosen sentinel station reflects the average TN concentration in the upper embayment that is the most representative of the conditions within the estuary and its sub-embayments.

When the model is validated to existing watershed and estuarine conditions, the MEP Linked Model provides MEP communities with a powerful planning and management tool for use in identifying the best sewering and disposal options, by running additional model simulations using alternative scenarios (various nitrogen loading schemes, enhanced flushing possibilities, and/or enhanced natural attenuation) for deciding what option provides the best nitrogen reduction and cost for restoring water quality as part of wastewater management planning; a process that ultimately leads to a comprehensive wastewater management plan (CWMP) with a preferred solution. The CWMP is then submitted to the state for its review and approval as part of the TMDL planning and implementation process.

1.3.4 MEP Technical Reports

The MEP Technical Report is the final product from SMAST that defines the nitrogen discharge load of the watershed and its subwatersheds, the embayment's hydrology, and proposes a hypothetical nitrogen reduction scenario for restoring water quality to the threshold concentration at the sentinel station. Town officials should not assume that the nitrogen load reduction scenario proposed in this report is the preferred option. They should decide on a strategy that works best for their community prior to making a final decision. These include such factors as population/housing densities, availability of land for construction of proposed wastewater treatment/disposal facilities, proximity to existing satellite treatment plants, and the costs and benefits of each scenario. Identifying what makes environmental and cost-benefit sense could require several additional model simulations before the preferred option is identified for the CWMP the town is preparing.

1.3.5 MEP Estuarine Restoration Process

As outlined in Figure 1.2, the MEP represents a long-term wastewater planning and implementation process, with a repeating cycle that relies heavily on five action steps:

Step 1: Gather Watershed Data

This involves watershed delineation, land use data, embayment hydrology, water quality, and habitat sampling for a three–year period with oversight and support by the University of Massachusetts at Dartmouth's School of Marine Science and Technology (SMAST) and Applied Coastal Research and Engineering, Inc (ACRE). In addition, SMAST coordinated its efforts with the Cape Cod Commission to generate watershed-based nitrogen loads.

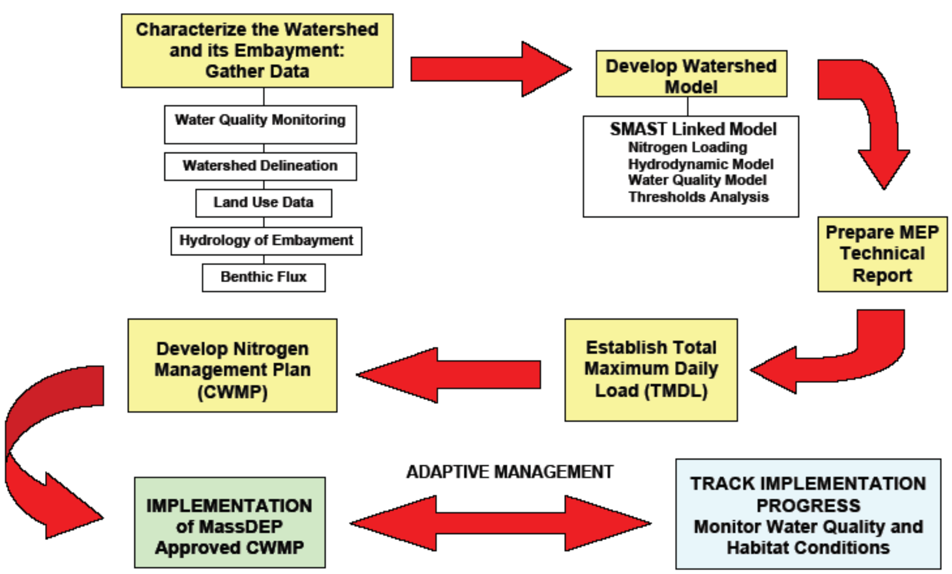


Figure 1.4: The Massachusetts Estuary Project Restoration Process

Step 2: Develop the Watershed Model

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 the watershed and each sub-embayment;
- uses realistic best-estimates of N loads from each land-use (as opposed to loads with built-in safety factors such as 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, when properly calibrated and validated for a given embayment, becomes a nitrogen management planning tool as described in the model overview in Appendix B. The model can assess solutions for the protection or restoration of nutrient-related water quality and allows testing of management scenarios to support cost/benefit evaluations. In addition, once a model is fully functional it can be refined for changes in land-use or embayment characteristics at minimal cost. 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) nitrogen sensitivity, (2) nitrogen threshold loading levels 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

For detailed information on the MEP Linked Watershed Embayment Model, please refer to Appendix B for a description, as the modeling results are not intuitively clear to non-technical community decision makers. SMAST and ACS provided oversight on all model runs for use in preparing the MEP Technical Reports.

Application of the Linked Watershed-Embayment Model

The approach developed by the MEP for applying the linked model to specific sub-embayments, for the purpose of developing target N loading rates, is as follows:

- Select one or two sub-embayments within the 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;

- Use site-specific information and a minimum of 3 years of sub-embayment-specific data to select target/threshold nitrogen concentrations for each sub-embayment. This is done by refining the draft threshold nitrogen 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 mouth of the embayment system;

- Run the calibrated water quality model using different watershed nitrogen loading rates to determine the loading rate that will achieve the target nitrogen concentration within the sentinel sub-embayment. Differences between the modeled nitrogen load required to achieve the target nitrogen concentration and the present watershed nitrogen load represent nitrogen management goals for restoration and protection of the embayment system as a whole.

Step 3: MassDEP establishes the TMDL

MassDEP utilized the findings of the MEP Technical Report as its basis for establishing nitrogen TMDLs for the MEP's 89 bay embayment systems. The Department utilizes the nitrogen loads from the Technical Report and presents them as daily loads in accordance with the requirements of the Federal Clean Water Act. The TMDL for an affected embayment typically requires very significant watershed reductions in nitrogen loads in the range of 50-80%. They also set watershed-based nitrogen reductions for use in restoring estuarine water quality to its designated uses.

TMDLs are used by MassDEP to set groundwater discharge and NPDES permitting conditions. As stated earlier, the MEP has chosen the restoration of eelgrass or healthy benthic animal communities as the ultimate measure for determining if the TMDL has been met at the designated embayment sentinel station. While specific nitrogen threshold concentrations have been designated as the ambient water column concentration necessary to achieve that level of restoration, the ultimate test will be the concentration that is restorative of habitat, even if the concentration in the estuary is greater than the specified threshold. If the standard has been met and neither eelgrass nor benthic animal communities are restored, then the affected estuary must be re-evaluated to determine what additional strategies are required to achieve the habitat restoration target. At best, the nitrogen threshold concentration for water quality restoration is an estimate, based on water quality conditions that sustain eelgrass beds elsewhere on Cape Cod.

Beyond the restoration of eelgrass because it provides valuable habitat for shellfish and finfish, the other objectives for restoring water quality are to prevent algal blooms, protect benthic communities from impairment or loss and to maintain dissolved oxygen concentrations that are protective of the estuarine communities.

Step 4: Develop the Comprehensive Wastewater Management Plan (nitrogen management plan)

Towns use the TMDL reports as the basis for the nitrogen management planning they would undertake for the reductions they would ultimately propose to the state with the submission of their Comprehensive Wastewater Management Plan (CWMP).

Traditionally, wastewater management/facilities planning has focused on a community-based approach to mitigate the wastewater discharge impacts to affected inland and coastal waters. However, with the introduction of EPA's Total Maximum Daily Load (TMDL) requirement, pollutant load reductions are now required for the watershed as a whole. It is for this reason that the MEP and the TMDL reports do not identify town specific load reductions when two or more towns share a coastal watershed to a nitrogen-impaired embayment.

Step 5: MassDEP Approves CWMP, MassDEP Issues Permit, Applicant Implements CWMP

Following public comment and approval of the CWMP by the Massachusetts Environmental Policy Act (MEPA) Unit, MassDEP reviews the applicant's CWMP proposal to determine if the mitigation measures are adequate to address the nitrogen load reductions from the watershed. If approved, the MassDEP prepares a groundwater or surface water (NPDES) permit that defines the requirements and conditions for the proposed layout and design of the wastewater collection, and treatment system. Also defined in the permit are the water quality discharge limits and the water quality/habitat monitoring requirements for determining if compliance with the threshold concentration has been met at the sentinel station(s) in the affected embayment(s).

Following construction of the wastewater infrastructure and the hookup of area homes and businesses, the permittee monitors water quality and habitat conditions in the embayment to determine if the nitrogen reductions were sufficient in restoring water quality. If not, the permittee(s) adjusts their wastewater implementation plan via adaptive management, with MassDEP oversight, or maintains its implementation until the target restoration threshold at the sentinel station in the embayment is achieved.

1.3.6 Natural Attenuation of Nitrogen

Natural attenuation (attenuation or attenuated load) as described in this report, is defined as denitrification, a microbiological process that occurs in anoxic (without oxygen) zones (and all the other conditions necessary for denitrification) in the sediment and sediment-water interface, involving the biological reduction of nitrate (NO3) to nitrogen gas (N2) by the following series of reactions: NO3 to NO2 (nitrite) to NO (nitric oxide) to N2O (nitrous oxide), and finally as a N2 gas emission.

As groundwater flows down gradient to the coast, denitrification occurs as this plume is intercepted by the carbon-rich sediments of one or more lakes and ponds, and/or rivers. MEP research studies have validated this assumption and modeled a 50 percent nitrogen removal in the Linked Model whenever a groundwater plume path is expected to pass through a lake or pond; or a 30 percent reduction whenever the plume is intercepted by a streams and a wetland system. Therefore, the MEP Linked Model assumes 50% removal in ponds and 30% in streams and wetlands associated with them.

An in depth study of over 200 peer-reviewed and other publications was the subject of a MassDEP subcontract under this EPA cooperative agreement to the Woods Hole Group (WHG) and Teal Associates to confirm the role of nitrogen attenuation in different types of wetlands (bogs, fens, emergent, shrub-scrub, wet meadows, cranberry bogs, forested & open wetlands, salt ponds, marshes and mudflats) and waterbodies (streams, rivers, lakes and ponds). Information was also sought from the researchers who have authored previous studies for any unpublished/in press studies. Publications were also sought on the design for constructed wetlands and the site modifications to enhance natural attenuation rates. Finally, the literature review also examined data obtained from model, laboratory, and field projects.

This review identified denitrification in wetlands as the most effective nitrogen removal mechanism from surface and ground water, followed in effectiveness by small ponds, large ponds and streams. Vegetative uptake played only a minor role in nitrogen removal. The role of pH, oxygen content, muck content as a carbon source, stream and/or groundwater flow, and temperature are fully described, each with optimal environmental conditions for promoting nitrate attenuation.

Following the completion of this literature review, the contractor, as a contract deliverable, presented its findings at two public forums: on April 24, 2007 at the Buttonwood Park Zoo in New Bedford, and on April 25, 2007 at the Harwich Community Center. These meetings were well attended and strategically important to the Department and the MEP in providing the public's point of view on the use of natural and enhanced nitrogen attenuation processes.

This research represented a first step in the policy development process for external and internal discussion concerning the effectiveness, limitations in use, and applicability under existing state statutes and regulations of nitrogen attenuation. The findings of this review of the literature will allow the MassDEP to consider the effectiveness of nitrogen attenuation as a treatment option to reduce impacts from nitrogen-contaminated groundwater that would otherwise contribute to estuarine eutrophication (Appendix K: Executive Summary of WHG Report).

The following copies of this literature review are available for downloading at the MassDEP Website, under Estuaries Project Reports: http://www.mass.gov/dep/water/resources/coastalr.htm.

- Final Report: Natural Attenuation of Nitrogen in Wetlands and Waterbodies,
- Literature Review, Bibliography with Abstracts and Annotations
- Natural attenuation (literature findings as Excel spreadsheet

Key findings of the report are as follows:

1. The most effective nitrogen removal from surface and ground water is via denitrification in wetlands, small ponds, large ponds and streams.
2. The conditions that maximize nitrogen removal include a nitrate loading rate of ~ 2 to 3 mg/l, detention time of about one day in anoxic zones with labile organic carbon, near neutral pH, and temperatures ~ 10° C.

If the natural (microbiological) attenuation capabilities of these ecosystems systems are enhanced or restored, it can be argued that less sewering and wastewater treatment may be needed to meet the nitrogen threshold at the sentinel station in the estuary. However, this view may have unintended consequences; as these wastewater plumes are also sources of phosphate and bacteria, both subject to future TMDL requirements for the affected lakes and ponds.

1.3.7 The MEP Community Partnership

As described earlier the MEP partnership includes the coastal communities of southeastern Massachusetts, the services provided by SMAST, ACRE, the Cape Cod Commission, and MassDEP throughout the CWMP planning and implementation process. For their part, the towns are required to contribute approximately 40% of the overall cost and to provide three years of water quality sampling and monitoring data. The MEP communities must also establish a local committee consisting of officials and citizens who would interface with SMAST and MassDEP staff throughout the planning and implementation phases of comprehensive wastewater management planning.

When the financial considerations for participation are resolved, the MEP process begins at the SMAST designated sampling sites to assess water quality and habitat conditions and eventually for use in calibrating and validating the MEP Linked Model. When the MEP Technical and the MassDEP TMDL reports are completed and the EPA approves the TMDL, MassDEP is ready to provide technical assistance throughout the CWMP decision-making and implementation process.

1.3.8 MEP Resources

MassDEP	Home page for the MEP, including maps and background articles: http://mass.gov/dep/water/resources/coastalr.htm Total Maximum Daily Loads (TMDL) http://www.mass.gov/dep/water/resources/tmdls.htm Comprehensive Wastewater Management Plans http://www.mass.gov/dep/water/laws/wwtrfpg.pdf Water Resource Management Planning http://www.mass.gov/dep/water/laws/iwrmp.pdf MEP Embayment Restoration and Guidance for Implementation Strategies http://www.mass.gov/dep/water/resources/mamep.doc
SMAST	Home page for the MEP Technical Reports at the University of Massachusetts School of Marine Science and Technology (SMAST) http://www.oceanscience.net/estuaries/
State House Bookstore	State Bookstore, Room 116, State House Boston, MA 02133 (617) 727-2834 http://www.state.ma.us/sec/spr/spridx.htm

1.4 Applicable Federal, State, County, and Local Roles

1.4.1 Federal Role

The Clean Water Act (See 33 U.S.C. § 1251) is the federal law that governs the cleanup of impaired inland and coastal waterways, enacted in 1972 with the goal of eliminating the discharge of pollutants to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." To achieve this objective, one of the CWA's principal sections strictly prohibits discharges of pollutants into the "navigable waters of the United States" (see 33 U.S.C. § 1311(a)) without a National Pollution Discharge Elimination System (NPDES) permit from the Environmental Protection Agency ("EPA"). The CWA (see 33 U.S.C. § 1362(7)) defines the term "navigable waters" to mean "waters of the United States, including the territorial seas". For the past thirty years, the control of point, end-of-pipe, wastewater discharges to the environment has been very effective, leaving much of the wastewater discharged from nonpoint sources such as stormwater runoff and on-site waste water treatment plants untouched. The CWA establishes the basis for identifying impaired inland and coastal waters, defining the source(s) of the impairment(s), and defining the reductions in pollutant load to restore water quality that will not exceed the Total Maximum Daily Load (TMDL). The goal of this Rule, as defined in the Clean Water Act, is for the States to work with interested parties to develop Total Maximum Daily Loads or TMDLs for polluted waters. A TMDL is essentially a "pollution budget" designed to restore the health of the polluted body of water for use in swimming, fishing, and healthy populations of fish and shellfish.

A statutory and regulatory framework exists in Massachusetts relevant to the implementation of nutrient mitigation measures in support of the information provided by the Massachusetts Estuaries Project.

1.4.2 State Role

1.4.2.1 Massachusetts Clean Waters Act – M.G.L. Chapter 21, §§26 through 53

Under Massachusetts General Laws Chapter 21, § 27, MassDEP, among its powers and duties is directed to:

- Adopt regulations that DEP "deems necessary for the proper administration of laws relative to water pollution and to the protection of the quality and value of water resources…"

- Adopt water quality standards and periodically examine the water quality of MA waters, and to publish the results together with the water quality standards.

- Establish effluent limits, permit programs and procedures applicable to the management and disposal of pollutants, as well as related monitoring, sampling, and reporting requirements for dischargers.

- Conduct a continuing planning process that will result in plans for reducing, controlling and eliminating discharges to all MA waters, and to prepare or supervise the preparation of, and adopt, comprehensive river basin and regional plans "for abatement of such discharges by means of treatment works or other practical control facilities and methods."

- "Encourage" the adoption of water pollution prevention, control, and abatement plans by municipalities and other users of Massachusetts' waters.

Under the Massachusetts Clean Waters Act, MassDEP has the authority to unilaterally establish a wastewater management district (MGL Chapter 21, §§ 28, 29, 30, 32, 35 and 36), and could use this authority to implement solutions on a watershed basis more quickly than might occur by the towns sharing a watershed if they were left to act on their own priorities.

As described in MassDEP's MEP Guidance "Introduction to Management Districts in Massachusetts", MGL Chapter 21, §§ 28-30, 32, 35, and 36 authorize MassDEP to propose, and in some cases, mandate the establishment of water pollution abatement districts consisting of one or more municipalities, or designated portions of one or more municipality. A core power of a water pollution abatement district is to construct, operate, and manage "abatement facilities". The term "abatement facilities" as defined in Chapter 21, § 26A includes "facilities for the purpose of treating, neutralizing, or stabilizing sewage and such industrial and other wastes as are disposed of by means of the facilities, including treatment or disposal plants, the necessary intercepting, outfall and outlet sewers, pumping stations integral to such facilities and sewers, equipment and furnishings thereof and their appurtenances." A district also has an obligation to develop a plan for abating sources of pollution within the district, including identifying the sources of pollution, the means by which and the extent to which such pollution is to be abated, and the facilities needed to abate the pollution. However, these statutory provisions do not specifically address the extent to which a district may abate sources of pollution identified in its plan by means other than an abatement facility owned and operated by the district. To date MassDEP has not exercised its authority under the Massachusetts Clean Waters Act to propose or to require the establishment of a water pollution abatement district.

Pollutant is broadly defined under Chapter 21, §26 as "any element or property of sewage, agricultural, industrial or commercial waste, runoff, leachate, heated effluent, or other matter, in whatever form and whether originating at a point or major nonpoint source, which is or may be discharged, drained or otherwise introduced into any sewerage system, treatment works or waters of the Commonwealth." (Emphasis added.) Note: Neither the MA Clean Waters Act nor the MassDEP existing regulations at 314 CMR further defines what constitutes a "major" nonpoint source. In comparison, the federal Clean Water Act does not regulate or permit discharges from nonpoint sources. Thus, when a TMDL identifies needed reductions in pollutant loadings from nonpoint sources, such reductions may only be implemented under a state law that regulates such discharges. As noted above, MassDEP has state law authority under Chapter 21 to expressly regulate "major" nonpoint sources of pollutants as well as broad authority to promulgate regulations that MassDEP deems necessary for the proper administration of water pollution laws and to protect water resources.

Under Massachusetts General Laws Chapter 21, §43, "no person shall discharge pollutants to Massachusetts waters without a permit from MassDEP, nor shall any person engage in any other activity that may be reasonably expected to result, directly or indirectly, in such a discharge, or construct, maintain, or use a sewer extension or connection without a permit from MassDEP, unless exempted by MassDEP regulation." Chapter 21, §43 directs MassDEP to adopt regulations with respect to permit proceedings and determinations.

1.4.2.2 Title 5: On-Site Sewage Treatment and Disposal Systems

Over 30% of the homes in Massachusetts and over 85 percent on Cape Cod have on-site wastewater systems, as do small businesses and institutions that are located in unsewered areas. Under Massachusetts General Laws (M.G.L.) c. 21A, §13 any wastewater treatment that is designed to receive less than 10,000 gallons per day, must comply in accordance with Title 5 requirements (310 CMR 15.000: The State Environmental Code, Title 5, *Standard Requirements For the Siting, Construction, Inspection, Upgrade and Expansion of On-Site Sewage Treatment and Disposal Systems and for the Transport and Disposal of Septage*).

While Title 5 is administered by the Department of Environmental Protection ("MassDEP"), pursuant to its authority granted by the State Legislature via M.G.L. c. 21A, §13, the Legislature provides local approving authorities, primarily town Boards of Health, with the authority to approve most on-site sewage and disposal systems. Additionally, local authorities may enact more stringent regulations than those required by MassDEP. However, MassDEP is the approving authority for systems owned or operated by the state or federal government, and for systems with a design flow of at least 10,000 gallons per day ("gpd"). These include: innovative/alternative (I/A) systems; shared systems; variances granted by the local approving authority; upgrade or expansion of systems with a design flow between 10,000 and 15,000 gpd; and any other system which MassDEP determines requires its review.

In some situations, a local approval is subject to MassDEP approval. In other instances, local and state authorities may allow a variance from the provisions of Title 5. A variance may be authorized by the state or local approving authority whenever two conditions are met: (1) where the applicant has established that enforcement of the provision of Title 5 would be "manifestly unjust" considering the circumstances of the individual case; and (2) where the applicant has established that a level of environmental protection that is at least equivalent to that provided under Title 5 can be achieved without strict application of the regulations.

If the variance application is approved locally, the applicant must then seek approval from MassDEP. Until then, no work is authorized. Additionally, variance approvals may be conditioned by either the local approving authority or MassDEP with required monitoring and reporting, deed recordation, financial assurances, or other qualifications.

Nitrogen Sensitive Areas - Title 5 regulations (310 CMR 15.214) state, "certain on-site septic systems located in Nitrogen Sensitive Areas, must comply with a wastewater discharge that does not exceed 440 gpd per acre. This means a home may not exceed four bedrooms on a one-acre lot or two bedrooms on a half-acre lot. This Commonwealth of Massachusetts Regulation (CMR) affects discharges serving new construction in coastal watersheds to nitrogen sensitive estuaries or other areas designated by MassDEP as nitrogen sensitive, including drinking water supply well zones of contribution defined as 1) Interim Wellhead Protection Areas (IWPAs) and Approved Wellhead Protection Areas (Zone IIs). The location of these designated Nitrogen Sensitive Areas are mapped and made available to the public. In addition, Title 5 has provisions for designating nitrogen sensitive embayments as nitrogen sensitive areas.

310 CMR 15.216 allows the 440-gpd nitrogen loading limitation to be calculated in the aggregate in two situations. First, one or more municipalities, or a district composed of two or more municipalities, may seek MassDEP approval for an aggregate determination of flows and nitrogen loading across a region-wide area. Local boards of health may thereafter approve site-specific facility aggregation plans in accordance with a MassDEP-approved Community Aggregation Plan. Second, a board of health and MassDEP may approve a site-specific Facility Aggregation Plan that authorizes the 440-gpd limitation to be met across the facility and other land areas for which nitrogen credit is sought.

1.4.2.3 Groundwater Quality

Under the Massachusetts Clean Water Act (M.G.L. c. 21, § 43) and the Groundwater Discharge regulations (314 CMR 5.03) discharges of pollutants to the groundwater of the Commonwealth for flows greater than 10,000 gpd are not authorized without a permit by MassDEP. Permit applicants have the option of demonstrating compliance of their discharge or through an alternative nutrient loading approach. In addition to regulating these discharges, the Massachusetts Clean Water Act (M.G.L. c. 21, §§ 26 through 53) also require that MassDEP regulate the outlets for these discharges and any treatment works associated with the discharges.

These permitted discharges must also comply with the Massachusetts Groundwater Quality Standards (314 CMR 6.00) that establish classifications, water quality criteria, and designated uses for groundwater. MassDEP is authorized to establish effluent limits in groundwater discharge permits. MassDEP also has broad authority under 314 CMR 6.07 to subject its groundwater discharge permits to “such conditions as [MassDEP] may deem necessary to insure compliance” with the minimum groundwater quality criteria.

1.4.2.4 Surface Water Quality

Under the Massachusetts Clean Water Act (M.G.L. c. 21, § 27) and the Massachusetts Surface Water Discharge Permits Quality Standards (314 CMR 3.03) discharges of pollutants to the surface waters of the Commonwealth are not authorized without a MassDEP permit. Under 314 CMR 3.06, MassDEP may also issue general permits that regulate one or more categories of surface water discharges by multiple dischargers who have applied for coverage under the general permit.

These permitted surface water discharges must also comply with the Massachusetts Surface Water Quality Standards (314 CMR 4.00) which designate the most sensitive uses for which “the waters of the Commonwealth shall be enhanced, maintained and protected; prescribe the minimum water quality criteria required to sustain the designated uses; and contain regulations necessary to achieve the designated uses and maintain existing water quality".

Under 314 CMR 4.03, MassDEP may limit or prohibit surface water discharges to assure compliance with the water quality standards. In establishing effluent limits, MassDEP must consider background conditions and existing discharges. MassDEP also has authority to limit or prohibit discharges to protect existing uses and to prevent interference with the attainment of designated uses in downstream and adjacent segments.

1.4.3 County Role

Barnstable County has taken a number of initiatives that address the importance of assisting the towns with the preparation and financing of wastewater management plans following the approval of a TMDL by the US Environmental Protection Agency. These initiatives by the Barnstable County Health and Environment Department (BCHDE), Cape Cod Commission, Wastewater Implementation Committee, and the Cape Cod Water Protection Collaborative are briefly described below. Consult their websites for more information.

1.4.3.1 Barnstable County Health and Environment Department and the Massachusetts Alternative Septic System Test Center

The Barnstable County Health and the Environment Department (BCHDE) and its 15 municipal boards of health have been actively investigating, since the early 1990s, the feasibility of enhancing the capacity of septic systems to remove nitrogen. Since 1995 when MassDEP revised its Title 5 regulations (310 CMR 15.000) "innovative and alternative (I/A)" systems were allowed for the disposal and treatment of wastewater. As a result of this revision, since 1999, more than 1,100 I/A systems were installed on Cape Cod (Heufelder, Rask, and Burt 2007).

The Massachusetts Alternative Septic System Test Center, located at the Otis Air National Guard Base on the Massachusetts Military Reservation on Cape Cod, led by The Buzzards Bay National Estuary Program (BBP), in collaboration with Massachusetts Department of Environmental Protection (MassDEP), BCDHE, and UMass Dartmouth's School of Marine Science and Technology (SMAST), was established to field test the performance of proposed I/A systems as part of the testing and approval process provided by the 1995 Title 5 revisions. In addition, the Center identified the operational costs of these new innovative technologies and assists vendors in getting their technologies approved for use in Massachusetts.

A report by the BCHDE, in conjunction with the 15 Boards of Health in Barnstable County, recently presented the results of many pilot studies that defined the performance of several nitrogen-removal I/A systems on Cape Cod soils. A copy of this report "Performance of I/A onsite septic systems for the removal of nitrogen in Barnstable County, Massachusetts 1999-2007" is available for downloading at: http://www.buzzardsbay.org/etimain.htm

In addition to their work at the Test Center, the BCHD is currently engaged in a two-year study, entitled: "Developing of Smart Growth Planning tools to deal with gross impact of sewering" with funding provided by the Massachusetts Environmental Trust. In 2007, the first year of the study, a working group was convened with representation from the towns with a focus on promoting public education on wastewater and sewering issues.

1.4.3.2 Cape Cod Commission

Since its founding in 1990, the Cape Cod Commission has administered a No Net Nitrogen (NNN) Policy for Developments of Regional Impact or DRIs (new retail, office, industrial or private construction greater than ten thousand square feet, additions greater than five thousand square feet, or outdoor commercial space greater than forty thousand square feet, and any proposed development, including the expansion of existing developments, that is planned to create or accommodate more than thirty dwelling units).

The regional No Net Nitrogen Policy requires that DRIs when proposed in ground watersheds with documented marine water quality problems or defined as nitrogen sensitive must maintain or improve existing nitrogen loadings. Developments may meet this requirement by providing additional wastewater treatment capacity for nearby dischargers, installing denitrifying on-site wastewater systems for existing septic systems, and/or contributing financially to town or watershed planning that support nitrogen reduction efforts.

1.4.3.3 Wastewater Implementation Committee

Barnstable County Commissioners established the Wastewater Implementation Committee (WIC) in 2002 as an advisory committee to the County on countywide wastewater management planning and as a regional forum for "sharing information and coordination between towns, county and state programs. As a regional forum on wastewater management, its goal was to identify opportunities for consensus among its stakeholders that would lead to a new regional wastewater management plan; including options for establishing Wastewater Management Districts for use in determining which are most appropriate for town consideration. The WIC goals were ambitious in facilitating and encouraging towns to initiate wastewater management strategies that protect public health, restore coastal and fresh surface water quality, preserve community character and provide growth center infrastructure."

In 2004 the WIC published study "Enhancing Wastewater Management on Cape Cod: Planning, Administrative, and Legal Tools", conducted by a WIC working group led by Wright-Pierce and other consultants, conducted four case studies involving the towns of Barnstable, Orleans, Mashpee, and Falmouth concerning their capabilities and limitations to address future needs for wastewater management. Because of this effort the WIC working group recommended several planning, administrative and legal tools and actions for consideration/follow-up by the towns, the county and the state. For Mashpee, the Study highlighted the potential benefits and challenges presented by the large number of private sewage treatment facilities serving commercial and residential developments. On one hand, these facilities have prevented further nitrogen loadings to the estuary, and in the future can be part of the town's wastewater structure. However, they were built as standalone facilities without considering municipal or watershed needs, and the technology used may not be what the town would have chosen.

In 2005, thirty thousand dollars ($30,000) was awarded and allocated between the Towns of Eastham and Wellfleet for a study on the use I/A wastewater disposal systems for mitigating nitrogen-loading impacts.

1.4.3.4 Cape Cod Water Protection Collaborative

The Cape Cod Water Protection Collaborative, created in 2005 through ordinance by the Barnstable County Assembly of Delegates inherited the work of the WIC with the goal of addressing the inadequacy of the Cape's wastewater infrastructure to mitigate wastewater discharge impacts to its inland and coastal waters.

As stated in its authorizing legislation, the Collaborative is "To offer a coordinated approach to enhance the wastewater management efforts of Towns, the Regional Government and the Community for the provision of cost-effective and environmentally sound wastewater infrastructure, thereby protecting Cape Cod's shared water resources". In addition, it is charged to: "1) Attract state, federal and public-private revenue sources for financing assistance to the Towns for wastewater projects; 2) Maximize regional cooperation and action in managing wastewater; 3) Coordinate the development of infrastructure that is cost-effective, technologically efficient and environmentally appropriate; and 4) Educate the public concerning the contribution wastewater management makes to sustaining Cape Cod's economic and environmental health."

In addition, the Collaborative assists the Cape's towns prepare and adopt comprehensive wastewater management plans within three years of receiving the TMDL data from MassDEP; ensuring the plans are consistent with the Regional Wastewater Management Plan.

1.4.4 Local Role

Citizen-monitoring groups, regional planning and environmental organizations, and city/town agencies (e.g., Selectmen, City councils, Boards of Health, Planning Boards, and Departments of Public Works) all have a role when it comes to the implementation of wastewater management related measures for their community. It may be in the form of promoting public education on the issues of concern or more specifically related to needed planning, funding, zoning, and/or regulatory measures. Under Massachusetts General Law, cities and towns have local options to address land use nitrogen reductions, many of which are discussed in the MEP Embayment Restoration and Guidance for Implementation Strategies at http://www.mass.gov/dep/water/resources/mamep.doc. This MEP report provides useful information covering the following topics:

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

Massachusetts General Laws Chapter 111, § 31 provides broad general powers to municipal boards of health to promulgate reasonable regulations that can exceed the State's minimum Title 5 requirements, provided that the board states the reasons and/or local conditions supporting the more stringent regulation at a public hearing.

Towns are enabled to address nitrogen reductions through other existing authorities and measures, including but not limited to:

- Adopting local bylaw for coastal watersheds that have been defined and mapped as nitrogen sensitive that limits the onsite disposal systems to 440 gallons per day per acre nitrogen loading or no more than four bedrooms (110 gallons per day/bedroom) pursuant to 310 CMR 15.214
- Adopting local bylaws to manage fertilizer, pursuant to 310 CMR 15.216
- Adopting local bylaws requiring water reuse by dischargers
- Adopting local bylaws related to house drainage, pursuant to Chapter 111, §127

- Adopting a bylaw that mandates Title 5 upgrades to I/A systems for Zone IIs and NSAs that are more restrictive than Title 5 (see 310 CMR 41)
- Deciding areas to sewer and mandating owners of abutting property to connect to a common sewer, pursuant to Chapter 83 §3 and §11
- Requiring ongoing system management in the disposal system construction permits, pursuant to 310 CMR 15.003
- Issuing and enforcing Conservation Commission Orders of Conditions, pursuant to 310 CMR 10.00

Additionally, towns may address nitrogen reductions through an inter-municipal wastewater district. This can be accomplished through a Comprehensive Water Resources Management Plan that identifies the wastewater infrastructure and management needs for a watershed shared by more than one town. CWMP's not only propose a plan, they also investigate the need for the proposed facilities, consider alternatives, and must be approved by MassDEP. A MassDEP approved CWMP consists of the following elements:

- A description of the proposed treatment works, and the complete collection and wastewater treatment system of which it is a part
- A description of the Best Practicable Wastewater Treatment Technology
- A cost-effective analysis of the feasible conventional, innovative and alternative wastewater treatment works, processes and techniques
- A cost-effective planning period of 20 years
- A demonstration of the non-existence or possible existence of excessive infiltration/inflow in the sewer system
- An analysis of the potential open space and recreation opportunities associated with the project
- An evaluation of the environmental impacts of alternatives to meet the requirements of MEPA
- An evaluation of the water supply implications of the project
- For the selected alternative, a concise description
- A public participation program that includes as a minimum one public meeting to discuss the alternatives and their environmental impact and a public hearing on the recommended plan including its environmental impact.

If these elements are present, the MassDEP may approve an inter-municipal wastewater management district's plan.

MassDEP's guidance document: Guide to Comprehensive Wastewater Management Planning and at 310 CMR 44 which defines MassDEP's authority and responsibilities to select, approve and regulate water pollution abatement projects receiving financial assistance under the State Revolving Fund ("SRF") Program should be consulted to assist municipal officials, consulting engineers, citizens groups, and other interested parties in developing comprehensive wastewater management plans.

For alternative residential development planning patterns that are protective of coastal waters, readers may want to consider the recommendations provided by National Oceanic and Atmospheric Administration's (NOAA) Coastal Services Center at its website: http://www.csc.noaa.gov/alternatives.

1.5 Wastewater Treatment and Effluent Discharge Siting

The location of treatment plant discharges is an increasingly challenging issue for MEP communities, given the space limitations at preferred sites where housing densities favor a treatment facility and the prohibition under the Massachusetts Ocean Sanctuaries Act ((M.G.L. c132A section 15-16) from siting new surface water discharges in Nantucket Sound or to Massachusetts Bay.

Section 14A of the Ocean Sanctuaries Act states the ocean sanctuaries "… shall be protected from any exploitation, development, or activity that would significantly alter or otherwise endanger the ecology or the appearance of the ocean, the seabed, or subsoil thereof, or the Cape Cod National Seashore". As a consequence, NPDES permits are not allowed; requiring all future wastewater treatment facilities to discharge treated wastewater flows to the subsurface environment, once the CWMP proposal for a wastewater treatment works has been approved and permitted as a MassDEP groundwater discharge permit.

1.6 Watershed-based Permitting and Nutrient Trading in this Project

Watershed based permitting and nutrient trading are important tools to improve water quality. EPA has led the way in promoting their use, and has developed policies and guidance to help states and communities use them appropriately.

EPA's primary interest in funding this grant to MassDEP is to understand how watershed-based permitting and nutrient trading can support implementation of the nitrogen loading limits established by the Massachusetts Estuaries Project (MEP). Both the state and municipalities will play critical roles:
Communities will determine how these tools fit into local TMDL implementation plans.
MassDEP will evaluate changes needed in state regulations or permitting to support them.

Lessons learned from this project will help other communities in Massachusetts and other states determine how best to use watershed-based permitting and nutrient trading.

1.6.1 What is Watershed-based Permitting?

Watershed-based permitting is a tool to address all point and nonpoint sources of pollution within a geographic area, rather than issuing permits to individual pollution sources. Watershed-based permitting can range from synchronizing the timing of permits within an estuary to issuing a single permit that regulates all discharges. For more information, see EPA material:
http://cfpub.epa.gov/npdes/wqbasedpermitting/wspermitting.cfm)

The right approach to watershed-based permitting depends on circumstances in each watershed, sources of nitrogen, and the structure and flexibility of federal, state, and local regulatory systems. For example, EPA is particularly interested in watershed-based permitting as it relates to NPDES permits for surface water discharges. MassDEP is interested also in permits issued under the Commonwealth's groundwater and on-site discharge regulations.

In addition to determining the appropriate watershed-based permitting for three pilot estuaries, this project will identify the regulatory and permitting obstacles in Massachusetts to implementing watershed-based permitting and develop a road map to address them. The road map could include changes in state regulations, new legal entities at the local level for permitting purposes, new permitting and enforcement tools for communities, and other options.

1.6.2 What is Nutrient Trading?

Nutrient trading is an approach to meeting water quality goals by identifying the most cost-effective ways to reduce pollution and using financial incentives to encourage reductions by as many dischargers as possible. According to the EPA, "Trading can provide greater efficiency in achieving water quality goals in watersheds by allowing one source to meet its regulatory obligations by using pollutant reductions created by another source that has lower pollution control costs." For more information: http://www.epa.gov/owow/watershed/trading.htm

A nitrogen trading program relies on: 1) the commodity that will be traded; 2) a demand for the commodity; and 3) a structure for trading the commodity. In this report, the commodity for trading is the kilograms of nitrogen that the MEP Linked Model calculated scientifically for reduction from the watershed that would ultimately achieve the nitrogen threshold concentration for restoring water quality in the estuary. For the purpose of this report, the watershed-wide nitrogen loads that have been quantified for reduction by the Massachusetts Estuaries Project for each sub-watershed and town sharing this coastal watershed provided the basis for inter-municipal discussions regarding wastewater management planning and implementation that is cost and environmentally effective for restoring water quality by the participating communities.

In Massachusetts, the trading tools used are variable and dependent on local circumstances. For example, a nutrient offset program or trading is used whenever a wastewater facility applies for a new or increased wastewater discharge to a nitrogen sensitive coastal watershed. Typically, the nitrogen offset program is applied to individual projects requiring a discharge permit in areas without a comprehensive wastewater management plan (CWMP) in order to insure that no additional nitrogen is applied to an impacted watershed. In these circumstances, approval is granted in exchange for sewering a sufficient number of on-site septic systems so that, at a minimum, the outcome of the permit to expand results in a watershed reduction of nitrogen to the estuary. More complex trading tools do exist elsewhere that utilize formal nutrient trading markets, in which sources of pollution buy and sell credits for pollution discharges. Whatever tool is use, it is clear that EPA has made it clear in its draft framework for watershed-based trading (1996) that trades must be consistent with attainment of water quality standards and occur within a regulatory (permitting), enforcement, public participation framework. The EPA also stressed that the boundaries of trading should generally coincide with watershed or water body segment boundaries. This correlation ensures that the environmental outcomes of trading between parties occur within the boundaries of the same watershed that the boundaries are of manageable size, and are selected to prevent localized problems.

In this project, the participating Case Studies communities utilized the findings of the MEP as the basis for resolving how they would "trade" or share responsibility for the nitrogen load reductions they are responsible under EPA's watershed-based TMDL. At the same time MassDEP and the Pilot Project Teams utilized what was learned from these Case Studies to identify changes in state policy and regulations to facilitate inter-municipal, watershed-based TMDL planning and implementation.

Chapter 2: Popponesset Bay Pilot Project

Figure 2.1 Aerial view of Popponesset Bay showing the sand spit that impedes tidal exchange with Nantucket Sound

2.1 Popponesset Bay Watershed Facts

Key Feature	TMDL implementation in a tidal estuary
Project Name	Popponesset Bay Watershed, Inter-municipal Watershed TMDL Implementation
Scope/Size:	Watershed area: 20.5 square miles (ca. 12,942 acres); approximately 9 miles north to south and just over 3 miles east to west.
Land Type	18 % Rural undeveloped, urbanizing with 36% residential, 2% limited agriculture including golf course, 9% ponds and lakes, and 35% municipal, pubic and private open space.
Pollutant	Nitrogen
Wastewater Infrastructure	Watershed is without municipal sewer; 5 private sewage treatment plants; most properties with residential on-site wastewater disposal systems.
Hydrology	The Popponesset Bay system consists of five embayments (Popponesset Bay, Pinquickset Cove, Ockway Bay, Mashpee River, and Shoestring Bay) and three Rivers with surficial flow from the watershed (Mashpee River, Santuit River and Quaker Run). This embayment system exchanges tidal water with Nantucket Sound through a single maintained inlet at the tip of Popponesset Bay. *
TMDL Development	NPS subsurface, nitrogen discharges primarily from residential on-site septic systems and secondarily from fertilizers use associated with cranberry bogs and golf course turf management.
Data Sources	Towns of Mashpee, Barnstable, and Sandwich; Cape Cod Commission; Mass. Department of Environmental Protection; University of Massachusetts @ Dartmouth-School of Marine Science & Technology (SMAST)
Data Mechanisms	Water quality monitoring results, watershed/parcel specific defined estimates of nitrogen loading based on drinking water use records, USGS delineation groundwatersheds, and MEP Linked Watershed-Estuary Nitrogen Management Model (Linked Model) for calculating load thresholds.
Monitoring Plan	Yes
Control Measures	In 2001, the Town of Mashpee initiated comprehensive wastewater planning to reduce the sources of watershed nitrogen loads affecting the Popponesset Bay system and its embayments. Planning is underway to prepare a comprehensive wastewater management plan with input from the neighboring towns of Barnstable and Sandwich. At the time of this report, Barnstable has initiated its planning while Sandwich has not.

* A complete description of all 5 sub-embayments is presented in Chapters I and IV of the MEP Technical Report

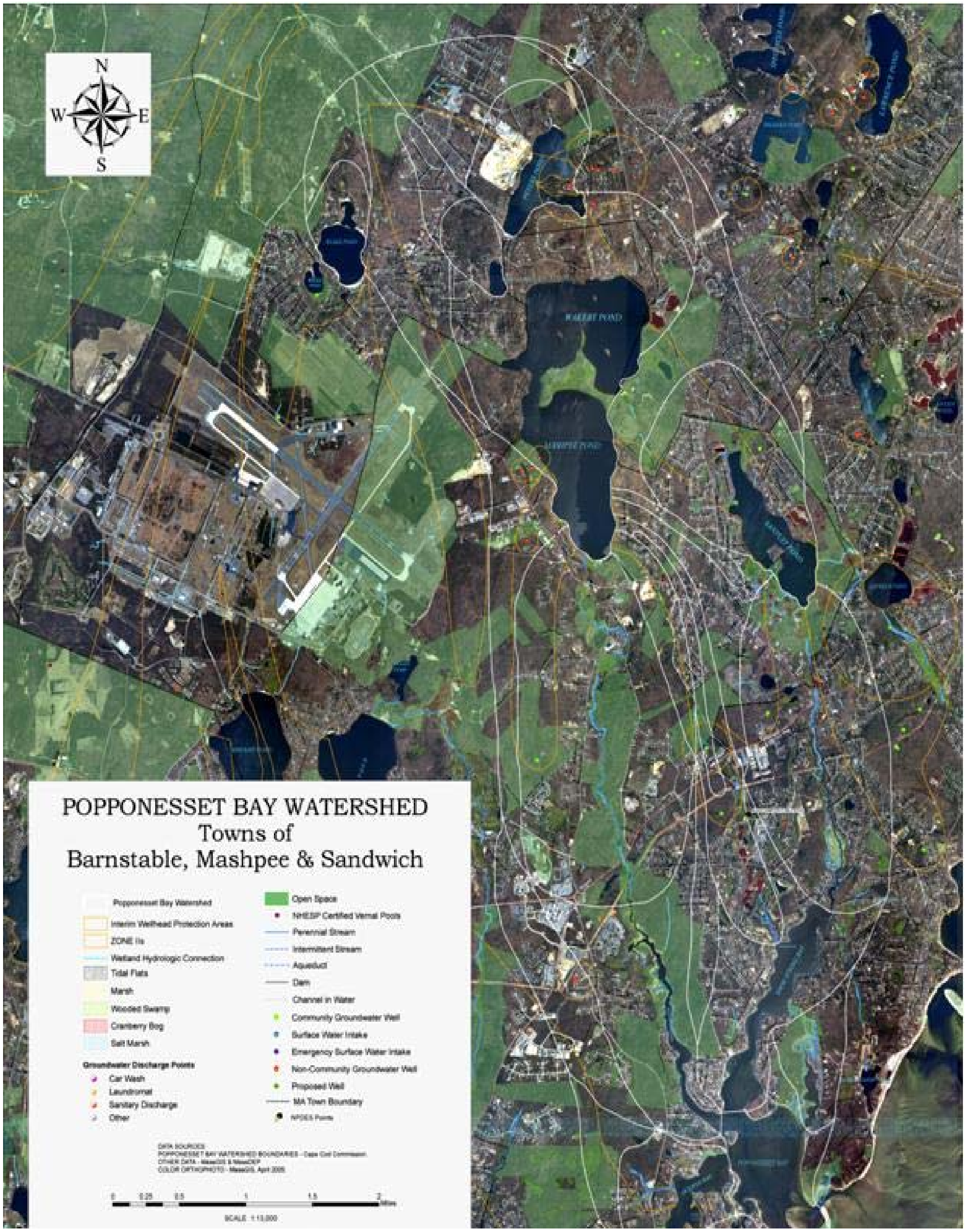


Figure 2.2 Delineation of the Popponesset Bay Watershed

2.2 The Popponesset Watershed

2.2.1 General Description

The Popponesset Bay Watershed and its five embayments (Popponesset Bay, Pinquicket Cove, Ockway Bay, Mashpee River, and Shoestring Bay) lie along the southern shores of the Cape Cod Basin. Three estuarine river systems (Mashpee River, Santuit River, and Quaker Run) discharge directly to the Bay and the Bay ultimately discharges to Nantucket Sound through a single outlet (Figure 2.2). As shown in Figure 2.3, the five embayments are subdivided further into two or more sub-embayments.

These embayments constitute important components of each Town's natural and cultural resources. However, the nature of these enclosed embayments in close proximity to populous regions of the watershed brings two opposing elements to bear: (1) as protected marine shorelines they are popular for boating, recreation, and land development and (2) as enclosed bodies of water, the pollutants they receive may not be readily flushed. In particular, the sub-embayments within the Popponesset Bay Watershed are at risk of further eutrophication from high nutrient loads in the groundwater and runoff from their watersheds. Because of excessive nutrient discharges, the Mashpee River, Shoestring Bay, and Popponesset Bay embayments have been listed as impaired waters requiring TMDLs (Category 5) in the MA 2006 Integrated List of Waters.

The watershed drainage area consists of 13,458 acres (21.029 sq miles) and slightly over 9 miles north and south and just over 3 miles east and west. The Popponesset Bay embayment is roughly 1 mile long and a slightly over half a mile wide - shore-to-shore (Figure 2.3, No. 26). The land area of the watershed is shared with the towns of Mashpee, Barnstable (Cotuit Village), and Sandwich. Nearly two thirds of the 21 square mile watershed area is within Mashpee, followed by lesser amounts by the towns of Sandwich and Barnstable (Table 2.1).

Table 2.1 Popponesset Watershed Land Area by Town

TOWN	**Town Area within Popponesset Watershed**		
	Acres	Square Miles	Percent
Barnstable	1,469.236	2.296	10.92%
Mashpee	8,573.633	13.397	63.71%
Sandwich*	3,414.999	5.336	25.37%
Total	13,457.868	21.029	100.00%

* Area includes all water, including estuarine

The Massachusetts Military Reservation has 369 acres ~ 10.8% within the Town of Sandwich and 2.74% of the land area within the Popponesset Watershed.

This southern coastal region of Cape Cod between the Popponesset Bay and West Bay entrances can be considered a moderately dynamic region, where natural wave and tidal forces continue to reshape the shoreline. Due to the protection afforded by the islands of Martha's Vineyard and Nantucket, the south shore of Cape Cod is protected from the influence of long period open ocean wave conditions. Similar to many portions of the Massachusetts coast, the available sediment supply influences the migration and/or stability of tidal inlets. Tidal inlets can become overwhelmed by the gradual wave-driven migration of a barrier beach separating the estuaries from the ocean. In addition to these natural coastal processes, man-made structures often can influence the stability of a shoreline/tidal inlet system.

2.2.2 Geology and Hydrogeology

The hydrogeology of this watershed, like most of Cape Cod, consists predominantly of glacial deposits of sand and gravel. Several glacial kettle-hole ponds characterize the Mashpee River subwatershed while a small glacial pond and large kettle hole pond (Santuit Pond) define the Santuit River subwatershed.

Unlike off Cape locations where surface topographic features characterize a watershed's boundary and drainage pattern, Cape Cod's ground watersheds are defined by the elevation and direction of flow of its water table (Cambareri and Eichner 1998, Millham and Howes 1994 a, b). The Sagamore Lens is the contributing source of the Popponesset Bay groundwater. The aquifer's convex shape causes it to resemble a lens, and it is often referred to as the freshwater lens. Popponesset's embayments are of varying size and hydraulic complexity; each defined by their rates of flushing, salinity, and shallow depths and their proximity to a heavily developed and populated sub-watershed.

2.2.3 Water Quality

Water quality studies have been ongoing since the early 1980s when DEQE (now MassDEP) Shellfish Sanitation Section (now delegated to the Massachusetts Division of Marine Fisheries) identified excessive levels of coliform bacterial contamination in the Mashpee River. Following this discovery, the DEQE ordered the closure of the Mashpee River to shell fishing. This finding prompted Mashpee to conduct additional water quality studies by its consultant and the work of others:

- October 1987. "Sources of Bacterial and Nutrient Contamination into the Mashpee River, Santuit River and Shoestring Bay" (KV Associates, Inc.)
- 1988. To evaluate the impacts from stormwater discharges (under winter conditions) and the delineation of the recharge zone to the Mashpee River, Quaker Run and the Santuit River.
- July 1988. The Sewer Commission in conjunction with its work for a proposed a sub-regional wastewater treatment plant adjacent to the Mashpee landfill, commissioned a study to identify flow and water quality conditions of the Mashpee River. This study concluded that Popponesset Bay and its embayments were degraded by nutrient additions and classified the embayment system eutrophic.
- 1991. "A Cumulative Impact Assessment Plan to Reduce and Control Sources of Contamination in the Mashpee and Santuit/Shoestring Bay River Estuaries" (KV Associates, Inc.) A modeling study for use in providing long-term management in preserving water quality of the Mashpee River and Shoestring Bay.
- 1997 and 1998. "Nutrient Related Water Quality within the Popponesset Bay System, Part I: Summer Survey of Nutrient and Oxygen Levels" (Howes, B. and David Schlezinger). This study assessed if nutrient-related water quality impairment was affecting the Popponesset embayment system. The Mashpee River, Ockway Bay, and Shoestring Bay were identified with nutrient related water quality impacts.
- 1993. "The Cape Cod Coastal Embayment Project Study" (Cape Cod Commission) funded with EPA section 319 MassDEP pass through money, was among the first to document water quality degradation to Popponesset Bay with sub-watershed nitrogen loads.
- 2002. "Cape Cod Coastal Nitrogen Loading Studies" by the Cape Cod Commission, funded by MassDEP through Clean Water Act section 604b grant (#99-03/604). Using the results of 604b-funded water quality studies from the mid to late 1990s, this study revised tidal flushing studies in the Popponesset Bay system including the Mashpee River to produce nitrogen management options for the watershed.
- 2004. "Popponesset Technical Report" (MEP) Evaluated the full extent of the watershed impacts on the Popponesset Bay system based on 1997 – 2003 water quality studies.

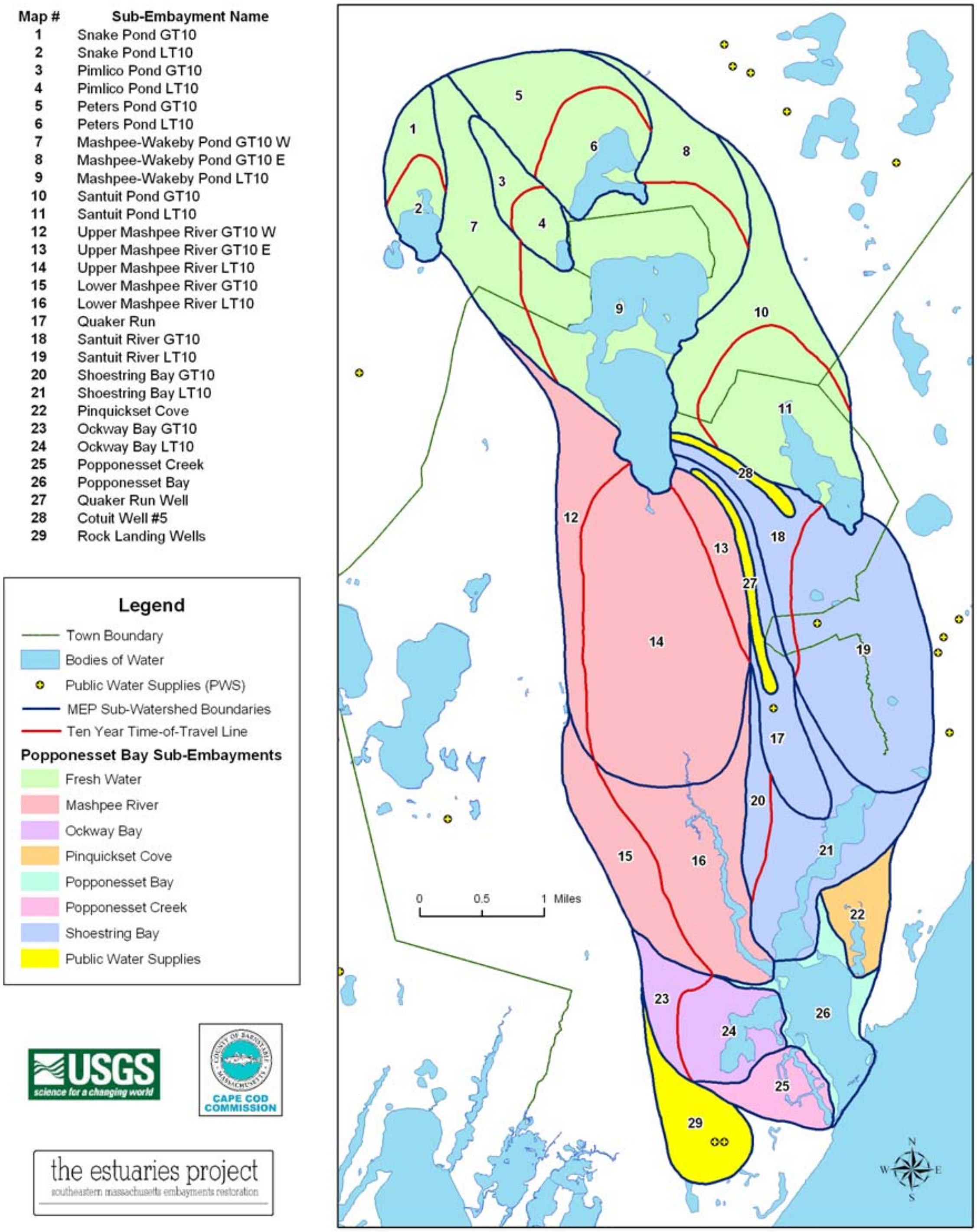


Figure 2.3 The Popponesset Bay Watershed and its Groundwatersheds

The MassDEP Cape Cod Watershed Water Quality Assessment Report to EPA initiated studies of the Popponesset Bay, Mashpee River and Shoestring Bay embayments to assess their status as SA waters. This designation, as defined by the MassDEP Surface Water Quality regulations (314 CMR 4.05(4)(a)), means these waters are:

> "…. an excellent habitat for fish, other aquatic life and wildlife, including for their reproduction, migration, growth and other critical functions, and for primary and secondary contact recreation. In certain waters, excellent habitat for fish, other aquatic life and wildlife may include, but is not limited to, seagrass. Where designated in the tables to 314 CMR 4.00 for shellfishing, these waters shall be suitable for shellfish harvesting without depuration (Approved and Conditionally Approved Shellfish Areas). These waters shall have excellent aesthetic value"

In view of the past and recent water quality studies that confirmed water quality degradation, the Mashpee River, Shoestring Bay, and Popponesset Bay sub-embayments are listed as impaired waters on the Massachusetts 2006 Integrated List of Waters that require TMDLs (Category 5) to comply with the Clean Water Act under Section 303(d) (Table 2.2). The environmental damage affecting the Popponesset, Mashpee River and Shoestring Bay embayments include pollutant loadings from nutrients and pathogens, periodic decreases of dissolved oxygen, decreased diversity of benthic animals, and periodic algal blooms. For more information: http://www.mass.gov/dep/water/resources/2006cmt2.pdf.

Habitat quality of the Popponesset Bay System is highest near the tidal inlet to Nantucket Sound and poorest in the inland-most tidal reaches. This is indicated by gradients of the various indicators. For example, nitrogen concentrations are highest inland and lowest near the mouths. In addition, the nitrogen loads from the contributing sub-watersheds to the Popponesset Bay sub-embayments ranged from 0.76 kg/day in Pinquickset Cove to 39.99 kg/day in the Mashpee River. The sub-watershed loads affecting the Bay ranged from 0.422 mg/L (milligrams of nitrogen per liter) in Popponesset Bay to 0.958 /L in mg the Mashpee River.

Table 2.2 Embayment Waters within the Popponesset Bay Watershed on the 2006 Integrated List

NAME	SEGMENT ID	DESCRIPTION	SIZE	POLLUTANT LISTED
Mashpee River (9662775)	MA96-24_2006	Quinaquisset Avenue to mouth at Shoestring Bay (formerly to mouth at Popponesset Bay), Mashpee.	0.09 sq mi	- Nutrients - Pathogens
Popponesset Bay (96918)	MA96-40_2006	From line connecting Ryefield Point, Barnstable and Punkhorn Point, Mashpee to inlet of Nantucket Sound (including Ockway Bay and Pinquickset Cove), Mashpee/Barnstable.	0.67 sq mi	- Nutrients
Popponesset Creek (9662800)	MA96-39_2006	All waters west of Popponesset Island (from Popponesset Island Road bridge at the north to a line extended from the southeastern most point of the island southerly to Popponesset Beach), Mashpee.	0.04 sq mi	- Pathogens
Shoestring Bay (96905)	MA96-08_2006	Quinaquisset Avenue to Popponesset Bay (line from Ryefield Point, Barnstable to Punkhorn Point, Mashpee, including Gooseberry Island), Barnstable/Mashpee.	0.31 sq mi	- Nutrients - Pathogens

2.2.4 Eelgrass Habitat

The first aerial photographic surveys of Popponesset Bay in 1951 documented eelgrass beds with significant coverage within the central bay and the upper bay near the mouth of Shoestring Bay (Table 2.3, Figure 2.4) suggesting these waters were of high quality without the impacts associated with nitrogen loading (Charles Costello, MassDEP Communication). However, follow-up MassDEP field surveys in 1995 and in 2001 identified an embayment system in decline with the loss of eelgrass throughout the Popponesset Bay System. Today, the nitrogen loads affecting the embayment system have been sufficient to promote the growth of microalgal blooms during the summer months, as suggested by their high chlorophyll a levels (exceeding 20 μ/L). As stated earlier, these algal blooms are of sufficient density in the water column to shade the floor of the seabed. Without adequate sunlight, the eelgrass beds are unable to sustain their energy requirements via photosynthesis and eventually perish. For the same reason, these ecosystems cannot be reestablished as habitat and spawning ground, nursery, and protective cover for commercially important finfish, and shellfish. The eelgrass beds that were first identified in 1951 have since been replaced by macro algae, which are undesirable because they do not provide the high quality habitat for fish and invertebrates. In the most severe cases, this habitat degradation has the potential of leading to 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.

The complete loss of eelgrass beds throughout the Popponesset Bay Watershed makes the presence or loss of eelgrass a difficult parameter to use in evaluating water quality within the sub-embayments. Yet, infaunal study results indicate an ecosystem capable of supporting diverse healthy communities in the region nearest the tidal inlet, with most of the system having an infaunal habitat that is significantly impaired under present N loading conditions.

Table 2.3 Popponesset Bay's Eelgrass Acreage (Past and Present)

Embayment	**1951 (Acres)**	**1995 (Acres)**	**2006 Acres)**	**Percent Loss**
Popponesset Main Bay	85.41	0	0	100
Shoestring Bay	10.64	0	0	100
Mashpee River	0.83	0	0	100
Ockway Bay	0	0	0	
Pinquicket Cove	0	0	0	
TOTAL	96.88	0	0	100

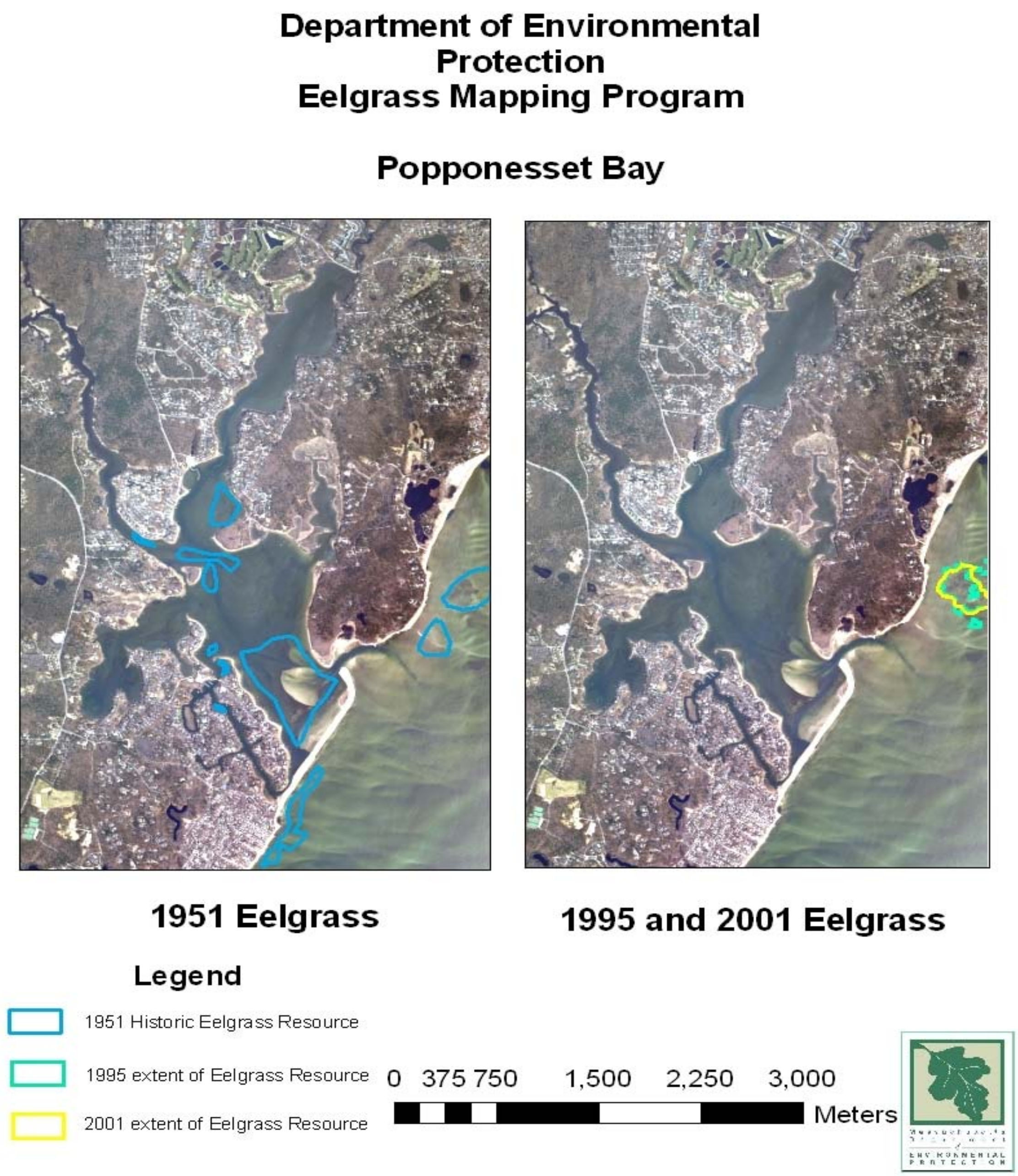


Figure 2.4 Pleasant North Orthophoto of Past (1951) and Present (2001) Distribution of Eelgrass Beds - 1951 historical imagery not field checked (Source: MassDEP, Charles Costello)

2.2.5 Sentinel Station

The sentinel station was located within the upper region of the central basin to Popponesset Bay at the mouth of Shoestring Bay (Figure 2.3), and the uppermost eelgrass bed detected in the 1951 data. Under present loading conditions the sentinel station supports a measured nitrogen level at mid-ebb tide of 0.581 mg/L TN and a tidally corrected average concentration of 0.451 mg/L TN. This location was selected as a sentinel station because: (1) it was the upper extent of the eelgrass coverage in 1951, (2) restoration of nitrogen conditions supportive of eelgrass at this location will necessarily result in even higher quality conditions throughout the whole of the central basin, and (3) restoration of nitrogen concentrations at this site should result in conditions similar to 1951 within Shoestring and Ockway Bays. Shoestring Bay and Ockway Bay should then be supportive of high quality habitat for benthic animal (Infaunal) communities. Based upon current conditions, the infaunal analysis (Chapter VII, MEP Technical Report) coupled with the nitrogen data (measured and modeled), indicated that nitrogen levels on the order of 0.4 to 0.5 mg/L TN are supportive of high quality infaunal habitat within the Popponesset Bay System.

2.2.6 Watershed Land use

Land Use in the watershed, as identified in the MEP technical report, is predominantly residential and public municipal and public/private open space, with one third of the lots with single-family homes (Figure 2.5).

Vegetative cover consists primarily of a mixture pine, oak and beech with limited agricultural production, confined to cranberry production.

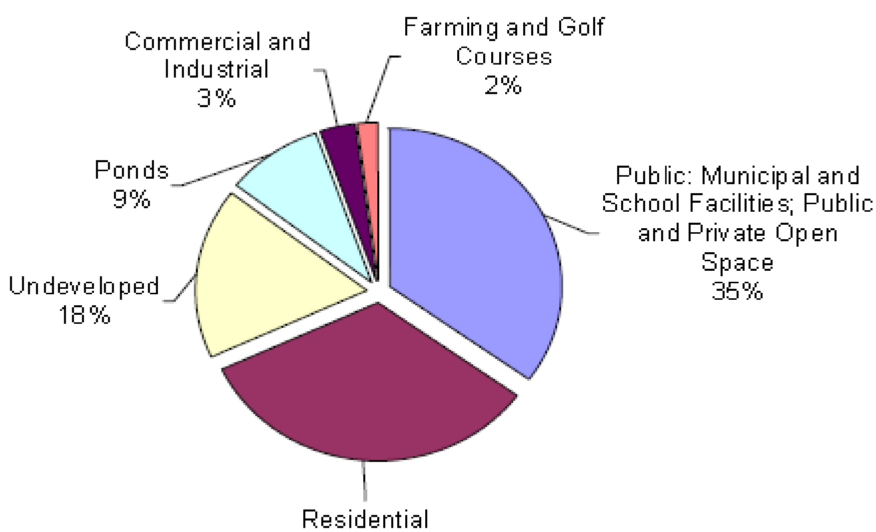


Figure 2.5 Popponesset Watershed Land Uses

2.3 Sources of Nitrogen

There are many sources of nitrogen affecting the estuarine water quality and each has an impact. Table 2.4 and Figures 2.6a-c identify three major sources: atmospheric deposition, sediment regeneration (benthic flux) and contributions from both natural and anthropogenic sources in the watershed. Figures 2.6a-c illustrates three levels of understanding. Figure 2.6a represents the percentage of all the loads affecting water quality from all estuarine and watershed sources. Figure 2.6b identifies the percentage of the sources of nitrogen from the watershed and Figure 2.6c represents the percentage of those watershed sources that can be controlled by wastewater management practices. As presented in Figure 2.6a, loads contributed to the estuary are not always from the watershed; there is also atmospheric deposition and nitrogen regeneration from the biological decay of biomass deposited in the embayment's sediment layer (benthic flux). When considering the nitrogen contributions affecting the coastal waters from the watershed, on-site septic system loads represent 63 percent of the overall load and 84 percent of the controllable load.

Because the contributions of nitrogen from atmospheric deposition and those recycled from the sediment are not loads that can be controlled by any watershed-based management strategy, we are left with the watershed loads (Figure 2.6b) that can be controlled (Figure 2.6c).

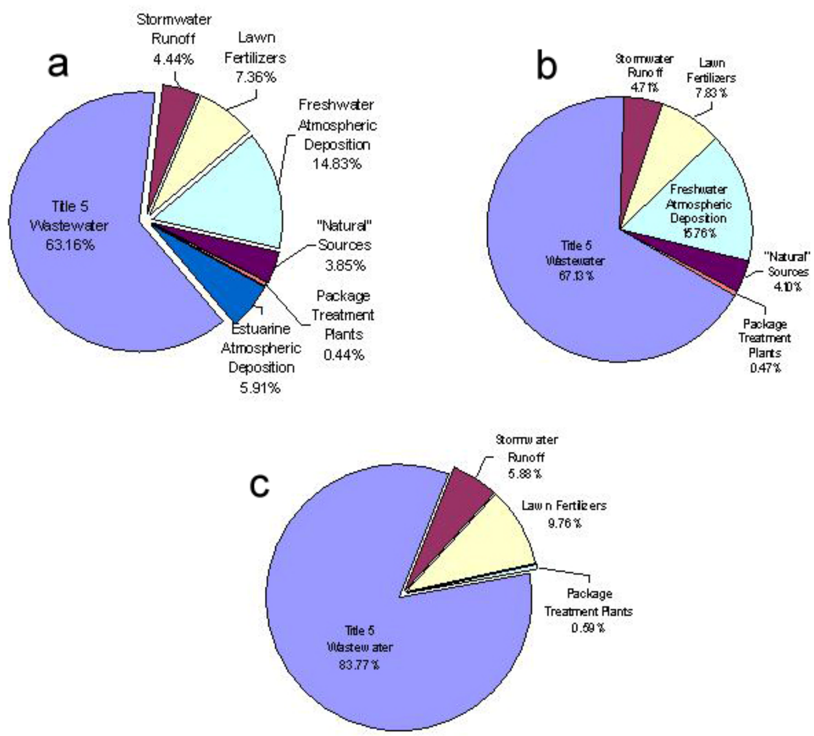


Figure 2.6a-c. Popponesset Bays Estuary and Watershed Nitrogen Sources of (a) Combined Unattenuated Nitrogen Loads, (b) Watershed Sources of Unattenuated Loads and (c) Combined Watershed Loads that are Controllable. Source: SMAST Popponesset Bays Technical Report by Howes, B. et. al, 2004, Chapter 4, Table IV-4.

Table 2.4 Sources of Nitrogen Loads to the Popponesset Bay Embayment and Watershed

Source	Kg N/Year
Title 5 Wastewater	32300
Stormwater Runoff	2268
Fertilizers (lawns and agriculture)	3765
Fresh Water Surface – Atmospheric Deposition	7584
"Natural" Sources	1971
Package Treatment Plants	227
Estuarine Surface Water - Atmospheric Deposition	3022.2
Total Unattenuated Load	51137.2

Clearly, the reduction of the septic load, representing 84 percent of the controllable (stormwater, fertilizers, package treatment plants) watershed load is the source that must be controlled and also the subject of this and other management plans. The use of the Linked Model for the reduction of nitrogen takes into account the contributions from atmospheric and benthic flux, as it simulates the affect of any plan for a septic load reduction that addresses the threshold concentration that must be achieved at the sentinel location in the bay.

2.3.1 Wastewater Treatment Plants and Onsite Systems

Approximately ninety seven percent of the 3509 residential and commercial parcels are served by onsite systems and the remaining three percent are served by package treatment plants. The number of these systems was not determined as the number of public water service connections and those on private wells within the watershed, not the number of parcels, was the most valuable in determining the watershed's nitrogen loads (SMAST confirmed that 90% of the residential metered water use was returned to the watershed as wastewater). Since a service connection to a condominium frequently includes multiple units, each with its own service connection, it was decided not to estimate the number of onsite Title 5 systems. However, it is clear - the majority of the parcels are served by on-site septic systems with nearly 2000 dwellings/homes served by small package treatment plants (Sterns and Wheeler, 2007. Town of Mashpee, Popponesset Bay Needs Assessment Report)

Fewer than four percent of all on-site systems in the watershed are nitrogen-reducing systems, which have been approved for a 19 or 25-mg/Liter nitrogen effluent limit.

The deployment of I/A nitrogen-reducing onsite systems creates a public support challenge to long-term nitrogen reduction plans, for two reasons. First, they cannot be the long-term solution for wastewater treatment. Although they are more effective than conventional septic systems in reducing nitrogen loads by 25-45%, (from 30-35 mg/L to 19 mg/L), most affected estuaries require nitrogen reductions in the range of 60-80%. Secondly, these I/A systems are expensive to install and operate, and can fail unless managed carefully. In addition, if an owner is required to spend a substantial sum to install one of these systems, they may understandably be reluctant to spend more money for sewering or other higher-level technology because the I/A system contributed to the solution.

To help educate the public about the environmental impact of nitrogen reducing systems and to instill the importance of taking collective action, the Pilot Team requested the School of Marine Science and Technology to model the impact of sewering all properties in the watershed with innovative/alternative Title 5 systems (IA) under build out conditions (i.e., all existing plus any projected development under current zoning). The results of the model runs confirmed the belief that the IA systems alone would not achieve the required reductions to restore and sustain water quality at the TMDL threshold concentration.

The five privately owned wastewater treatment facilities in the Popponesset watershed, designed for large commercial or residential developments, currently contribute less than 1% (0.47 %) of the total yearly controllable load to Popponesset Bay (Figure 2.6b). The unused capacity of the five privately owned treatment plants provides an opportunity, following future wastewater management planning, to evaluate the potential of upgrading and extending their use to adjoining neighborhoods with Title 5 septic systems given their design flow, and their relatively high nitrogen discharge limit (three of the four plants with a nitrate concentration limit of 10 mg/L, and one without a limit).

However, wastewater flows from residential (whether they fail or comply with code requirements) and small commercial developments (less than 10,000 gpd) represent the lion's share (84 percent) of the controllable load. Through the CWMP process, towns will need to consider the technical, managerial, financial, and inter-municipal coordination issues related to the selection of a wastewater treatment option for town and/or watershed wide utilization and benefit.

It is likely, following the completion and approval of a MassDEP approved` CWMP, that a variety of wastewater treatment options will be implemented, singularly or in combination. It is highly possible that the excess capacity of existing treatment plants will be insufficient to treat the required additional flows. New plants may be needed, while existing plants may be incorporated within a proposed overall watershed-wide system. In addition, comprehensive wastewater management planning and implementation may require additional nitrogen reduction technologies to lower the nitrate discharges of existing plants below the current 10 mg/l permit limit; thus maximizing on costs and benefits, flows, and nitrate reductions at Title 5 septic system locations.

2.3.2 Treatment Plant Discharge Locations

Identifying a suitable location to construct a treatment facility and to discharge its treated effluent is an increasingly difficult issue on Cape Cod and other MEP communities, given the space limitations at preferred sites where housing densities favor a treatment plant and the prohibition under the Massachusetts Ocean Sanctuaries Act ((M.G.L. c132A section 15-16) from siting new surface water discharges in Nantucket Sound or to Massachusetts Bay. The Act prescribes that these locations "… shall be protected from any exploitation, development, or activity that would significantly alter or otherwise endanger the ecology or the appearance of the ocean, the seabed, or subsoil thereof, or the Cape Cod National Seashore". As a result, future wastewater treatment plants on Cape Cod and the Islands will continue to discharge treated wastewater flows to the subsurface environment as permitted as a MassDEP groundwater discharge permit.

Yet, this limitation may be challenged in view of recent studies that have identified low level, part per trillion, of pharmaceuticals and personal care products (some of which are endocrine disruptors) in drinking water, presumably entering groundwater from wastewater effluent from Title 5 septic systems and/or state permitted wastewater treatment plants. In view of these and other public health concerns, there may a public outcry against future groundwater discharges as they may pose a public health nuisance and a reexamination of the limitations imposed by the Ocean Sanctuaries Act. Under MGL c132a § 16A, there are "…cases where the prohibition in section fifteen against discharges of municipal wastes into the ocean sanctuaries may not further the purposes of the act, such discharges may be allowed; provided, however, that a suitable quality of effluent is achieved to protect the appearance, ecology, and marine resources of the sanctuary; and, provided further that the department, in its discretion, upon application, grants a variance from the prohibitions of said section fifteen for the proposed discharges, subject to the provisions of sections sixteen B to sixteen F, inclusive".

High growth rate MEP communities may find limitations in the siting of these wastewater treatment discharges if the only lands available for discharge are within Zones of Contribution (Zone IIs) to public supply wells and coastal watershed to nitrogen sensitive estuaries. While the Groundwater Regulations (310 CMR 5.00) provide adequate public health protection safeguards for the siting of state permitted wastewater treatment plants within Zone IIs, towns are also exploring increasingly creative options for wastewater disposal in coastal watersheds to nitrogen sensitive embayments. The Town of Mashpee considered in its CWMP the possibility of locating wastewater discharge outside the Popponesset Bay watershed to an area where groundwater would flow directly to Nantucket Sound rather than the nitrogen sensitive Popponesset Bay estuary. The Popponesset Team evaluated the potential of relocating a wastewater disposal site near New Sudbury's wastewater treatment facility. Unfortunately, the proposed site could handle a maximum of 500,000 gpd, compared to the need for disposing 3-4 million gpd.

2.3.3 Stormwater

Sources of water quality impairment also exist from stormwater runoff off buildings, roads, and driveways. Collectively they contribute 4% of watershed-wide unattenuated controllable load, slightly more in sub-watersheds with a greater percentage of developed land. Stormwater and fertilizer management are closely related, because lawn fertilizers frequently wash off lawns during rainfall events and becomes part of the stormwater runoff load.

The EPA NPDES Phase II stormwater-permitting program, which regulates stormwater discharges, requires certain towns to have general permits that commit them to carry out a variety of Best Management Practices (BMPs). Examples from the towns' Annual Reports include detection of illicit discharges, treatment of discharges, changes in local management practices such as street sweeping and collection of hazardous wastes, public education, and local bylaw changes to prohibit dumping into stormwater drains. Reducing fertilizer use will also attenuate nitrogen loading from stormwater.

MassDEP's revised Stormwater Policies and Guidance should be consulted for recommended best management practices for controlling stormwater impacts to surface waters. SMAST has also identified the following BMPs that warrant further investigation for nitrogen removal:

- Vegetated swales
- Retention ponds
- Constructed wetlands
- Sand/organic filters
- Infiltration basins/trenches

2.3.4 Fertilizer Use

The following account for 10% of the unattenuated, locally controllable load of nitrogen in the watershed:

- Lawns and town parks: 76% of the unattenuated fertilizer load is contributed from residential lawns and town parks. This represents 7.6% of the total unattenuated controllable load with residential lawns supplying most of the load. The MEP Technical Report estimates that only half of all residences fertilize, and at rates well below the recommendations by lawn care companies. As more seasonal homes become year-round, there is potential for a significant increase nitrogen loads from lawn fertilizing.
- Farmland and cranberry bogs: MEP Technical Report data files list approximately 29 acres as agricultural land, or 0.42% of the total Popponesset Watershed acreage and most in cranberry production.

- Golf courses (Willowbend, and portions of Quashnet Valley and Cotuit Highlands): Golf courses contribute 24% of the unattenuated fertilizer load, equal to 2.4% of the total unattenuated controllable load. Loads from golf courses are a larger share of the load in the sub-watersheds where they are located - primarily in the Upper and Lower Mashpee River, Quaker Run, Santuit River, and Shoestring Bay.

2.4 Demographics

2.4.1 Land Use Change

During the past 58 years, land use development pressures within the Popponesset Watershed have been dramatic with a substantial loss of undeveloped land (Figure 2.7). Coincident with this change was a substantial increase in the number of year round single-family homes and the conversion of seasonal to year-round residences. These changes are also reflected in the loss of undeveloped forest land for suburban use (Figure 2.7).

Table 2.5 List of acreage of developed and undeveloped land in the Popponesset Watershed from 1951 to 1999 (MassDEP GIS)

YEAR	Developed Acreage	Undeveloped Acreage	Total Acreage*	Percent Developed	Percent Undeveloped	TOTAL_PCT
1951	533	11097	11630	5%	95%	100%
1971	1317	10306	11623	11%	89%	100%
1985	2535	9088	11623	22%	78%	100%
1999	4628	6994	11622	40%	60%	100%

* Exclusive of acreage from lakes and ponds
+ Refer to Figure 2.8 for landuse codes for these two categories of land use.

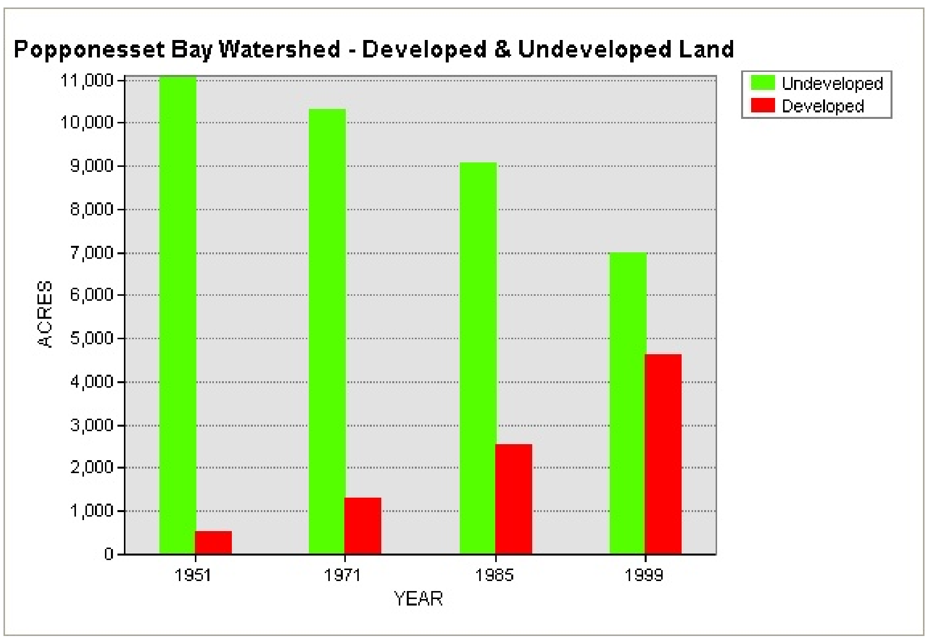


Figure 2.7 Graph of acreage of developed and undeveloped land in the Popponesset Watershed from 1951 to 1999 (MassDEP GIS)

As expected, water quality problems associated with this transformation are primarily from on-site wastewater treatment systems, and to a lesser extent from stormwater runoff – and the use of lawn

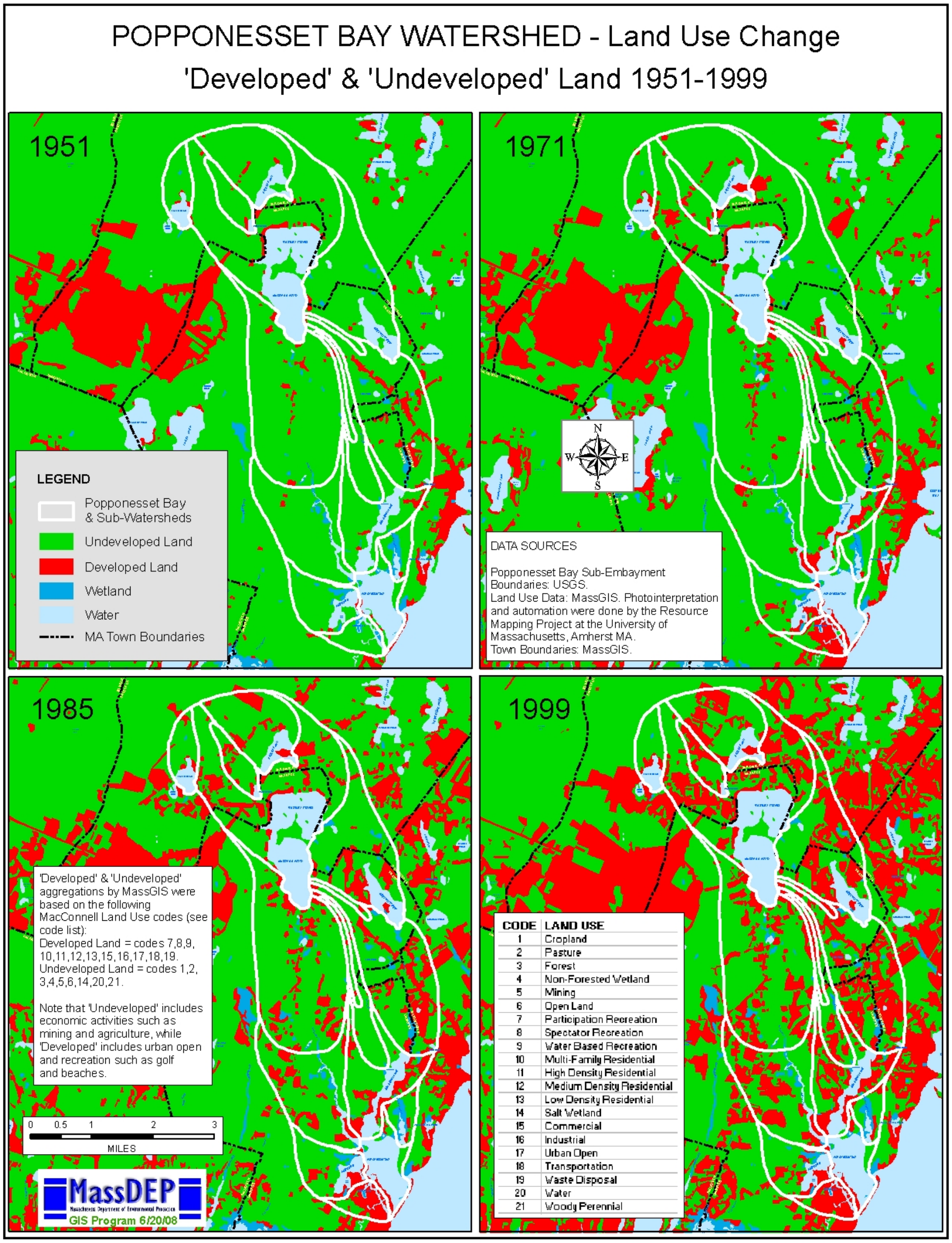


Figure 2.8 Map of acreage of developed and undeveloped land in the Popponesset Watershed from 1951 to 1999 (MassDEP GIS)

fertilizers. The installation of onsite Title 5 systems in these unsewered areas of the watershed has greatly affected the water quality of the sub-embayments from the subsurface discharge of wastewater effluent from these on-site systems. These discharges enter the groundwater system and eventually affect surface water bodies down gradient as it flows seaward. In the sandy soils of Cape Cod, the movement of nitrogen in groundwater is unimpeded, flowing at the same rate as groundwater at an average rate of one foot per day.

2.4.2 Population Growth

US Census data indicate a population growth rate that has consumed an increasingly greater percentage of the open space in the three towns since the 1950s (Figures 2.7 and 2.8 and Table 2.5), with the Town of Mashpee taking the lead in population growth for all time intervals (1950 to 2000; 1990 to 2000; and 2000 to 2006) (Figure 2.9 and 2.10). The highest rate of growth occurred from 1950 to 2000 with a 2856 percent increase, followed by Sandwich at 737 percent and Barnstable at 356 percent. While these rates reflect town wide patterns, they also reflect increases in residential development and wastewater discharges within the watershed from on-site water septic systems, mostly in the town of Mashpee representing 64 percent of the land area within the Popponesset Bay watershed. Dramatic declines in water quality, and the quality of the estuarine habitats, throughout Cape Cod, have paralleled its population growth. Intuitively, it can be argued that the nutrient load increases affecting the groundwater system of the Popponesset Watershed is directly related to the increase in subsurface wastewater disposal systems that accompanied both land development and population growth.

Table2.6. Percent Population Growth from 1950 to 1990, for the Popponesset Watershed Towns

Town	1950 – 1960	1950-1970	1950-1980	1950-1990	1950-2000	1990 – 2000	1990 - 2006
Barnstable	28.5	89.3	194.8	291	356	16.7	15.6
Mashpee	98	194	745	1700	2856	64.2	81.9
Sandwich	-14	117	261	541	737	30.6	32.4
TOTAL	20	85	196	235	443	61.6	64

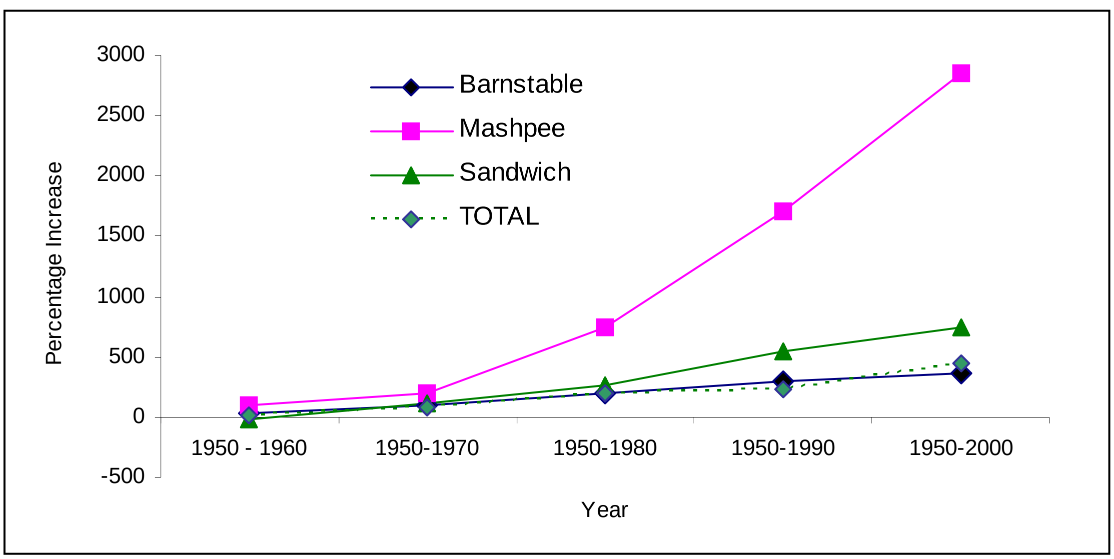


Figure 2.9 Percent population increase since 1950 for Popponesset Watershed Towns

The population of Mashpee and Barnstable, as with all of Cape Cod, has increased markedly since 1950. http://www.capecodcommission.org/data/trends98.htm#population). Of the three towns, Mashpee underwent the greatest percentage increase (Table 2.5, Figures 2.9 -10) following the 1983 federal court settlement of the land claim by the Wampanoag Indian tribe to reclaim the entire town as tribal land. This suit clouded Mashpee's property titles for nearly a decade. When the court ruled that the Wampanoag Indian tribe had no legal grounds because it was not federally recognized the town's landowners were no longer constrained in developing or selling their properties. As a result, land development and population growth in Mashpee, representing 64 percent (Table 2.1) of the land area within the watershed, "led not only Cape towns but the entire State and probably all of New England, more than doubling (+113%) from 3,700 in 1980 to 7,884 in 1990." The town of Barnstable, the largest of Cape Cod's 15 communities, added the most new residents (10,051) from 1980 to 1990 (Figure 2.9). A Cape Cod Commission study (Cape Trends Report, 1998) reported that the town of Barnstable, from 1990 to 1996, gained another 2,750l new residents for a 7% increase to 43,699; the second highest of the 351 Massachusetts cities and towns (following Franklin's 4,569). The Town of Sandwich also saw a substantial increase in growth for the same six-year period for a 16% increase from 15,489 to 17,916 - the highest percentage gain increase among Cape towns.

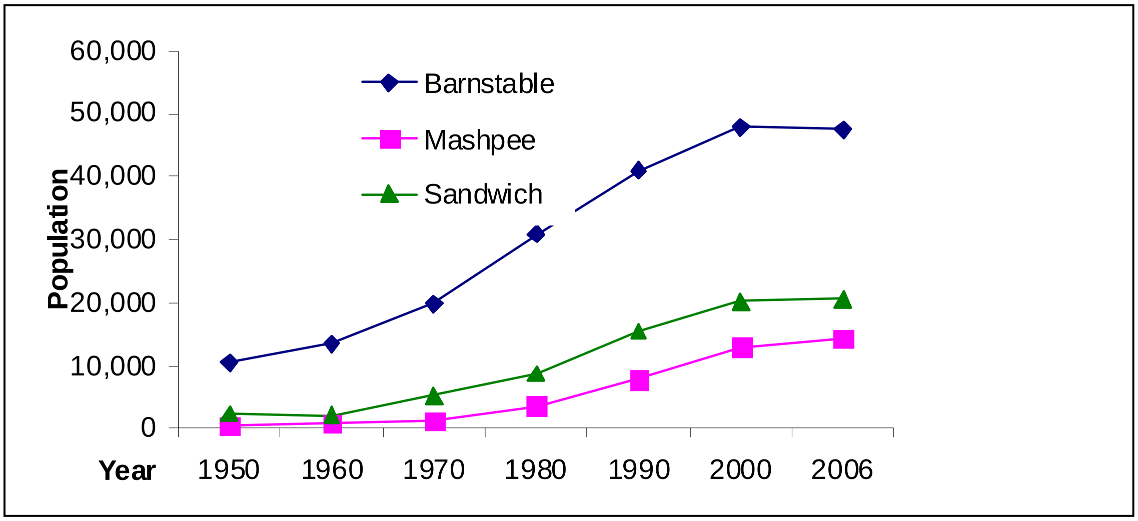


Figure 2.10 Population growth since 1950 for the Popponesset Watershed Towns

The MEP Popponesset Bay Technical Report (2004) estimated the population of the Popponesset watershed at 14,000 with the average household size at 2.54. Since the completion of the MEP Technical report (2004), basing its estimates on 2001 data, the three towns continued to grow. For example, the Town of Mashpee's estimated 2006 population (US Census) outpaced both Sandwich and Barnstable with an increase of 10.79 percent (12,946 to 14,343) from 2001 to 2006 period; while Sandwich grew a modest 1.3 percent (20,238 to 20,508) and Barnstable having a –0.92 percent (from 47,821 to 47,380) (Table 2.5, Figure 2.9).

The significance of these statistics is clear; in the absence of municipal sewering, Title 5 on-site septic systems continue to serve new households with ever increasing nitrogen loads to this estuary beyond the 2004 MEP Technical Report estimates; meaning that the MEP Technical and EPA approved TMDL estimates of loads and reductions will need to take into account the estimates the MEP Technical Report has identified as inevitable and provides an estimate of these future loads under the buildout conditions provided by current zoning for each of the towns sharing this watershed.

2.4.3 Population Density

US Census population density (Figure 2.11), reported as persons per square mile, are also helpful in assessing land use development patterns as they define where the wastewater burden affecting the Popponesset Bay embayments are the greatest. Overall, this increase in population density within the Popponesset Bay watershed is expected to contribute greatly to the nitrogen loads affecting this embayment system.

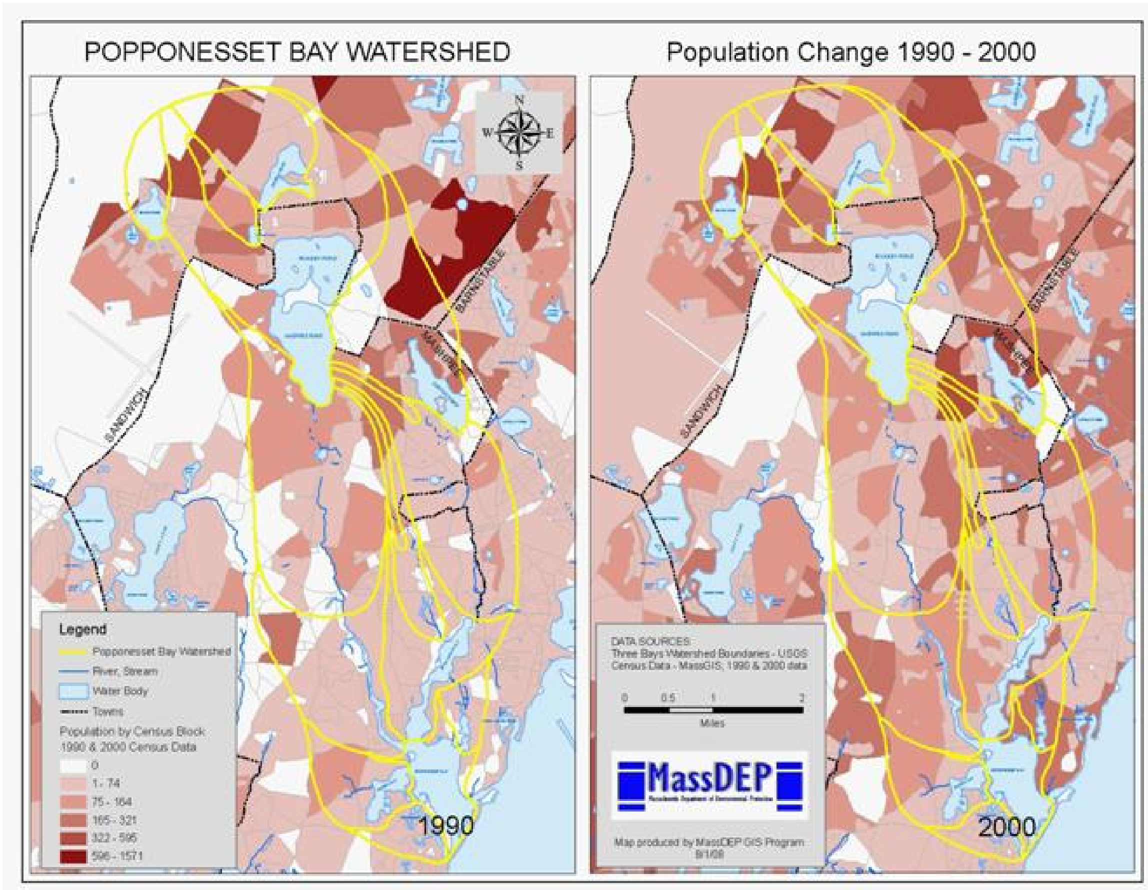


Figure 2.11 Change in population density in the Popponesset Watershed from 1990 to 2000 (US Census)

2.5 Building the Popponesset Bay Watershed Team

This Pilot Project relied on a team of key local officials and citizens, with Mashpee as the lead town with support from the Cape Cod Commission, MassDEP, and SMAST (Table 7). In addition to the three town leads, membership included staff from Mashpee's Offices of Health, Conservation, Shellfish, and Waterways, and the Planning Board. The key players from Barnstable were from the Department of Public Works and the Growth Management Department. Sandwich's key player was the Health Agent (appointed position). Key players from environmental organizations included the Mashpee Environmental Coalition, Three Bays Preservation, Cotuit Waders, and Nantucket Sound Keeper. The title of these individuals is less important than their ability to collaborate regionally and to connect with other key staff and elected officials from their towns. Staff from SMAST attended in the early stages of the Pilot and to develop and discuss modeling scenarios. Consulting engineers and Barnstable County staff also attended occasionally or as requested.

Prior to the first meeting, MassDEP met with key officials in each town to explain the project and requested that each town agree in writing to provide the time of local officials and staff needed to move the process along. The groundwork for initiating and engaging inter-municipal collaboration within the Popponesset Bay Watershed had already been established by Mashpee's pre-existing watershed wide wastewater management planning, involving participation of town officials from the towns of Sandwich and Barnstable as Citizens Advisory Committee (CAC) members.

Table 2.7 Popponesset Bay Pilot Project Team

Name	Affiliation
Baker, Edward	Mashpee Environmental Coalition
Barker, Claire	MassDEP, Project Manager (former)
Counsell, Lindsey	Three Bays Preservation\Barnstable Growth Management Department (former)
Buschinfeldt, Evelyn	Mashpee Environmental Coalition
Dudley, Brian	MassDEP, MEP Coordinator, Hyannis
Eichner, Eduard	Cape Cod Commission – Water Scientist
Ells, Mark	Town of Barnstable, DPW Director
Fudala, Tom	Town of Mashpee, Planning Department and Sewer Commission
Hanks, Jim	Town of Mashpee, Chair Waterways Commission (former)
Kane, Beverly	Town of Mashpee, Chair Planning Board
Mason, David	Town of Sandwich, Board of Health/Water Quality Advisory Committee
Molloy, Ken	Cotuit Waders
Rockwell, Heather	Nantucket Sound Keeper
Saad, Dale	Town of Barnstable, DPW Special Projects Manager
Solbo, Steve	Town of Mashpee, Conservation Agent (former)
Weissman, Mark	Massachusetts Marine Fisheries Commission
York, Rick	Town of Mashpee, Shellfish Constable
Zoto, George	MassDEP, Project Manager, Hyannis

2.5.1 Team Meetings

The Pilot Project Team met, on average, once a month over five years from 2003 to 2008 and covered a broad range of issues affecting the restoration of water quality to the Popponesset Bay system.

Team meetings focused on:

- In-depth understanding of the Technical Report and use of the Linked Model.
- Review of the nitrogen reduction scenario described in the MEP Technical Report (Chapter 8.3) to help develop alternate nitrogen reduction scenarios to be evaluated through additional modeling.
- Three model runs by SMAST proposed by the team to determine if the alternate reductions achieve the threshold concentration at the sentinel station in Popponesset Bay by testing the results of non-sewering alternatives such as on-site septic denitrification systems, and natural attenuation in old cranberry bogs.
- Allocation of load reduction responsibilities between towns.
- Discussion of local and state wastewater management and regulatory issues.
- Providing outreach to the local community on results of case studies and interact with other case study communities on nitrogen reduction issues of mutual interest.

Initially, staff from SMAST attended to introduce the MEP approach for data collection, quantification of nitrogen loads, and the environmental "what if" inputs to the MEP Linked Model for use in calculating outcomes for reducing watershed nitrogen loads and/or its allocation by town.

Town staff from other offices typically attended meetings that addressed technical and policy related issues in their area of expertise and responsibility; however, as the focus shifted to the broader management and multi-town issues, they were less likely to attend. A key success factor was their staying abreast of the project through meeting notes, and becoming involved at times when a topic was important to their work.

The impact of having one town take the lead on implementation may be mixed: on one hand, it was clear that Mashpee will move ahead with planning and implementation regardless of the planning by the towns Sandwich and Barnstable. At the same time, the towns with a minority stake may not participate because their focus may be on the watersheds within their town borders where they are the lead or because town officials and citizens may not fully understand or agree with the nitrogen loads they are responsible for reducing. For example, with only 25% share of the watershed and none of it fronting on Popponesset Bay or the Mashpee or Santuit Rivers, it may be a hard sell to convince Sandwich taxpayers about their responsibility for reducing their contributions to the Popponesset Watershed. They may view that they would derive no benefits from such a costly action as their coastal frontage is to the north, on Cape Cod Bay, where its residents have easy access to the town beaches and boat landings.

During its first two years, the Popponesset Bay Pilot Project Team spent a great deal of its time becoming familiar with the fundamentals of wastewater pollution and wastewater management options, including:

- Wastewater Loads: Treatment Plants and Onsite Systems
- Pollution Prevention: Fertilizer Management, Water Reuse and Conservation, and Stormwater Management
- Enhanced Natural Attenuation
- Other: Aquaculture, Weed Harvesting, Dredging, and Inlet Alteration

These options led to more detailed discussions concerning the reduction of each town's nitrogen load as a shared responsibility as outlined below and presented as SMAST Technical Memos describing the outcome of scenario runs for the nitrogen reductions proposed by the Team. The technical issues discussed, and presented in this report, also include:

- Wastewater Nitrogen Load Allocations
- Nitrogen Load Reduction Scenarios
- SMAST Technical Memoranda
- Water Quality Monitoring
- Monitoring Requirements and Data

2.6 Assessing and Characterizing the Problem

As part of the MEP, the health of the estuarine habitat was evaluated for use in establishing the water-quality threshold to maintain or improve habitat quality. Nitrogen threshold levels are defined by the MEP as "the average water column concentration of nitrogen that will support the habitat quality being sought".

On April 10, 2006, the SMAST and the Massachusetts Department of Environmental Protection determined that the total nitrogen threshold concentration of 0.38 N L^{-1} is supportive for the restoration of eelgrass habitat in Popponesset Bay at its designated sentinel station at the upper portion of Popponesset Bay and the mouth of Shoestring Bay (Howes et al., 2006; MassDEP TMDL, 2006). This threshold concentration stems from field assessments of water quality where eelgrass beds exist. These beds are located in: (1) Stage Harbor, Chatham where tidal water also exchanges with Nantucket Sound and for which a MEP target has already been set; (2) Waquoit Bay where a vestigial eelgrass bed exists near the inlet (measured TN of 0.395 mg N L^{-1}, tidally corrected <0.38 mg N L^{-1}); (3) West Falmouth Harbor and (4) other Cape Cod systems with similar nitrogen dynamics.

The nitrogen load reductions identified to achieve the 0.38 mg N L^{-1} threshold concentration at the sentinel station in the estuary from each of the five sub-watersheds ranged from 1 to 26 kg/day. These load reductions for each sub-watershed were the basis for discussion – to identify an equitable approach to reduce the contributing loads from each town's portion of the watershed. The Popponesset TMDL report should be consulted for a more detailed presentation. (http://www.mass.gov/dep/water/resources/tmdls.htm - popp)

2.6.1 Enhanced Natural Attenuation: Potential of the Santuit Pond Preserve

A number of sites in the Popponesset Bay watershed were studied to evaluate the potential of utilizing enhanced natural attenuation to reduce the nitrogen loads in groundwater. The Team focused on an area of abandoned cranberry bogs in the Santuit Pond Preserve; an area bordering the Towns of Mashpee and Barnstable and jointly owned and managed by the two towns and the Commonwealth's Division of Fish and Game (Figure 2.12).

The Preserve's 293 acres of forest and open land, with upland habitat, wetlands, vernal pools, and portions of Santuit Pond and the Santuit River in addition to abandoned cranberry bogs appeared to have significant potential for nitrogen attenuation. The area of interest includes eight or more abandoned cranberry bogs on the west side of the Santuit River, ranging from less than 1 to several acres. Two of the bogs abut the Santuit River. Except for the two western-most bogs, all have standing water at some time during the year; the amount of periodic flooding and/or standing water seems to have increased in the years since the bogs were abandoned.

Two proposals were discussed by the Team and modeled to determine the potential of reducing the nitrogen loads by natural attenuation. These enhancements for improving natural attenuation included:

- Deepening of abandoned bogs into open water ponds.
- Converting abandoned cranberry bogs to freshwater wetlands, thereby increasing the sinuosity of streams and the opportunity for denitrification by stream and wetlands sediments.
- Modifying the historic flow regime to maximize the ponding that takes place in many abandoned cranberry bogs, thereby increasing retention times.

In the fall of 2005, staff from MassDEP, Barnstable, Mashpee, and Three Bays Preservation walked the area to evaluate site conditions and its suitability for the needed changes. During this period, SMAST, Three Bays Preservation, and the Town of Barnstable began sampling flow rates and direction, nitrogen transfers among bogs, and the nitrogen discharge from the bogs to the river.

Utilizing the results of their field studies, the Pilot Team requested SMAST's assistance to analyze the potential of natural attenuation from two proposed alterations: 1) deepening three bogs to create ponds enhancing their function and increasing the watershed area from which nitrogen would be drawn; and 2) managing the flow regime through a greater number of bogs. In brief, three bog/ponds (Bogs A, B, C) within the Santuit Pond Preserve would be "converted" to fresh ponds to enhance natural attenuation (Figure 2.12). The two eastern bogs are permanently flooded. It was discovered that deepening the three bogs was estimated to promote a very small gain in natural attenuation because of the small amount of flow to the Santuit River (~ 5 % during winter and ~ 25% during summer of (2005-2006) captured by the up gradient bogs system. Based on the limited data set, these limited flows regimes appeared to have a nitrogen attenuation of > 160 kg N/yr west of the bogs and between 200-240 kg N/yr when the adjacent bogs are also removing additional nitrogen. However, when the flows and pond/wetland management are optimized by increasing the attenuation efficiency to 40-50%, SMAST estimated a conservative increase in N removal of 320-400 kg N/yr and still higher rates of removal when flooding promoted natural plant species uptake.

SMAST suggested that natural attenuation could be enhanced by increasing the flow regime. Based on the flow and natural attenuation calculations in one bog during a 3-month period, SMAST estimated a 40 – 50 % increase in natural attenuation efficiency with the potential of attenuating 400-600 kg N annually by optimizing flow between the ponds and maintaining flooded conditions. This suggests that natural attenuation has the potential of removing 500 kg N/year and the avoided cost of sewering 90-95 homes, based on an estimated 5.3 kg/year (2.1 kg/N/yr per person x 2.54 persons per household in the watershed) of nitrogen discharged per house.

At best, SMAST's Linked Model calculations were estimates. More data collection is required for use in considering the true nitrogen attenuation potential of the Santuit Pond Preserve bogs. Based on SMAST's recommendations, the Popponesset Team will continue to collect additional data to quantify the true potential of the nitrogen attenuation option of the bogs. Additional modeling will be needed when field study results become available on the composition and depth of the bottom sediments; the underlying aquifer materials, including year long groundwater and surface water flow patterns through this system; and quantitative evaluations of nitrogen removals under managed conditions for the watershed acreage and flow regimes; especially during the critical summer months. The Management Committee has approved a survey of the site to determine historic flow patterns among bogs, and SMAST is continuing its monitoring in order to obtain 12 months of data on flows and current attenuation. Future steps require hydro-geological studies to evaluate the capacity for flooding or deepening the bogs to increase the retention and contact time with the bog muck sediments to enhance the potential of nitrogen removal by natural attenuation. Local officials will also need to evaluate the desirability of having open water in each bog.

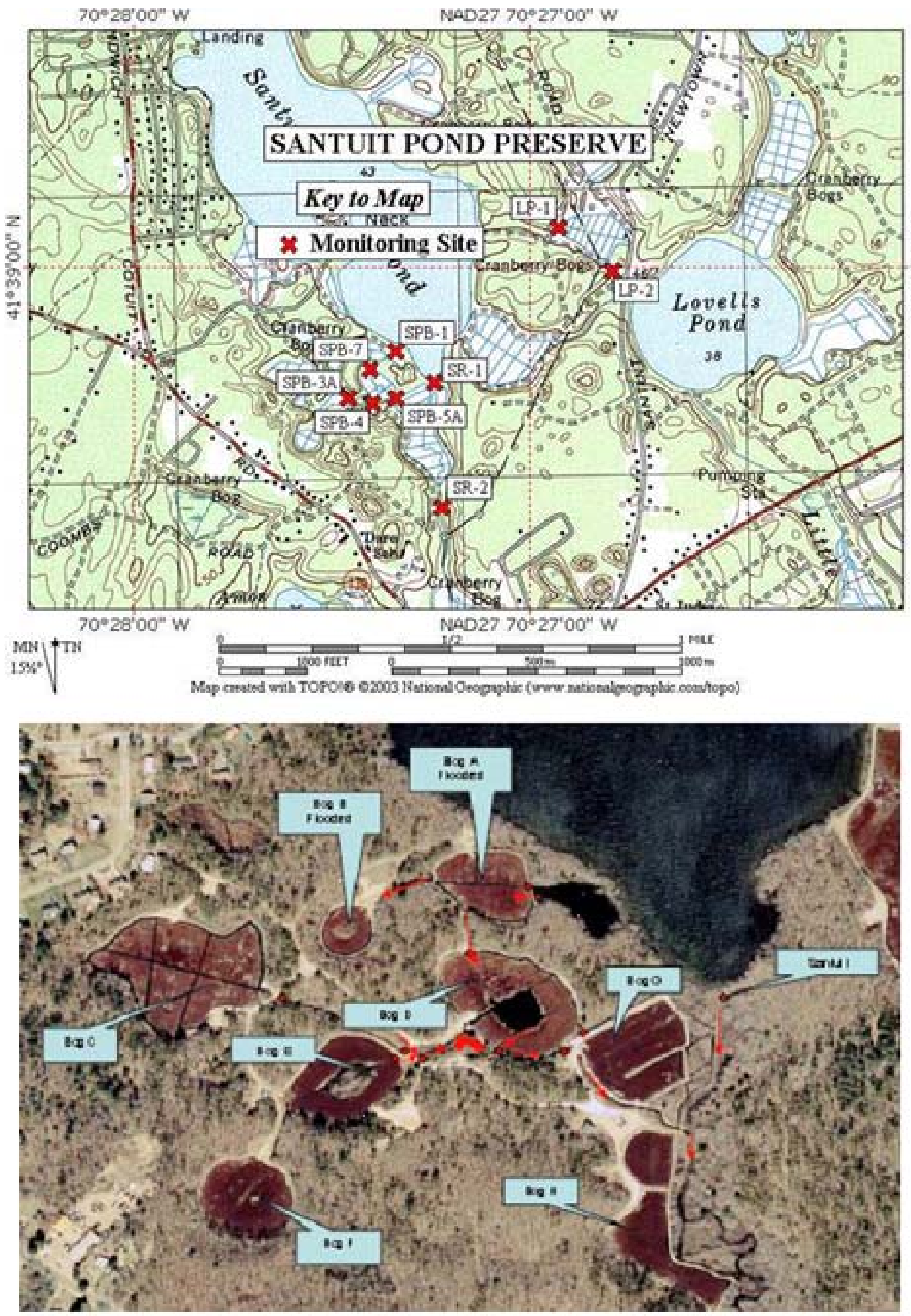


Figure 2.12 Santuit Pond Preserve - Map and aerial view of monitoring sites, courtesy of Three Bays Preservation, Inc.

In addition to potentially avoiding the cost of sewering a significant number of houses in this area, restoration of the bogs will likely increase habitat diversity, by replacing a monoculture with native vegetation, and make the area more attractive the public for passive recreation.

In response to this interest in natural attenuation as an alternative to wastewater treatment, MassDEP initiated a scientific and regulatory review to govern this strategy. Massachusetts has some of the nation's most protective wetland regulations: the Wetlands Protection Act Regulations at 310 CMR 10. The Wetlands Protection Act does have room for projects that impact a wetland resource but provides for overall resource enhancement. Existing examples are fish ladders and management of invasive species in ponds. MassDEP's Guidance for Aquatic Plant Management in Lakes & Ponds describes the Department's approach to resource enhancement projects.

Extending this approach to projects that enhance natural attenuation of nitrogen will require balancing the various interests of the Wetlands Protection Act. For example, alterations could negatively impact a freshwater wetland (e.g., destruction of bordering wetlands vegetation) in order to improve water quality in a downstream estuary.

The following key elements of the Guidance are already clear.

1. Enhanced natural attenuation cannot be the only method used for attenuating nitrogen in a watershed, but must be considered in conjunction with other strategies that also includes wastewater treatment, stormwater and fertilizer controls, and water conservation. Enhanced natural attenuation may be useful in combination with other attenuation alternatives such as wastewater treatment and stormwater management.
2. Alterations in different resource types will raise different issues with the Wetlands Protection Act. The following list ranks protected resources in increasing order of concern:
    a) Creation of wetlands constructed from uplands raise the fewest concerns
    b) Wetlands systems which have already been altered, e.g., recently abandoned cranberry bogs
    c) Resources which have been altered, but are long-standing (e.g., long-abandoned cranberry bogs)
    d) Conversion of one type of resource to a different type
    e) Alteration of pristine, well-functioning wetlands would raise the most concerns. Salt marshes are of particular concern because of their limited scope and high ecological value. Although the Wetlands Protection Act does not have a resource enhancement exemption for coastal habitat, projects that enhance the salt marsh are allowed under 310 CMR 10.32 (5).
3. Alterations must demonstrate a positive impact on the interests of the Wetlands Protection Act. Strong cases for alteration will have the following characteristics:
    a) Large number of wetland functions supported (e.g., pollution prevention, fish habitat, preventing erosion and siltation)
    b) Documentation of negative impacts and efforts to minimize the impact
    c) High percentage of nitrogen attenuation
    d) Ability to predict and measure attenuation.

The first step in MassDEP regulatory evaluation of Enhanced Natural Attenuation has been a search of scientific literature to document the effectiveness of natural attenuation of nitrogen in different types of wetlands and waterbodies, describe optimal designs and site modifications to enhance existing natural attenuation rates, and establish data needs for review of natural attenuation project proposals. The Pilot Project funded this work by the Woods Hole Group of Falmouth, MA. See Appendix H for the Executive Summary of this report or download one or more of the project deliverables listed on page 13 of the Estuaries Project Report: Natural Attenuation of Nitrogen in Wetlands and Waterbodies.

A detailed discussion of the Santuit Pond Preserve study is presented as scenario 3 in the SMAST document "*Popponesset Bay: Results Pilots Modeling Scenarios –Final*" dated May 2, 2006, with final revision dated June 15, 2006 (Appendix I).

2.6.2 Aquaculture: Shellfish Growing and Harvesting on the Lower Mashpee River

In 2004, the Mashpee's Shellfish Constable initiated a pilot project to determine the potential for growing oysters to attenuate nitrogen in the lower Mashpee River (Appendix J)

The Shellfish Constable's working hypothesis is based on the belief that the addition of significant numbers of oyster seed to this embayment system via shellfish aquaculture can have an important role in reducing the nitrogen loads affecting the estuary, through nitrogen attenuation and denitrification in sediments under the shellfish growing area. Because these animals are filter feeders, it is believed that their increased presence can have a significant role to reducing the system's total nitrogen through the assimilation of the phytoplankton into shellfish biomass. Once fully implemented, it is believed that such a project has the potential of removing several hundred kilograms of nitrogen annually, or close to 10% of the amount needed to meet the threshold nitrogen targets. The additional community benefits include the opportunity to educate the public on estuarine restoration and harvesting local oysters.

However, given the Pilot Project Team status and the uncertainties inherent in a biological process, the Local Team agreed that the potential nitrogen reductions from shellfish aquaculture should not be written into a restoration plan.

2.6.3 Harvesting Aquatic Vegetation on the Mashpee River

Several years ago, the Mashpee Wampanoag Tribe proposed to harvest and compost aquatic vegetation on the Mashpee River, with a process used in the Florida Everglades. The Waterways Commission is investigating this option, and more information may be available in the future, following the conclusion of this study. Note that vegetation harvesting raises a large number of technical and regulatory issues. Its potential to disturb the river bottom habitat would also need to be evaluated.

2.6.4 Dredging and Flushing Improvements

The shoreline hydrodynamics along Nantucket Sound is dynamic and heavily impacted by tides, ocean currents, and storms. Openings to the Sound naturally migrate or close. As a result, most Cape communities, including Mashpee through its Waterways Commission, have active dredging programs to maintain and improve existing navigation channels to the town's waterways. Dredging of the inlet to improve flushing of the Bay with each tidal cycle was also investigated by the Pilot Team; an effort led by the Chair of Mashpee's Waterways Commission.

The Popponesset MEP Technical Report (pages 129-135) documented negligible or negative impacts affecting nitrogen concentrations from the dredging of the Mashpee River and the 1916 channel in Popponesset Bay. The Technical Report recommends that the main inlet between the Bay and Nantucket Sound be maintained at its existing cross-section. However, the Mashpee Waterways Commission is exploring other options for dredging with the goal of reducing nitrogen levels through improved flushing while improving navigation at the same time.

2.7 Exploring Implementation Options

2.7.1 Comprehensive Water Resources Management Plans

An important measure of success for this Pilot Project is the usefulness of its results in subsequent local comprehensive planning. The Pilot provided more general modeling than would be done in comprehensive planning, but screened out a wastewater treatment option (denitrifying onsite systems) and raised the potential for an innovative reduction alternative (enhanced natural attenuation in wetlands). However, this discussion of the Pilot's findings and recommendations are much less detailed than that provided in comprehensive planning, particularly for towns such as Mashpee already engaged in a parallel planning track.

The Pilot focused in later meetings on issues of governance, management and allocation outside the typical scope of comprehensive planning. Ideally, results of these discussions will inform the towns on the way forward on non-technical aspects of restoring Popponesset Bay. In order for the Pilot to benefit local comprehensive planning, it will also be important for members of the Pilot Team to stay involved, either through the Community Advisory Committee or through liaison with the Town Planning Office/Sewer Commission in Mashpee, and the Barnstable and Sandwich officials with planning responsibility.

A watershed-wide nitrogen management plan is the ideal option for coordinated planning and implementation. It might be structured in several ways:

- A watershed-based Plan written specifically for a group of towns.
- One document that pulls together relevant information from plans of several towns.
- One town's plan that addresses watershed-wide issues and contains input from other towns in the watershed (the current Mashpee CWMP approach).

Although shared planning is easiest for towns, all starting their planning at the same time, most MEP towns are at different stages of planning. In these cases, coordination is even more important. Through the Pilot Project, Mashpee, Sandwich, and Barnstable have taken several of the suggestions below made by MassDEP:

- Begin talking together early in the process, by jointly reviewing the MEP Technical Reports and TMDL, discussing shared concerns, and even submitting joint comments on the Technical Report. Discussions and decisions about cost-sharing can happen regardless of whether towns are in the formal planning process
- Schedule inter-municipal briefings on the MEP and Technical Reports.
- Discuss nitrogen attenuation options and request model runs based on input from all towns.
- Coordinate formal planning and construction schedules where possible, or at least share information on individual plans.
- When formal planning begins, appoint Community Advisory Committee (CAC) members from other towns that share the estuary, as Mashpee has done.
- Create a joint written record of mutual decisions and a schedule of key points down the road at which coordination will be needed.
- For towns planning to include a number of estuaries in a town-wide plan, pursue implementation in watersheds solely within their town boundaries and hold off on final decisions in shared watersheds.

2.7.2 Inter-Municipal Collaboration

When towns collaborate to address the nitrogen reductions from their town, they are more likely to consider the time and cost savings involved in the planning and implementation of a watershed-wide

CWMP. MassDEP's primary recommendation is to make decisions on cost sharing separately from decisions on which restoration scenario is the most cost-effective and environmentally appropriate. The second decision should be based on watershed-wide criteria alone, while planning and cost-sharing decisions will be influenced, among other things, by intermunicipal dynamics and public acceptability.

Experience offers four additional guidelines on making cost-sharing decisions:

1. First agree on the criteria for choosing a cost sharing method.
2. Start with the nitrogen load contributions provided by MassDEP.
3. Consider a variety of cost-sharing methods.
4. Consider trading programs as part of cost sharing.

As a further response to this and similar requests concerning inter-municipal collaboration by other MEP communities, MassDEP prepared "Guidelines for Multi-Town Collaboration" for use by a town's leadership when deciding, among its many approaches, some choices for taking action and sharing responsibility for the management and cost for the restoration of water quality.

Concerning the selection of treatment options and the best locations, as defined by the MEP Linked model "what if" scenario model runs, municipal collaboration is more likely to acknowledge the limitations of natural attenuation when the proposed sites for sewering are closest to the estuary where the impacts on water quality are the greatest. As many factors are at play in deciding where, how much, and how to reduce N loading, with some sub-watershed locations more cost-effective than others, the team decided that this issue is strictly a local decision that must be decided by the leadership of each community.

2.8 Allocating Wastewater Nitrogen Loads

2.8.1 Unattenuated and Attenuated Loads

Figure 2.13 illustrates the nitrogen reductions that are possible from natural attenuation. The town of Sandwich's headwater discharge of 10,585 kilograms/year of unattenuated nitrogen, furthest from the shores of the Popponesset embayment system, is biologically reduced to 2,886 kilograms per year by the time it reaches the estuary as an attenuated load. In contrast, the unattenuated load discharges from the towns of Mashpee and Barnstable, with discharges closest to the estuary, have a significantly limited capacity for the reduction by natural attenuation. As a result, the Town of Mashpee is the largest contributor of attenuated nitrogen to Popponesset Bay at 65 percent, followed by Sandwich at 22 percent and Barnstable at 13 percent.

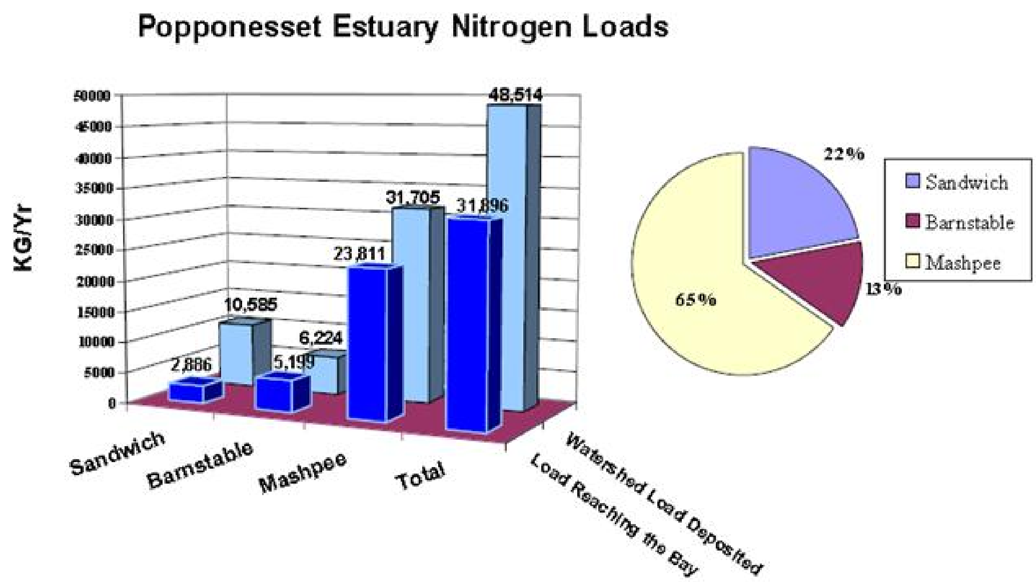


Figure 2.13 Unattenuated nitrogen load deposited in the watershed and attenuated nitrogen load reaching the Bay from each watershed town

2.8.2 Controllable and Uncontrollable Loads

Readers of MEP Technical reports have been introduced to three categories of discharged loads: those that are controllable and those that are uncontrollable, as well as those that are the most practical to control as part of a wastewater management plan. There are distinctions. An example of an uncontrollable load is atmospheric deposition of nitrogen resulting from power plant emissions and other combustion sources that affect water quality. Another uncontrollable load is the regeneration of nitrogen occurring in the sediments of the estuary from benthic flux (the decay of the plant and animal detritus deposited from the water column and from those living in this ecosystem). Since these loads are uncontrollable, they are considered inputs to the model and not a component of the watershed load. In other words, when calculating the maximum load that must be removed from the watershed or embayment, uncontrollable loads have to be handled separately and additional reductions are needed in the watershed to offset the gains from uncontrollable sources.

As defined in the MEP, the controllable sources of nitrogen consist of discharges from on-site septic systems, wastewater treatment plants, stormwater runoff, and fertilizer use (agriculture, lawns/turf). However, it is understandable why the MEP technical report relies heavily on the removal of septic loads of nitrogen throughout the various sub basins of the watershed since septic system discharges of nitrogen represent 63 percent of the nitrogen from all sources and more than 84 percent of the controllable sources (Figure 2.6 and Figure 2.14).

The nitrogen loads reductions discussed at Team meetings focused on the controllable septic loads (excluding atmospheric deposition, benthic flux, runoff, or fertilizer loading), as defined in Table VIII-1 of the Popponesset MEP Technical Report Chapter 8 (Critical Nutrient Threshold Determination...). The septic loads were calculated from drinking water use statistics compiled by the

Mashpee Water District for the 1997 to1999 period, the Cotuit[1] Water District for 1998 – 2000, and the Town of Sandwich Water Department for 1998 – 2000.

The nitrogen loads that affect the estuary, as presented in the MEP Technical Reports, are those that have been microbiologically decayed to nitrogen gas through denitrification (attenuated loads) vs. those loads discharged directly to the ground and not yet denitrified (unattenuated loads). When all is said and done, it's the attenuated load that the estuary "sees". Groundwater discharges in close proximity to the estuary have a limited capacity for natural attenuation and frequently, depending on proximity to the estuary, affects water quality directly as an unattenuated load. For example, the Town of Sandwich, the furthest away from Popponesset Bay, has the greatest nitrogen reduction from natural attenuation that the Town of Mashpee (Figure 2.13).

Towns sharing a coastal watershed should agree on the criteria they would use for deciding the load reductions they would be responsible for in their CWMPs. This may involve a lengthy process for an understanding of the sources that can be controlled by sewering at the source of the discharge, the role of natural attenuation, and the apportionment of responsibility for reducing controllable loads from its turf.
Also, where and how much of a reduction should be planned that addresses the attenuated load limit that each town should not exceed to affect the TMDL sentinel station concentration. As an example, the MEP technical report's scenario for restoring water quality to the sentinel station in the Bay relied on the reduction of septic load reductions as the controllable load because they by in large, represent over 80 percent of the controllable watershed load. As one of many scenarios, Figure 2.14 defines the nitrogen reduction scenario used by SMAST (MEP Technical Report for the Popponesset) that identifies the percent reduction in septic loads (sewering) required to achieve the sentinel threshold concentration in Popponesset Bay. As this figure demonstrates, 100 percent sewering of locations closest to the estuary where the loads are unattenuated and have the greatest impact to the estuary, achieved the target threshold concentration at the sentinel location. This is only one of several scenarios that could have been chosen. However, the scenario a town chooses in its CWMP planning will decide if it is the most cost effective and environmentally sound choice.

A complete presentation of the additional scenario runs the Pilot Project Team requested of SMAST can be found in Appendix L; including the questions asked by the Team and the answers conveyed by SMAST.

2.8.3 Putting It All Together

Deciding how to put these calculations to work in defining what each town within a watershed should do to reduce their share of the nitrogen load is a matter each town will decide, at some point. Keep in mind this exercise is somewhat hypothetical, relying on modeling to define the loads that should not be exceeded, when in fact, the criterion that will determine if compliance is met for TMDL compliance purposes will be the re-establishment of eelgrass or habitat for benthic animals.

With this said, there are controllable loads and those that are not. There are loads that undergo natural attenuation when the geography is advantageous for removing nitrogen and those that do not. As stated previously, there is also the issue of the unattenuated load when close proximity of a discharge to the bay is a factor in releasing the full effect of the load to the estuary. How should towns sharing a watershed decide what reductions are needed at the sentinel station, given the fact that the loads being discharged vary among towns and even within subwatersheds with a same town?

[1] Cotuit is a village in the Town of Barnstable

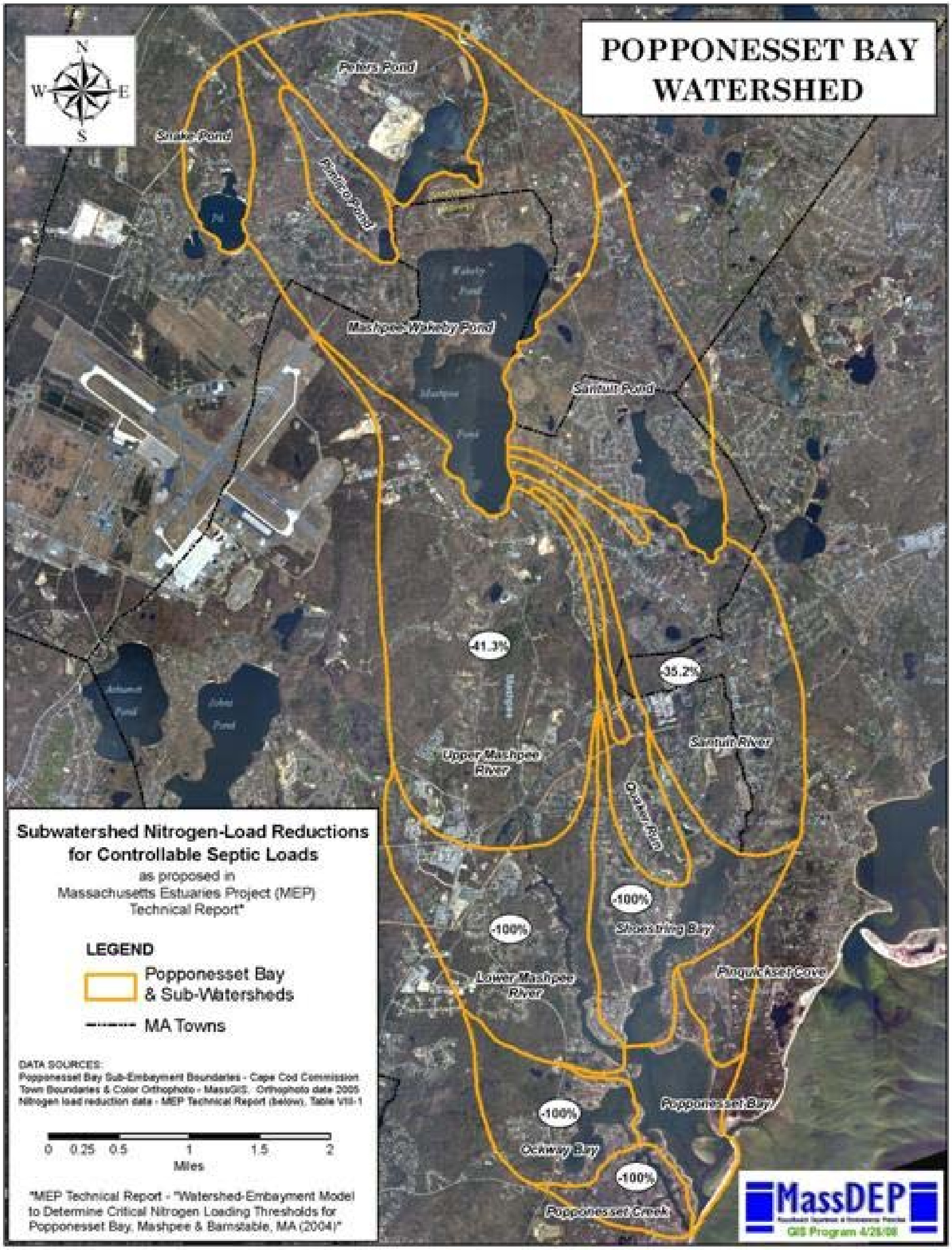


Figure 2.14 MEP Technical Report scenario with the percent reduction in septic loads needed in each subwatershed to restore water quality at the sentinel station
Source: Popponesset MEP Technical Report, Chapter 8, Table VIII-2)

These were issues the Popponesset Team spent a great deal of time discussing. As will be reported, there are different points views on what should be done. First, it should be understood that the MEP Technical and MassDEP TMDL reports are the basis for defining both subwatershed and watershed-wide nitrogen loads with little consideration concerning its town of origin. As a result, town-by-town nitrogen loads, attenuated and unattenuated, were not included. This however, was information the Team desired. Consequently, at the request of the Team, MassDEP calculated the controllable (septic, lawn fertilizers, wastewater treatment, and stormwater runoff) town-by-town unattenuated and attenuated loads utilizing the following formula.

- Unattenuated present loads were based on parcel coverage, where parcels were assigned to a watershed based on which watershed 50 percent or more of the land is located, then the parcel loads were calculated from on-site wastewater systems, wastewater treatment plants, lawn fertilizer and natural systems.

- Impervious surface contributions (i.e. stormwater runoff) were estimated by applying the percentage of each town's area within the watershed to the overall impervious surface area load. These loads could not be calculated directly because town-specific data on road area were not incorporated in the original model.

- Surface water contributions were estimated both from the loads of freshwater bodies completely within each town's boundaries and, for water bodies shared by two or more towns, by apportioning the loads based on the percentage of the water body in each town.

- Estimates of attenuated loads are based on the MEP Technical Report methodology.

The outcome of MassDEP's calculation of town-specific unattenuated and attenuated loads from various sources (on-site septic systems, wastewater treatment facilities, fertilizers, stormwater runoff from impervious surfaces, direct atmospheric deposition to water surfaces, and recharge from natural areas is presented in Table 2.8.

Table 2.8 Unattenuated and Attenuated Nitrogen Loads by Town

Town	**Unattenuated N**		**Attenuated N**	
	Kg/yr	**% of Total**	**Kg/yr**	**% of Total**
Sandwich	10,585	22	2,886	9.0
Barnstable	6,224	13	5,199	16.3
Mashpee	31,705	65	23,811	74.7
Total	48,514	100%	31,896	100%

The nitrogen loads presented in the MEP Technical and MassDEP TMDL reports are based on detailed, parcel-specific calculations for all parcels and portions thereof within the watershed.

This information, derived from the MEP nitrogen loading data and summarized in the Technical Report's "rainbow table" (Table IV-5), served the Team in its discussion concerning the town-by-town assignment of responsibility where each town is allocated an N load for subtracting from its town boundaries. In conjunction with the watershed load limit provided in the TMDL, the town-by-town calculation of loads provided a limit that each town should also not exceed now or in the future as zoning permits at buildout. Table 2.8 defines the actual load reaching the embayment from each town under current (2000 – 2001 data) loads. As Table 5 suggests, the load defined in the Technical Report will need to be updated, as the population for Mashpee which represents 64 percent of the watershed (Table 1) has continued to show a significant 17 percent increase in its population from 1990 to 2006 (Table 6). However, for TMDL purposes, the watershed controllable load shown in Table 8 (reprinted from the TMDL report) should not exceed 40.18 Kg/day for the watershed as a whole. The current "existing" controllable load (2000 – 2001 data) of 76.06 Kg/day must be reduced by 47.2 percent in order to achieve the threshold sentinel concentration for compliance with the TMDL. However, as shown in Table 2.9, the required reductions will not be the same for each of the affected subembayments.

As a result, please note, any plans for reducing loads must take into account the differences in each subembayment. However, these targeted subwatershed threshold loads as presented in Table 2.9 must be further reduced because they did not take into account the loads from atmospheric deposition and benthic flux. Table 2.11 (from TMDL report) accomplishes this final step by either increasing or decreasing the loads that must not be exceeded in each subembayment.

Table 2.9 Nitrogen loading rates from present controllable watershed sources, loading rates necessary to achieve target nitrogen concentrations, and the percent reduction needed to achieve the target.

Popponesset Bay System Sub-embayments	Present controllable watershed load [1] (kg/day)	Target Threshold Watershed Load [2] (kg/day)	Percent watershed load reductions needed to achieve threshold loads
Mashpee River	34.15	16.17	52.7
Shoestring Bay	31.24	19.72	36.9
Ockway Bay	3.15	0.76	75.9
Pinquickset Cove	0.77	0.76	1.3
Popponesset Bay	6.75	2.77	59
	76.06	40.18	47.2

[1] Composed of combined fertilizer, runoff, WWTP effluent, and septic system loadings
[2] Target threshold watershed load is the load from the watershed needed to meet the embayment threshold N concentration of 0.38 mg/L identified in Table 2 above.

The critical element of this TMDL process is achieving the sub-embayment specific N concentrations presented in Table 2.11 that are necessary for the restoration and protection of water quality and eelgrass habitat within the Popponesset Bay sub-embayments. In order to achieve those target concentrations, N loading rates must be reduced throughout the Popponesset Bay System. Table 2.10 lists target watershed threshold loads for each sub-embayment. If those threshold loads are achieved, the overall Popponesset Bay System will be protected.

This loading reduction scenario is not the only way to achieve the target N concentrations. Towns are free to explore other loading reduction scenarios through additional modeling as part of the CWMP process.

Table 2.10 The Total Maximum Daily Loads (TMDL) for the Popponesset Bay System, represented as the sum of the calculated target thresholds loads (from controllable watershed sources), atmospheric deposition, and sediment sources (benthic flux).

Embayment System And Sub-embayments	Range of Average Observed System Nitrogen Concentration [1] (mg/L)	System Threshold Nitrogen Concentration (mg/L)
Popponesset Bay		0.38
Mashpee River	0.958-0.627[2]	
Shoestring Bay	0.690-0.520[2]	
Ockway Bay	0.677-0.536[2]	
Pinquickset Cove	0.527	
Popponesset Bay	0.485-0.422[2]	

[1]Target threshold watershed load is the load from the watershed needed to meet the embayment threshold concentrations identified in Table 2.11. The goal of this TMDL is to achieve the identified N threshold concentration in the identified sentinel system. 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] Projected sediment N loadings obtained by reducing the present loading rates (TMDL Report Table 3) proportional to proposed watershed load reductions and factoring in the existing and projected future concentrations of PON.

[3] Sum of target threshold watershed load, atmospheric deposition load, and benthic flux load.

Table 2.11 Observed nitrogen concentrations at present and calculated target threshold nitrogen concentrations derived for the Popponesset Bay Sub-embayments

Popponesset System Sub-embayment	Target Watershed Threshold Load [1] (kg/day)	Atmospheric Deposition (kg/day)	Benthic Flux [2] (kg/day)	/TMDL [3] (kg/day)
Mashpee River	16.2	0.7	9.4	**26**
Shoestring Bay	19.7	2.2	-8.7	**13**
Ockway Bay	0.8	1.1	1.1	**3**
Pinquickset Cove	0.8	0.3	-0.3	**1**
Popponesset Bay	2.8	4.0	-5.5	**1**

[1] calculated as the average of the separate yearly means of 1997-2003 data. Individual yearly means and standard deviations of the average are presented in MEP Tech Report Tables A-1 Appendix A

[2] listed as a range since it was sampled as several segments (see MEP Tech Report Table A-1 Appendix A)

2.8.4 Allocating Loads a Watershed Scale

The Commonwealth's history of strong local home rule and municipal authority presented a challenge for allocating town-by-town, watershed wide load reductions. With this understood, the team decided that any allocation of responsibility should conform to the following principals.

- Environmental Benefit
    - Make progress toward restoring estuarine habitat and water quality standards

  - Measure progress and use adaptive management as required
- Equity
  - Water quality restoration considers all significant sources of nitrogen
  - All who contribute to the problem and/or benefit from the solutions help pay
  - All towns, regional entities, and other interested parties are included in the decision-making process
- Efficiency
  - Those closest to the problem decide the most cost-effective solution
  - Local, regional, and state stakeholders coordinate on solutions without duplicating efforts
  - Possibilities exist for voluntary solutions and trading
  - State regulations and policies are not unnecessary barriers to solutions

The allocation of nitrogen reductions as a fair and shared responsibility was the most contentious issue for the Local Team, affected by the different ideas of fairness, and the differing interpretations of the MEP Linked modeling results. After much discussion, Team members settled on the following formula.

- The allocation of responsibility for reducing nitrogen is based on a reduction from all existing 2000/2001 nitrogen sources within the Popponesset Bay watershed (septic systems, wastewater treatment, fertilizers, impervious surface discharges, freshwater bodies (atmospheric inputs), and natural surfaces (fields and forests)). These loads do not include direct atmospheric deposition (onto the sub-embayment surface) or benthic flux inputs. These loads, as of 2000/2001, were run through the MEP Popponesset model which determined that a 49.2 percent reduction from 2001 levels would be required to meet the Popponesset nitrogen threshold at the sentinel location in the Bay. The remaining 50.8 percent of the 2001 load constitutes the allowable load for each town.
- All towns should reduce nitrogen by the same percentage of their unattenuated load.
- Require each town or inter-municipal reduction plan to achieve the nitrogen threshold at the sentinel station which, in turn, will to restore the currently impaired eelgrass and benthic infaunal habitats throughout the estuarine system.

From a local perspective, this approach reflects a sense of fairness and burden sharing: since each town contributes to the problem, each town should contribute to its restoration. Furthermore, the voters of a community may resist contributing to the solution unless they know that each town is equally engaged. For these reasons, this team chose the unattenuated nitrogen loads by town, as it reflected the actual loads discharged to the ground that contributed to the problem (albeit less because of natural attenuation).

This approach was deemed “fair” and simple to explain to decision makers and the public, and not dependent on N modeling scenarios.

Model runs would determine the single lowest possible percentage reduction of nitrogen in all sub-watersheds that would meet the sentinel and secondary nitrogen targets. A similar approach, presented in the Popponesset MEP Technical Report, resulted in a watershed-wide reduction of 45.2%, so the concept of an equal percent reduction by town had the possibility of working. The only significant caveat was that both of these analyses were based on greater percent reductions in selected subwatersheds and lower reductions in others.

Determining the watershed-wide average reduction each town would be responsible for reducing required multiple Linked model runs with an anticipated reduction higher than the 47 percent average reduction in the TMDL and the SMAST June 15, 2006 Tech Memo (Appendix I). The goal was to determine if a constant watershed nitrogen load reduction (evenly applied to all watershed sources) could be developed and meet the nitrogen threshold at the sentinel site for Popponesset Bay. The MEP was requested to determine what reduction was needed to meet the TMDL target for the watershed. The result of the MEP Linked model was a 49.2 percent reduction of the watershed load (Figure 15) [refer to Appendix A (Howes, Brian et al. April 6, 2007. Scenario Run of Popponesset Bay, SMAST Technical Memo (Appendix A - Scenario 07-1)]. It was determined that if each town made a 49.2 percentage reduction of its 2001 unattenuated nitrogen load, it would provide the optimal reduction of all sources of nitrogen within Popponesset Bay. When achieved, the nitrogen threshold at the sentinel location would be attained. The model estimated that the sentinel station would be lowered to 0.352 mg TN/L, below the 0.372 mg TN/L threshold developed in the MEP Technical Report and well below the TMDL N Threshold of 0.380 mg TN/L. The infauna "check" stations were also well within the acceptable range (0.4-0.5 mg TN/L). It was determined that the nitrogen reductions produced by this scenario should be sufficient to restore the eelgrass and infaunal animal habitats throughout this estuarine system.

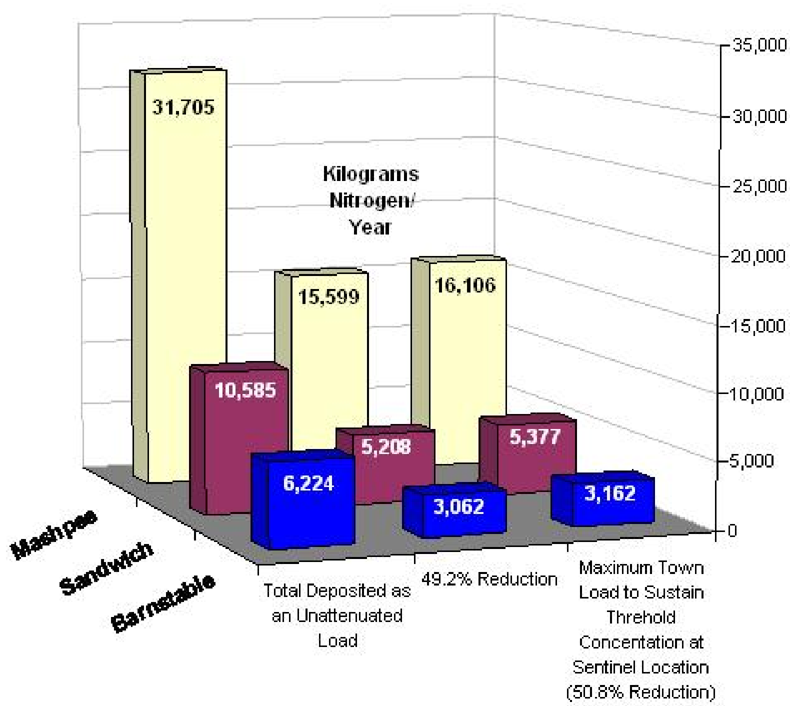


Figure 2.15 Equal Percentage for each town of Nitrogen Reduction Deposited as an Unattenuated Load to the Popponesset Watershed*

*Based on 2001 MEP Popponesset Technical Report loads. A portion of the nitrogen load from Sandwich is contributed by the Massachusetts Military Reservation (369 acres ~ 10.8% within the Town of Sandwich and 2.74% of the land area within the Popponesset Watershed).

As a result, the Team chose to apply the "fair share" 49.2 percentage system-wide reduction from each town's total contribution of nitrogen to the watershed (Figure 2.15). In effect, this resulted in a nitrogen load target for each town of 50.8 percent of its 2000/2001 load. In essence, this 50.8 percent remainder sets in place a permanent target that must not be exceeded in the future to restore and sustain water quality at the sentinel station in the Bay. All of the discussions on allotting responsibility for sharing and the reduction calculations were originally based on attenuated loads at the sentinel location (less benthic and estuary surface, as they were in the hydraulic model). The common thread was whatever arrives at the bay is what impacts it, not what goes into the ground. Both the town percent share calculations and the reduction calculation were based on attenuated values. The TMDL is based on attenuated load and that was the basis for arriving at the 49.2% calculation that was later verified by SMAST modeling.

However, it's important to understand that each of the subwatersheds of a watershed-embayment system, regardless of being in the same or different towns, have different attenuation factors. The only way to apply the standard percent reduction to a town's unattenuated load is to apply it evenly to each subwatershed because each subwatershed within a Town can have different attenuation factors and as a result generate different outcomes at the sentinel location.

For most towns this means reducing the septic load, as this load in the Popponesset Watershed represents 63 percent of all the loads (Figure 2.6a) and 84 percent of the controllable loads (Figure 2.6c) and is the easiest controllable load to reduce. By reducing this load and to compensate for the loads that cannot be controlled from atmospheric deposition and benthic flux (Figure 2.6a), the load that finally reaches the estuary as an attenuated load is sufficient to comply with the 0.38 mg/L system threshold nitrogen concentration at the sentinel station. The actions a town would propose to meet their target will require further scenario runs because the attenuation factors for each subwatershed are different.

Towns sharing a watershed resource elsewhere are free to decide on another approach for their watershed wide reductions. Deciding where to reduce the unattenuated loads can make a huge difference in terms of effectiveness and cost. Also, the reduction of all existing nonpoint source loads that go beyond septic loads will not be easy, as it includes impacts from fertilizers and stormwater runoff from impervious surfaces. Also important to remember, towns in coastal watersheds that already exceed their nitrogen limit will continue to grow. With this in mind, towns must plan for the future to address the loads that already exceed the carrying capacity of these estuarine ecosystems. They must plan for buildout conditions that zoning allows accommodating this future growth while protecting water quality that promotes healthy eelgrass and benthic animal habitat.

The reduction of nitrogen discharged by each town reduces the watershed loads before it has secondary impacts to down-gradient lakes and ponds. It reinforces the message that everyone living in the watershed is responsible for its share of reduction through a MassDEP approved CWMP. Secondly, it was reasoned that it does not require model runs and defines each town's reduction through a simple subtraction. In addition, the equal reduction method establishes the means to calculate an allocation for each town and sub-watershed. The allocated load could be achieved by each town individually or by purchasing reductions if an adjoining town is able to reduce the load more cost effectively.

2.8.5 Calculating the Town Nitrogen Load

It must be understood that the MEP uses the attenuated load to determine the effect of the land based nitrogen load on coastal water quality at the sentinel station. As such, it's the attenuated load from each town and its subwatersheds that is the significant factor. It's important for the reader to understand that the nitrogen reductions required by each town to achieve the threshold concentration must take into account, on a site-specific subwatershed basis, the fact that each sub-watershed's capacity to attenuate a nitrogen plume will vary because the "natural attenuation factors" vary in number but also in magnitude.

As a consequence, calculating a town load reduction must first take into account the site-specific attenuation factors affecting nitrogen denitrification within each subwatershed. This means wastewater management planning to determining what load must be reduced, must begin by back calculating from the attenuated load that affects the sentinel station from each subwatershed. Back calculating requires an understanding where attenuation will or will not take place in each subwatershed. Each time adding the percentage gained based on the number and magnitude of each natural attenuation factor until the sub-watershed's headwaters location has been reached. Technically this is the unattenuated load that must be reduced for that subwatershed of the town. Following similar calculations for other subwatersheds, the town will result in an unattenuated load for reduction. Thus, when planning the 50.8 percent load max, town planners will need to take the attenuation factors within each subwatershed into account when they decide where the loads must be reduced and by how much. When decided, it will be the unattenuated load that will be identified for reduction.

MassDEP calculated the attenuated and unattenuated loads for each subwatershed before calculating the attenuated loads for each town. As we know, some subwatersheds will have a greater reduction from natural attenuation because of the number of lakes and ponds the nitrate plume passes through. Other subwatersheds, without lake and pond attenuation factors will not "see" a reduction at all.

2.8.6 Follow-Up

The load targets proposed by the Pilot Team as a shared responsibility provide a useful tool for towns to consider. It is, however, only one approach. Towns should discuss and agree if this makes sense to them. Once decided, the Towns may chose to work on this alone or to collaborate for a joint proposal through an inter-municipal agreement that addresses the required watershed wide reductions.

Yet, the town-by-town approach may unnecessarily duplicate planning efforts and may not be the most environmentally and cost effective means for decisions affecting where and how much to sewer within the watershed. It also requires time and money for the model runs to calculate the single town, subwatershed-wide percentage reductions that are needed to meet the targets. It also creates a potential problem of "over-controlling" nitrogen.

As there are many factors at play in decision making for reducing nitrogen loads (type of treatment, where and how much to sewer), with some sub-watershed locations more cost-effective than others, the Team decided this issue is best decided by the leadership of each community. As a first step, at their May 2007 meeting the Team agreed that they had accomplished as much as they could. Their appointment to the team by their communities did not authorize them to do more than to participate and contribute to the dialogue on a shared responsibility to reduce nitrogen loads by promoting inter-municipal watershed-wide, regional planning. Their role was strictly related to wastewater management planning and as such they were not in any position commit their town to do more.

They did not have the authority to act as liaisons to their towns or commit their towns to the teams findings and recommendations. To complete their charge the Pilot Team decided it should first focus on a presentation of its findings and recommendations on wastewater management to their town's leadership.

It was agreed that the presentation would discuss the topics.

- The town-by-town nitrogen allocation;
- The equal percent reduction for each town;
- The attenuated nitrogen load affecting the Bay from each town vs. the unattenuated load discharged to the watershed;
- The progress each community has made or is undertaking to reduce nitrogen loads to the watershed;

- The makeup of and tasks for an inter-municipal committee for a Popponesset Bay CWMP – discussing whether the current committee makeup of the Popponesset Bay Project is a useful model, discussing and agreeing on the nitrogen reduction measures and costs that would be pursued to the Popponesset Bay Watershed as a whole

It was the hope that these presentations to would lead to inter-municipal dialogue and agreement on a course of action that would lead to a Memorandum of Agreement to address the "fair share" reductions proposed by the Team. Ultimately, to address these matters, an inter-municipal planning committee on such matters may be necessary with membership authorized by their towns for advice on how to proceed; or to take advantage of the CWMP currently in preparation by the Town of Mashpee that addresses the required reductions for the entire Pleasant watershed.

The first presentation by the Pilot Project was to the Town of Sandwich's recently appointed Water Quality Advisory Committee (WQAC) at its first meeting in November 2007. Presentations were also by attended by Mashpee's CWMP consultant engineers, Stearns and Wheeler. Topics discussed were the Pilot Project Team's accomplishments; including the MEP methodology, how the MEP data was used to derive the "fair-share" percentage nitrogen reduction, and the proposal for an inter-municipal committee with the authority to represent each town's interest in CWMP planning and implementation. The Pilot Project's findings and recommendations, identified below, resonated favorably with the WQAC.

- An inter-municipal committee representing the views and interests of each town saves money for a CWMP that the town would not have to fund on its own;
- Time is still on their side to partner with the Town of Mashpee for a CWMP that could address Sandwich's needs as well (far better than waiting until 30-day MEPA comment period when the final CWMP is under review for approval by EOEEA); and
- The ability to perform nitrogen reduction scenario runs as an inter-municipal planning committee for the important CWMP decisions concerning best locations for sewering, treatment and groundwater discharge with the goal of achieving the most cost effective environmental benefit" – not to mention the implications related to nitrogen trading among the three towns.

Unfortunately, at the time of this meeting, the Town of Sandwich had not initiated any wastewater related planning to address the TMDLs that had been prepared for Popponesset Bay and the Three Bays watersheds – nor had Sandwich been able to identify available funding.

During May 2008, the Sandwich Board of Selectmen had authorized the town to hire a consultant to advise the Water Quality Advisory Committee on all maters related to the MEP and the planning that is underway in the Towns of Mashpee and Barnstable. Unfortunately, this authorization must wait until funding becomes available to the Town from the Commonwealth, as the town had budget constraints to sustain existing programmatic needs.

The second presentation before the Mashpee Sewer Commission also resonated favorably with the WQAC. It was clear that the Town of Mashpee is open to developing a cooperative agreement with the Towns of Barnstable and Sandwich that could include the provision for creating an inter-municipal committee for CWMP implementation, including adaptive management. To further such an endeavor, it was recommended during one of the last meetings of the Pilot that the towns of Sandwich and Barnstable should also include a provision in their CWMP for collaborative implementation of their CWMPs.

To this end, the video that was completed recently will be the vehicle to introduce the Pilot and hopefully enlist interest and participation through a formal working agreement with the Town of

Mashpee as it plans to undergo additional scenario runs for deciding the best locations to sewer within the watershed as a whole that also includes locations within Sandwich and Barnstable. It was agreed by all that the opportunity to develop a formal working arrangement that utilizes the CWMP the Town of Mashpee is preparing is one that should not be missed. The CWMP in preparation by Mashpee should be the vehicle to define the three town's joint needs. It would afford the opportunity to assess how a jointly planned proposal for reduction could achieve the results that affords the possibility for buying nitrogen credits for work that would be more cost and environmental beneficial if the reductions are addressed in the next town.

The process for promoting a formal working relation between the towns, utilizing the CWMP the Town of Mashpee has begun. Presentations are planned this September when this report is published and if all goes well the towns will consider the value of a jointly prepared CWMP that addresses their portion of the watershed, including the cost of implementation and the environmental benefits within their town and neighbor's for the watershed and the embayment resource the share.

The rest will be up to the towns' leadership. Will they jointly explore and develop joint strategies for nitrogen reduction that coincides with the recommendation of the Pilot or go beyond the calculations of their relative contribution? Time will tell.

2.9 Final Thought

The plan towns prepare, either alone or jointly, for the reductions identified in one or more scenario runs are the best estimate of the required reductions from the watershed. The science behind this project is the best it can be, but there are limits in how these estimates can be used, as no model is fail safe. Secondly, the parcel data that is collected to define current watershed loads of nitrogen from nonpoint sources of pollution will soon become outdated. For this reason, plans may need to assess whether the buildout projections should be further refined to address future load estimates. What is also important to understand, growth will always be a factor in this equation but this equation will always have a limit that should not be exceeded for each embayment system. The fact that these loads have been from nonpoint sources will not make the resolution of this problem easy. It is important to understand that most embayments systems can achieve their thresholds without 100 percent sewering. The correct mix of treatment options and locations for sewering should be determined through additional scenario runs, hopefully through the involvement of the towns sharing the resource area with its high dependence on on-site septic systems estimated at over 85 percent. The load limit that the estuary should "see" from the watershed is one that town planners sharing this resource will need to evaluate as an ongoing shared responsibility; making sure treatment capacity within the watershed has adequate capacity and treatment capability for keeping loads at levels that are protective of a restored habitat or one that is undergoing restoration through adaptive management, until those conditions have been restored and maintained.

Chapter 3: Three Bays Pilot Project

Figure 3.1 Aerial photo of the Three Bays Embayment System showing the two outlets that impede tidal exchange with Nantucket Sound
Photo courtesy of Three Bays Preservation, Inc.

Figure 3.2 Floating Algal Mats at Warren's Cove
Photos courtesy of Three Bays Preservation, Inc.

3.1 Three Bays Watershed Facts

Key Feature	TMDL implementation in a tidal estuary
Project Name	Three Bays Watershed and Embayment System Inter-municipal Watershed TMDL Implementation
Scope/Size:	Watershed area: 20.5 square miles (ca. 12,942 acres); approximately 9 miles north to south and just over 3 miles east to west.
Land Type	17% rural undeveloped, urbanizing with 32% residential, 2% limited agriculture
Pollutant	Nitrogen
Wastewater Infrastructure	Watershed is without municipal sewer; is dependent on residential on-site septic systems with the exception of two wastewater treatment facilities, the Horace Mann Charter School and the Cotuit Landing Shopping Plaza.
Hydrology	The Three Bays system consists of five embayments (Cotuit Bay, West Bay/Eel River, North Bay, Prince Cove and Warren's Cove). This embayment system exchanges tidal water with Nantucket Sound through two maintained inlets at both the east and west end of Sampson Island. *
TMDL Development	Nonpoint source nitrogen discharges primarily from residential on-site septic systems and secondarily from fertilizers use associated with cranberry bogs and golf course turf management.
Data Sources	Towns of Barnstable, Mashpee, and Sandwich; Cape Cod Commission; Massachusetts Department of Environmental Protection; University of Massachusetts at Dartmouth - School of Marine Science Technology (SMAST)
Data Mechanisms	Water quality monitoring results, watershed/parcel specific defined estimates of nitrogen loading based on drinking water use records, USGS delineation of groundwatersheds, and MEP Linked Watershed-Estuary Nitrogen Management Model (Linked Model) for calculating load thresholds.
Monitoring Plan	A continuing "funded" commitment at least to 2010 at this time.
Control Measures	Board of Health regulations, two-acre zoning, and stormwater runoff restrictions.

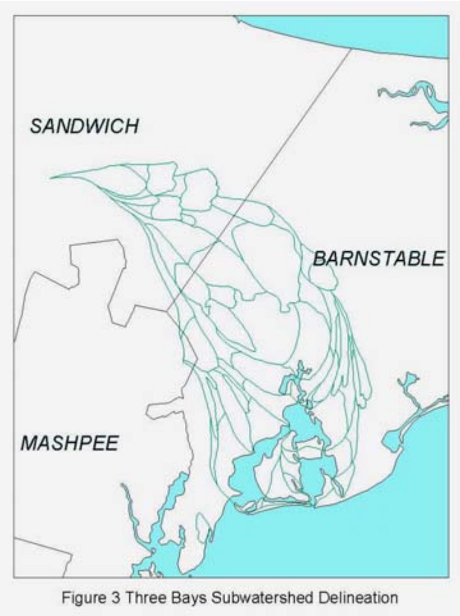
* A complete description of all 5 embayments is presented in Chapters I and IV of the MEP Technical Report (Howes, B. et al., 2006)

3.2 The Three Bays Watershed

3.2.1 General Description

The Three Bays Watershed and its five main subembayments (Cotuit Bay, West Bay/Eel River, North Bay, Prince Cove and Warren's Cover). The estuarine reach of the Marstons Mills River is considered part of the Prince Cove / Warren's Cove subembayment system flowing into the head of North Bay in the modeling and thresholds analysis (Figures 3.3-3.5).

The Three Bays embayment system exchanges tidal water with Nantucket Sound through two inlets at the east and west ends of a barrier beach, referred to as Dead Neck/Sampson Island. The eastern most inlet connecting Nantucket Sound to West Bay was opened by dredging in 1900 and is armored on both the Oyster Harbors Beach/Dead Neck side as well as the Wianno Beach side.



The Three Towns of the Three Bays Watershed

These sub-embayments constitute important components of each Town's natural and cultural resources. However, the nature of these enclosed sub-embayments in close proximity to populous regions of the watershed brings two opposing elements to bear: 1) as a protected marine shoreline they are popular for boating, recreation, and land development and 2) as enclosed bodies of water, where the pollutants they receive may not be readily flushed due to the proximity and density of development along their shores.

The watershed drainage area consists of 13,717 acres and 21 sq miles and ~ 6.9 miles north and south and ~ 3.6 miles east and west (Table 3.1). The major Bay, consisting of Cotuit, West and North Bay is roughly 2 miles long and a slightly over two miles wide -shore-to-shore (Figure 3, No. 26?).

Table 3.1 Three Bays Watershed Land Area by Town

TOWN	Town Area within Three Bays Watershed *		
	Acres	Square Miles	Percent
Barnstable	10,944.30	17.10	79.78%
Mashpee	84.94	0.13	0.62%
Sandwich	2,688.04	4.20	19.60%
Total	13,717.28	21.43	100.00%

* Area includes all water, including estuarine

The entire Three Bays system has a surface coverage of 13,717 acres, including several small subembayments attached to the system's main sub-embayments (Figure 3.3). Cotuit Bay is the largest sub-embayment of the Three Bays system, covering 469 acres. The average depth of the whole embayment is 6.2 ft. West Bay has area coverage of 343 acres and an average depth of 5.3 ft. North Bay has an area coverage of 309 acres, and an average depth of 5.3 ft. Prince Cove together with Warren's Cove and the Marstons Mills River are the northernmost reaches of the Three Bays system, with 93-acre coverage. The Marstons Mills River is the largest surface source of fresh water into the estuary.

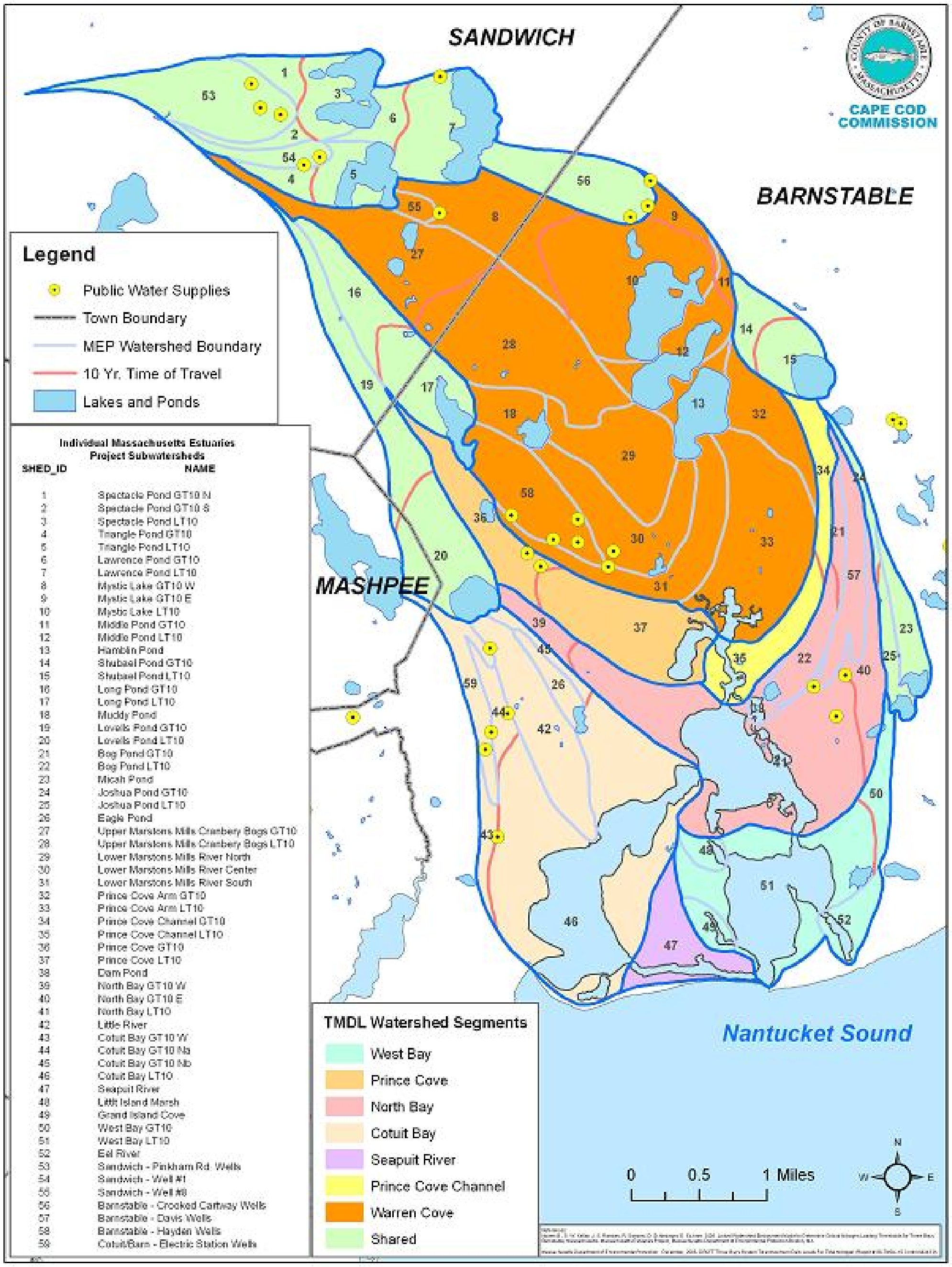


Figure 3.3 Three Bays Sub-embayments: Cotuit Bay, West Bay, North Bay, Prince's Cove, Warren's Cove and Little River, Marstons Mills River and Seapuit River

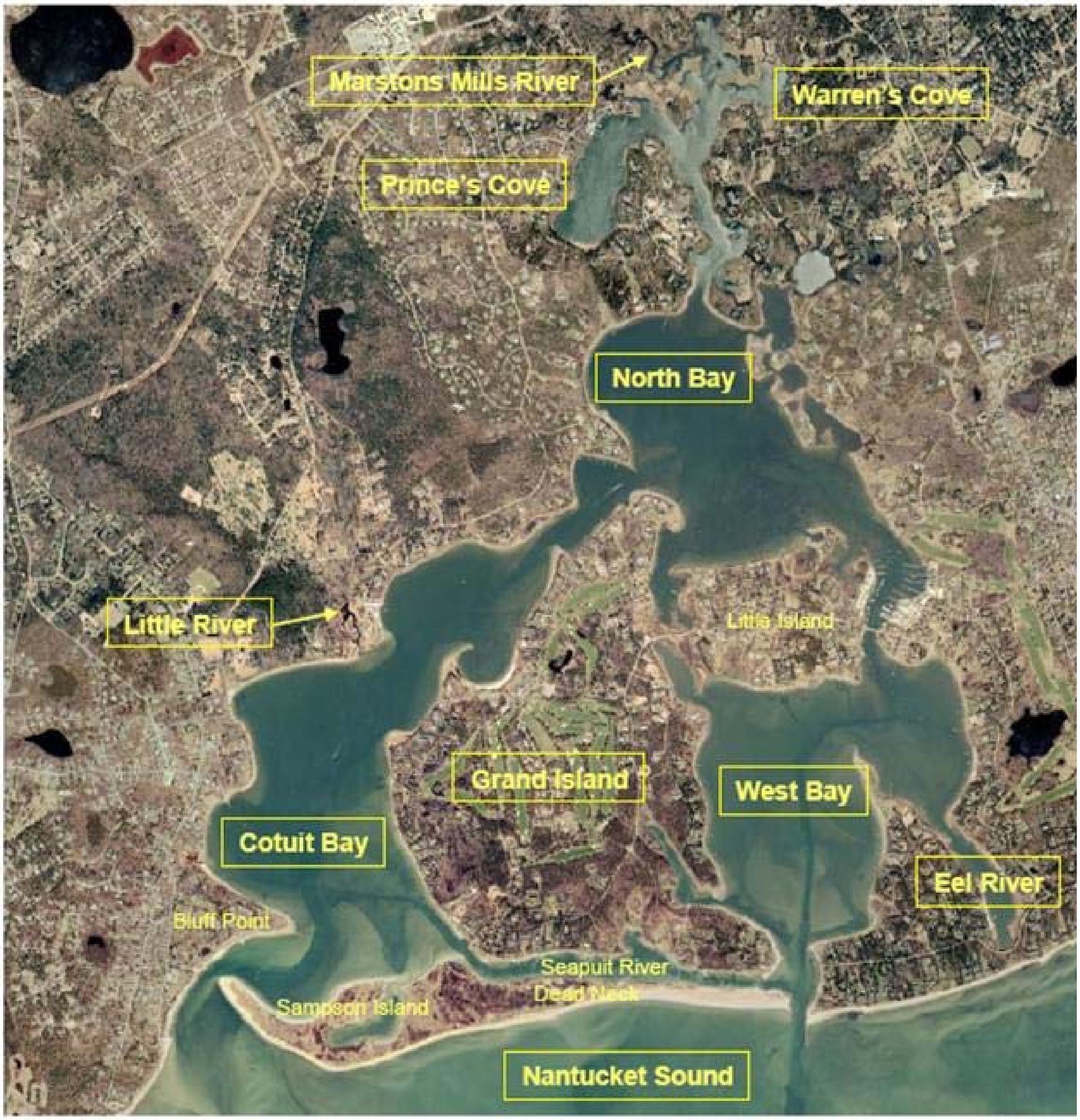


Figure 3.4 Three Bays Embayment System: Tidal waters enter the Bay through two inlets from Nantucket Sound. Freshwaters enter from the watershed primarily through 2 surface water discharges (Marstons Mills River and Little River) and direct groundwater discharge.

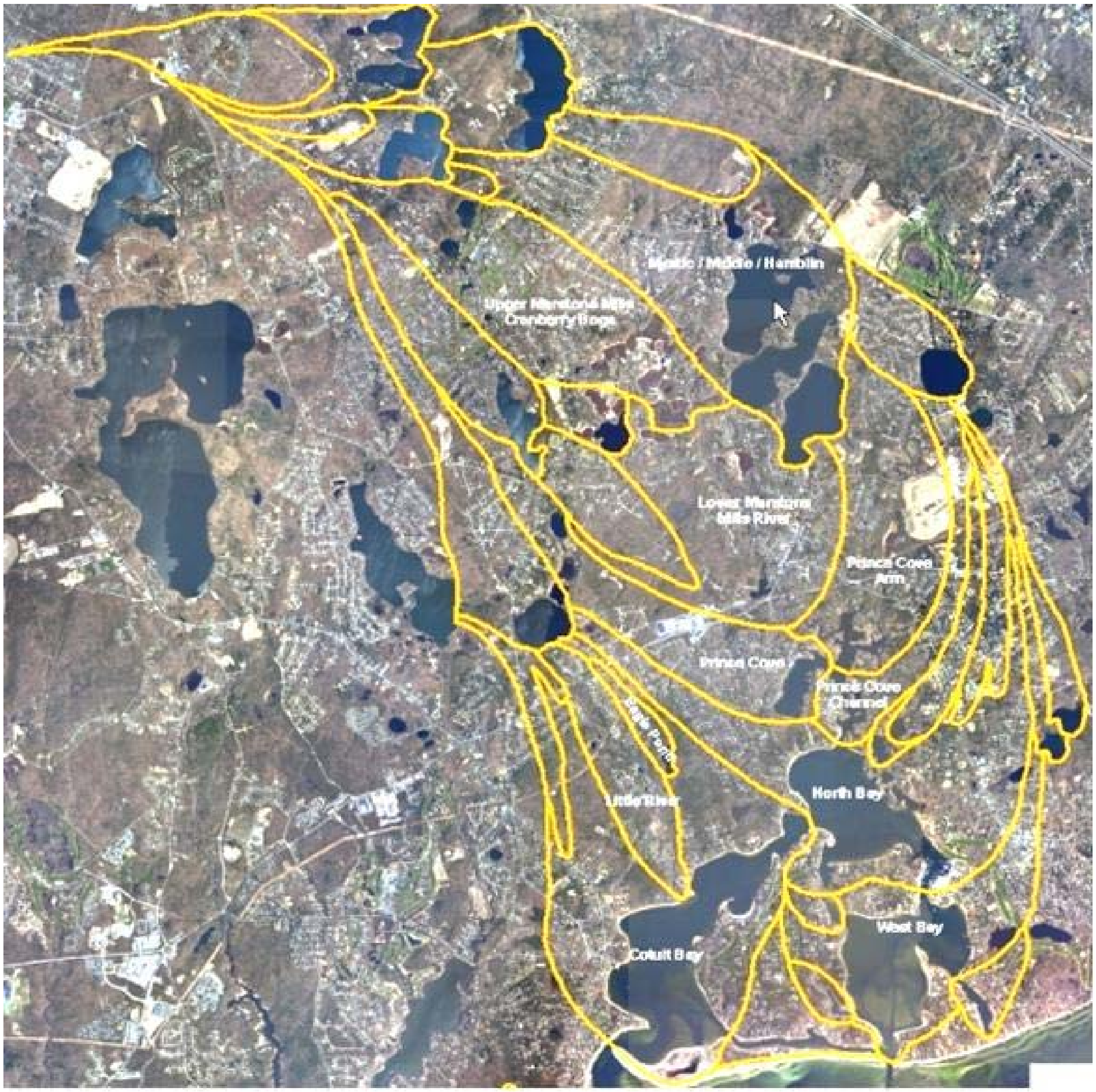


Figure 3.5 Three Bays Sub-watersheds: Cotuit Bay, West Bay, North Bay, Prince/Warren's Cove, Little River, and Marstons Mils River

Eighty percent of the 21.43 square mile watershed area is within Barnstable (Villages of Cotuit, Osterville, Marstons Mills), followed by the town of Sandwich at almost 20 percent, with the Town of Mashpee with less than 1 percent.

Within the Three Bays System, the tidal portion of the Prince Cove and Warren's Cove sub-embayment system (Marstons Mills River), including the upper portion of North Bay, show the greatest diversity of estuarine habitats with most of the System's salt marsh area, shallow tidal flats, and large salinity fluctuations being present in this area (Figure 3.4). In contrast, Cotuit Bay and West Bay show more typical embayment characteristics dominated by open water areas, small fringing salt marshes, relatively stable salinity gradients and relatively large basin volumes relative to tidal prism. Although the upper two sub-embayment systems up-gradient of North Bay and the open water portions of Cotuit Bay and West Bay exhibit different hydrologic characteristics (river dominated versus tidally dominated), the tidal forcing for these systems is generated from Nantucket Sound.

Nantucket Sound, adjacent Dead Neck (Oyster Harbors Beach), exhibits a moderate to low tide range, with a mean range of about 2.5 ft. Since the water elevation difference between Nantucket Sound and the Three Bays system is the primary driving force for tidal exchange, the local tide range naturally limits the volume of water flushed during a tidal cycle (note the tide range off Stage Harbor Chatham is ~4.5 ft, Wellfleet Harbor is ~10 ft).

This southern coastal region of Cape Cod between the Cotuit Bay and West Bay entrances can be considered a moderately dynamic region, where natural wave and tidal forces continue to reshape the shoreline. Due to the protection afforded by the islands of Martha's Vineyard and Nantucket, the south shore of Cape Cod is protected from the influence of long period open ocean wave conditions. Similar to many portions of the Massachusetts coast, the available sediment supply influences the migration and/or stability of tidal inlets. Tidal inlets can become overwhelmed by the gradual wave-driven migration of a barrier beach separating the estuaries from the ocean. In addition to these natural coastal processes, man-made structures often can influence the stability of a shoreline/tidal inlet system.

3.2.2 Geology and Hydrogeology

The Three Bays sub-embayments are of varying size and hydraulic complexity; each defined by their rates of flushing, salinity, and shallow depths and their proximity to a heavily developed and populated sub-watershed.

The hydrogeology of this watershed, like most of Cape Cod, consists predominantly of glacial deposits of sand and gravel. These highly-permeable soils are a major pathway for nutrient transfers from sub-watersheds to the adjacent coastal waters in this region. The presence of both groundwater and surface water pathways for input of nutrients into this and other Cape Cod estuarine systems has a significant impact on its response to changing nutrient loadings with the surrounding watershed from changing land-uses. Overall, this coastal watershed area consists of several small and large glacial kettle-hole ponds with the Marstons Mills River as the major contributor of freshwater to the system.

Unlike off Cape locations where surface topographic features characterize a watershed's boundary and drainage pattern, Cape Cod's groundwatersheds are defined by the elevation and direction of flow of its water table (Cambareri and Eichner 1998, Millham and Howes 1994 a, b). The Sagamore Lens is the contributing source of the Three Bays groundwater. The aquifer's convex shape causes it to resemble a lens and it is often referred to as the freshwater lens. The separation of this freshwater lens and the salt groundwater beneath causes the characteristic lens curvature due its buoyancy and the greater density of the saltwater. This groundwater system is also the recipient of the nitrogen load impacts that are derived from wastewater discharges and fertilizer use throughout this area.

3.2.3 Water Quality

Habitat and water quality assessments were conducted throughout the Three Bays system based upon available water quality monitoring data, historical changes in eelgrass distribution, time-series water column oxygen measurements, and benthic community structure. At present, the Three Bays system is showing significantly impaired to severely degraded habitat quality in the Prince Cove and Warrens Cove sub-embayments as well as the upper portion of North Bay. The lower portion of North Bay as well as Eel River are showing indications of moderate impairment, bordering on significant impairment, while Cotuit Bay and West Bay are both showing signs of moderate impairment (Table 3.2).

The impairment of water quality from nitrogen enrichment frequently results in the depletion of oxygen during the evening hours when the biological systems within the embayment utilize the dissolved oxygen for their metabolic processes; however, the oxygen levels will rise significantly above atmospheric equilibration levels during the day because these systems are dominated by phytoplankton (or epiphytic algae), when they undergo photosynthesis. The level of oxygen depletion and the magnitude of daily oxygen excursion and chlorophyll a levels indicate highly nutrient enriched waters and impaired habitat quality within the estuary. As shown in Table 3.3, Cotuit Bay, West Bay, North Bay and Prince Cove are currently under seasonal oxygen stress with oxygen levels less than 6 mg/L, consistent with nitrogen enrichment and elevated levels of chlorophyll a from the algal blooms throughout the embayment's water column. As a result of these turbid water (high chlorophyll a) conditions, the eelgrass beds that were once supported within this system (Figure 3.7), restricted to the shallows of North and Cotuit Bays or to Prince Cove and West Bay, are no longer present.

Table 3.2 Embayment Waters within the Three Bays System on the 2006 Integrated List

Waterbody Name	Waterbody Segment	Description	Size	Pollutant Listed
Cotuit Bay	MA96-63_2004	From North Bay at Point Isabella oceanward to a line extended along Oyster Harbors Beach, Barnstable.	0.85 sq mi	-Nutrients -Pathogens[1]
North Bay	MA96-66_2004	From Fox Island to just south of Bridge Street and separated from Cotuit Bay at a line from Point Isabella southward to the opposite shore (including Dam Pond), Barnstable.	0.47 sq mi	-Nutrients -Pathogens[1]
Prince Cove	MA96-07_2004	Includes adjacent unnamed cove east of Prince Cove to North Bay at Fox Island, Barnstable.	0.14 sq mi	-Nutrients -Pathogens[1]
Seapuit River	MA96-64_2004	South of Osterville Grand Island to Cotuit Bay and West Bay, Barnstable.	0.06 sq mi	-Pathogens[1]
West Bay	MA96-65_2004	South of the Bridge Street bridge to Nantucket Sound including Eel River, Barnstable	0.52 sq m	-Nutrients

In view of these and past and recent water quality studies that confirmed water quality degradation, the Cotuit Bay, North Bay, Prince Cover, Seapuit River, and West Bay sub-embayments have been listed as waters requiring TMDLs (Category 5) in the MA 2006 Integrated List of Waters. This report can be found at http://www.mass.gov/dep/water/resources/2006cmt2.pdf (Table 3.2). The environmental damage affecting these embayments includes pollutant loadings from nutrients and pathogens, periodic decreases of dissolved oxygen, decreased diversity of benthic animals, and algal blooms.

Table 3.3 Major water quality indicators of habitat impairment observed in the Three Bays System

Waterbody Name	Eelgrass Loss[1]	Dissolved Oxygen Depletion	Chlorophyll *a*[2]	Macro-algae	Benthic Fauna[3]
Prince Cove	100%	< 6 mg/L up to 60% of time < 4 mg/L up to 27% of time SI/SD	>10ug/L up to 93% of time >20 ug/L up to 63% of time SI	MI	SD
Upper North Bay	100%	< 6 mg/L up to 66% of time < 4 mg/L up to 24% of time SI/SD	>10ug/L up to 68% of time >20 ug/L up to 10% of time MI/SI	No data	SD
Lower North Bay	100%	< 6 mg/L up to 46% of time < 4 mg/L up to 1% of time MI/SI	>10ug/L up to 24% of time >20 ug/L 0% of time MI/SI	No data	MI/SI
Cotuit Bay	100%	< 6 mg/L up to 73% of time < 4 mg/L up to 1% of time MI/SI	>10ug/L up to 32% of time >20 ug/L up to 2% of time MI	MI	GF/MI
West Bay	100%	< 6 mg/L up to 49% of time < 4 mg/L up to 19% of time SI	>10ug/L up to 14% of time >20 ug/L 0% of time GF/MI	MI	GF/MI
Warrens Cove	100%	SI/SD	SI	SD	SD

[1] Based on comparison of present conditions to 1951 Survey data.

[2] Algal blooms are consistent with chlorophyll *a* levels above 20ug/L
[3] Based on observations of the types of species, number of species, and number of individuals
GF – Good to Fair – little or no change from normal conditions*
MI – Moderately Impaired – slight to reasonable change from normal conditions*
SI – Significantly Impaired- considerably and appreciably changed from normal conditions*
SD – Severely Degraded – critically or harshly changed from normal conditions*
* - These terms are more fully described in MEP report "Site-Specific Nitrogen Thresholds for Southeastern Massachusetts Embayments: Critical Indicators December 22, 2003

The major indicators of habitat impairment, resulting from excess nutrient loadings, is fully detailed in Chapter VII, Three Bays MEP Technical Report "Assessment of Embayment Nutrient Related Ecological Health" (http://www.oceanscience.net/estuaries/report/3Bays/Chapter7_3Bays_MEP.pdf)

3.2.4 Eelgrass Habitat

The first field surveys of the Three Bays in 1951 documented eel grass beds with significant coverage throughout the shoreline area of the Three Bays (Table 3.4, Figure 3.7 (Charles Costello, MassDEP personal communication) suggesting these waters were of high quality without the impacts associated with nitrogen loading. However, follow-up MassDEP field surveys in 1995 and in 2001 identified an embayment system with a significant decline in eelgrass coverage, from a coverage of 151 acres in 1951 to 11.5 acres in 1995. Unfortunately, the nitrogen loads affecting this embayment system has been sufficient to promote the growth of microalgal blooms during the warm summer months, as the high chlorophyll a levels (exceeding 20 μ/L) indicate (Table 3.3, Figure 3.6)). As is well known, these phytoplankton blooms result in sufficient density in the water column that the seabed no longer receives the sunlight exposure the eelgrass beds require to sustain their energy via photosynthesis and will eventually perish. As a result, the eelgrass beds that were first identified in 1951 have since been replaced by macroalgae, which are undesirable because they do not provide the high habitat quality for fish and invertebrates. Until the water column nitrogen levels are reduced and under control from their contributing sources, it is unlikely that these eelgrass ecosystems will be reestablished as habitat and spawning ground, nursery, and protective cover for commercially important finfish, and shellfish.

Figure 3.6 Floating Algal Mat and Phytoplankton Bloom at South Prince Cove displaying limited light transparency
Photo courtesy of Three Bays Preservation, Inc

Table 3.4 Three Bays Eel Grass Acreage (Past and Present)

Embayment	1951 (Acres)	1995 (Acres)	2006 Acres)	Percent Loss
Three Bays	125	11.2	0	100

3.2.5 Sentinel Station

The upper region of the narrows between North Bay and Cotuit Bay (at the entrance to the Narrows) was selected as the best location for the sentinel station for the Three Bays embayment system. This location was selected because (1) it is relatively deep (reflecting the larger Three Bays basins) and it supported a major eelgrass bed in the 1951 survey; (2) achieving the threshold nitrogen level at this location will result in high quality habitat conditions throughout Cotuit and West Bays; (3) restoration of nitrogen concentrations at this location should result in conditions similar to 1951 within Prince and Warren's Coves and North Bay; (4) nitrogen levels restorative of eelgrass beds at the sentinel location should provide for marginal beds in the shallows of Prince Cove and North Bay and (5) achieving the threshold nitrogen level at the sentinel location will require removal of sufficient nitrogen related stress as to restore infaunal animal habitat in the adjacent deeper waters of Prince Cove and North Bay.

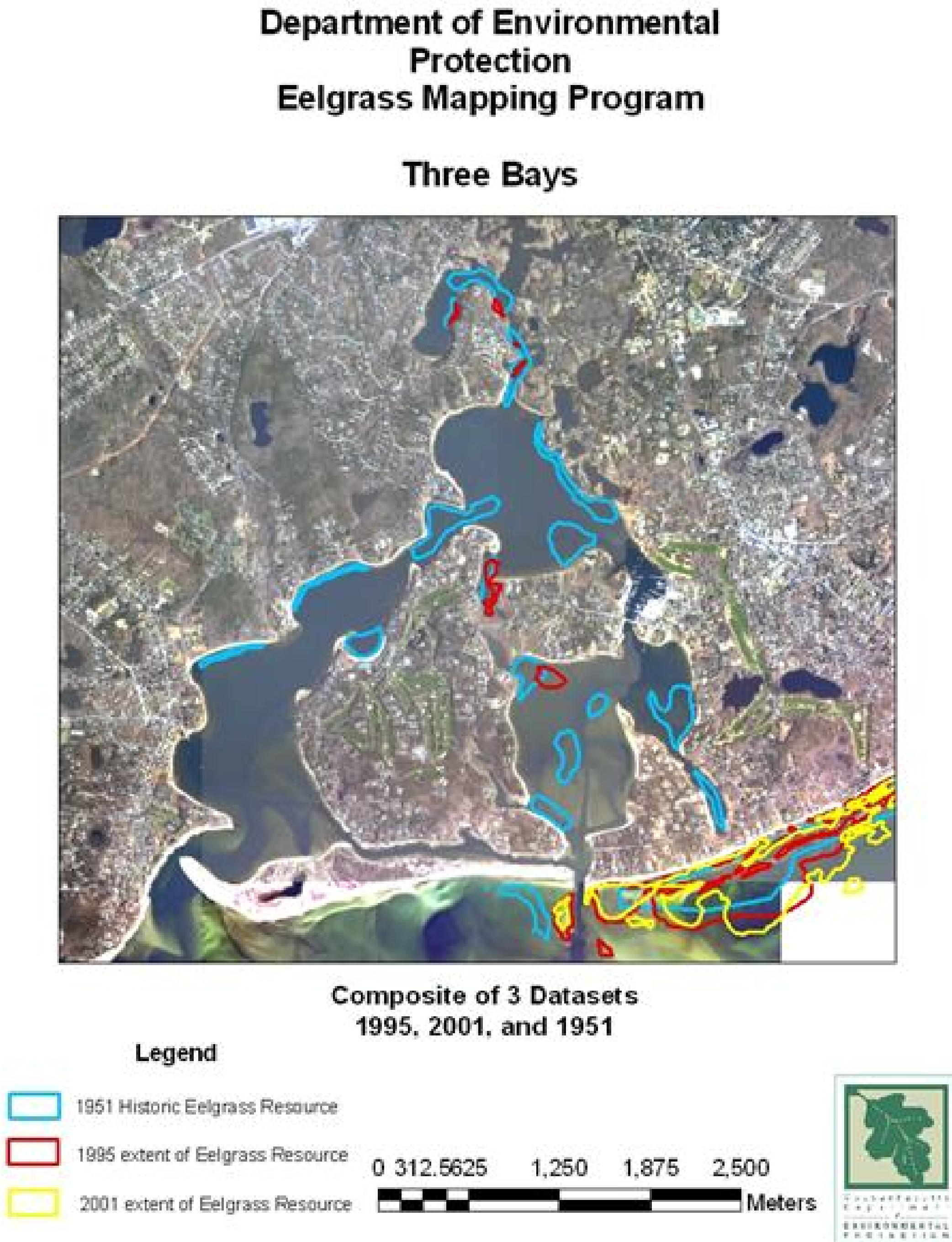


Figure 3.7 Eelgrass Beds past and present distribution in the Three Bays embayment system

Based on current conditions, the infaunal analysis (Chapter VII, MEP Technical Report (Howes et. al., 2006) coupled with the nitrogen data (measured and modeled), indicated that target nitrogen concentration of 0.38 mg at the sentinel location and 0.40 mg/L TN L-1 within the marginal regions (shallows) of North Bay are supportive for the restoration of eelgrass in this system of high quality infauna habitat within the Three Bay System.

The target nitrogen concentration of 0.38 mg/L TN L-1 was set for restoration of eelgrass in this system at the sentinel location and 0.40 mg TN L-1 within the marginal regions (shallows) of North Bay. This secondary level to check restoration of marginal beds in North Bay (0.40 mg TN L-1) is consistent with the analysis of the restoration of eelgrass beds at a reference site in nearby Great Pond in Falmouth, where eelgrass beds in deep water could not be supported at a tidally averaged TN of 0.412 mg TN L-1 at depths of 2 m. Currently, as reported in the Three Bays SMAST Technical Report, the existing nitrogen level at the sentinel location at mid-ebb tide is 0.581 mg/L TN L-1.

3.2.6 Watershed Land use

Land use in the watershed, as identified in the MEP technical report, is predominantly residential and public municipal and public/private open space, with nearly one half of the lots with single-family homes (Figure 3.8). Residential land use represents slightly less than half (46%) of the watershed area. Public service (government owned lands including open space, roads, and rights-of-way) is the second highest percentage of the watershed (28%). In addition, 76% of the parcels in the system watershed are zoned as single family residences (MADOR land use code 101) and single family residences account for 88% of the residential land area. In addition, residential land uses are the predominant land use in all the major Three Bays subwatersheds with a range of 39% to 63% of the subwatershed areas. Public service land uses are the second highest percentage in all of the major subwatersheds except for the Seapuit River subwatershed where undeveloped land uses are the second highest. Overall, undeveloped land uses account for 11% of the whole Three Bays watershed and are shown in Figure 3.8. But it's important to understand how this landuse category is defined, since the classification of undeveloped as presented later on this report (section 3.4.1) includes lands held for conservation/open space purposes such as parks, golf courses, and agriculture. Commercial properties account for 2% of the Three Bays watershed area.

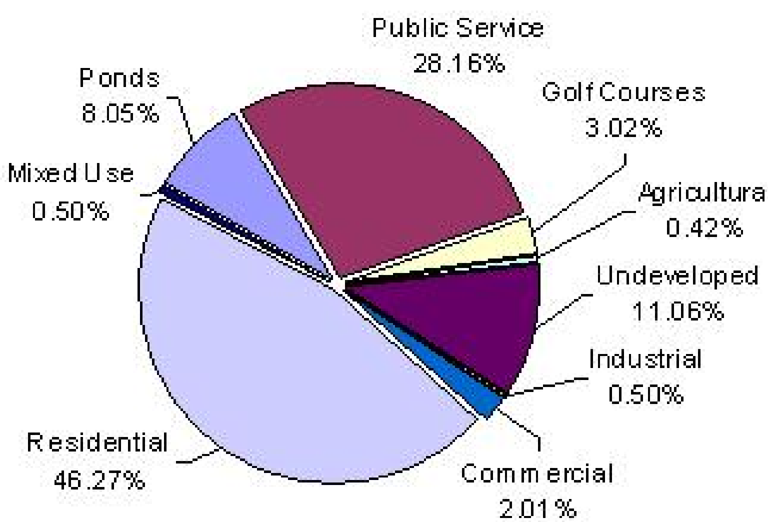


Figure 3.8 Three Bays Watershed Land Uses
Source: MEP Technical Report, Chapter 4, p.30, Figure IV-2

Vegetative cover consists primarily of a mixture pine, locust, and oak with limited agricultural production, confined to cranberry production.

3.3 Sources of Nitrogen

The nitrogen sources affecting estuarine water quality are many and collectively each has an impact. Table 3.4 and Figures 3.9 identify three major sources: atmospheric loads (atmospheric deposition), sediment regeneration (benthic flux) and those contributed from the watershed from both natural and anthropogenic sources. Figures 3.9a-c are designed to present a better understanding of the loads affecting water quality from estuarine and watershed sources and the percentage of those watershed sources that can be controlled by wastewater management practices. As presented in Figure 3.9a, it is clear that the loads contributed to the Three Bays estuary are not always from the watershed. Clearly, on-site septic system loads represent 67 percent of the overall combined overall load (watershed and atmospheric deposition to the estuary) and 83 percent of the controllable load (Figure 3.9c).

Because the contributions from atmospheric deposition and those recycled from the sediment are not loads that can be controlled by any watershed-based management strategy we are left with the watershed loads (Figure 3.9b) and those that can be controlled (Figure 3.9c).

Table 3.4 Sources of Nitrogen Loads to the Three Bays Embayment and Watershed System

Source	Kg N/Year
Title 5 Wastewater	53584
Stormwater Runoff	2828
Lawn Fertilizers	7920
Water Body Surface	8555
"Natural" Sources	1641
Package Treatment Plants	39
Estuarine Atmospheric Deposition	5712.25
Unattenuated Load	80279.25

Clearly, the reduction of the septic load, representing 83 percent of the controllable (stormwater, fertilizers, package treatment plants) watershed load is the source that must be controlled and also the subject of this and other management plans. The use of the Linked Model for the reduction of nitrogen takes into account the contributions from atmospheric and benthic flux, as it simulates the outcome of any plan for a septic load reduction to address the threshold concentration that must be achieved at the sentinel location in the bay.

3.3.1 Wastewater Treatment Plants and Onsite Systems

The Three Bays watershed is dependent on on-site septic systems with the exception of two wastewater treatment facilities, designed for the Horace Mann Charter School (3907 gpd average daily flow) and the Cotuit Landing shopping plaza (5206 gpd average daily flow), that currently contribute less than 1% (0.06 %) of the total yearly controllable load to Three Bay (Figure 3.9). The unused capacity of the two treatment plants provides an opportunity to accommodate some capacity, following future wastewater management planning, and to utilize their design flow and their denitrifying capability and to evaluate the potential of upgrading and extending their use to adjoining neighborhoods with Title 5 septic systems. However, the unused capacity of these package treatment plants is insufficient to provide the capacity needed to reduce the required loads within the watershed for TMDL purposes.

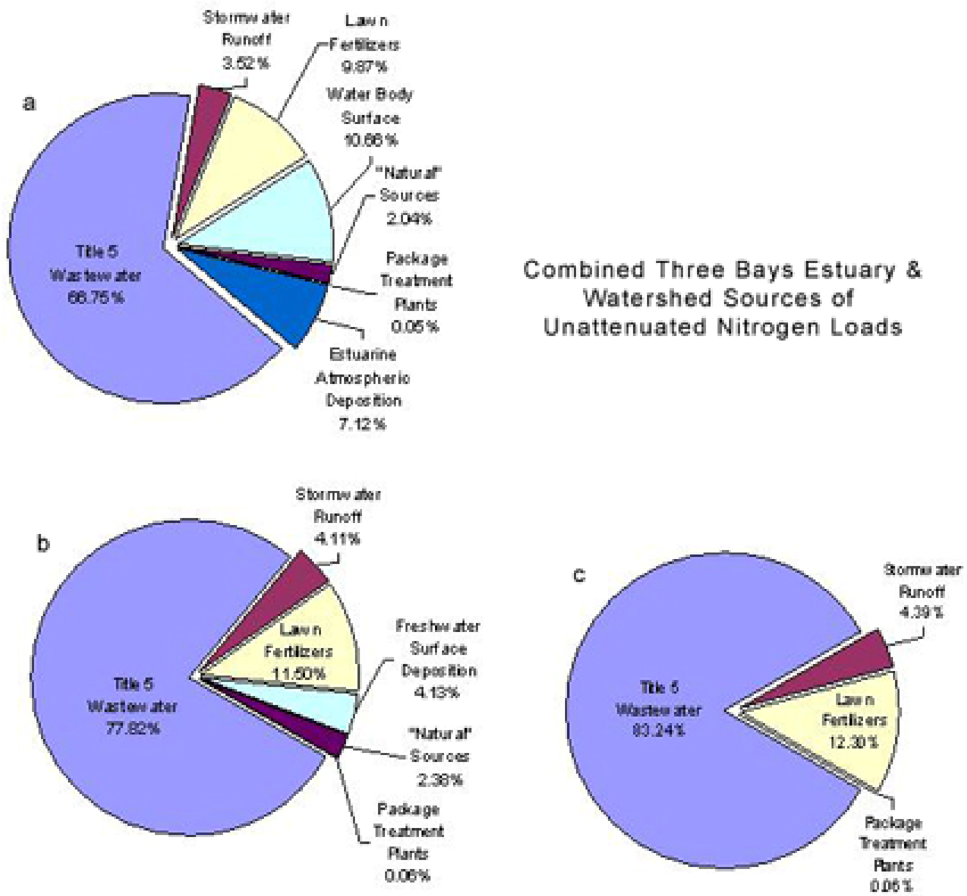


Figure 3.9 a-c Combined Three Bays Estuary and Watershed Sources of (a) Unattenuated Nitrogen Loads (top), (b) Watershed Sources of Unattenuated Loads (bottom Left) and (c) Percentage of the Combined Watershed Loads that are Controllable (stormwater, fertilizers (agriculture, lawns/turf), treatment plants) (bottom right). Source: SMAST Three Bays Technical Report (Howes, B. et. al. 2004), Chapter 4, Table IV-4.

Through the CWMP process, the Town of Barnstable's Comprehensive Wastewater Facilities Plan has been underway for more than a decade; receiving MEPA approval in October 2007 for an increase in its capacity from 2.1 MGL to 4.2 MGD with recharge of treated effluent at Hyannis Water Pollution Control Facility (WPCF). Construction is underway on the increased capacity of the Hyannis WPCF, with the expected completion in winter of 2009. There were issues of concern about the capacity of the treatment disposal beds to accommodate future flows (above 4.2 MGD). Following years of study for an alternative site for discharge, the decision was made to install piping for the additional flows to an offsite location to a town-owned location near the Community College.

In view of the nitrogen load reductions identified for the Three Bays in the recently released MEP Technical Report (Howes et. al, 2006) and the EPA approved TMDL, the Town of Barnstable is re-evaluating its facilities plan to address the significant nitrogen reductions required from the Three

Bays and other embayment systems within the town for which TMDLs have been issued. Since the 1997 MEPA approval had not addressed the significant reduction in nitrogen loads that are needed to restore water quality to these embayments, including Three Bays, town officials are considering use of the increased treatment capacity of the Hyannis facility to accommodate the sewering the town's coastal embayments with nitrogen TMDLs, including the Three Bays. During the filing of this report, the preliminary design layout of the expanded sewer main and pump station locations was under evaluation by the town's consultant to address the nitrogen and bacteria TMDLs that were issued by MassDEP for the watersheds to the impacted southshore embayment systems, including the Three Bays watershed to maximize cost savings and use of existing mains, and pump stations. The issue of water balance still remains; whether the treated wastewater at the Hyannis facility must be returned for disposal at its watershed of origin.

3.3.2 Treatment Plant Discharge Locations

High growth rate MEP communities, similar to Barnstable, face limitations in the siting of wastewater treatment discharges when the only lands available for discharge are within Zones of Contribution (Zone IIs) to public supply wells and coastal watershed to nitrogen sensitive estuaries. While the Groundwater Regulations (310 CMR 5.00) provide adequate public health protection safeguards for the siting of state permitted wastewater treatment plants within Zone IIs, towns are also exploring increasingly creative options for wastewater disposal in coastal watersheds to nitrogen sensitive embayments. The Town of Barnstable is currently considering the possibility of utilizing its wastewater treatment facility within the village of Hyannis, as this treatment plant recently completed a significant upgrade in its treatment plant's capacity. However, the Town is also examining the use of existing town owned properties within the Three Bays watershed and existing, privately permitted small scale treatment plants as well to assure that the water withdrawn from public supply wells and discharged as wastewater remains within the watershed of origin.

3.3.3 Stormwater

Sources of water quality impairment also exist from stormwater runoff from impervious surfaces (buildings, driveways, and roads), representing 4.4% of watershed-wide controllable load, and slightly more in sub-watersheds with a greater percentage of developed land (Figures, 3.9a and 3.9c; and Figure IV-4 of MEP Technical Report (Howes, B. et al., 2006)). Overall, stormwater runoff represents 3.5 percent of the nitrogen load affecting the embayment system as a whole (Figure 3.9a) and stormwater and fertilizer management are closely related, because lawn fertilizer use frequently washes off lawns during rainfall events and becomes part of the stormwater runoff load.

The EPA NPDES Phase II stormwater-permitting program, that regulates stormwater discharges, requires the Town of Barnstable to have a general permit that commits the Town to carry out a variety of Best Management Practices (BMPs). Through zoning requirements (Site Plan Review ordinance, Article IX §240-103 and site development standards (amended 11-15-2001 by Order No. 2002-029; explored further in Chapter 5)) developers must use best management practices to eliminate the potential of off-site discharges of stormwater.

The Town of Barnstable has a funded Coastal Mitigation Program which corrects untreated discharge from entering into their coastal embayments from any Town roadway or property (boat ramps, ways-to-water, etc.). In FY 2008/2009 there are four on going projects under this program in the Three Bays Area.

MassDEP's Stormwater Policies and Guidance should be consulted for recommended best management practices to control stormwater impacts on surface waters. SMAST has also identified the following BMPs that warrant further investigation for nitrogen removal:

- Vegetated swales
- Retention ponds
- Constructed wetlands
- Sand/organic filters
- Infiltration basins/trenches.

3.3.4 Fertilizer Use

Fertilizer use is the third largest contributor of nitrogen load to the Three Bays embayment system, following septic wastewater and freshwater surface waters (Figure 3.9a). As a controllable watershed load, fertilizer use is the second largest source of watershed nitrogen loading for use primarily in residential lawns and golf course greens. Fertilizers account for 9.87 percent of the overall Three Bays watershed nitrogen load (Figure Table 3.9b) and 12.3 percent of the controllable watershed nitrogen load (Figure 3.9c).

Considering that four golf courses (Wiano Golf Club, Oyster Harbors Club, Ridge Club, and Holly Ridge) and 46 percent of the watershed that is in residential development with lawns that undergo annual fertilizer applications these impacts to the embayments can be controlled with proper use management. The Popponesset Pilot had determined that golf courses contribute 24% of the unattenuated fertilizer load, equal to 2.4% of the total unattenuated controllable load. Also to understand, nitrogen leaching from fertilizer applications on golf courses can be a larger share of the load in the sub-watersheds where they are located in close proximity to the bay where natural attenuation may not reduce those loads prior to entering the coastal embayment.

3.4 Demographics

3.4.1 Land Use Change

During the past 48 years, land use development pressures within the Three Bays Watershed have been dramatic with a substantial loss of undeveloped land from 88% in 1951 to 47% in 1999 (Table 3.5 and Figures 3.10-3.11). Coincident with this change was a substantial increase in the number of year round single-family homes and the conversion of seasonal to year-round residences. These changes also coincide in nearly a 50 percent loss of undeveloped forest land for suburban use.

Table 3.5 Developed and Undeveloped Land (1951, 1971, 1985,1999) in the Three Bays Watershed (Source: MassDEP GIS)

YEAR	Developed Acreage	Undeveloped Acreage	Total Acreage *	Percent Developed +	Percent Undeveloped +	TOTAL_PCT
1951	1370	10178	11548	12%	88%	100%
1971	2304	9243	11547	20%	80%	100%
1985	4157	7389	11546	36%	64%	100%
1999	6107	5439	11546	53%	47%	100%

* Exclusive of acreage from lakes and ponds
+ Refer to Figure 3.11 for landuse codes for these two categories of land use.

As one would expect, land development dominated by residential use in an unsewered watershed is expected to result in a diminishment of waters quality to impacted inland and coastal waters from the subsurface discharge of wastewater effluent from these residential wastewater disposal systems. These discharges, including those resulting from lawn fertilizer use and stormwater runoff, enter the groundwater system and eventually flows down-gradient to the receiving surface waters of the estuary. The nitrogen load that is received by the estuary will vary from one sub-watershed to another; in each case dependent on the number wetland systems (lakes, ponds, marshes) that intercept this wastewater plume to undergo denitrification prior to its discharge to the estuary. In the sandy soils of Cape Cod, these groundwater flows at an average rate of one foot per day.

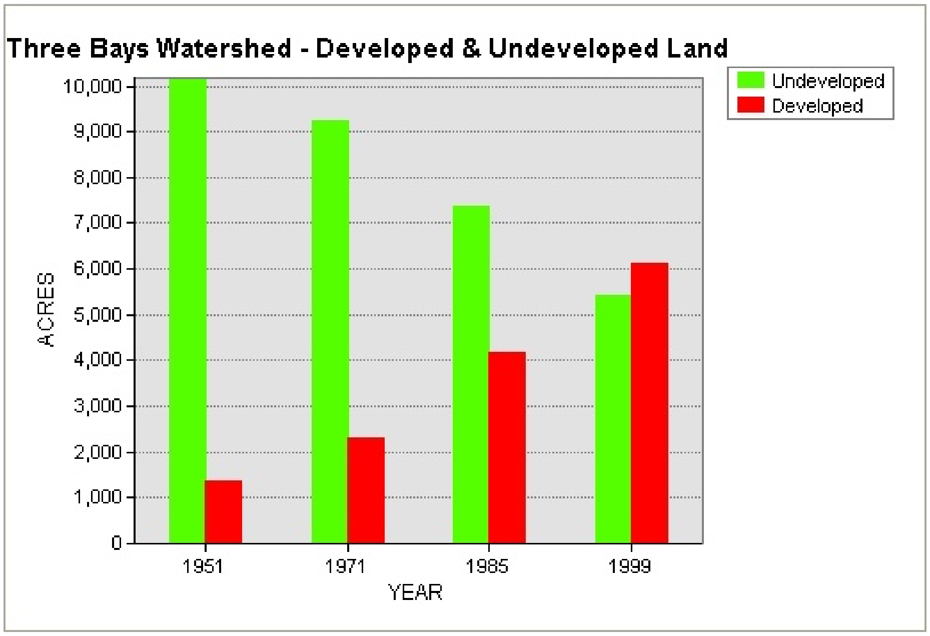


Figure 3.10 Graph showing land use change (1951, 1971, 1985, 1999) in the Three Bays Watershed represented as developed and undeveloped (Source: MassDEP GIS)

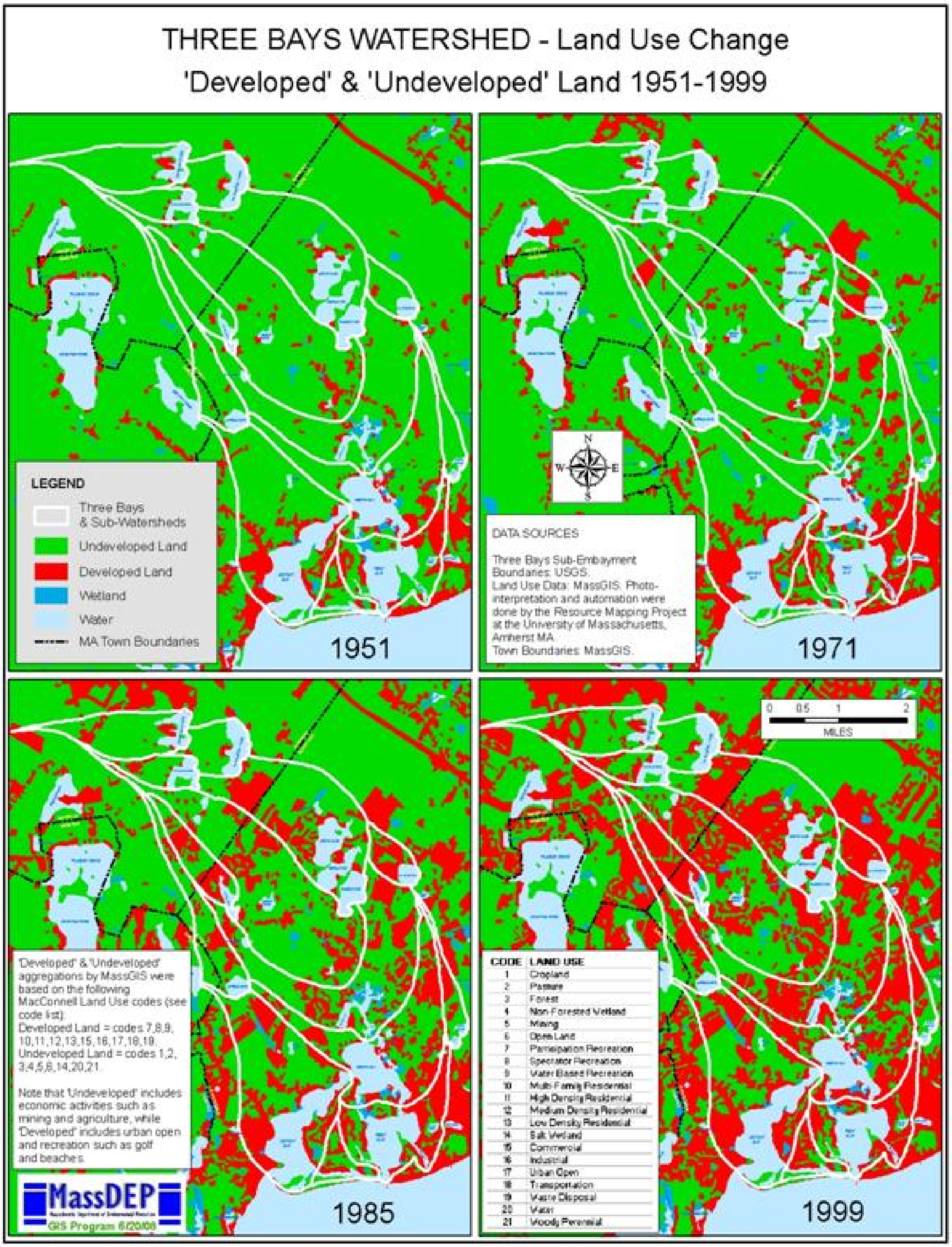


Figure 3.11 Maps showing land use change (1951, 1971, 1985, and 1999) in the Three Bays Watershed represented as developed and undeveloped (MassDEP GIS)

3.4.2 Population Growth

US Census data indicate a population growth rate that has consumed an increasingly greater percentage of the open space in the three towns since the 1950s (Table 3.6; Figures 3.12-3.13) with the Town of Mashpee taking the lead for all time intervals (1950 to 2000; 1990 to 2000; and 2000 to 2006). The highest rate of growth occurred from 1950 to 2000 with a 2856 percent increase, followed by Sandwich at 737 percent and Barnstable at 356 percent. While these rates reflect town wide patterns, they also reflect increases in residential development and wastewater discharges within the watershed from on-site water septic systems.

Dramatic declines in water quality, and the quality of the estuarine habitats, throughout Cape Cod, have paralleled its population growth. Intuitively, it can be argued that the nutrient load increases affecting the groundwater system of the Three Bays Watershed is directly related to the increase in subsurface wastewater disposal systems that accompanied both land development and population growth.

Table 3.6 Percent Population Growth, since 1950 and again from 1990 for the Three Bays Watershed Towns of Barnstable, Sandwich, and Mashpee

Town	1950 – 1960	1950-1970	1950-1980	1950-1990	1950-2000	1990 – 2000	1990 - 2006
Barnstable	28.5	89.3	194.8	291	356	16.7	15.6
Mashpee	98	194	745	1700	2856	64.2	81.9
Sandwich	-14	117	261	541	737	30.6	32.4
TOTAL	20	85	196	235	443	61.6	64

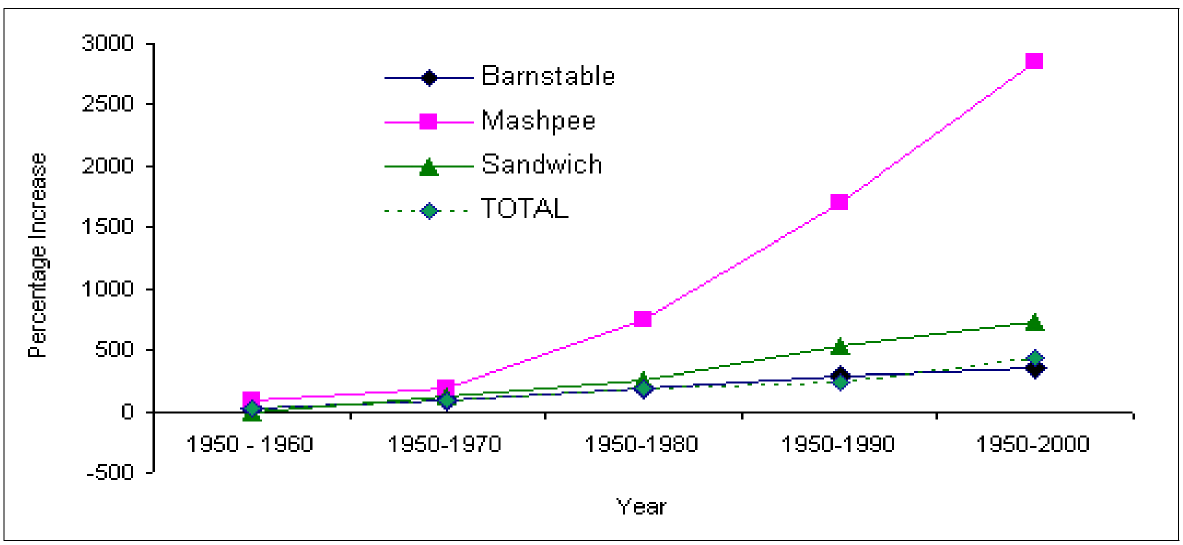


Figure 3.12 Percent Population Increase since 1950 for Three Bays Watershed Towns

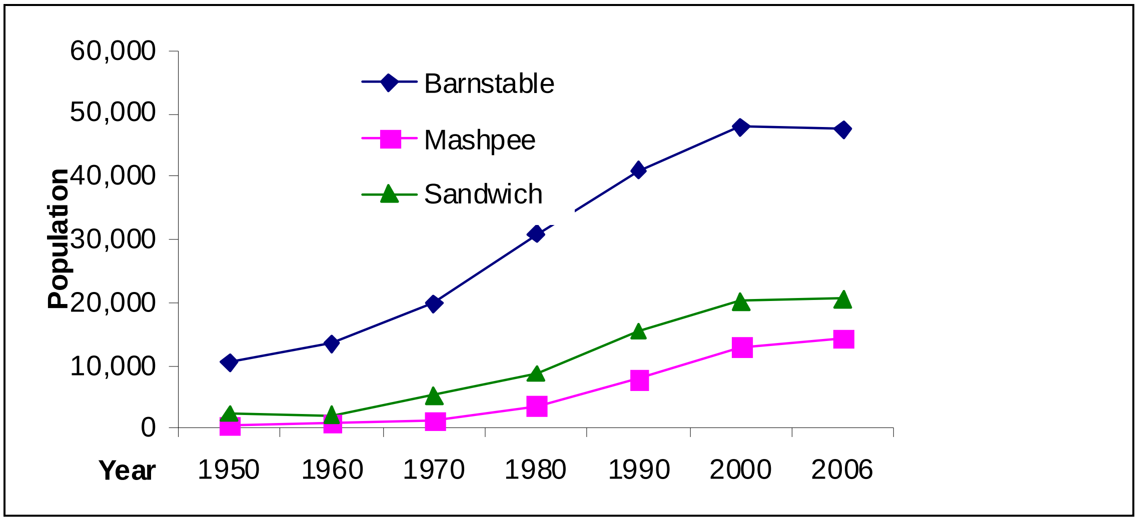


Figure 3.13 Population Growth since 1950 for the Three Bays Watershed Towns

The population of Mashpee and Barnstable has increased markedly since 1950. Of the three towns, Mashpee has undergone the greatest percentage increase (Table 3.6, Figures 3.12-3.13) as a result of the 1983 federal court settlement of the land claim by the Wampanoag Indian tribe to reclaim the entire town as tribal land. The town of Barnstable, the largest of Cape Cod's 15 communities, added the most new residents (10,051) from 1980 to 1990 (Figure 5) and from 1990 to 1996 gained another 2,750 new residents for a 7% increase to 43,699; the second highest of the 351 Massachusetts municipalities (Franklin had the largest increase). The Town of Sandwich also saw a substantial increase in growth from 1990 to 1996 for a 16% increase from 15,489 to 17,916 - the highest percentage gain increase among Cape towns. For more information, see the Cape Trends Report, 1998.

Based on the data presented in the MEP Three Bays Technical Report (2006) the estimated the population of the Three Bays watershed is approximately 13,600 based on an average household size at 2.41 multiplied by the 5,668 residential parcels in the watershed. Since the completion of the MEP Technical report in 2004, basing its estimates on 2001 data, the three towns continued to grow. For example, the Town of Mashpee's estimated 2006 population (US Census) outpaced both Sandwich and Barnstable with an increase of 10.79 percent (12,946 to 14,343) from 2001 to 2006 period; while Sandwich grew a modest 1.3 percent (20,238 to 20,508) and Barnstable having a –0.92 percent (from 47,821 to 47,380) (Table 4, Figure 7).

The significance of these statistics is clear; Title 5 on-site septic systems continue to serve new households with ever increasing nitrogen loads to this estuary beyond the 2004 MEP Technical Report estimates. In recognition that these increases are inevitable the MEP Technical Report provides an estimate of these future loads under the build-out conditions provided by current zoning for each of the towns sharing this watershed.

3.4.3 Population Density

US Census population density statistics, reported as persons per square mile, are also helpful in assessing land use development because it defines locations within the watershed where the wastewater burden affecting the Three Bays embayments are the greatest. Overall, this increase in population density within the Three Bays, and the accompanying wastewater disposal that accompanied this population increase, has played a major role in the observed declines in estuarine habitat quality throughout much of the area.

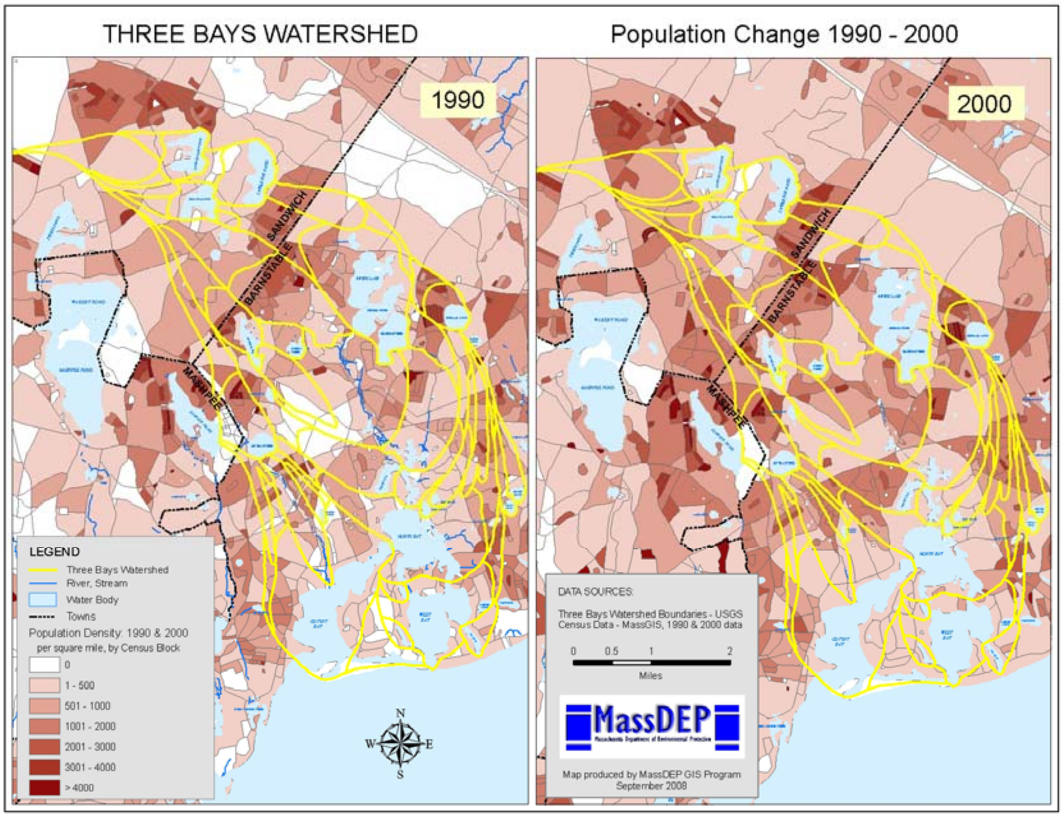


Figure 3.14 Changes in Population Density for the Three Bays Watershed from 1990 to 2000.
(Source: US Census**)**

3.5 Three Bays Pilot Project

3.5.1 Building a Watershed Team

This Pilot Project relied on a team of key local officials and citizens with support from the Cape Cod Commission, MassDEP, and SMAST (Table 3.6). As most of the Three Bays Watershed is located within the borders of the Town of Barnstable, Barnstable town officials took the lead and responsibility for initiating and coordinating much of the planning for the Pilot Project. The DPW's Special Projects Manager coordinated with the DEP Project Manager in all aspects of the project, including those requiring input from town officials of the three towns. This was important for the Town as it had been undergoing a townwide nitrogen management plan of its own in conjunction with meeting the TMDL-related nitrogen and bacteria reduction requirements for other embayments within its town borders with TMDLs.

The key players from Barnstable included members from the Department of Public Works and Growth Management Departments. Others team players included the Three Bays Preservation, Inc. – an environmental advocacy organization, town of Sandwich and Mashpee officials. Sandwich representation focused on a member of the selectman appointed Water Quality Advisory Committee. The names and title of the participants are listed in Table 3.6. Their role was to address how they would utilize the nitrogen load data for a reduction that would all three towns would support. Staff from SMAST attended in the early stages of the Pilot and to develop and discuss modeling scenarios. Consulting engineers and Barnstable County staff also attended occasionally or as requested.

Prior to the first meeting in November of 2007 MassDEP had previously met with key officials in each town to explain the project and requested each town to agree in writing to provide the time of local officials and staff to move the Pilot Project Team's planning process along.

Table 3 6 Three Bays Watershed Pilot Team

Name	Affiliation
Cambareri,Tom	Cape Cod Commission, Water Resources Program Manager
Counsell, Lindsey	Three Bays Preservation
Daley, Patty	Town of Barnstable, Growth Management Department Director and Wastewater TAC
Eichner, Eduard (former)	Cape Cod Commission, Water Scientist
Ells, Mark	Town of Barnstable, DPW Director and Wastewater TAC
Fudala, Tom	Town of Mashpee, Planning Department Director and Chair of Sewer Commission
Gahagan, Bill	Three Bays Preservation Association
Heller, Judy	Three Bays Preservation Association
Howes, Brian	University of Massachusetts – Dartmouth, SMAST; Director, Coastal Systems Program
Largay, Richard	Three Bays Preservation Association, Board of Directors
Mason, David	Town of Sandwich, Health Agent
McKean, Thomas	Town of Barnstable, Health Department Director
Rask, Susan	Barnstable County Department of Health & Environment
Rowland, Peggy	Three Bays Preservation Association
Saad, Dale	Town of Barnstable, DPW Special Projects Manager and Wastewater TAC
Seymour, Steve	Town of Barnstable, Growth Management Department Engineer and TAC
Schwinn, Don	Three Bays Preservation Association
Weeks, Nate	Stearns and Wheler – Town of Barnstable Consultant
Wyle, Ruth	Town of Barnstable, Growth Management Director and Wastewater TAC
Zoto, George	MassDEP, MEP Project Manager
Zylich, Michael	Town of Sandwich, Water Quality Advisory Committee, member

3.5.2 Team Meetings

The Pilot Project Team met roughly monthly when the project began in November of 2007

Team meetings focused on:

- In-depth understanding of the Technical Report and use of the Linked Model.
- Review of the nitrogen reduction scenario described in the MEP Technical Report (Chapter 8.3)
- Now that the TMDLs are developed, how should they be applied?
- How should responsibilities be assigned for N reductions in shared watersheds?

- Three model runs were proposed by the TAC and MassDEP to determine if the reductions achieve the threshold concentration at the sentinel station in Three Bays by testing the results of sewering different locations or sewersheds within the Town of Barnstable.
- Discussion of local and state management and regulatory issues.

As 87 percent of the land area of the watershed resided within the town limits of Barnstable, it was clear that Barnstable would take the lead with the planning and implementation of the nitrogen reductions within the watershed. Regardless, the towns Sandwich and Mashpee also have responsibility to contribute to the load reductions from their town borders. However, the town of Mashpee with less than one percent of the land area within this watershed did not attend meetings because their own CWMP planning was underway for the Popponesset and Waquoit Watersheds, of which they were responsible for most of the nitrogen reductions (greater than 60 percent) from those watersheds.

Prior to the first scheduled meeting, the Town Manager, DPW Director and Special Projects Manager, the Executive Director of the Three Bays Preservation, and community members who reside in the Three Bays Watershed met to support the project and to discuss the project's goal.

The November 2007 meeting of the Pilot Project Team was attended by staff from SMAST and the Cape Cod Commission to introduce Pilot Team members to the MEP approach for data collection, quantification of nitrogen loads, and the environmental "what if" inputs to the MEP Linked Model for use in calculating outcomes for reducing watershed nitrogen loads and/or its allocation by town.

Following this first meeting, other town staff from other offices attended when the subject of those meetings addressed technical and policy related issues in their area of expertise and responsibility.

During the tenure of this Case Study, the Three Bays Pilot Project focused its energies on identifying potential areas for sewering and locations for treating the estimated wastewater flows.

As the Pilot Project Team consisted of the same three major partners as the Popponesset Pilot Project Team, there was no need discuss the MEP approach, the interpretation of the MEP Technical Reports and how this data could be used to address the nitrogen-reduction sharing by the three towns. The focus was on where and how much to sewer within the watershed that would achieve the threshold concentration at the sentinel station located in the Cotuit Narrows. Other issues addressed, to a limited degree, included:

- Wastewater Loads: Treatment Plants and Onsite Systems
- Recharge of treated effluent into the Three Bays Watershed
- Pollution Prevention: Fertilizer Management, Water Reuse and Conservation, and Stormwater Management
- Enhanced Natural Attenuation at the Mill Pond located at Rt. 149 and Rt. 28
- Moving water from one watershed to other watershed.
- Outreach to elected officials

3.5.3 SMAST Linked Model Runs

3.5.3.1 Barnstable TAC Scenario Run Options

The areas for sewering (also known as a "sewershed") and the sites for treating and discharging the treated flows were designated by the Town of Barnstable's technical staff (TAC) and MassDEP utilizing the data presented in the April 2006 Three Bays Tech Report (Howes et. al., 2006). A "sewershed" is an engineering planning area based on the roadway network, the location of pump stations and other infrastructure and the intensity of development to be sewered Their proposed scenarios for sewering (Table 3.7) was later submitted to SMAST to calculate if the proposed nitrogen reductions would achieve the nitrogen threshold concentration at the sentinel location in the Bay. These sewering scenarios examined the nitrogen reduction potential of sewering three locations using at two sites for treatment and disposal; using an existing treatment facility at a shopping plaza in Cotuit (Option A), and the construction of a small treatment plant on land abutting the Barnstable Transfer Station (Option B):

Please refer to Figure 3.15 to visualize the extent of the sewersheds and the locations proposed for discharge of the treated wastewater.

Figure 3.15 Sewershed Locations Proposed for Septic Load Reductions in the Three Bays Watershed

Scenario 1: Two treatment facilities and two discharge areas

There are two (2) possible sites known as Discharge Areas “A” and “B”.
(Option A) The first discharge site is Area "A" located in Prince Cove GT10 near the Cotuit Shopping Plaza on Route 28 (Assessors map: 040 parcel: 003T00 & C00).

(Option B) The second site is Discharge Area "B” in Middle Marstons Mills LT10 next to the Barnstable Transfer Station (Assessors map: 099 parcel: 028-001).

Scenario 2: One treatment facility and discharge area
All effluent will be discharged at Discharge Area "B" in Middle Marstons Mills LT10, the land next to the Barnstable Transfer Station (map: 099 parcel: 028-001).

Scenario 3: Nutrient sharing between towns
Determine the Nitrogen Load to the Three Bays Estuary originating from each of the 3 towns comprising the contributing area, Barnstable, Mashpee, Sandwich (See Table 3.8).

The output of the SMAST scenario runs is fully described in the SMAST Technical memo (Appendix O). The restoration goals for these scenario runs were based on removing sufficient N loads, primarily from septic systems, to support infaunal habitat in North Bay and eel grass habitat in both East and West Bay. The proposed reductions for the identified subwatersheds were insufficient to restore the water quality at the sentinel station location in the bay. As listed below, the resultant nitrogen concentrations at the sentinel location for each scenario were above the restoration target of 0.38 mg N/L.

Scenario 1 - 0.454 mg/L
Scenario 2 - 0.448 mg/L
Scenario 3 – described in section 3.5.3.2 “Fair Share”

Table 3.7 Three SMAST Scenarios for reducing nitrogen in the Three Bays Watershed

Scenario 1. Two Treatment Facilities (5 mg/l N) And Discharge Areas. Discharge Area "A" located in Prince Cove GT10	
Sub-embayment	Percent Treated and Discharged to Area "A"
Prince Cove LT10	100
North Bay GT10W	100
North Bay LT10	20
Upper Marstons Mills River	10
Prince Cove GT10	5
Lower Marstons Mills River LT10	20
Discharge Area "B" located in Middle Marstons Mills LT10	
Sub-embayment	Percent Treated and Discharged to Area "B"
Upper Marstons Mills River	90
Lower Marstons Mills River LT10	55
Lower Marstons Mills River GT10	40
Middle Marstons Mills River LT10	80
Bog Pond LT10	60
Bog Pond GT10	90
COMM Davis/Arena/McShane Wells	90
North Bay GT10E	30
Joshua Pond GT10	90
Joshua Pond LT10	60
Micah Pond	95

Scenario 2. One Treatment Facility (5 mg/l N) And Discharge Area. Discharge Area "B" located in Middle Marstons Mills LT10	
Sub-embayment	Percent Treated and Discharged to Area "B"
Prince Cove LT10	100
North Bay GT10W	100
North Bay LT10	20
Upper Marstons Mills River	100
Prince Cove GT10	5
Lower Marstons Mills River LT10	75
Lower Marstons Mills River GT10	40
Middle Marstons Mills River LT10	80
Bog Pond LT10	60
Bog Pond GT10	90
COMM Davis/Arena/McShane Wells	90
North Bay GT10E	30
Joshua Pond GT10	90
Joshua Pond LT10	60
Micah Pond	95
Scenario 3. Nutrient Sharing between Towns.	
Run the amount of nitrogen that is in the Three Bays watershed that originates in Sandwich	
and Mashpee. Having those numbers will give us a basis to begin to think about nutrient trading	
with our neighbor towns.	

3.5.3.2 Scenario Run Results and Proposed Future Options

It was also learned that eighty two percent of the nitrogen loads that affected this embayment system occur within a 10 year time of travel from their discharge in the Three Bays headwaters.

Additional MEP model runs are under consideration as part of the town's CWMP to identify other locations within the Three Bays watershed for sewering. A town-wide assessment of sewering needs will also address the cost and benefit of using the existing centralized treatment facility in the Village of Hyannis. Also under consideration is the option of assisting the Town of Mashpee with its costs for the Popponesset, if they would sewer portions of the Village of Cotuit as part of its CWMP to sewer the Popponesset Watershed.

If use of the centralized treatment facility in Hyannis is considered as the most cost and environmentally effective solution to reduce the watershed loads in the Three Bays, the Town and ultimately MassDEP will need to decide if returning this treated wastewater to its Three Bay source watershed source location is necessary for water balance considerations.

The following questions for future nitrogen-reduction scenario runs are under consideration:

- Would a 100 percent reduction of the nitrogen load in the subwatersheds that abut the North Bay and a 20 percent in those abutting Cotuit and West Bays achieve the threshold concentration at the sentinel location?
- The assumption that the nitrogen load reductions that effectively restore water quality is dependent on maintenance dredging of the inlets sufficient to sustain current levels of flushing with Nantucket Sound.
- Would the sewering of the subwatersheds with the greatest population densities (near Route 28) be sufficient to restore water quality?

- Groundwater is discharged to Mill Pond (at Rt 149/Rt 28) at 5 million gallons/day. At that rate, the Town should explore the potential of using this site to enhance the treatment of nitrogen by increasing the depth of the pond for storage and ultimately for reduction by natural attenuation via the pond and wetlands ecosystems at this location.
- Would 100% sewering of the Three Bays watershed allow treatment effluent to be discharged to location "B" within the watershed and meet the threshold concentration at the sentinel station? The analysis of this scenario is underway and results should be available in October 2008.

"Fair Share"

The third scenario was geared to determining the nitrogen loads that originate within the Three Bays Watersheds from the three towns comprising the contributing area of the watershed. Having those numbers provided the Pilot Project Team with numbers to start thinking about nutrient trading.

At the first Pilot Project Team's first meeting, the outcome of the third scenario was presented by the Cape Cod Commission; which in essences highlighted the "fair share" concept that was championed by the Popponesset Pilot Project team.

The data presented by the Commission, as shown in Table 3.8 and Figure 3.15, defined the town-specific attenuated and unattenuated loads for existing land uses and those expected in the future, at build-out, under current zoning. This information was offered to spur discussion concerning the allocation of the nitrogen reductions each town would address in its CWMP and ultimately for use in deciding each town's financial responsibility. When decided, the allocation of loads between towns could be a nitrogen trading option to help reduce the assigned maximum watershed load each town would reduce and not exceed in the future after the load reductions had restored water quality at the sentinel location in the Bay. To help understand how the complexity of assigning a load reduction, Figure 3.16 was prepared to further define the town-specific nitrogen loads by subwatershed as attenuated and unattenuated nitrogen load for existing and future built-out conditions. However, as explained earlier, the reductions in nitrogen loads will vary within each subwatershed because the natural attenuation factors are not the same. In some cases, due to the presence or absence of wetlands and pond systems, there may be a significant net reduction in the load while in other subwatersheds there may be none.

Figure 3.10 displays the variability in subwatershed controllable loads (septic, fertilizer, stormwater runoff) and the percentage of the load that is needed for reduction to restore water quality at the sentinel location. When viewed in conjunction with Table 3.9, it becomes clear which of the three towns have the greatest loads for reduction. For example, Table 3.9 identifies an 85% nitrogen reduction is required for the Prince Cove Channel and of this load 100% of it originates from the Town of Barnstable (3.10). Also, an 84% reduction is required from North Bay and of this reduction 98% of it originates in the Town of Barnstable.

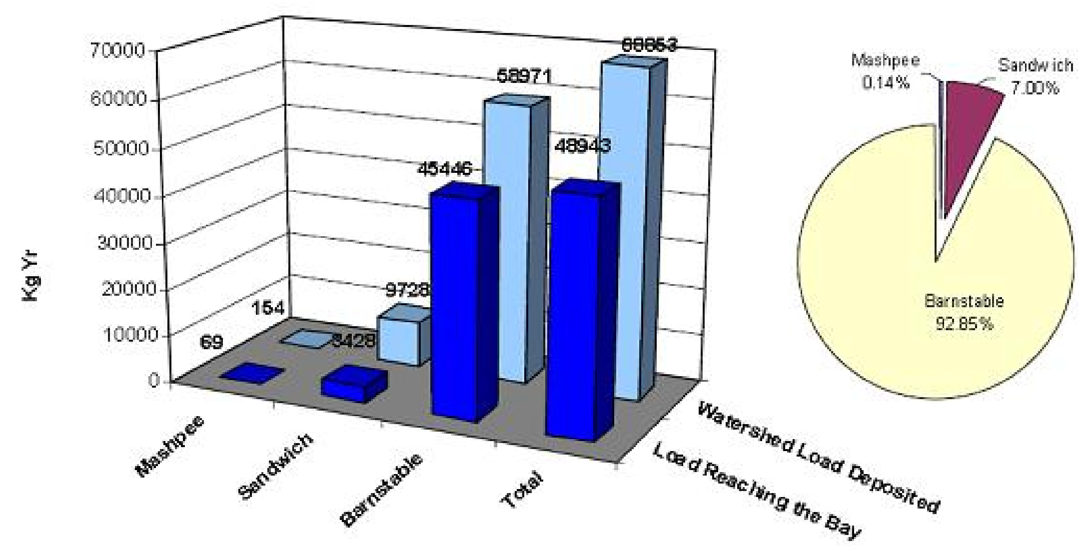


Figure 3.16 Nitrogen Loads from the three towns under existing conditions described as (a) the unattenuated loads deposited to the watershed, (b) the attenuated load that reaches the Bay and (c) a pie chart that defines the percent of attenuated load contributed by each town.

Table 3.8 Unattenuated load deposited to watershed and attenuated nitrogen load that reaches the Bay from each of the three towns sharing the Three Bays Watershed (Source: Cape Cod Commission Technical Memo, see Appendix O).

			Nitrogen Load (kg/y)							
			Existing				Built -out			
Town	Area (acres)		Unattenuated		Attenuated		Unattenuated		Attenuated	
Barnstable	9418	87%	58971	86%	45446	93%	66481	84%	50959	92%
Sandwich	1464	13%	9728	14%	3428	7%	12468	16%	4500	8%
Mashpee	85	0%	154	0%	69	0%	277	0%	124	0%
Total	10882	100%	68853	100%	48943	100%	79226	100%	55583	100%

Table 3.9 Percent reductions of controllable watershed loads that are required to restore water quality to the threshold concentration at the sentinel station

Sub-embayments	Present Controllable Sub-Watershed Load [1] (kg/day)	Target Threshold Sub-Watershed Load [2] (kg/day)	Percent controllable sub-watershed reductions needed to achieve threshold load levels
Cotuit Bay	23.77	22.34	6 %
West Bay	17.90	15.97	11 %
Seapuit River	3.77	3.77	0 %
North Bay	27.48	4.47	84 %
Prince Cove	31.30	17.89	43 %
Warren Cove	10.08	5.05	50 %
Prince Cove Channel	5.02	0.77	85 %

[1] Composed of combined fertilizer, runoff, WWTP effluent, and septic system loadings
[2] Target threshold watershed load is the load from the watershed needed to meet the embayment threshold N concentration of 0.38 mg/L identified in Table 2 above.

Town of Barnstable Officials has stated that their town-wide wastewater management planning would address the necessary loads from the Three Bays watershed for the purpose of achieving the nitrogen threshold concentration at the sentinel location. Inter-municipal memoranda of understanding would be pursued with the towns of Sandwich and Mashpee to cost share the sewering of the watershed for the purpose of allocating load reductions by town that is the most cost effective for achieving the nitrogen threshold concentration at the sentinel location in the estuary.

Dr. Howes cautioned the towns in using this “fair share” approach for apportioning loads that land held in conservation and other open space protected lands (Zone I’s to public water supply wells) are included in the acreage for each town; suggesting they may want to exclude these protected lands from their calculation as they are unlikely to generate anthropogenic sources of nitrogen loading.

Table 3.10 Attenuated and unattenuated load by sub-watershed, under existing and build-out conditions, for the Towns of Barnstable, Sandwich, and Mashpee

TMDL Segment	N Load (kg/y)															
	Existing Unattenuated				Existing Attenuated				Buildout Unattenuated				Buildout Attenuated			
	BAR	SAN	MAS	TOTAL	BAR	SAN	MAS	TOTAL	BAR	SAN	MAS	TOTAL	BAR	SAN	MAS	TOTAL
Cotuit Bay	10712	1175	134	12020	8971	511	59	9541	12258	1437	240	13935	10087	625	105	10817
West Bay	7185	0	0	7185	6960	0	0	6960	7557	0	0	7557	7328	0	0	7328
Seapuit River	1375	0	0	1375	1375	0	0	1375	1645	0	0	1645	1645	0	0	1645
North Bay	11475	179	20	11673	10648	89	10	10748	12629	219	36	12884	11688	109	18	11815
Prince Cove	4636	882	0	5519	4420	457	0	4877	5190	1134	0	6324	4964	583	0	5547
Warren Cove	21380	7492	0	28872	11051	2370	0	13421	24601	9678	0	34279	12851	3183	0	16034
Prince Cove Channel	2208	0	0	2208	2021	0	0	2021	2600	0	0	2600	2396	0	0	2396
TOTAL	58971	9728	154	68853	45446	3428	69	48943	66481	12468	277	79225	50959	4500	124	55583

TMDL Segment	N Load (%)															
	Existing Unattenuated				Existing Attenuated				Buildout Unattenuated				Buildout Attenuated			
	BAR	SAN	MAS	TOTAL	BAR	SAN	MAS	TOTAL	BAR	SAN	MAS	TOTAL	BAR	SAN	MAS	TOTAL
Cotuit Bay	89%	10%	1%	100%	94%	5%	1%	100%	88%	10%	2%	100%	93%	6%	1%	100%
West Bay	100%	0%	0%	100%	100%	0%	0%	100%	100%	0%	0%	100%	100%	0%	0%	100%
Seapuit River	100%	0%	0%	100%	100%	0%	0%	100%	100%	0%	0%	100%	100%	0%	0%	100%
North Bay	98%	2%	0%	100%	99%	1%	0%	100%	98%	2%	0%	100%	99%	1%	0%	100%
Prince Cove	84%	16%	0%	100%	91%	9%	0%	100%	82%	18%	0%	100%	89%	11%	0%	100%
Warren Cove	74%	26%	0%	100%	82%	18%	0%	100%	72%	28%	0%	100%	80%	20%	0%	100%
Prince Cove Channel	100%	0%	0%	100%	100%	0%	0%	100%	100%	0%	0%	100%	100%	0%	0%	100%
TOTAL	86%	14%	0%	100%	93%	7%	0%	100%	84%	16%	0%	100%	92%	8%	0%	100%

3.5.3.2 Inter-municipal Sharing of Wastewater Treatment Capacity

Barnstable continues its wastewater/nutrient management planning with the Towns of Sandwich and Mashpee as the three towns continues to express a desire for a shared responsibility to reduce the nitrogen loads from their portions in both the Three Bays and Popponesset Bays Watersheds. Current thinking, while not official, is that this would first require the support of Barnstable’s elected leadership who must approve all appropriations by the town. Plans are currently underway in the three towns to educate both the leadership of each town concerning nitrogen pollution sources, impacts to affected subembayments, what was learned from the Pilot Project, and proposals for joint, intermunicipal collaboration concerning where sewering would be the most cost effective in achieving the desired results in the estuary for the three towns. For example, it may be beneficial for Barnstable to coordinate with the Town of Mashpee in its CWMP to address the nitrogen reductions needed from the village of Cotuit (the southwestern and western most portion of the Town) to protect the Popponesset Bay system by paying the Town of Mashpee to sewer these areas because Mashpee’s plan for sewering includes properties that abut Barnstable. A similar cost saving arrangement is currently under consideration with the Town of Yarmouth, where it would be more cost effective to have the village of West Yarmouth’s nitrogen loads addressed by having Barnstable extend its sewer mains to those properties that abut the Village of Hyannis where the waterwater treatment facility is located.

This arrangement also benefits the Town of Barnstable because the newest expansion of its wastewater treatment facility in the village of Hyannis is expected to be completed in 2009, at a time when there will be sufficient treatment capacity to accommodate the flows from West Yarmouth and funding that would help defray the cost of the newly expanded facility.

3.5.4 Proposals for Sewering the Three Bays Watershed

3.5.4.1 Inter-municipal Planning

Intermunicpally, the three towns have discussed on an unofficial basis the possibility of joint planning for the nitrogen reductions they are responsible for reducing for TMDL compliance purposes within the watersheds they share. As discussed earlier, the towns of Barnstable and Mashpee are both engaged in the preparation of a CWMP that addresses the load reductions from the sub-watersheds within their town boundaries. However, while the Town of Sandwich has expressed an interest in inter-municipal planning, the Town is currently unable to cover the costs of hiring a consultant to address the nitrogen loads within its town borders. As discussed earlier in the Popponesset Case Study, Sandwich succeeded in taking its first step when the selectmen understood the importance of addressing the impacts of the town's nitrogen loads to the Popponesset and Three Bays Embayments when the Board appointed the Water Quality Advisory Committee. This advisory committee includes representation from the Conservation Commission, Planning Board, Public Works, Board of Health, and Board of Selectmen. How soon Sandwich is able to collaborate with its neighbors will depend on its ability to hire a consultant through funding expected resulting from a NRD settlement penalty for contamination of the town's groundwater source of drinking water.

3.5.4.2 Actions Completed and Proposals for Follow-Up by the Town of Barnstable

Those actions completed and underway by the Town of Barnstable are numerous. These includes a town-wide CWMP that addresses the nitrogen and bacteria reductions needed as defined in the MEP technical and TMDL reports. Plans are also underway to upgrade it's wastewater treatment facility in the Village of Hyannis and to expand its collection system westward toward Mashpee for sewering the Three Bays and possibly in the Popponesset Watershed; anticipating some actions that would be mutually beneficial to each community.

Treatment Upgrade and Sewer Expansion: To date, $1.2M was appropriated for the design of the sewer expansion plan and $8 M for the upgrade in treatment capacity at the Hyannis Water Pollution Control Facility (WPCF). The preliminary design for the first phase of expansion of Barnstable's' Comprehensive Wastewater Facilities Plan that was approval by the MEPA unit and the Cape Cod Commission in October 2007 is currently undergoing review. The Comprehensive Sewer Expansion Plan is undergoing development; with a preliminary design layout of sewer main and pump station locations westward of the Hyannis WPCF to Areas of Concern (AOC) in the Village of Centerville (including Lake Wequaquet and Long Pond areas). When completed, this will assure an efficient expansion of the sewer system while maximizing use of existing mains and pump stations. The preliminary design plan also includes coverage for other AOC's. The Hyannis WPCF increase in treatment and discharge capacity to 4.2 MGD is expected for completion during the winter 2009.

As part of its planning, Barnstable official are considering the transfer wastewater flows outside of the Three Bays watershed for treatment at the Hyannis WPCF. In anticipation of the CWMP need to address water balance, an opinion may be required from MassDEP concerning the Commonwealth's position on transferring water from one coastal ground watershed within a Cape Cod lens to another – all within the confines of the Sagamore lens. Does the Cape's groundwater lens characteristic with a span of many square miles have the same need to restore waters balance as required by a CWMP for an off Cape surface drainage watershed for water balance considerations? In other words, would water transfer between coastal watersheds within the Sagamore Lens, over time, have local groundwater elevation impacts on the coastal watershed the water is transferred from to where it is received? This is one issue that MassDEP will need to address in the future as part of any regional plans for sewering one or more nitrogen-sensitive watersheds with TMDLs.

The transfer of wastewater outside the watershed of origin for disposal, reuse, and or groundwater recharge, at some point will require guidance from MassDEP concerning the permitting requirements under the Wetland Protection Act; especially concerning the use of wetlands for the natural attenuation of nitrogen loads and water recharge. MassDEP has begun the process of defining the capacity of wetland systems to treat wastewater via natural attenuation when the Department funded the Woods Hole Group and Teal Associates to perform a literature review on this subject. While a decision has not been made concerning the use of natural attenuation as a nitrogen removal treatment option, MassDEP has made the commitment to address this through regulatory policy or regulations as a potential low cost treatment option for towns to consider.

Promoting the need to sewer continues to be the focus of public discussions in Barnstable. In addition, a workshop is planned with the Town Council, its elected leadership, to inform them on the status of the preliminary design and need to proceed with the expansion of its sewering to address the town's nitrogen-sensitive watersheds.

The Town anticipates adopting a sewer neutral policy in the Local Comprehensive Plan (LCP) and with ordinances/regulations to ensure that existing development expansion is limited to allowed on-site Title 5 flows. The Barnstable Board of Health has adopted several regulations that deal with sewer connections and I/A systems, which can be viewed on the Towns web site.

Mill Pond Dredging/ Nitrogen Attenuation Proposal: Joint plans to increase natural attenuation of the fresh water system with support by another town (Sandwich) are under consideration to help defray the cost of demonstration project. Increasing the depth of this shallow pond, through dredging using the county dredge, would be studied to determine if natural attenuation would further reduce the nitrogen load passing through this system. The concept is based on the premise that a great deal of the groundwater from headwater locations pass through this pond. By increasing the limited storage and retention capacity of this shallow pond – currently with a sediment depth of 12 feet and 3 feet of open water, it is hoped the project would demonstrate further attenuation of nitrogen than is possible as a shallow pond.

Streambeds/upland wetlands for multiple uses: Ideas discussed for future consideration as low tech, innovative, low cost options for reducing nitrogen loads that should be explored:

- Disposal of Treated Wastewater: CWMPs should explore the possibility of siting inland wastewater disposal sites that would take advantage of natural attenuation to "polish" treated wastewater discharges with concentrations at 3 – 4 mg/L N to lower concentrations prior to its discharge to the estuary.

- Restoring the streambed from Hamlin Pond, near Cape Cod Resources location, should be explored. With NOAA funding support, this streambed which has been filled in by Cape Cod Resources could be restored to full function with wetland habitat function and nitrogen attenuation, while at the same time restoring habitat for anadromous fish.

3.5.5 Pilot Project Team Issues and Suggestions

CWMP related issues that require MassDEP policy

- Transferring water between watersheds. What is allowed for water transfer between different watersheds? Needed more information on how to handle the watershed flows; wastewater pulled out of one watershed vs. treated water recharged into another watershed. Must treated wastewater be returned to the watershed it was generated from? Can wastewater be treated in one town and recharged in another town?
- Permitting for changing wetlands types for natural attenuation and recharging of water. How much can CWMP depend on natural attenuation for treatment? How much can natural systems be manipulated to enhance natural attenuation of existing systems? What are the procedures and permitting necessary to change one type of a wetland to another (i.e. old abandoned cranberry bog changed to open water pond system)?
- What is the timeline for communities who are to work jointly on a shared watershed when the towns are at very different levels at the planning stages and funding? What are MassDEPs expectations of a timeline for the development of implementation plans considering these differences?
- Funded mandates

Obstacles that must be overcome to address watershed-based TMDL implementation

- It must be clear to all towns sharing a watershed that they must work together and that none of the towns is without some responsibility to restore the embayment habitat.
- Funding of projects and the cost of sewering
- Locating sites for wastewater treatment and effluent discharge.

Role of community-based outreach and planning in the implementation of proposed wastewater mitigation measures

- Funding is the key issue. If the towns cannot convince people that implementation is a needed program then you will not receive the needed money to proceed. Must win over Town Council to support sewering projects and other nutrient treatment programs (NDA, stormwater/road work, etc.). Citizen Advisory Committee (CAC) can be the bridge between the technical staff and the community when proposing projects.

Lessons Learned to Share with Other Coastal Watershed Communities

- If a high percentage of the watershed and waterbody is in one community then the other towns that share the watershed/waterbody often look at the problem as not theirs. As the other towns look at their other watersheds, they reconsider and understand that we are all in this together.
- We need to use terms which are more familiar to town government (ex .the use of MOUs is more familiar and user friendly).
- It is a long journey that each town must make and with the help of other towns in the watershed, we can make the journey together and hopefully a more cost-effective, environmentally-sound outcome will be achieved, with a restored habitat that we can all enjoy and profit from.
- Community-based outreach and planning is critical to funding the implementation of proposed CWMP measures. If the towns cannot convince people that implementation is a needed program then you will not receive the needed money to proceed. Must win over elected officials to

support sewering projects and other nutrient treatment programs (NDA, stormwater/road work, etc.). A Citizen Advisory Committee (CAC) can be the bridge between the town's technical staff and the community when proposing projects for funding.

- Obstacles that must be overcome locally and/or regionally to address watershed-based TMDL implementation:
  - It must be clear to all towns involved that they must work together and that none of the towns sharing a watershed is without some responsibility to restore the embayment habitat.
  - Funding of projects and the cost of sewering.
  - Locating sites for wastewater treatment and effluent discharge

Chapter 4: Pleasant Bay Watershed

Figure 4.1 Aerial views Pleasant Bay displaying its single inlet (top) and the breach to its barrier beach that resulted in a second inlet on April 19, 2007.
(Photo provided by the Town of Chatham Kelsey-Kennard air view, www.capecodphotos.com)

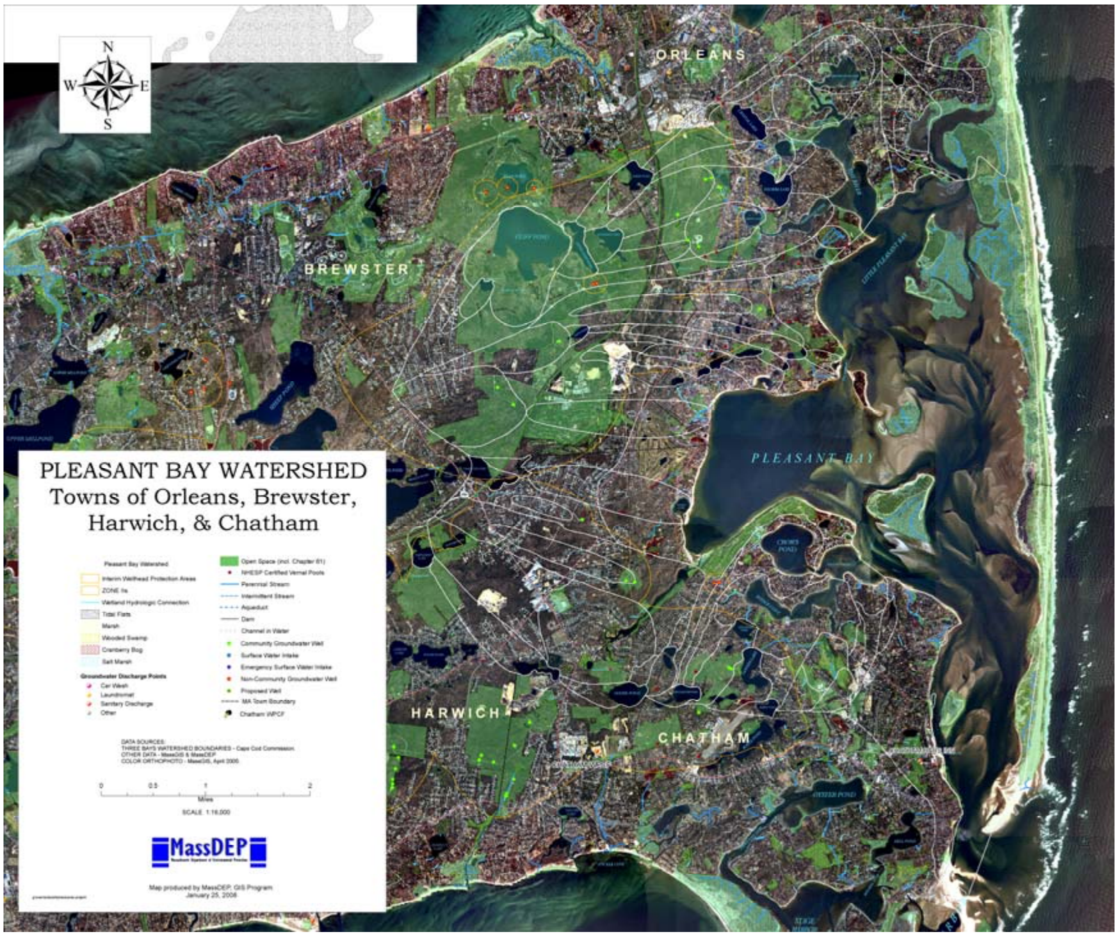


Figure 4.2 Aerial photo of the Pleasant Bay Watershed and its embayments showing the southern inlet that impeded tidal exchange with the Atlantic Ocean, prior to April 19, 2007 when a new second inlet was formed on the barrier beach.

4.1 Pleasant Bay Watershed Facts

Key Feature	TMDL implementation in a tidal estuary
Project Name	Pleasant Bay Watershed, Inter-municipal Watershed TMDL Implementation
Scope/Size:	Watershed area: 33.75 square miles (ca. 21,599.72 acres); approximately 9 miles north to south and just over 3 miles east to west
Land Type	38% residential (predominantly single family homes); 37% government building, lands and roads; 12% undeveloped, 5% golf/recreational; 3% commercial/mixed use; 1% agricultural
Pollutant	Nitrogen
Wastewater Infrastructure	A centralized wastewater treatment facility services a portion of the Pleasant Bay Watershed. The towns of Orleans, Brewster, and Harwich are without municipal sewer; Orleans hosts a regional septage treatment plant; approximately 5 private sewage treatment plants; most properties with residential on-site wastewater disposal systems.
Hydrology	The Pleasant Bay system consists of 19 TMDL sub-embayments (Meetinghouse Pond , The River-upper, The River-Lower, Lonnies Pond, Areys Pond, Namequoit River, Paw Wah Pond, Pochet Neck, Little Pleasant Bay, Quanset Pond, Round Cove, Muddy Creek Upper, Muddy Creek Lower, Pleasant Bay, Ryders Cove, Frost Fish Creek, Crows Pond, Bassing Harbor, and Chatham Harbor. Currently this hydrologically active and dynamic embayment system exchanges tidal water with Nantucket Sound to the South and the Atlantic Ocean to the east through two inlets. (Figure 4.1)*
TMDL Development	NPS subsurface, nitrogen discharges primarily from residential on-site septic systems and secondarily from fertilizer use
Data Sources	Towns of Chatham, Orleans, Harwich, and Brewster; Cape Cod Commission; Massachusetts Department of Environmental Protection (MassDEP); University of Massachusetts at Dartmouth -School of Marine Science Technology (SMAST)
Data Mechanisms	Water quality monitoring results, watershed/parcel specific defined estimates of nitrogen loading based on drinking water use records, USGS delineation of groundwatersheds, and MEP Linked Watershed-Estuary Nitrogen Management Model (Linked Model) for calculating load thresholds.
Monitoring Plan	An on-going Citizens Water Quality Monitoring Program has trained and involved more than 150 citizen volunteers from the Chatham Water Watchers, Orleans Water Quality Task Force, and the Towns of Harwich and Brewster.
Control Measures	Since 1998, the Pleasant Bay Alliance has been engaged for the protection of Pleasant Bay through the development of a state approved, renewable 5-year watershed-wide Resource Management Plan with official representation from the towns sharing this watershed. The Alliance convenes a work group with representation from all four towns and regional and state agencies to facilitate regional collaboration to implement the TMDLs. All four towns are in the process of addressing watershed nutrient loads. In 2001, the Town of Chatham initiated comprehensive wastewater planning (CWMP) to reduce the nitrogen loads from its portion of the Pleasant Bay watershed. The Draft CWMP, approved in June 2008, when carried out will result in the sewering of most properties over a period of 30 years. Orleans and Harwich are presently developing CWMPs. Brewster is in an earlier stage of addressing nutrient loading. In addition, each town has or is in the process of adopting local regulations to manage nutrient loading.

4.2 The Pleasant Bay Watershed

4.2.1 General Description

The Pleasant Bay watershed and embayment system is shared with the towns of Brewster, Chatham, Harwich, and Orleans at the southeastern edge of Cape Cod, Massachusetts. Nearly three quarters of the watershed area lies within the towns of Orleans and Chatham and less in the towns of Brewster and Harwich (Table 4.1). The watershed drainage area consists of 20,680 acres and 21 square miles and slightly over 9 miles north and south and just over 3 miles east and west. This regional resource now has 2 openings in the barrier beach that separates it from the Atlantic Ocean located to the east.

The 19 sub-embayments, shown in Figure 4.2, vary in size and hydraulic complexity, characterized by varying rates of tidal flushing, shallow depths and heavily developed sub-watersheds. They are: Meetinghouse Pond, Lonnies Pond, Areys Pond, The River (upper and lower), Paw Wah Pond, Quanset Pond, Round Cove, Muddy Creek (upper and lower), Ryders Cove, Crows Pond, Bassings Harbor, Frost Fish Creek, Pochet Neck, Little Pleasant Bay, Pleasant Bay and Chatham Harbor. The 3 major sub-watersheds, having the largest contributing land area to the estuary are Little Pleasant Bay, Pleasant Bay and Chatham Harbor. This dynamic embayment system exchanges tidal flow with the Atlantic Ocean through two inlets created on Nauset Beach, the northern breach was created in 2007, the southern breach in 1987. Freshwater enters the system primarily through 3 surface water discharges into Paw Wah Pond, Lonnies Pond and Tar Kiln Marsh, as well as through direct groundwater discharges (Figures 4.2 and 4.3).

Table 4.1 Pleasant Bay Watershed - Area by Town

TOWN	**Town Area within Pleasant Watershed ***		
	Acres	**Square Miles**	**Percent**
Brewster	3,529.82	5.52	16.34%
Chatham	6,458.67	10.09	29.90%
Harwich	2,789.30	4.36	12.91%
Orleans	8,821.93	13.78	40.84%
Total	21,599.72	33.75	100.00%

* Area includes all water, including estuarine

Due to its extraordinary natural resources, the Conservation Commissions, Boards of Selectmen, and Planning Boards from all four towns of Brewster, Chatham, Harwich, and Orleans nominated Pleasant Bay as an Area of Critical Environmental Concern (ACEC). On March 20, 1987, Pleasant Bay's nomination was designated by the state as an ACEC. In 2002, the state's Natural Heritage and Endangered Species Program (NHESP) designated approximately 7,425 acres or 80% of this watershed as a core habitat in its BioMap Project, which highlights areas in Massachusetts with high biodiversity and most in need of protection. Today this resource enjoys all the protections provided by the Commonwealth of Massachusetts. The diverse and relatively unaltered habitats of this ACEC provide feeding, spawning, and nursery grounds for numerous shellfish, finfish, amphibians, reptiles, birds, and mammals.

Other important habitats include its islands, salt and freshwater ponds, rivers, bays, and barrier beaches. These areas provide flood control, storm damage prevention, improved water quality, wildlife habitat, and recreation opportunities to surrounding communities. The state-approved Pleasant Bay Resource Management Plan (1998) , Plan Updates (2003 and 2008), and Guidelines and Performance Standards for Docks and Piers in Pleasant Bay (2001) were prepared and coordinated by the Pleasant Bay Resource Management Alliance, the Pilot Project partner for this Case Study. These documents are used by the four watershed towns as a framework to protect the natural resources of this embayment system.

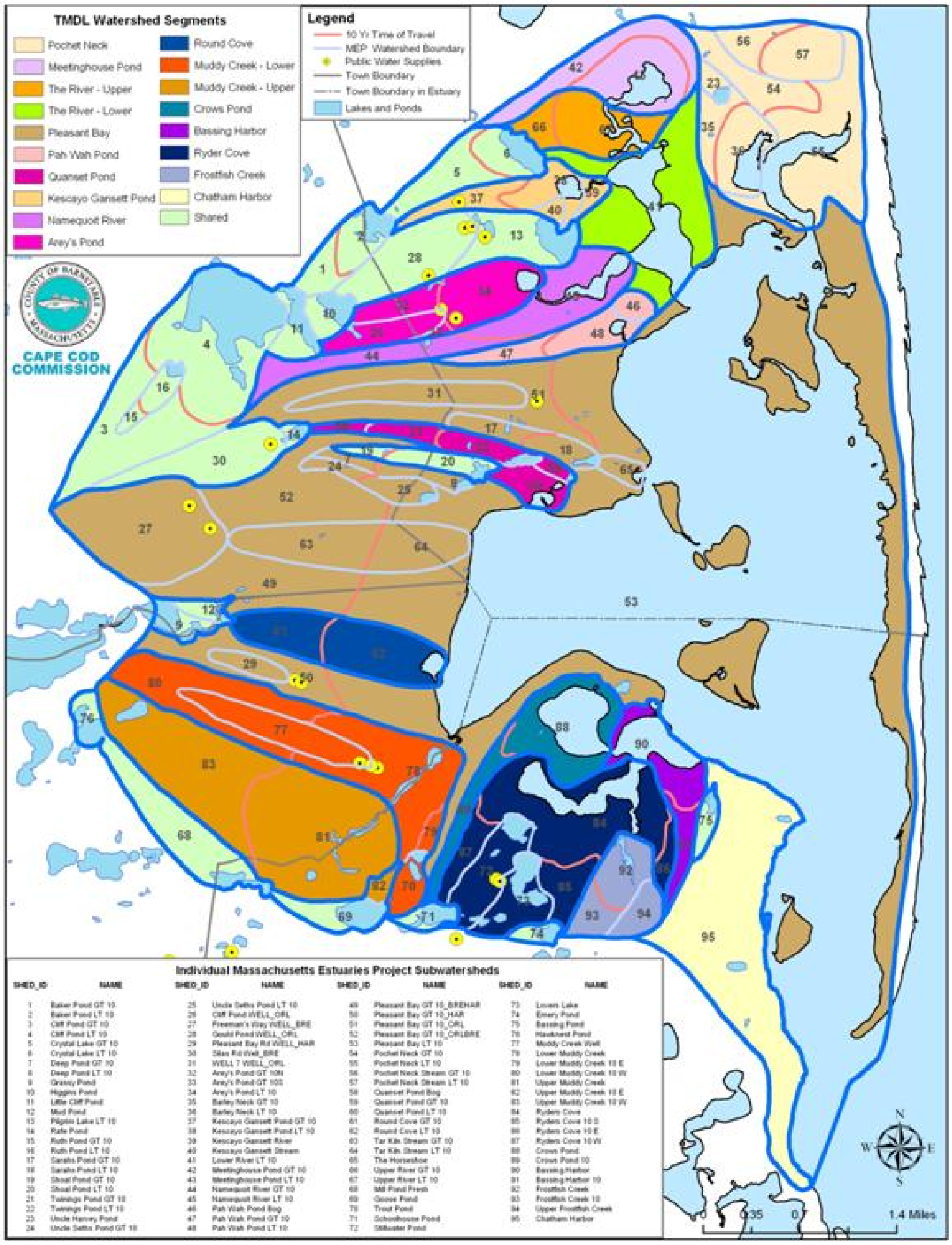


Figure 4.3 The Watersheds and Sub-Watersheds of Pleasant Bay

Figure 4.4 Contributing Sub-Embayments of Pleasant Bay

4.2.2 Geology and Hydrogeology

The hydrogeology of this watershed, like most on Cape Cod, consists predominantly of glacial deposits of sand and gravel. Several glacial kettle-hole ponds characterize the Pleasant Bay Watershed, the largest being Cliff Pond, Little Cliff Pond, Higgins Pond, Pilgrim Pond and Crystal Lake (Figure 4.2). The Pleasant Bay Watershed is within the Monomoy Lens waters resources area - a groundwater lens that provides both drinking water and surface water habitat. This groundwater system is also the recipient of the nitrogen load impacts that are derived from wastewater discharges and fertilizer use throughout this area. For more on the Monomoy Lens: http://simlab.uri.edu/cara/monomoy.htm and http://pubs.usgs.gov/sim/2004/2857/pdf/sim_plate.pdf

Unlike off Cape locations where surface topographic features characterize a watershed's boundary and drainage pattern, this Cape Cod's ground watershed is defined by the elevation and direction of flow of its water table (Cambareri and Eichner 1998, Millham and Howes 1994 a, b). Pleasant Bays sub-embayments are of varying size and hydraulic complexity; each defined by their rates of flushing, salinity, and shallow depths and their proximity to a heavily developed and populated sub-watershed.

4.2.3 Water Quality

Pleasant Bay and its tributaries have been designated by the MassDEP in its Cape Cod Watershed Water Quality Assessment Report as possessing outstanding resource waters (ORW) that are classified as Class SA waters (Appendix C). These waters are defined "as an excellent habitat for fish, other aquatic life and wildlife and for primary and secondary recreation. In approved areas they shall be suitable for shellfish harvesting without depuration (Open Shellfishing Areas)".

Through the efforts of the Chatham and Pleasant Bay Alliance Water Quality Monitoring Programs, both with MassDEP approved Quality Assurance Project Plans (QAPP), the water quality status of Pleasant Bay is well defined and served the needs of the MEP to characterize the levels of water quality impairment, lost habitat, and reductions in watershed nitrogen load needed to restore water quality. While water quality for Pleasant Bay as a whole has been excellent, consistent with its SA designation, there has been a decline most notably in the upper reaches of those sub-embayments that have been affected by the population pressures of development and by limited tidal flow and flushing. By example, water quality monitoring in the upper reaches of the sub-embayments to Little Pleasant Bay has identified moderately high nitrogen levels that are consistent with eelgrass loss. Over the years, these water quality monitoring efforts as well as others have documented water quality impairment and habitat loss. These include the following:

- 1998. The Cape Cod Coastal Embayment Project study by the Cape Cod Commission, funded with EPA section 319 MassDEP pass through money, was among the first to document water quality degradation to Pleasant Bay with sub-watershed nitrogen loads.
- 2002. MassDEP funded studies by the Cape Cod Commission in the mid to late 1990s under section 604b of the Clean Water Act, (99-03/604 Cape Cod Coastal Nitrogen Loading Studies). This study used the results from early 604b funded water quality and revised tidal flushing studies in the Pleasant Bay system, including the Mashpee River, to produce nitrogen management options for this system.
- 2003. Howes B., S. W. Kelley, J. S. Ramsey, R. Samimy, D. Schlezinger, E. Eichner. Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for Stage Harbor, Sulpher Springs, Taylors Pond, Bassing Harbor and Mudy Creek, Chatham, Massachusetts. Massachusetts Estuaries Project, Massachusetts Department of Environmental Protection. Boston, MA.

- 2006. Howes B., S. W. Kelley, J. S. Ramsey, R. Samimy, D. Schlezinger, E. Eichner. Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for Pleasant Bay, Chatham, Massachusetts. Massachusetts Estuaries Project, Massachusetts Department of Environmental Protection. Boston, MA.

In view of this embayment's designation as an ACEC, this coastal watershed and its embayment system constitutes an important component of this region's natural and cultural resources. Despite the biological diversity and the fact that most of the open waters of Pleasant Bay meet and exceed the Commonwealth's surface water quality standards, it is important to understand that many of these sub-embayments are in close proximity to areas of population density and limited tidal flushing, which collectively brings two opposing elements to bear: 1) as a protected marine shoreline this resource is popular for boating, recreation, and land development and 2) as an enclosed embayment with limited tidal flushing, the pollutants these bodies receive from these densely developed sub-watersheds from groundwater and stormwater runoff results in an accumulation of nitrogen that is not readily flushed. As a result, these sub-embayments are at risk from further eutrophication from the high nutrient loads they receive.

Past and recent water quality studies that confirmed water quality degradation, MassDEP confirmed in its 2004 Integrated List of Waters and its updated MA 2006 Integrated List of Waters that four of Pleasant Bay's sub-embayments were impaired and required TMDLs (Category 5), in compliance with the Federal Clean Water Act under Section 303(d) (Table 4.2). The environmental damage affecting these sub-embayments include pollutant loadings from nutrients and pathogens, periodic decreases in dissolved oxygen, decreased diversity of benthic animals, and periodic algal blooms (Table 4.3).

Table 4.2 Pleasant Bay Waters in Category 5 of the Massachusetts 2002 and 2004 Integrated List

Name	Waterbody Segment	Description	Size	Pollutant Listed
Crows Pond	MA96-47_2002	To Bassing Harbor, Chatham	0.19 sq mi	-Nutrients
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
Ryder Cove	MA96-50_2002	Chatham	0.17 sq mi	-Nutrients -Pathogens

As noted in Table 4.3, the TMDL report identifies several other water body segments that have the potential to be listed in Category Five once sufficient data has been compiled for these segments. Other sub-embayments in the TMDL report were determined to be high priorities based on three factors: (1) extent of impairment in the sub-embayments; (2) the initiative the towns took to assess the entire system; and (3) the commitment by the towns to restore and improve the sub-embayments. In particular, these sub-embayments are at risk of further degradation due to N loading from increasingly developed watersheds.

Table 4.3 Comparison of parameters for the impairment of waterbodies within the Pleasant Bay System

Pleasant Bay System	MassDEP Listed Impaired Parameter	SMAST Listed Impaired Parameter		Pleasant Bay System	MassDEP Listed Impaired Parameter	SMAST Listed Impaired Parameter
Meetinghouse Pond & Outlet		-Nutrients -DO level -Chlorophyll -Macroalgae -Benthic fauna		Muddy Creek - Upper	-Pathogens	-Nutrients -DO level -Chlorophyll -Benthic fauna
Lonnies Pond		-Nutrients -DO level -Chlorophyll -Macroalgae -Benthic fauna		Muddy Creek - Lower	-Pathogens	-Nutrients -DO level -Chlorophyll -Eelgrass loss -Benthic fauna
Areys Pond & Outlet		-Nutrients -DO level -Chlorophyll -Macroalgae -Benthic fauna		Crows Pond[1]	-Nutrients	-Chlorophyll -Macroalgae -Eelgrass loss -Benthic fauna
The River		-Nutrients -DO level -Chlorophyll -Macroalgae -Eelgrass loss\ - Benthic fauna		Bassing Harbor (Lower Basin)[1]		-Chlorophyll -Eelgrass loss -Benthic fauna
Paw Wah Pond		-Nutrients -DO level -Chlorophyll -Macroalgae -Benthic fauna		Frost Fish Creek	-Nutrients -Pathogens	-Nutrients -Chlorophyll -Macroalgae -Benthic fauna
Quanset Pond		-Nutrients -DO level -Chlorophyll -Benthic fauna		Pochet		-Nutrients -DO level -Benthic fauna
Round Cove		-Nutrients -DO level -Chlorophyll -Benthic fauna		Little Pleasant Bay		-Nutrients -DO level -Eelgrass loss -Benthic fauna
Ryders Cove	-Nutrients -Pathogens	-Nutrients -Chlorophyll -Macroalgae -Eelgrass loss -Benthic fauna		Pleasant Bay		-Nutrients -DO level -Chlorophyll -Eelgrass loss -Benthic fauna

[1] These segments are also classified as Category 5 on the Draft 2006 Integrated List.

The Pleasant Bay System is comprised of a variety of watersheds displaying a range of habitat health from "Healthy" (supportive of eelgrass, infaunal communities and with little oxygen stress) to "Degraded" (absence of eelgrass and benthic animals and periodic hypoxia/anoxia). There appears to be a clear relationship between habitat health and the level of nitrogen enrichment; habitat health is highest near the tidal inlet with the Atlantic Ocean and poorest in the less flushed enclosed embayments and the upper reaches of the embayments furthest away from the inlet.

4.2.4 Eelgrass Habitat

The first aerial photographic surveys of Pleasant Bay in 1951 documented eelgrass beds with significant coverage within the Pleasant Bay Embayment (Table 4.4, Figure 4.5). Personal communication with Charles Costello, MassDEP, suggests that these waters were of the highest quality without the impacts associated with nitrogen loading. However, follow-up MassDEP field surveys in 1995 and in 2001 identified an embayment system in decline with significant losses of eelgrass throughout the Pleasant Bay System (Table 4.3), ranging from 53% in Pleasant Bay North, 60% in Pleasant Bay South, and 60% overall.

Table 4.4 Pleasant Bay's Eelgrass Acreage (Past and Present)

Embayment	**1951 (Acres)**	**1995 (Acres)**	**2006 Acres)**	**Percent Loss since 1951**
Pleasant Bay North	367	313	194	52.86%
Pleasant Bay South	1771	1279	1068	60.30%
Overall	2138	1592	1262	59.03%

The nitrogen loads affecting this embayment system has been sufficient to promote microalgal blooms during the summer months, as suggested in Table 4.3 by their high chlorophyll a levels (exceeding 20 μ/L). As stated earlier, these algal blooms can be of sufficient density in the water column to shade the floor of the seabed. Without adequate sunlight, the eelgrass beds are unable to sustain their energy requirements via photosynthesis and eventually perish. For the same reason, these ecosystems cannot be reestablished as habitat and spawning ground, nursery, and protective cover for commercially important finfish, and shellfish. The eelgrass beds that were first identified in 1951 have since been replaced by macro algae, which are undesirable because they do not provide the high quality habitat for fish and invertebrates. In the most severe cases, this habitat degradation has the potential of leading to 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.

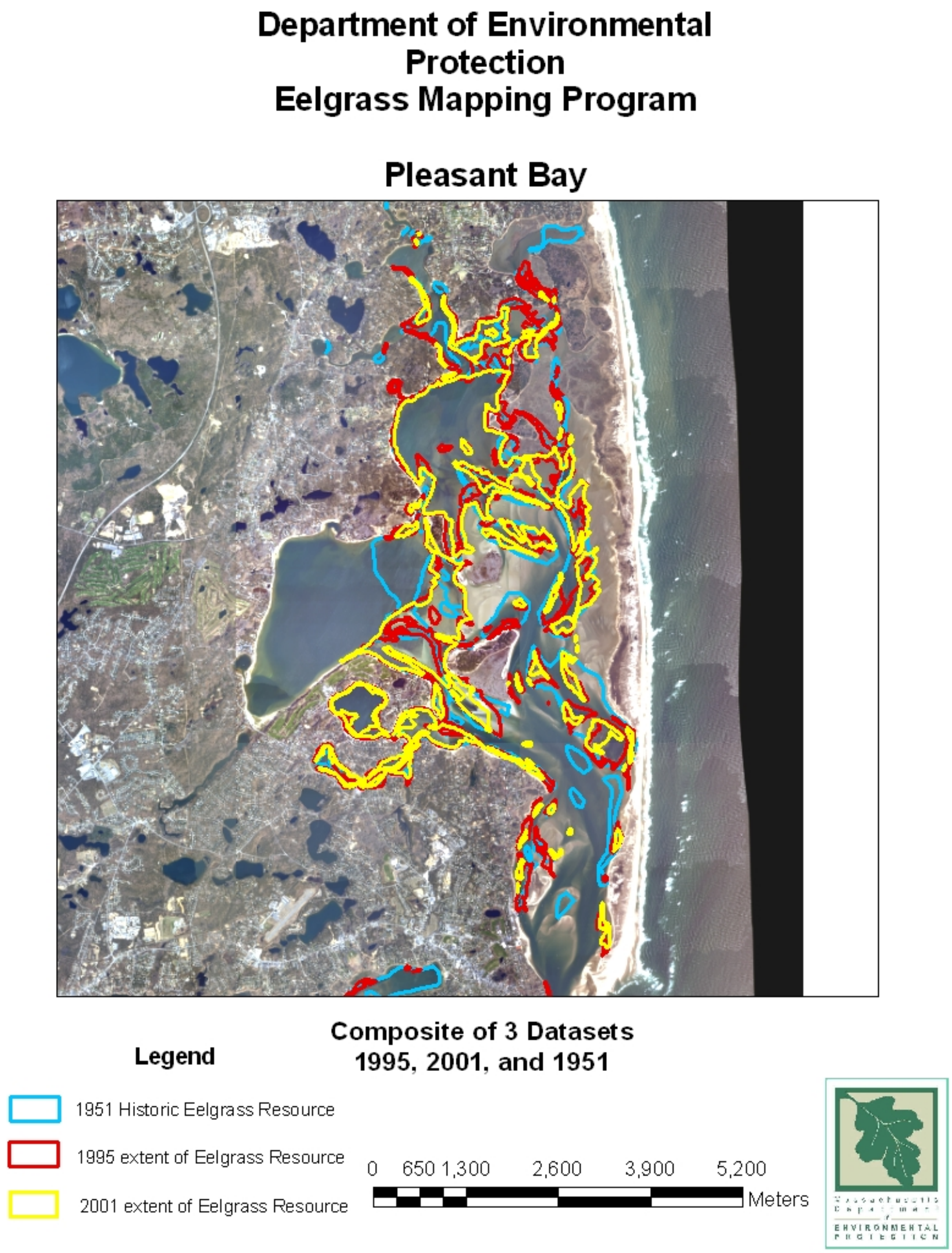


Figure 4.5 Past and present distribution of eelgrass beds in the Pleasant Bay system

4.2.5 Watershed Land Use

Land Use in the watershed, as identified in the MEP technical report, is predominantly residential (36%) and public municipal (35%) (Figure 4.6). In the individual sub-watersheds, residential land uses vary between 23 and 69% of the sub-watershed areas.

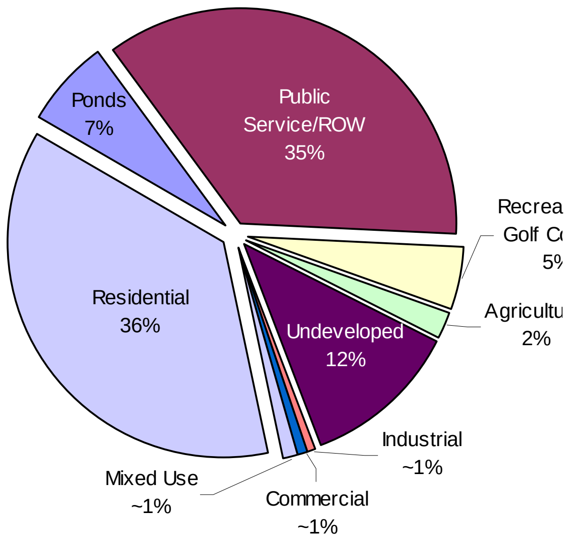


Figure 4.6 Land Use by percent within Pleasant Bay watershed
(Source: Figure IV-2, MEP Tech Report by Howes, B. et. al. 2006)

Public service land uses are the dominant category in sub-watersheds where residential land uses are the second highest percentage and are usually the second highest percentage use in sub-watersheds where residential uses are the highest. Recreational (e.g. golf courses) or undeveloped land uses are usually either the third or the fourth highest percentage land uses. Overall, undeveloped land uses account for 12% of the whole Pleasant Bay watershed, while commercial properties account for approximately 1-2% of the watershed area.

Vegetative cover consists primarily of a mixture pine, locust, and oak with limited agricultural production, confined to cranberry production.

4.3 Sources of Nitrogen

The nitrogen sources affecting an estuarine water quality are many and each has an impact. Table 4.5 and Figures 4.7a-c identify three major sources: atmospheric deposition, sediment regeneration (benthic flux), and those contributed from both natural and anthropogenic sources in the watershed. Figure 4.7(a) identifies all sources of nitrogen loading affecting estuarine water quality; demonstrating that 38% are from septic loads of nitrogen from Title 5 systems. Figure 4.7(b) identifies all sources of nitrogen affecting the watershed; showing that 69% are from Title 5 systems. While Figure 4.7(c) focuses only on the sources of the nitrogen in the watershed that can be controlled (septic, stormwater, and fertilizers); showing that 75% of this load is from Title 5 septic systems.

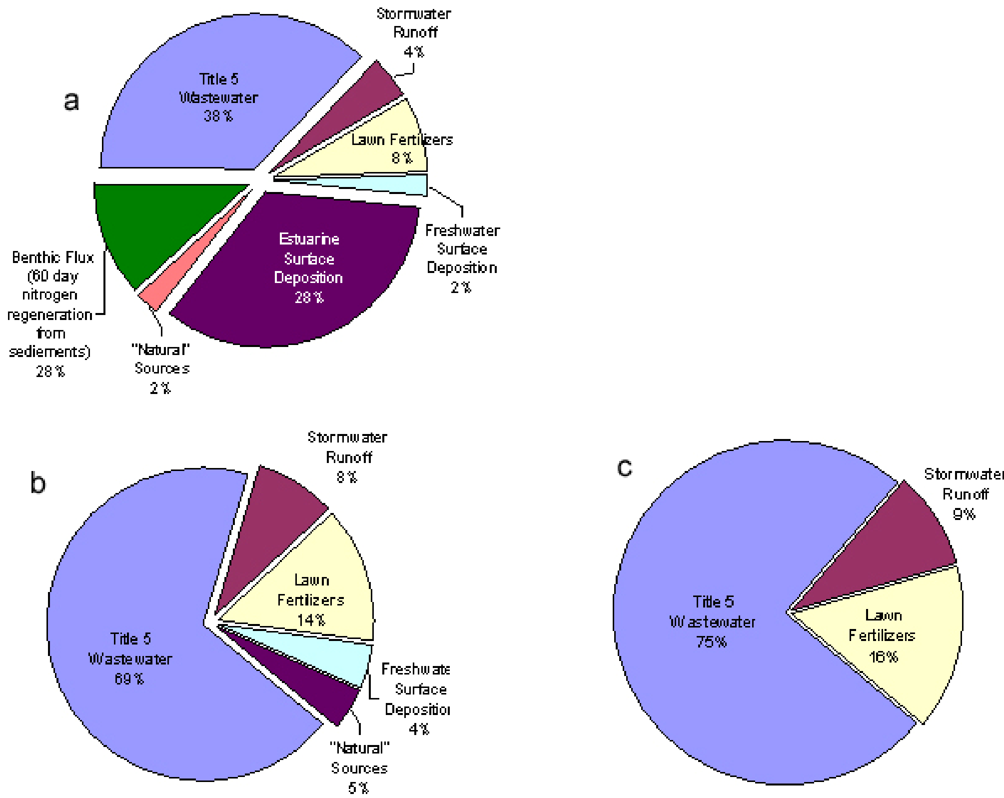


Figure 4.7a-c Pleasant Bay Estuary and Watershed Sources of Nitrogen Loading - (a) Overall unattenuated nitrogen loads, (b) Unattenuated nitrogen loads affecting the Watershed, and (c) Percentage of controllable nitrogen loads (stormwater, fertilizers, and treatment plants)
(Source: Appendix O - SMAST Pleasant Bay Technical Report (2006), Chapter 4, Table IV-4) and Executive Summary, Table ES-1b)

Figure 4.7(a) also shows that nearly 28% of the overall load comes from the biological regeneration of nitrogen in the estuarine sediments; the highest rate of regeneration of the 3 piloted embayment systems.

Table 4.5 Sources of Unattenuated Nitrogen Loads to the Pleasant Bay Embayment and Watershed

Source	Kg N/Year	Percent
Title 5 Wastewater	34290	38%
Stormwater Runoff	4074	4%
Lawn Fertilizers	7117	8%
Water Body Surface	33403	2%
"Natural" Sources	2283	2%
Estuarine Atmospheric Deposition	31278	28%
Benthic Flux (nitrogen regeneration from sediments (60 days))	67349	28%
Unattenuated Load	179794	100%

Wastewater flows from conventional Title 5 on-site septic systems represent the most significant percentage (75 percent) of the controllable watershed load, whether they fail or comply with code requirements. Watershed towns have begun the CWMP planning process to address the technical, managerial, financial, and inter-municipal coordination issues prior to the selection of a wastewater treatment option for town and/or watershed-wide utilization and benefit.

It is likely, following the completion and approval of a MassDEP approved CWMP, that towns will consider a variety of wastewater treatment options to be implemented, singularly or in combination. It is highly possible that the excess capacity of an existing treatment plant will be insufficient to treat the required additional flows. New plants may be needed, while existing plants may be incorporated within a proposed overall watershed-wide system. In addition, comprehensive wastewater management planning and implementation may require additional nitrogen reduction technologies to lower the nitrate discharges of existing plants below the current 10 mg/l permit limit; thus maximizing on costs and benefits, flows, and nitrate reductions at Title 5 septic system locations.

4.3.1 Wastewater Treatment

Chatham's centralized wastewater treatment facility serves a small portion of the Pleasant Bay watershed in downtown Chatham with the discharge outside this watershed. The remaining portions of Chatham, as well as the towns of Orleans, Brewster, and Harwich are without municipal sewer; primarily dependent on on-site wastewater disposal systems. In addition, Orleans hosts a regional septage treatment plant and a small number of private sewage treatment plants that serve the needs of locations with wastewater flows exceeding 10,000 gpd.

CWMP planning is underway in all four towns but most advanced in the Towns of Chatham and Orleans. As of September 2008, Chatham completed its CWMP and awaits MassDEP review and approval to begin construction of the sewer extensions that will sewer all locations of the community. Chatham will continue to use its existing treatment plant, which discharges its wastewater outside the Pleasant Bay Watershed. Orleans will soon be submitting its draft CWMP to the state for MEPA approval and then to MassDEP for its review and approval. Harwich is developing its draft CWMP and the town of Brewster has just begun its planning.

4.3.2 Fertilizer Use

Fertilizers on lawns and golf course greens are the second largest source of controllable watershed nitrogen loading, with lawns being the more predominant source. Fertilizers account for 8 percent of the overall Pleasant Bay watershed nitrogen load (Figure 4.7b) and 16 percent of the controllable watershed nitrogen load (Figure 4.7c).

In view of the fact that fertilizer use is the second largest controllable source of nitrogen, the Pleasant Bay Alliance took the initiative to apply for a Cape Cod Wastewater Protection Collaborative grant to: (1) determine and appropriate N leaching rate for fertilizer use in the watershed; (2) assess the implications, if any, of the leachng rate on established watershed loads; (3) develop and implement appropriate management responses, including public education. The study will ultimately provide useful information concerning application rates that are protective of Pleasant Bay and other nitrogen sensitive embayments. Pleasant Bay has four golf courses (Captains Golf Course, Eastward Ho in Chatham, Chatham Seaside Links, and Cape Cod National Golf Club on the border between Brewster and Harwich.) and 36 percent of the watershed that is in residential development with many lawns that undergo regular fertilizer applications. The Popponesset Pilot has found that golf courses contribute 24% of the unattenuated fertilizer load, equal to 2.4% of the total unattenuated controllable load. Also important to understand is that nitrogen leaching from fertilizer applications on golf courses can be a larger share of the load in the sub-watersheds where they are located since the golf course is often in such close proximity to the bay that natural attenuation may not reduce those loads prior to entering the coastal embayment.

Figure 4.8. View of Pleasant Bay from the Eastward Ho Golf Course in Chatham

4.3.3 Stormwater

Stormwater runoff impacts to the embayment system as a whole is minimal at 2% and this represents only 4% of the controllable load from the watershed (Figure 4.7a. and c).

4.4 Demographics

4.4.1 Land Use Change

During the past 58 years, land use development pressures within the Pleasant Watershed have been dramatic with a substantial loss of undeveloped land (Figures 4.9). Coincident with this change was a substantial increase in the construction of year round single-family homes and the conversion of seasonal to year-round residences. These changes are also reflected in the loss of undeveloped forest land for suburban use (Table 4.6 and Figure 4.10).

Water quality problems have been inevitable with this transformation of undeveloped open space to the construction of residential subdivisions primarily from on-site septic systems, and to a lesser extent from stormwater runoff, and the use of lawn fertilizers (Figure 4.7). The installation of onsite Title 5 systems which represent the dominant waterwater disposal option in the unsewered areas of the watershed has greatly affected the water quality of the sub-embayments. These discharges enter

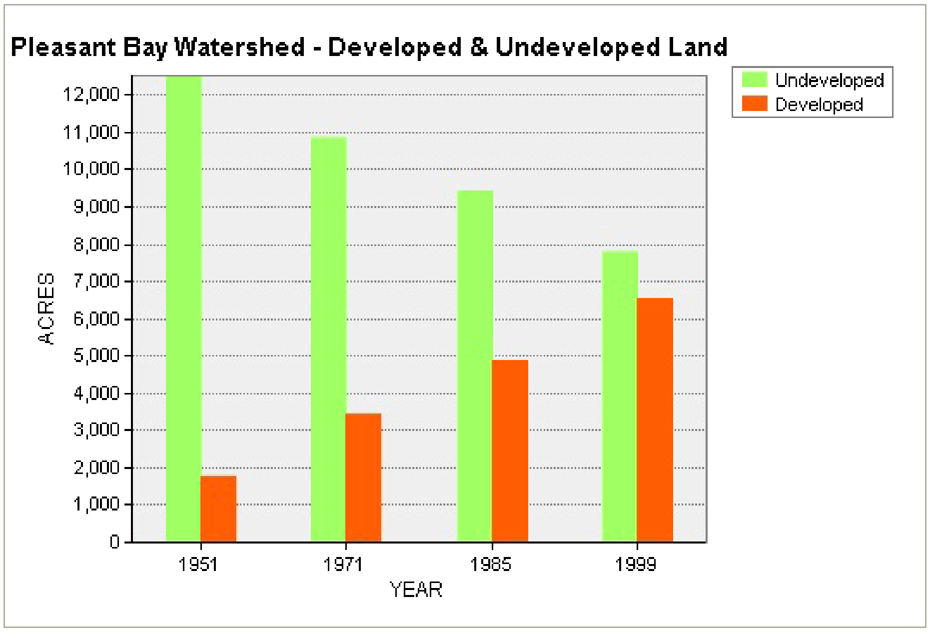


Figure 4.9 Chart showing change in developed and undeveloped land between 1951 and 1999 in the Pleasant Bay Watershed (source: MassDEP GIS)

the groundwater and eventually affect down gradient surface water bodies as this groundwater flows seaward. In the sandy soils of Cape Cod, the movement of nitrogen in groundwater is unimpeded, flowing at the same rate as groundwater at an average rate of one foot per day.

Table 4.6 Developed and undeveloped land (1951, 1971, 1985, 1999) in the Pleasant Bay Watershed (MassGIS)

YEAR	Developed Acreage	Undeveloped Acreage	Total Acreage *	Percent Developed +	Percent Undeveloped +	TOTAL PCT
1951	1775	12529	14304	12%	88%	100%
1971	3437	10865	14302	24%	76%	100%
1985	4859	9443	14302	34%	66%	100%
1999	6521	7808	14329	46%	54%	100%

* Exclusive of lakes and ponds
\+ Refer to Figure 4.10 for landuse codes for these two categories of land use.

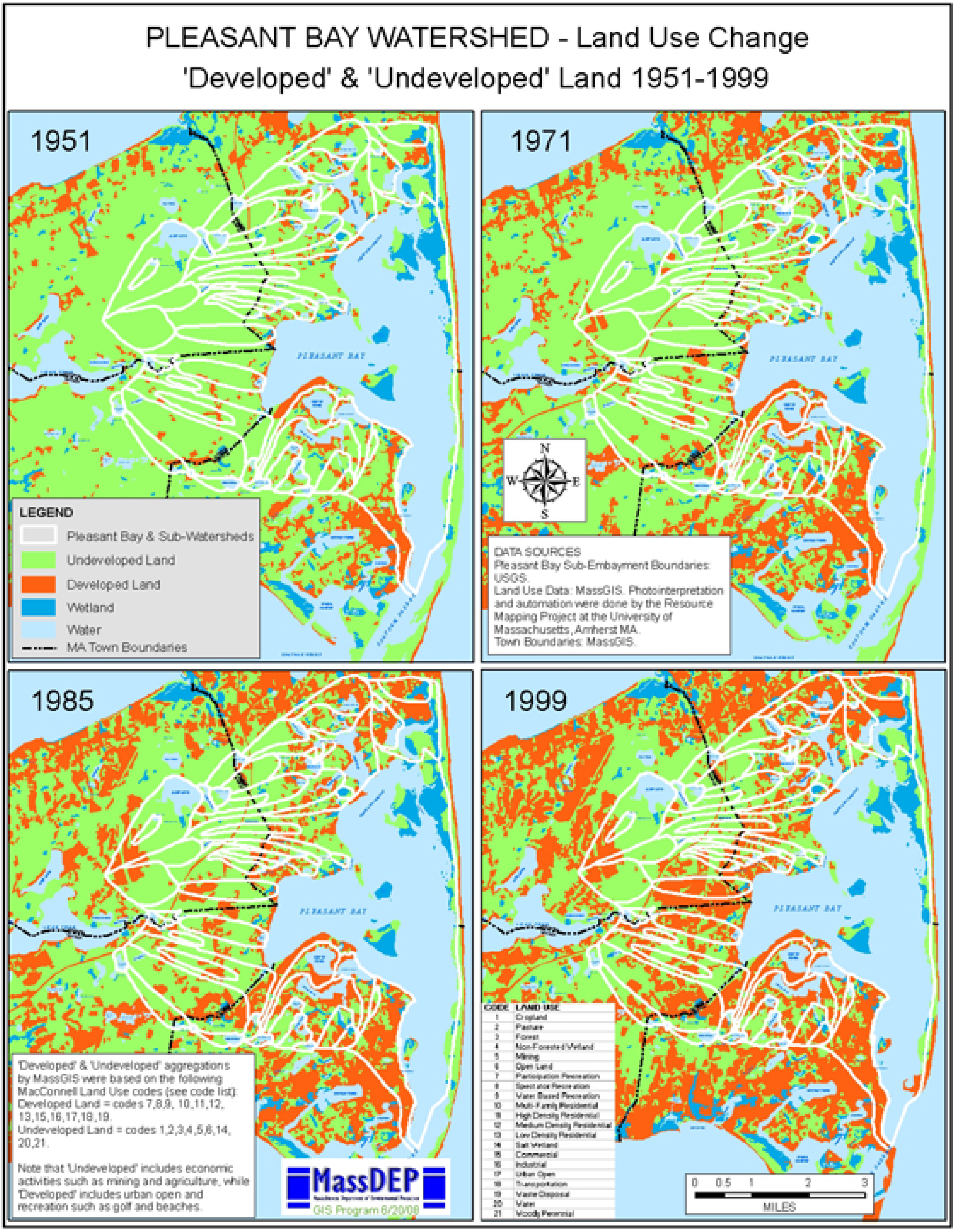


Figure 4.10 Map showing landuse change (1951, 1971, 1985, 1999) in the Pleasant Bay Watershed represented as developed and undeveloped (source: MassDEP GIS)

4.4.2 Population Growth

US Census data indicate a population growth rate that has consumed an increasingly greater percentage of the open space in the three towns since the 1950s (Figures 6. and 7; Table 4), with the Town of Brewster and Harwich taking the lead for all time intervals (1950 to 2000). The Town of Brewster led all towns with a 368 percent increase in its population since 1950; followed by the Town of Harwich (13 percent of Pleasant Bay Watershed) with a 367 percent increase, and the Town of Orleans (41 percent of the Pleasant Bay Watershed). While these rates reflect town wide patterns, they also reflect increases in residential development and wastewater discharges within the watershed from on-site water septic systems, mostly in the towns of Orleans representing 41 percent, followed by Chatham with 30 percent of the land area within the Pleasant Bay watershed. The high percentage population and development increase in the Town of Brewster is not expected to have impacted affected the Pleasant Bay watershed because a high percentage of this watershed is protected open space either for passive recreation or wellhead protection.

Table 4.6 Percent Population Growth, since 1950, for the Pleasant Bay Watershed Towns

Town	1950 – 1960	1950-1970	1950-1980	1950-1990	1950-2000
Chatham	33.2	85.4	147.1	167.8	169.6
Orleans	33.1	73.7	201.6	231.9	260.5
Brewster	25.2	81.4	429.5	755.1	922.7
Harwich	41.5	122.4	238.7	287.9	367.6
Overall	34.97	94.7	225.7	296.5	351.4

The significance of these statistics is clear; Title 5 on-site septic systems continue to serve new households with ever increasing nitrogen loads to this estuary. The 2006 MEP Technical Report

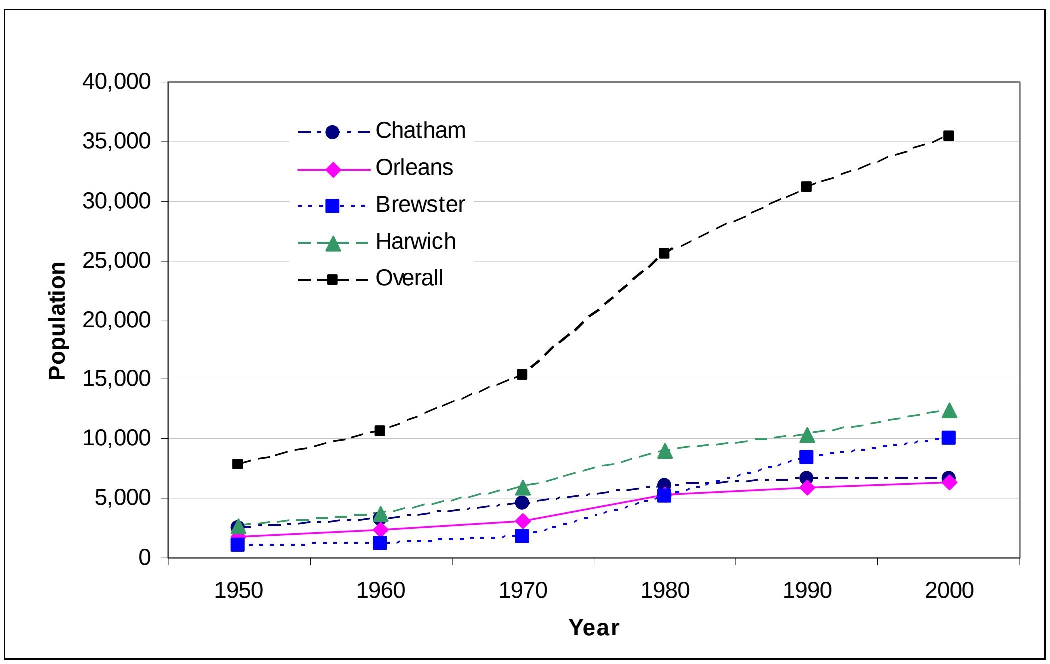


Figure 4.11 Percent Population Increase since 1950 for Pleasant Bay Watershed Towns of Chatham, Orleans, Brewster, and Harwich

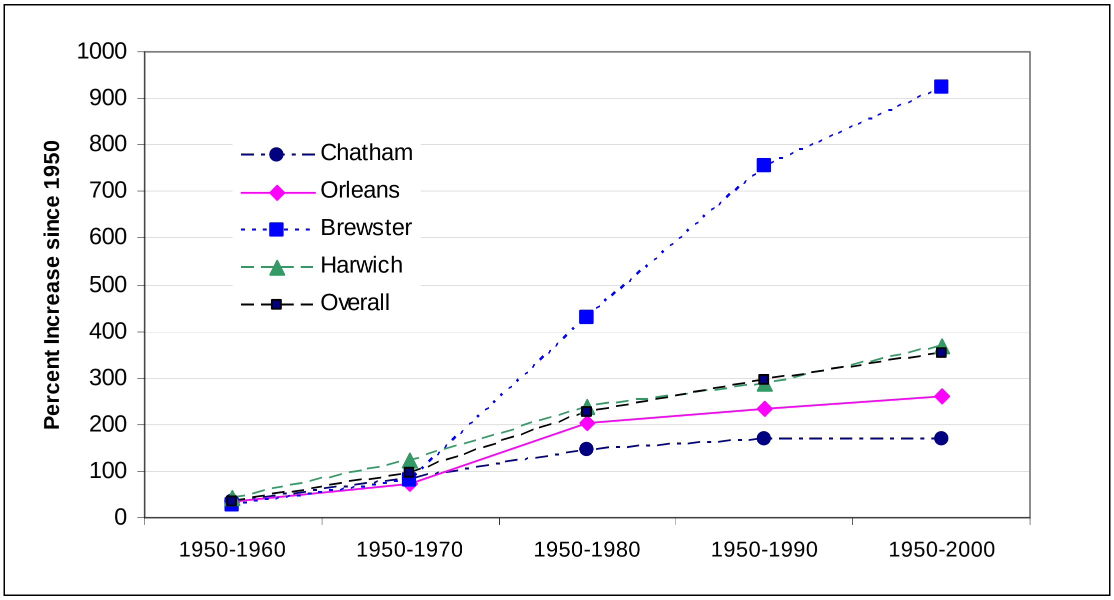


Figure 4.12 Population Growth since 1950 for the Pleasant Bay Watershed Towns

recognizes these increases are inevitable and provides an estimate of these future loads under the build-out conditions provided by current zoning for each of the towns sharing this watershed.

4.4.3 Population Density

US Census population density statistics, reported as persons per square mile, are also helpful in assessing land use development because it defines locations within the subwatershed where the wastewater burden affecting the Pleasant Bay embayments are the greatest (Figure 4.11).

It is well understood that as population density increases, and the accompanying wastewater disposal systems are installed, the nitrogen loads to the estuary significantly increases. This correlation between population density and increases in nitrogen loads is well established (Giblin and Gaines (1990). Their investigation of nitrogen loading to a small marine cove in Orleans, MA identified that septic-derived loads of nitrogen were greatest in those areas where building density was the greatest. Also, this nitrate in groundwater behaved conservatively in the sandy soils where the groundwater flow rates were the highest; indicating that the denitrification process did not reduce these loads prior to reaching the estuary.

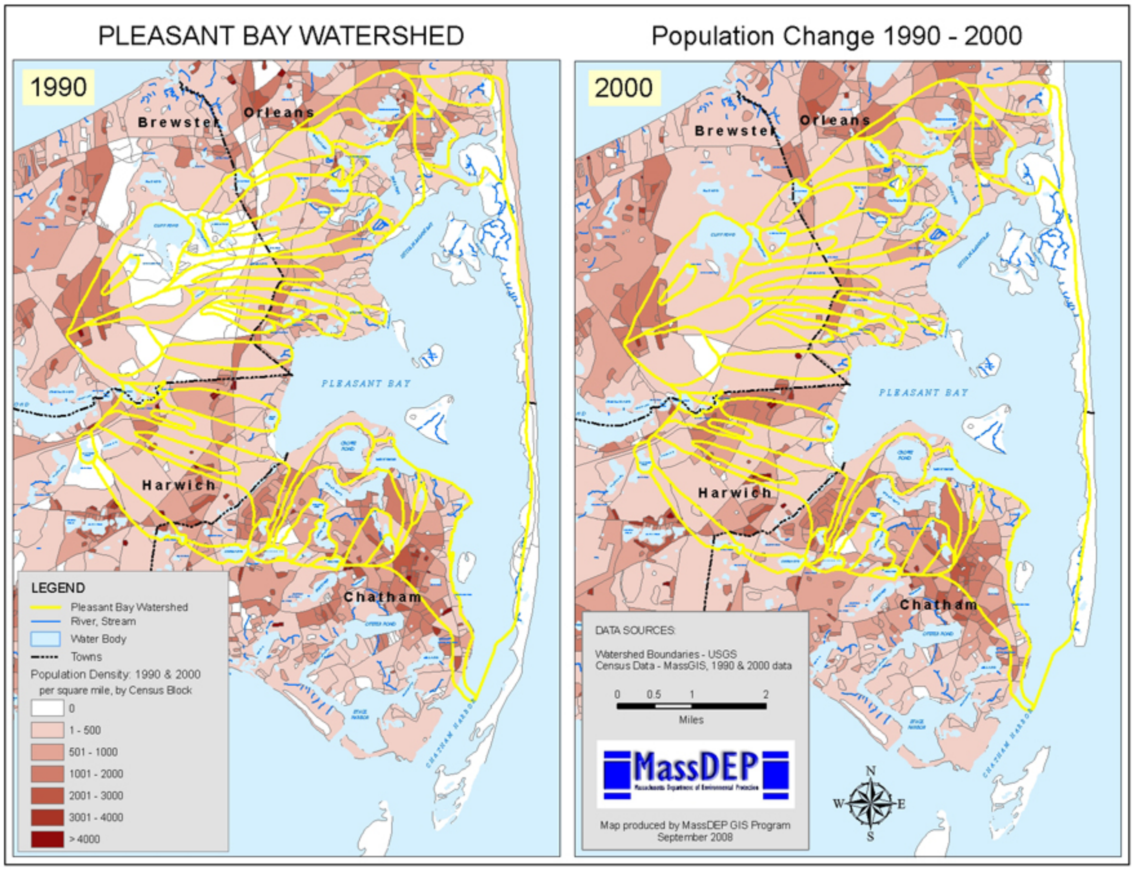


Figure 4.11 Changes in Population Density within the Pleasant Bay Watershed from 1990 to 2000

4.5 The Pleasant Bay Alliance Team

This Pilot Project enlisted the participation of the Pleasant Bay Resource Management Alliance (PBA or Alliance), an inter-municipal organization that was formed in 1998 through an MOA with the towns of Chatham, Orleans and Harwich. The Alliance is responsible with implementing the recommendations of the town and state approved ACEC Resource Management Plan as updated. The Alliance has established work groups to implement areas of the resource management plan, including the recently formed watershed planning work group to address nutrient loading issues. As defined in its updated Pleasant Bay Resource Management Plan (2008), the goals of the watershed planning work group are to:

- Continue to facilitate watershed-based collaboration to address nitrogen loading
- Support and encourage the four watershed towns to make progress in developing CWMPs
- Implement comprehensive wastewater management plans (CWMPs) that encompass the Pleasant Bay watershed, and
- Promote watershed-based collaboration to achieve total nitrogen Total Maximum Daily Loads (TMDLs) through the efforts of the Alliance's watershed work group to:

- Coordinate wastewater planning by undertaking plans and studies that will benefit multiple towns and coordinating relevant sections of towns' CWMPs, and
- Sponsor technical studies and model runs that explore system-wide issues and conditions and help to identify cost effective solutions to achieve targeted thresholds.

Because the Alliance had been involved in inter-municipal watershed based planning for over 4 years, it was clear the Pilot should enlist the participation of the Alliance. In addition, MassDEP representation had been ongoing, on an advisory basis for the last four years. Secondly, MassDEP and the Alliance had an invaluable recorded history of those many meetings that addressed how the towns would address inter-municipal, watershed-based planning and implementation; especially how the defined nitrogen reductions by the MEP Technical and the EPA approved TMDL Reports would be apportioned and implemented by the four towns.

Table 4.7 Pleasant Bay Watershed Team

Chuck Bartlett	Town of Chatham, Representative, PBA Steering Committee
Judith Bruce	Town of Orleans, Representative, PBA Steering Committee
Jillian Douglass	Town of Brewster, Asst Town Admin, PBA Steering Committee
Larry Ballantine	Town of Harwich Representative, PBA Steering Committee
Chris Miller	Town of Brewster, Director of Natural Resources, PBA Steering Committee
Frank Sampson	Town of Harwich, Chair, Water Quality Task Force, PBA TRC
Robert Canning	Town of Orleans, Health Dept., PBA TRC
George Meservey	Town of Orleans, Director, Community Development, PBA TRC
Bob Duncanson	Town of Chatham, Director, Health & Resources Dept., PBA TRC
Carole Ridley	PBA Coordinator
Gussie McKucisk	Town of Orleans, Chair, Cape Cod Water Protection Collaborative
Mike Giggey	Wright- Pierce, Orleans Consultant
Dave Young	Camp Dresser & McKee, Harwich Consultant
Nate Weeks	Sterns and Wheler, Chatham Consultant
Eduard Eichner (former)	Cape Cod Commission, Water Scientist
George Zoto	MassDEP, Project Manager, Hyannis
Brian Dudley	MassDEP, MEP Coordinator, Hyannis

Participation in the work group involves Steering Committee members who are appointed by their selectmen to serve on the Steering Committee, which governs the Alliance as the policy setting body that is also responsible and accountable for coordinating inter-municipal implementation activities. The work group also includes Technical Resource Committee members consisting of the towns' resource management professionals, and the coordinator who is responsible for managing Alliance programs and activities. This workgroup also consists of consultant engineers and agency liaisons from the Cape Cod Commission and MassDEP (Table 4.7). Staff from SMAST participated on an as needed basis to discuss development of and outcome of the selected scenario runs.

Town staff from other offices, typically attended meetings that addressed technical and policy related issues in their area of expertise and responsibility.

4.5.1 Alliance Team Meetings

There was no need to brief Pleasant Bay Alliance members about the MEP process as they were the first regional coalition of communities whose charge was to protect a coastal embayment system. The groundwork for initiating and engaging inter-municipal collaboration within the Pleasant Bay Watershed led to the publication of the first Resource Management Plan in 1998, and updated every five years afterwards in 2003, and most recently in 2008.

Unlike the Popponesset and Three Bays Pilot Projects, there was clearly no one town that took the lead. In this case, it was the Pleasant Bay Alliance, the inter-municipal entity whose charge was defined in 1998 when the Pleasant Bay ACEC was first established.

Since May 2005, PBA meetings discussed several of the issues pertaining to the goals of this Pilot Project, specifically:

- Water Quality Model runs by SMAST proposed by the team to determine how the nitrogen loads to the hydrologically active Pleasant Bay embayment system was affected from the changes in tidal flushing rates resulting from the opening/closing of inlets channel(s) to the to the Bay.
- Inter-municipal Coordination
- Allocating nitrogen load reduction responsibilities among the watershed towns
- Discussion of local and state management and regulatory issues.

Their initial focus was on the development of a white paper that was intended to provide a basis for on-going policy development on implementation issues, as well as for a dialogue with Boards of Selectmen and other key groups. After several months of discussions, the work group decided in November 2005 to suspend discussion of the white paper pending the release of the MEP Technical report and TMDL report. The rationale was that they first needed to know what the TMDL(s) would be, prior to any constructive discussion concerning mitigation. At that time, the work group discussion focused on the review and comment on the draft MEP Technical Report and later the TMDL report, and various public presentations concerning these documents.

However, in late 2006, discussions resumed on TMDL implementation issues when the PBA heard what was learned from the Popponesset Pilot Project (Chapter 2 of this report) and the *Fair Share* approach by the Cape Cod Commission.

4.5.1.1 Coordination and Development of CWMPs

At the Alliance’s November 9, 2005 meeting, it was agreed that a watershed-wide CWMP for Pleasant Bay is preferable to the coordination of plans from the individual towns. However, it was not clear how development of a watershed CWMP could be funded or managed. Coordination of individual town CWMPs may be more practical, but may not lead to the same optimization of strategies, either ecologically or economically. Once the MEP technical report was distributed in 2006, it was easier to answer questions about whether and how to combine or coordinate the CWMP process. (Also see chapter 7 for guidance on the inter-municipal CWMP process.)

4.5.1.2 Permitting

A great deal of discussion centered on watershed permitting at the PBA’s May 2005 meeting concerning the following issues:

- How would a watershed permit be issued?
- To what entity would a watershed permit be issued?
- What would a watershed permit contain?
- How would a watershed permit be enforced?

It was agreed that it was unlikely that MassDEP would treat individual septic systems as point sources. Therefore, groundwater discharge permits would go to a larger entity (town or district agency) and not an individual septic system owner.

The following permitting scenarios were discussed:

- MassDEP approves a CWMP and issues a permit to the town/district to implement the CWMP, and the district interfaces with the towns to confirm that implementation is in progress according to plan.
- Towns/district may also be issued permits for groundwater discharges (e.g. treatment plants or small neighborhood treatment systems).
- Individual systems would be permitted at the local/district level depending on how the affected town and MassDEP agreed to structure permitting.

This could mean different permitting levels. Some issued by MassDEP to the towns or district for the implementation of the MassDEP approved CWMP, and others issued by the towns/district to homeowners/developers for individual systems.

Unresolved Questions for the Alliance:

- How would the flow of permits occur so that there is the ability to achieve the TMDLs and monitor and enforce compliance?
- Who/what entity would be responsible for compliance reporting?

Although no follow-up action was taken, it was agreed that a watershed permit, if issued, should be:

- Designed to require timely progress toward an agreed upon goal
- Issued to an entity capable of implementation
- Include penalties for non-compliance
- Renewed with enough frequency to allow for adaptive management (7-20-05)

Subsequently, the Alliance communicated additional questions about monitoring and compliance issues to MassDEP on behalf of the towns. These and other issues, as lessons learned, are presented in the final chapter of this report for use by MassDEP in its efforts to assist town's in overcoming the barriers for watershed-wide TMDL planning and implementation.

4.6 Water Quality Modeling Parameters

This section briefly defines some modeling parameters that distinguish Pleasant Bay from the Popponesset and the Three Bays embayments. They are: the consideration of biologically active nitrogen or bioactive nitrogen; the use of three sentinel stations; and the connection between water quality and a dynamic barrier beach system that historically changes in the number and location of its inlets.

4.6.1 Biologically Active Nitrogen

Based on data provided by the town of Chatham and Pleasant Bay Alliance Water Quality Monitoring Program, the MEP identified very high levels of dissolved organic nitrogen within Bassing Harbor's waters. While some portion of the dissolved organic nitrogen is actively cycling, the vast majority is refractory (non-biologically active) within the timeframe of the tidal cycle of Pleasant Bay System. The result is that the dissolved organic nitrogen presents a large non-active pool that is generally separate from the nitrogen fractions that promote. The biologically active nitrogen (i.e. dissolved inorganic nitrogen, particulate (phytoplankton) organic nitrogen) that is readily available for uptake by phytoplankton and algae is collectively termed bioactive nitrogen and for the purposes of modeling Pleasant Bay loads, it was the appropriate form to model.

Given the biogeochemistry of this estuarine system, defining the nitrogen threshold concentration as bioactive nitrogen has less uncertainty in interpreting when the threshold concentration has been met for the achievement of water quality/habitat restoration. Therefore, while both values of total and bioactive nitrogen form the basis for guiding nitrogen reductions to achieve ecological restoration, the total nitrogen value should only be evaluated in light of the bioactive nitrogen threshold.

Given the large dissolved organic nitrogen pool within Pleasant Bay, the MEP adopted the same approach that was used for the MEP analysis of Bassing Harbor - based on the bioactive nitrogen pool. The concentrations of bioactive nitrogen appeared to be relatively consistent between embayments both within and outside of Pleasant Bay. The bioactive threshold value was converted to the total nitrogen by adding the dissolved organic nitrogen concentration which was derived for the site from direct measurements.

The nitrogen threshold concentration levels were developed to support both healthy eelgrass and healthy infaunal habitat at the designated sentinel locations. While there is significant variation in the dissolved organic nitrogen levels, the level of bioactive nitrogen supportive of healthy eelgrass habitat appeared to be relatively constant. Therefore, the MEP set a single eelgrass threshold based upon tidally averaged bioactive N levels and the stability of eelgrass as depicted in coverage from 1951-2001. The eelgrass threshold for bioactive nitrogen was set at 0.16 mg N L^{-1} based upon the Chatham analysis for Bassing Harbor (Howes, B. et. al.; 2003). That report identified healthy eelgrass communities in both Bassing Harbor, at a bioactive nitrogen concentration of 0.135 mg N L^{-1}, and in Stage Harbor at the mouth of Oyster River, at a bioactive nitrogen concentration of 0.160 mg N L^{-1}. The higher value of 0.16 mg N L^{-1} was used since the eelgrass habitat in Bassing Harbor was below its nitrogen-loading limit at that time.

4.6.2 Sentinel Stations

The choice of sentinel stations for Pleasant Bay and its embayments was based on a nitrogen threshold for restoring healthy eelgrass and infaunal (animal) habit. Due to the magnitude of this embayment system, three sentinel locations were selected for use in deciding if the nitrogen reductions within the watershed will meet the thresholds necessary for the restoration of eelgrass. Eelgrass is the preferred indicator for habitat restoration whenever historical record for its presence exists at a designated site. On the other hand, when this evidence is lacking or conditions are not suitable for eelgrass habitat, the infaunal (animal) habitat restoration standard is used.

The sentinel locations selected include the uppermost reach of Little Pleasant Bay (PBA-12) near Orlean's inlets to The River and Pochet, Upper Ryders Cove (PBA-03) and Lower Ryders Cove (CM-13).

The bioactive nitrogen threshold level for Little Pleasant Bay (and for the 2 stations in Ryders Cove) is 0.160 mg N L^{-1} (Figure 4.2 and 4.4). It should be noted that the threshold concentration for the two Ryders Cover sentinel locations is an average of the bioactive nitrogen concentrations at these two locations. Based upon the background dissolved organic nitrogen average of upper Little Pleasant Bay and Lower Pochet (0.563 mg N L^{-1}) and the bioactive threshold value, the total nitrogen level at the sentinel station (PBA-12) is 0.723 mg N L^{-1}. The goal is to improve the eelgrass habitat throughout Little Pleasant Bay and to restore the historic distribution in Pleasant Bay as the nitrogen levels decrease and the threshold concentration is achieved. In addition, the fringing eelgrass beds within The River and within Pochet should also be restored, as they are in shallower water than the nearby sentinel site and therefore able to tolerate slightly higher water column nitrogen levels. Moreover, the same threshold bioactive nitrogen level should be met for the sentinel stations in upper Ryders Cove as in Bassing Harbor System when levels are achieved at the sentinel station in upper Little Pleasant Bay. However, given the partial independence of the Bassing Harbor sub-embayment system relative to the greater Pleasant Bay System (i.e. its own local watershed nitrogen load plays a critical role in its health), the upper Ryders Cove sentinel station should be maintained as the guide for this sub-embayment to Pleasant Bay. It should also be noted that while the bioactive threshold is the same at both sites, the Total Nitrogen level in Ryders Cove is 0.523 mg N L^{-1}, due to the lower dissolved organic nitrogen levels in the lower Bay.

Several secondary "check stations" were also designated because several of the sub-embayments were semi-enclosed with limited tidal flushing. First, the MEP selected a sentinel sub-embayment within an embayment system based upon its location within the embayment - close to the inland-most reach - as this is typically where water quality is lowest in an embayment system. Therefore, restoration of water quality or protection of the sentinel sub-embayment habitat will result in the restoration of a high quality habitat throughout the estuary. Second, the sentinel sub-embayment should be sufficiently large to prevent a steep, horizontal water quality gradient as would be expected in the upper reaches of the estuary where a river or stream discharges its freshwater to a narrow and shallow headwater estuarine site. This second criterion is helpful because it can accurately determine the nitrogen level baseline for use in conducting predictive water quality modeling runs. Finally, this sentinel system should have the capacity to achieve the minimal level of habitat quality that is sufficient to restore the greater system (unless a multiple classification is used).

After the sentinel station (or stations) is selected, the nitrogen level associated with high and stable habitat quality (typically derived from a lower reach of the same or adjacent embayment) is used as the nitrogen threshold concentration or target concentration level. Finally, the watershed nitrogen loading rate is manipulated in the calibrated water quality model to determine the watershed nitrogen load that will produce the tidally averaged target nitrogen level at the sentinel location. Differences between the required modeled nitrogen load to achieve the target nitrogen level and the present watershed nitrogen load represent nitrogen management goals for restoration or protection of the embayment system as a whole.

Finally, while eelgrass restoration is the primary nitrogen management goal within the Pleasant Bay System, there are small basins which do not appear to have historically (1951) supported eelgrass habitat. For these sub-embayments, restoration and maintenance of healthy animal communities is the management goal.

4. 6.3 Establishing the Sentinel Threshold Concentration for Habitat Restoration

As part of the MEP, the health of the estuarine habitat was evaluated to establish the water-quality threshold to maintain or improve habitat quality. Nitrogen threshold levels are defined by the MEP as "the average water column concentration of nitrogen that will support the habitat quality being sought".

SMAST and the MassDEP determined that the bioactive nitrogen threshold concentration of 0.16 mg N L^{-1} is supportive of the restoration of eelgrass habitat in Pleasant Bay at its designated sentinel station at the upper portion of Pleasant Bay (PBA12) and the average of the concentrations of the Ryder Cover (PBA-03, CM-03) (Howes et al., 2006; MassDEP TMDL, 2007). This concentration served as the standard for restoration because field assessments identified a similar concentration in waters supporting eelgrass beds in other Cape Cod coastal waters such as (1) Stage Harbor, Chatham which also exchanges tidal water with Nantucket Sound and for which a MEP target had been set, and (2) Waquoit Bay where a vestigial eelgrass bed exists near the inlet (measured TN of 0.395 mg N L^{-1}, tidally corrected <0.38 mg N L^{-1}), (3) at West Falmouth Harbor and (4) other Cape Cod systems with similar nitrogen dynamics, since eelgrass beds no longer exist within Pleasant Bay estuary (or even at the adjacent Three Bays embayment system).

The nitrogen load reductions identified to achieve the 0.38 mg N L^{-1} threshold concentration at the sentinel station in the estuary from each of the five sub-watersheds ranged from 1 to 26 kg/day. These load reductions for each sub-watershed were the basis for discussion – to identify an equitable approach to reduce the contributing loads from each town's portion of the watershed. The Pleasant Bay TMDL Report (2007) should be consulted for a more detailed presentation.

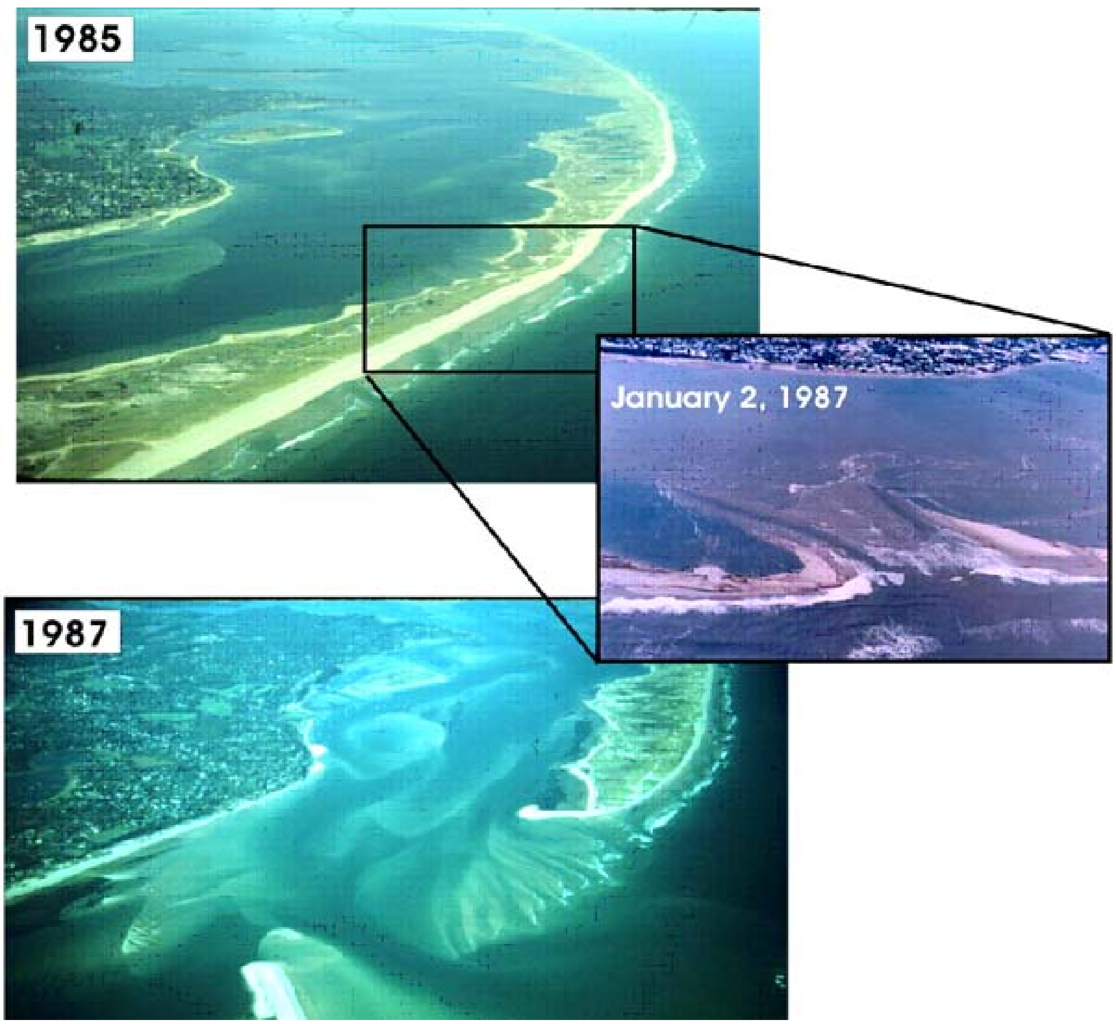


Figure 4.12 Phases of new inlet development pre and post January 2, 1987

Provided by the Town of Chatham, Kelsey-Kennard air view, www.capecodhootos.com

4.6.4 Impact of Inlet Formation on Embayment Water Quality

The SMAST Technical Report (Howes, B. et. al, 2006) and the EPA-approved TMDL Report (MassDEP, 2007) have taken into account that water quality within the Pleasant Bay embayment system is highly dependent on the makeup of Nauset Beach barrier beach which encloses much of Pleasant Bay. Any time a breach occurs with a new inlet created or whenever an inlet is closed, water quality within the Pleasant Bay system is directly affected. The addition of an inlet means more tidal exchange and greater flushing while the closure of an inlet has the opposite effect. The Pilot Project Team was keenly aware of the hydrodynamics of this hydrologically active system based on a long recorded history of Nauset Beach. Within the last twenty years two inlets formed. The first was formed in 1987 along its southern boundary (Figure 4.12 – 4.13) and unexpectedly happened again when a second inlet developed in April of 2007 (Figures 4.14). As a result, Pleasant Bay exhibits a two-channel system. Ocean water entering through the northerly 2007 breach flows behind Strong and Sipson's islands into Little Pleasant Bay; ocean water entering through the older, southerly 1987 breach flows around the other side of Strong Island into Big Pleasant Bay and Chatham Harbor.

For a brief summary of the changing makeup of this system, the abstract by Graham Giese (2008) should be read at http://gsa.confex.com/gsa/2008AM/finalprogram/abstract_148715.htm

An aerial video view of the existing two inlet systems can be down loaded at: http://www.revver.com/video/348046/aerial-video-of-new-chatham-break-cape-cod/ and

Photos documenting the changes that have occurred over time, from prior and following the development of the second inlet to the current condition: http://www.kerriganairviews.com/CQX2007Storm/

4.7 Pilot Project Scenario Runs

In view of the short-term changes in the configuration of Pleasant Bay, it was understood that before any watershed-based nitrogen reduction scenario runs could proceed that an in depth field survey of current conditions in the Bay was required. It was understood that the underlying hydrologic conditions of Pleasant Bay that provided the scientific basis for the MEP Technical Report and the TMDL were no longer applicable. The updating of the hydrologic conditions of Pleasant Bay began in earnest in November 2007 with funding provided by the US Army Corp of Engineers and the Pleasant Bay Alliance. This resulted in the report of "Hydrodynamic Model of Chatham Harbor/Pleasant Bay including 2007 North Breach (Ramsey and Kelley, 2008). Key findings of the updated hydrodynamic model are:

- 40% of the flood tide is coming through the new inlet, with about 4% of that incoming flow actually going out through the old inlet;
- The tidal prism in the system increased 14%;
- The tidal range increased 20% or 0.7 feet at Meeting House Pond, split between high and low tide; perhaps the range is slightly more at fish Pier.
- Going forward, high tides will not get much higher but low tides could get lower.

In view of these and potential future changes, the Alliance chose three model runs that address potential changes in the number and location of future inlets and its affect on Pleasant Bay's water quality. This information will be invaluable in identifying the best options for the CWMPs that are underway with the understanding that this barrier beach may return to a single inlet or, as a worse case, completely enclose the Bay. For the purpose of the Pilot Project, it was decided that the water quality conditions should be predicted for following scenario runs:

- Option 1. Presume the worse-case scenario if the barrier beach re-occupies its pre-1987 configuration with a single southern inlet (Figure 4.13). Identify the additional nitrogen load, compared to the threshold scenario detailed in the MEP Technical Report that would have to be removed to meet the nitrogen concentration threshold.
- Option 2. Maintain present conditions with a dual inlet scenario (Figure 4.1; Figure 4.14). Identify how dual-inlet flushing has affected the nitrogen concentrations previously defined in the current Pleasant Bay MEP Technical Report.
- Option 3. Potential single inlet system configuration. Identify conditions if the southern 1987 inlet closes and the northern 2007 inlet remains open.

The Alliance was also interested a re-run of the model under existing (2004) and build out loads.

Figure 4.13 Oblique view of Pleasant Bay and Nauset Beach prior to the 1987 inlet
(Source: Town of Chatham, Kelsey-Kennard air view, www.capecodhootos.com)

4.7.1 Limits on Performing these Scenario Runs

Scenario #1 did not require additional hydrodynamic analysis. Scenarios #2 and #3, however, required updating of the hydrodynamic model to define the threshold concentration at the sentinel locations because the 2007 inlet was created after the data that which was the basis for the 2006 MEP Technical Report was gathered. An in-depth assessment of the changes in bathymetry, tidal range, flow patterns, and tidal flow rates were carried out to refine the model to determine how the new inlet affected water quality throughout the Pleasant Bay system. The fieldwork to update this baseline data utilized the support from the US Army Corp of Engineers, the Pleasant Bay Alliance, Friends of Pleasant Bay, and a signed agreement with the Town of Chatham.

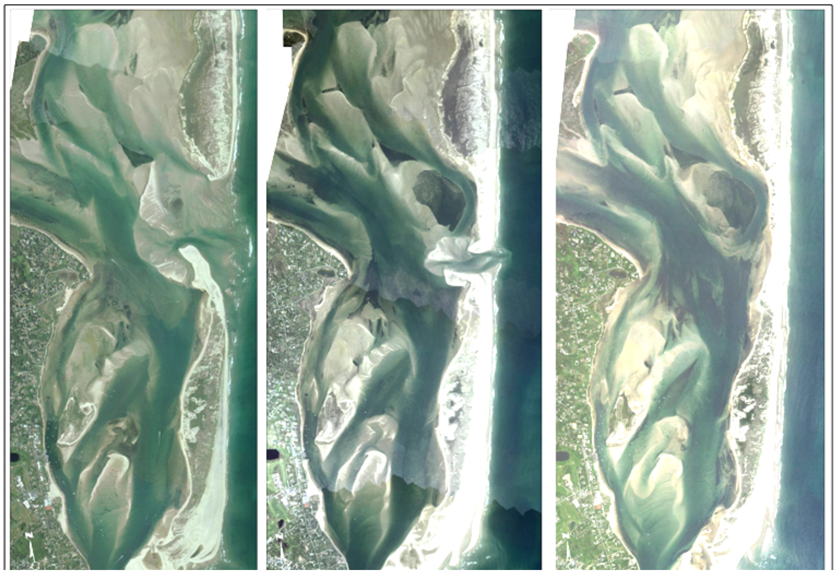


Figure 4.14 Sequence of Inlet Developments since April 2007 breach of Nauset Beach
Provided by the Town of Chatham, Kelsey-Kennard air view, www.capecodhootos.com

4.7.2 Scenario Runs

The final water quality model run, funded by the MassDEP Pilot Project was presented on the September 22, 2008 Technical Memorandum (Appendix P). The results of these scenario runs are briefly presented below.

- Option 1 (Pre-1987 single inlet configuration). This modeling scenario determined that the bioactive level of nitrogen was higher than the 0.16 mg N L^{-1} threshold concentration for bioactive nitrogen at the sentinel stations in Little Pleasant Bay (PBA-12), Upper and Lower Ryders Cove (PBA-03and CM-13, respectively) However, the secondary infaunal (animal) habitat threshold concentrations of 0.21 mg/L was achieved. Modeling of the single southern inlet under pre-1987 conditions required the modeler to estimate the watershed nitrogen loads during the 1950's when the greatest extent of eelgrass bed coverage exited in Pleasant Bay. With knowledge of where these eelgrass beds existed and the location of the inlet at its southern most extent, along with information of the tidal range, it was possible to estimate the 1950's sub-watersheds nitrogen loads by adjusting the tidal range at the inlet until the model simulated the nitrogen distribution across Pleasant Bay that was supportive of the eelgrass distribution patterns that were defined in the eelgrass distribution map of 1950. Using this approximation of conditions of the 1950's it was possible to consider existing nitrogen loads. The model assumed an 100% reduction of the attenuated septic load under current watershed loading conditions. This reduction "was intended to account for groundwater travel times and to offset other controllable loads (fertilizer use and stormwater runoff) that were unchanged from present conditions.

- Option 2 (Current 2007 dual inlet configuration). Under this scenario, the model determined that water quality improved significantly to a 0.158 mg/L concentration of biologically active nitrogen at the Little Pleasant Bay (PBA-12) sentinel location. As stated earlier, the 0.16 mg/L level has been determined to be restorative of eelgrass (Pleasant Bay Technical Memo Table 2). However, the improved flushing was insufficient in restoring water quality at the two Ryders Cover sentinel locations. The model indicated a bioactive nitrogen concentration of 0.19 mg N L^{-1} average of the modeled concentrations for Upper Ryders Cove (0.229 mg N L^{-1}) and Lower Riders Cove (0.150 mg N L^{-1}).

- Option 3 (Potential single northern inlet configuration). The model run predicted an improvement in water quality to Pleasant Bay, primarily due to its direct exposure to the Atlantic Ocean. However, this improved flushing was not significantly different from the dual inlet conditions at restoring water quality to the threshold concentration. This modeling was based on the dual inlet 2007 conditions, exemplified by the historical evidence from the 1850's when a similar northern breach ultimately caused the Nauset barrier beach to move landward toward its southern inlet, very similar to the occurrence that followed the 1987 breach.

Due to the timing of the completion of these model run results, coinciding with the termination of this project by EPA, the PBA was unable to discuss these results and the strategies they would pursue to address the load reductions for the restoration of water quality in Pleasant Bay. However, it is clear that these model results will generate questions among Work Group members and be the basis for additional model runs in the future, with the Alliance expressing its desire of becoming a clearinghouse for model runs that would have system-wide benefit that may not otherwise be pursued by an individual town.

4.8 Inter-municipal Wastewater Management Planning

4.8.1 Utilizing MEP Septic Load Reductions for Restoring Water Quality

As in all MEP Technical Reports, the percent reduction of the controllable septic load (Figure 4.7c) was the approach for reducing the nitrogen load from the watershed for habitat restoration at the sentinel locations in Pleasant Bay. Figure 4.15 identifies the percent septic load reductions recommended by the MEP Technical Report (Howes, B. et al., 2006), as one of many possible options, for each of the designated sub-watersheds to achieve the threshold concentration at the sentinel locations.

4.8.2 MEP Technical Report Septic Load Percent Reductions

Unlike the Popponesset Bay Watershed, the Pleasant Bay Alliance communities have decided to utilize the recommended percent septic load reductions that have been defined in the MEP Technical Report (Howes, B. et. al, 2006) for the sub-watersheds within their town borders (Figure 4.15). These reductions are the basis of any decisions regarding where and how much of an area within the watershed should be sewered, as well as what type of treatment plant would be the most environmentally sound and cost effective.

4.8.3 Town by Town Attenuated and Unattenuated Loads

To further assist the towns with its regional focus on wastewater management planning for the Pleasant Bay Watershed, the PBA requested the Cape Cod Commission to calculate the attenuated and unattenuated loads contributed from the four towns to the Bay's 95 sub-watersheds. While the towns' wastewater management plans are at various stages, the PBA Work Group continues to pursue its regional coordination approach to TMDL implementation. The attenuated and unattenuated loads presented in Table 4.8 and Figure 4.16 for the four towns under current and build out conditions, under current zoning, should further future discussions concerning an allocation of responsibility and costs for the reductions required from the watershed as a whole. The Cape Cod Commission member expressed his hope that these estimates would lead to a "fair share" allocation of responsibility for the reduction of nitrogen loads and cost savings.

Table 4.8 Unattenuated and Attenuated Loads to Pleasant from Brewster, Chatham, Harwich, and Orleans under existing and build-out conditions (Source: Howes, et al., 2006)

			Nitrogen Load (kg/y)							
			Existing				Built -out			
Town	Area (acres)		Unattenuated		Attenuated		Unattenuated		Attenuated	
Brewster	3,529.82	16.34%	7209	14%	6404	14%	8612	13%	7598	13%
Chatham	6,458.67	29.90%	17900	36%	17079	37%	20443	32%	19583	33%
Harwich	2,789.30	12.91%	8673	17%	8478	18%	11560	18%	11338	19%
Orleans	8,821.93	40.84%	16112	32%	14655	31%	23691	37%	21679	36%
Total	21,599.72	100.00%	49894	100%	46616	100%	64306	100%	60198	100%

At the November 2006 Work Group meeting it was expressed that each town should also look at present and projected loads in each sub-watershed in terms of the controllable load (wastewater discharge permits, new septic systems, fertilizer use, etc.) to determine if there are immediately identifiable components that could be managed to achieve the TMDL. Agreement on the loads reductions from each town would be an important first step.

Concerning the allocation of responsibility for the reduction of nitrogen loads among the PBA communities, the Alliance had two recurring themes at their December 2006 meeting:

1. The need to know each town's attenuated load in each subwatershed under current and build out conditions. While the MEP Technical Reports provided a parcel-based approach for calculating nitrogen loads within each sub-watershed and the watershed as a whole, town-specific loads were not calculated. Without this information, a discussion on allocating loads would be impossible.

2. The desire for MassDEP to provide an allocation of assimilative capacity by town, which would represent each town's share of the TMDL for a sub-embayment, and any average up to their attenuated load for that sub-embayment would be the portion the town is responsible for removing. MassDEP has not addressed this approach, primarily because the MEP Technical Report and the TMDL that is based on it's load calculations reflects only (a) one scenario of how the threshold concentrations could be met and (b) it provides a better basis for inter-municipal dialogue for watershed-wide planning and TMDL implementation.

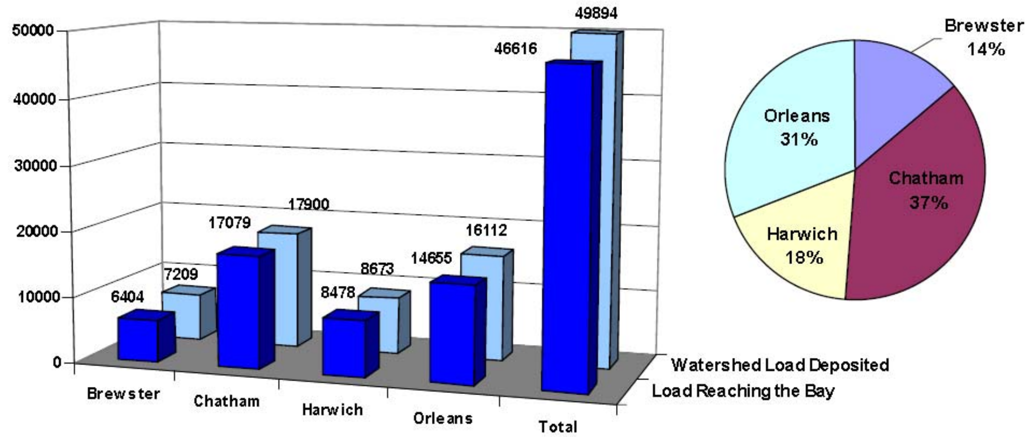


Figure 4.16 Bar graph of the unattenuated nitrogen load deposited to the watershed and the attenuated nitrogen load that reach the Bay from each of the four towns under existing conditions. Pie Chart of the percentage of the attenuated load that reaches the Bay from each town under existing conditions (see Table 4.8)

4.9 Inter-municipal Planning and Implementation

The PBA's Work Group continues to express interest in pursuing joint modeling scenarios for use by the towns in their CWMP decision-making. Also, as CWMPs are developed and implemented the scenarios will provide useful data for collaborative wastewater management planning for the restoration of water quality in Peasant Bay Watershed. As expressed recently at its January 08, 2008 meeting, the most telling scenario will be the outcome from the sewering proposals identified as the third alternative in the Chatham and Orleans' CWMPs. At this meeting, MassDEP agreed that the emphasis should be to achieve the threshold concentrations at the sentinel stations, and on how well the proposals collectively address the nitrogen threshold concentration. According to MassDEP, compliance will be based on steps the towns take to implement plans that are supported by model runs showing that threshold concentrations being met, even though meeting those concentrations may occur over a very long term.

The Towns of Chatham and Orleans have taken the lead among the PBA for their respective communities in the CWMPs that address the nitrogen loads affecting Pleasant Bay. The Town of Chatham is the furthest along of any MEP community. The CWMP has been approved by the Secretary of Energy and Environmental Affairs and is being reviewed by the MassDEP as the basis for approving groundwater discharge permit for Chatham. Orleans is in its final phase and will be seeking public comment on its draft plan prior to submitting it to the state's MEPA Unit for approval by the EOEEA Secretary.

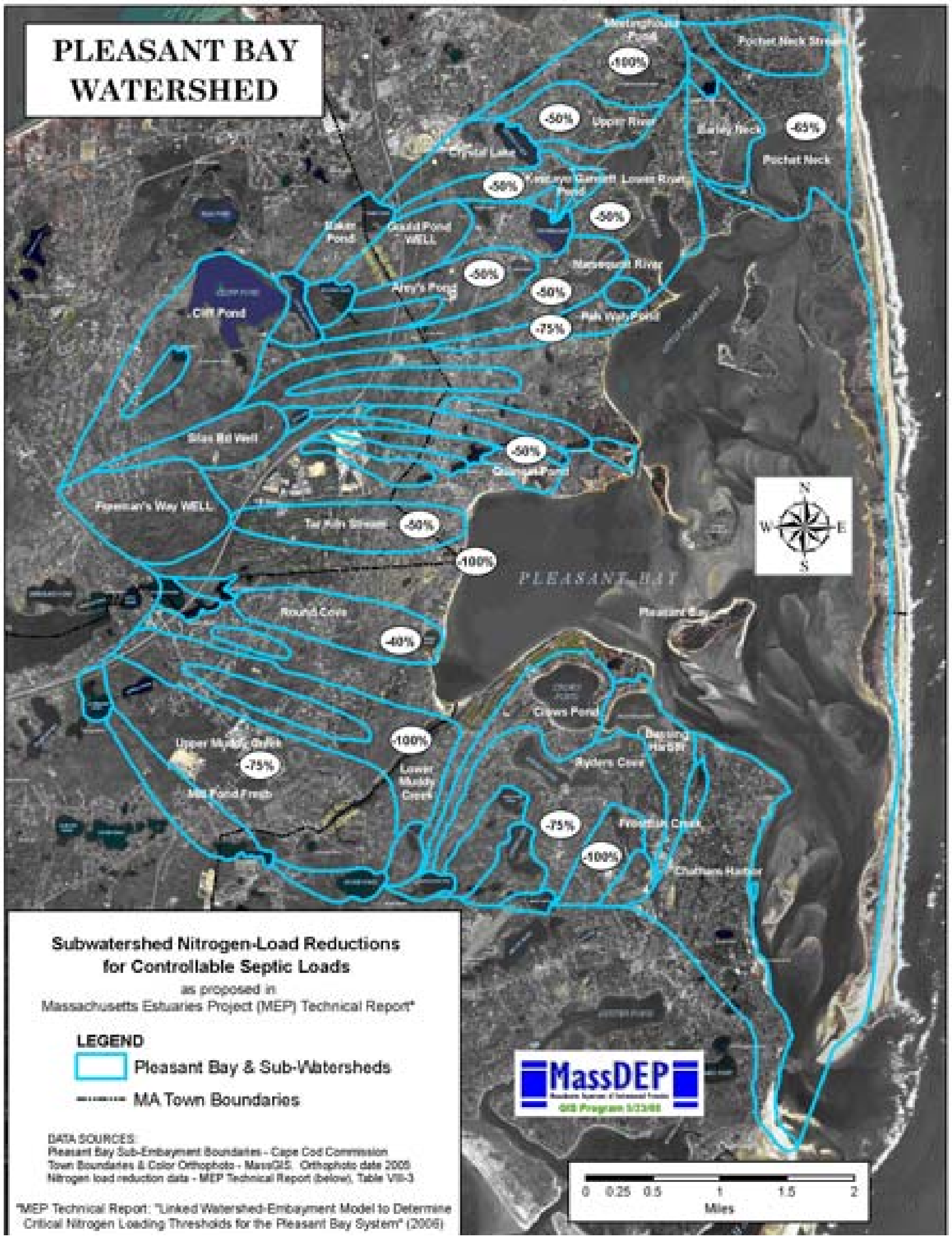


Figure 4.15 Percent reduction in septic load recommended for each of the designated Pleasant Bay embayments as defined by the MEP Technical Report
(Howes, B. et al., 2006)

4.9.1 Regional Implications of the Orleans CWMP

At the time this report was prepared, the Town of Orleans drafted a proposal for public discussion that identified locations for sewering within the Pleasant Bay watershed (Figure 4.17). The highlighted green locations in Figure 4.17 are one of several scenarios under consideration for sewering. Currently, the draft plan includes a phased-construction approach with the possibility of sharing use of the Tri-Town wastewater facility (currently for septage treatment) with its neighboring towns - presumably to help defray the annual operating costs. A phased, deferred construction option also provides the opportunity to accommodate future flows from its neighbors at a later date when their CWMPs are completed so they can address the costs and benefits of a shared regional facility. The draft CWMP suggests the opportunity of participating with the Town of Brewster to address its 14% attenuated nitrogen load (Table 4.8) to Pleasant Bay in "a Pleasant-Bay focused regional solution…" also with the potential of including wastewater flows from East Harwich and North Chatham.

In view of the fact that the CWMPs by the four towns are in various phases of completion with two near completion and/or approval, the phasing of CWMP implementation by the four towns has some merit. For the Town of Orleans it provides the potential benefit of accommodating wastewater flows from neighboring towns whose planning is still underway several years behind Orleans's efforts. Secondly, phasing has the added future benefit of synchronizing "watershed load reductions with other towns sharing a given watershed."

4.9.2 Regional Significance of the Economies of Scale Study

In recognition of the difficulties of implementing a regional approach that addresses the economies of scale in the construction and operation of a regional facility, the Town of Orleans in collaboration with the Towns of Harwich, Brewster, and Eastham embarked in a Cape Cod Water Protection Collaborative funded study "Economies of Scale Associated with Regional Wastewater Infrastructure and Appropriate Cost Sharing Formulas" that is nearing completion. When completed, this study will quantify the potential cost savings associated with regional wastewater treatment and disposal facility. One of the two case studies evaluated, which should be of interest to the PBA, addresses a prospective treatment facility located in the Pleasant Bay Watershed near South Orleans. This facility would address the Pleasant Bay load reductions from the towns of Orleans, Harwich, and Brewster. Most importantly, this study would provide a load allocation for each town and the projected cost savings, using several formulas that address cost sharing.

As stated in the grant proposal, justification for this study was clear.

> "In the absence of watershed management districts or other regional entities charged with developing regional wastewater infrastructure, there is the strong possibility that Cape Cod towns will view town-owned facilities as the primary options. Regional facilities may have benefits, but they also entail significant practical and political hurdles. It would be an appropriate use of CCWPC grant funds to document the cost savings to towns participating in a regional wastewater facility, to help overcome some of the political hurdles to joint facilities. There are 5 principal cost items in wastewater infrastructure: 1) collection, 2) transport to the treatment plant, 3) treatment, 4) transport to the disposal location, and 5) disposal. At the scale of all Cape Cod towns, the economies of scale in wastewater treatment are significant; it might cost two or three times as much to treat a gallon of wastewater at a small single-town plant than it would at a larger regional facility. Offsetting these cost benefits are added transport costs. Complicating the situation is the fact that, given the scarcity of large sites for effluent disposal, one town might benefit significantly from disposal

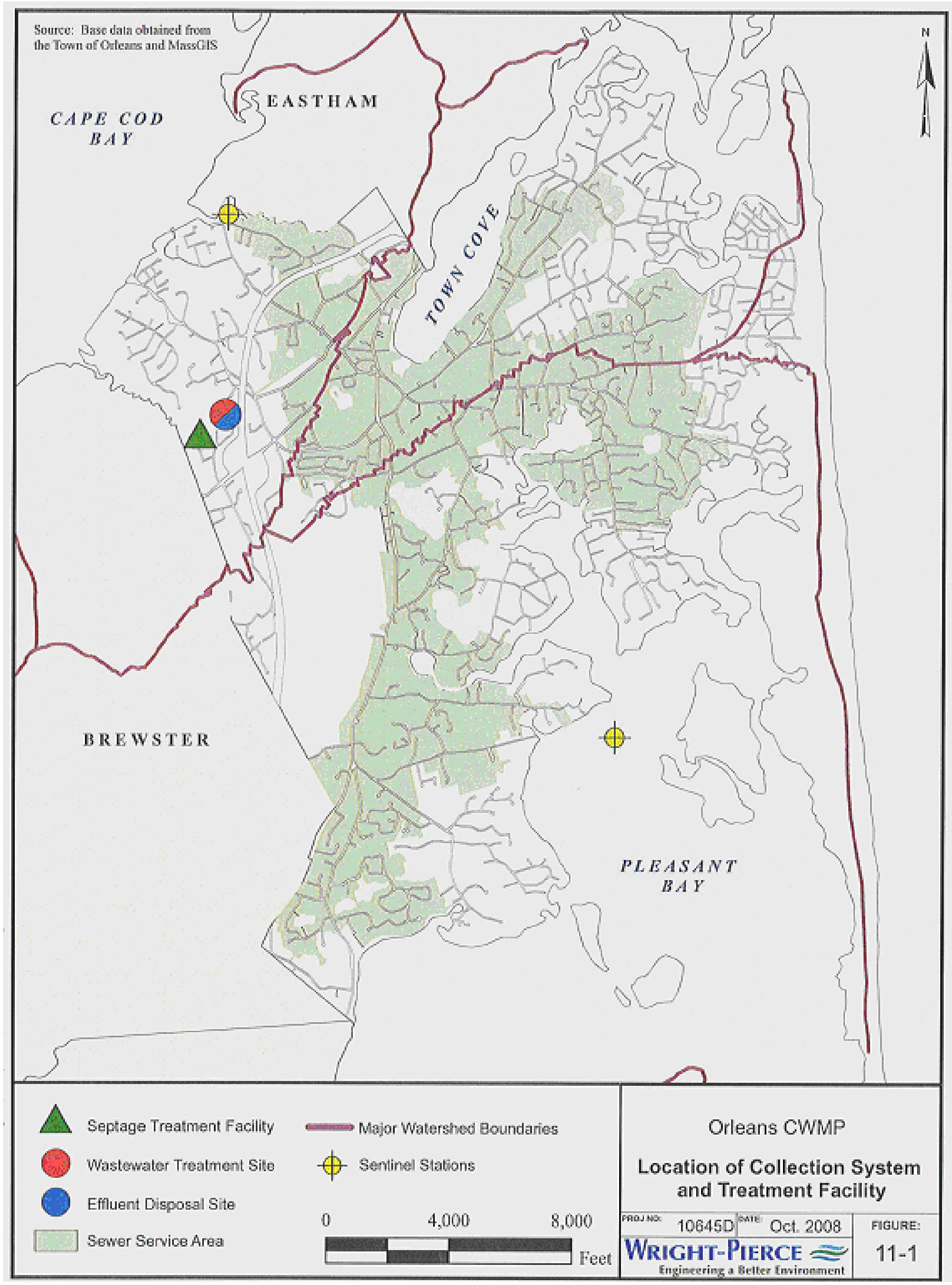


Figure 4.17 Town of Orleans CWMP Proposal for Public Discussion identifying locations within the Pleasant Bay Watershed for sewers

Courtesy of Town of Orleans.

capacity in a bordering town. Conceptual-level cost estimates will be prepared to explore the cost benefits of regional treatment plants in two locations: 1) at the Tri-Town site in Orleans serving portions of Orleans, Eastham and Brewster; and 2) at a site in South Orleans or the easterly section."

Nitrogen Trading Potential - When completed this study provides the potential to establish a unit cost for future nitrogen trading. The allocated costs are expected to be transformed into a cost per pound of nitrogen removed. These unit costs would then serve as a basis for future nitrogen trading, as well as to establish benchmarks for cost comparison and evaluation against each town's CWMP recommended cost projections. Pleasant Bay Alliance members are hopeful that this study will provide cost savings that would sway local decision makers toward a regional inter-municipal approach to sewering.

4.10 Lessons Learned for MassDEP's Future Planning

4.10.1 Possible Management and Permitting Mechanisms

Based on MassDEP's current policies and regulations, what new management and permitting mechanisms would you recommend to address the EPA mandated TMDL load reductions for Pleasant Bay?

- Codification of point of compliance – through the Working Group the Alliance communities have learned about the policy direction under discussion by MassDEP regarding point of compliance. MassDEP's codification of this approach through a policy guidance or similar document has been requested.
- Clarification on the nature of approving CWMPs would also be helpful and, specifically, clarity on the level of detail that would be provided in a groundwater discharge permit to a town or district.
- Monitoring protocol and reporting procedures – The Alliance has requested clarification on monitoring requirements, protocols and reporting procedures necessary to demonstrate TMDL compliance.
- Policy guidance is needed to address how or if TMDLs may be modified in light of changes in the inlet barrier beach configuration. It also would be important to know if a town's CWMP could be approved without a model scenario that showed concentrations being met throughout the system. This latter question relates to the fact that towns are at different stages of the planning process.

4.10.2 Monitoring and Permitting Compliance

The following summarizes the latest information concerning monitoring and compliance issues as they are being developed by MassDEP.

MassDEP is currently thinking that compliance points will reflect milestones in the phased implementation of approved CWMPs. On-going monitoring will be required, but MassDEP will not be looking at restoration targets as points of compliance. However, MassDEP will evaluate monitoring results for trends leading to water quality improvement and habitat restoration.

The current position is based on the understanding that CWMPs are built on the model that indicates if you undertake measures that are intended to lead to a level of nitrogen loading, then the restoration should follow. It is fair to base compliance on what MassDEP is asking the towns to undertake.

Specifics of the monitoring requirements still need to be developed.   Eelgrass monitoring will be done by the state. Benthic monitoring will likely be on a five-year schedule. Water quality monitoring will be continued, but could be scaled back, and adequate pre- and post facilities monitoring requirements would need to be determined. We discussed the pros and cons of suspending monitoring prior to the baseline period versus keeping it going at a scaled back rate.

Monitoring is likely to be long-term because evidence of restoration may well extend beyond the 20 year planning horizon for CWMPs. One scenario is that the water quality concentrations are achieved but eelgrass does not regenerate. Other factors would need to be considered. The PBA discussed ongoing research on eelgrass restoration, and the possibility that if water quality targets are met, then eelgrass restoration could be undertaken. (5-23-07)

4.10.3 Local or Regional Obstacles for watershed-based TMDL implementation

- The Bay is a large and intricate estuarine system with a watershed encompassing four towns. The nature of the system, the number of sub-embayments with shared sub-watersheds, and the number of towns involved adds layers of complexity to the planning process.

- One hurdle in facilitating coordinated action is the differences in the timelines for the four towns' respective wastewater management planning efforts. Because the towns are at different stages in the planning process, their needs for information and joint analysis differ. Also, the level of public awareness and familiarity with the issues of nitrogen loading and facilities planning vary for each town.

- Although not necessarily an obstacle, the dynamic nature of the inlet and barrier beach formation poses a challenge in terms of understanding and monitoring baseline conditions.

4.10.4 Role of community-based outreach and planning in wastewater mitigation

- Each of the four towns manages a process to provide public input into their respective wastewater management plans. Local input through advisory committees, public meetings, media coverage and presentations to local committees and boards plays an important role in building awareness and understanding of the facilities planning process.

- Implementation actions such as facilities development are expected to take place within towns or between groups of towns. The Alliance is not expected to undertake implementation actions other than for monitoring, compliance reporting, modeling, public information, and development of coordinated responses or strategies.

- The Alliance incorporates public outreach in nearly all of its wastewater planning initiatives. The work group facilitated by the Alliance brings together community representatives of different disciplines to discuss issues, share information, and develop strategies. Many of the work group participants are active in local and regional environmental organizations. The Alliance has also hosted public forms for the release of technical information, and input on TMDL development. Public forums will also be planned for the fertilizer management study and the Muddy Creek resource assessment noted above.

- The Alliance also publishes Citizens Guides to Estuarine Protection which are subwatershed based publications designed to provide essential information on watershed physical features and functions, as well as the implications of nutrient loading for ecosystem health.

4.11 Final Thoughts

The Pleasant Bay Alliance continues to address its mission, through its updated five-year plan, in its role of bringing communities together to address the nitrogen load reductions identified in the MEP Technical Report. Because the CWMPs for each of the four towns are at different stages of development and implementation, the PBA clearly has an important role in promoting its regional approach toward wastewater management planning and implementation. Town-by-town efforts alone cannot address the watershed-wide nitrogen reductions required to restore and sustain the dependent fragile ecosystems of the Pleasant Bay embayment system - a significant natural resource that been listed by the State as core habitat in its BioMap and as an Area of Critical Environmental Concern. As such, the PBA is uniquely positioned through its memorandum of agreement to promote the collaboration among the towns. However, there will be CWMPs that will undergo several iterations before one succeeds in addressing the resource protection needs of an embayment system that is affected by the changing configuration of its barrier beach. As defined by the PBA Work Group scenario runs, any plan must consider the possible changes this barrier beach will undergo in the future and how each change affects water quality; including the worse case, of an embayment without an inlet that flushes nitrogen from this system to the Atlantic. It appears that the wastewater planning required to achieve the restoration and continued protection of this regional resources will continue long into the future through the PBAs monthly Work Group meetings. Similar collaborative efforts could easily be duplicated among coastal communities sharing a coastal watershed elsewhere for the protection of these fragile embayment systems that are vital not only for its recreational uses but also for the habitat they provide as breeding ground and nursery to many dependent shellfish and commercial fisheries.

Chapter 5: Municipal, Regional, and State Accomplishments -Public and Private

5.1 Inter-Municipal CWMP Coordination and Planning

Pleasant Bay Resource Management Alliance

The PBA has served to spearhead and coordinate among the towns sharing the Pleasant Bay Watershed a number of initiatives for the protection of Pleasant Bay, including CWMPs, nitrogen trading, and research studies.

- Coordinated local funding and input into the system-wide assessment of Pleasant Bay under the MEP, and coordinated local input throughout the process of developing TMDLs;
- Convened a monthly work group of local regional and state officials to discuss the status of local wastewater planning and strategies for regional cooperation;
- Discussed at the work group meetings coordination of planning timelines, requirements for monitoring and compliance with TMDLs, and needs for additional data made available through modeling and other analyses.
- Sponsored SMAST Linked model rounds and other analyses that support a greater understanding of (1) how physical changes in the system could affect nitrogen loading and reduction targets and (2) the combined system wide effects of selected local actions;
- Managed two projects relevant to multi-town nutrient reduction efforts: (1) watershed wide fertilizer management study to determine whether it is feasible to obtain significant reductions through management of this nitrogen source; and (2) a study of the resource impacts, permitting strategy and cost allocation methods associated with re-installing a dike in Muddy Creek for purposes of nitrogen attenuation;
- Individual alliance communities have implemented policy and regulatory changes to address nitrogen loading as described in the preceding section.

5.2 Municipal Accomplishments

Regulatory and zoning measures have been underway for some time in the Towns of Mashpee, Barnstable, Sandwich, Brewster, Chatham, Harwich, and Orleans. The zoning, regulatory, and planning initiatives adopted by these communities are briefly outlined below; each addressing one or of the measures that were adopted for the protection of the three embayments of this case study - Popponesset Bay, Three Bays, and Pleasant Bay.

5.2.1 Town of Mashpee

Mashpee has taken a number of planning, regulatory and zoning actions to mitigate the impacts from excess nitrogen loading to its estuaries; these are discussed below.

5.2.1.1 Wastewater Management Planning

The Town of Mashpee began Nutrient Management Planning in 1997 with monitoring of nitrogen levels in Popponesset Bay and Waquoit Bay. This was followed by an assessment of the data. The Town of Mashpee expanded its planning in 1999 to encompass all the ground-watersheds the town shares with its neighbors, including Popponesset Bay, Hamblin-Jehu Pond, and Waquoit Bay. The town's share with other, out-of-town, estuaries is negligible.

When the MEP began in 2000, MassDEP recommended that Mashpee should postpone its planning until the MEP Technical Reports for its embayments were completed. In this way, the plan would utilize the latest science-based findings on nitrogen pollution and the recommended nitrogen reductions to restore surface water quality. Based on the findings of the 2004 Popponesset Technical Report and the TMDL that followed, Mashpee renewed its CWMP efforts in the Fall of 2006 with the Sewer Commission taking the lead with the completion of the Stage 1 Needs Assessment in April 2007.

As of May 2008, when this report was undergoing completion, the Town of Mashpee had completed three of the four steps leading to the Draft CWMP.

5.2.1.2 Zoning

Cluster Development Bylaw (§174-47); amended by Town Meeting at its October 2006 meeting encourages "…the preservation of open space, to reduce the impact of new development of Town's water quality and natural resources". Cluster subdivision, with a minimum of 50% open space, is mandatory for subdivisions of 5 acres or more.

Water Quality Report Bylaw (§174-27); amendment by Town Meeting at its October 2006 meeting, requires developers of subdivisions located within the groundwater recharge zone of any great pond or bay or other surface water body over one (1) acre to prepare a water quality report of potential project impacts on surface- and ground water quality as well as what mitigation efforts the developer will undertake to reduce or mitigate those impacts. The by-law specifies the use of MEP reports and TMDL targets and assumes the following phosphorus and nitrogen loading rates:

> **Lawns -** 1.08 pounds nitrogen and 0.0069 pound phosphorous per one thousand (1,000) square feet per year, with 5000 sq. ft. average lawn size assumed per lot in a single-family subdivision
>
> **Stormwater -** 1.5 mg/l nitrogen for road runoff, 0.75 mg/l for roof runoff and 0.072 mg/l for natural areas; or alternately, nine-hundredths (0.09) pound nitrogen per road mile per day.

Stormwater Management Bylaw (§174-27.2); requires any new residential or non-residential development requiring either subdivision approval, a special permit, plan review, or a building permit for a building over one thousand (1000) square feet in area to provide a system of stormwater management and artificial recharge of precipitation. Stormwater should be designed to achieve the following purposes: prevent untreated discharges to wetlands and surface waters; preserve hydrologic conditions that closely resemble pre-development conditions; reduce or prevent flooding by managing the peak discharges and volumes of runoff; minimize erosion and sedimentation; result in no significant degradation of groundwater; reduce suspended solids, nitrogen, volatile organics and other pollutants to improve water quality; and provide increased protection of sensitive natural resources. For new single or two-family residences, stormwater runoff from rooftops, driveways and other impervious surfaces shall be routed through vegetated water quality swales, or as sheet flow over lawn areas or to constructed stormwater wetlands, sand filters, organic filters and/or similar systems capable of removing nitrogen from stormwater. For new subdivision roadways or for lots occupied or proposed to be occupied by uses other than single or two-family homes, a stormwater management plan is required, which provides for artificial recharge of precipitation to groundwater through site design that incorporates natural drainage patterns and vegetation and through the use of constructed (stormwater) wetlands, bioretention facilities, vegetated filter strips, rain gardens, wet (retention) ponds, water quality swales, organic filters or similar-site-appropriate current best management practices capable of removing significant amounts of nitrogen and other contaminants from stormwater.

In addition, the Planning Board's Consulting Engineer, Charles Rowley, completed a report in May of 2006 entitled "Stormwater Report on Runoff to Mashpee and Santuit Rivers from Public Ways"

5.2.1.3 Regulations

Board of Health regulatory requirement for denitrifying systems (on-site wastewater disposal systems) that reduce nitrogen discharges to 10 mg/L, measured at a monitoring well down-gradient from the leaching facility 10" from the lot line, compared with 36 mg/L at the leaching area from a conventional septic system for discharges with design flows greater than 600 gallons per day (six bedrooms or more).

The Conservation Commission wetland regulations - were amended with detailed design specifications to reduce nitrogen loading from lawns (new and renovated). They were also amended to set inland/coastal water quality standards in its Regulation 32 with site-specific limits necessary to control accelerated or cultural eutrophication.

Planning Board rule on lawn area - The Planning Board has obtained regulatory commitments from developers to limit lawn size in new developments, usually to 1000 sq. ft., based on its Water Quality Report zoning by-law. However, these are virtually impossible to enforce.

Zoning and Conservation Regulations on Denitrifying Systems - Both zoning and conservation commission regulations require denitrifying systems in other circumstances. As of autumn 2006, approximately 250 denitrifying systems were approved and 228 installed, more than in any other town on Cape Cod.

5.2.2 Town of Barnstable

Efforts by the Town of Barnstable to protect its inland and coastal resources were recognized in 2002 when EPA New England awarded the town it's Environmental Merit Award for growth management and environmental protection initiatives to protect the town's fragile environment, while addressing the importance of providing affordable housing. The Merit Award recognized the town's newly adopted two acre zoning in environmentally sensitive areas (about one half of the town); a nitrogen management ordinance to promote innovative and alternative wastewater disposal systems; a smart growth ordinance that allows for higher-density zoning in the Hyannis' business district (a sewered area); a comprehensive building cap; cluster zoning for subdivisions; and an affordable housing plan.

5.2.2.1 Zoning

Resource Protection Overlay District (Ch. 240, §36) - This overlay residential zoning district was adopted by the Town Council on October 26, 2000 to require a minimum, buildable lot area of 87,120 sf (two acres) for the purpose of reducing future nitrogen loading to the watershed recharge areas to the Centerville River, Popponesset and Shoestring Bays, and the Three Bays estuaries; together with areas dependent upon private well water supplies. Collectively, this residential overlay district covered nearly one half of the town. See Appendix Q for details.

Site Plan Review - Barnstable's Site Plan Review Regulations (§ 240-39 (4) (j) state, in part that: all surface water runoff from structures and impervious surfaces shall be disposed of on-site, but in no case shall surface water drainage be across sidewalks or public or private ways. In no case shall surface water runoff be drained directly into wetlands or water bodies (except for drainage structures in place as of the effective date of this regulation). All drainage systems shall be designed to minimize the discharge of pollutants by maximizing appropriately designed vegetated drainage channels and sedimentation basins that allow for adequate settling of suspended solids and maximum infiltration (with due regard to the design constraints). Dry wells, leaching pits and other similar drainage structures may be used only where other methods are not practicable. Subject to ambient surcharge conditions, roof runoff shall be recharged to the ground via a system of dry wells and/or infiltration systems. Nontoxic roof materials shall be used to minimize the leaching of toxic materials to the groundwater.

5.2.2.2 Regulations

Board of Health (BOH) Regulations - An Interim Board of Health Regulation was adopted on 6/30/2008 to protect saltwater estuaries (Article XV Protection of Saltwater Estuaries §360-45) by limiting the allowable discharge of sanitary sewage from residential buildings to "... not exceed 440 gallons per 40,000 square feet of lot area." This means an approved lot with less than 30,000 square feet is allowed a discharge of 330 gallons. Simplified, this corresponds to the number of bedrooms, using the Title 5 standard of 110 gallons per bedroom (Appendix P). Some other protective BOH regulations for the embayments are listed below.

- Ch.360: On-Site Sewage Disposal Systems - To protect groundwater, freshwater, wetlands and water course from contamination by septic waste.
- Article I (§360-1): Location of Components with respect to water bodies.
- Article III (§360-3): Floodplain Sewage Regulation
- Article VI (Ch. 360): Groundwater Protection – To protect groundwater from nitrate contamination (§360-12), also with (§360-13) - to connect to public sewers when available.
- Article X Ch. 360: Monitoring of Alternative Technologies and Article XIII Ch. 360: Innovative and Alternative Systems - identifies nitrogen reduction requirements in proximity to fresh water and marine water resources and to other sensitive environmental receptors.
- Article XV §360-45: Protection of Saltwater Estuaries (Adopted 6-30-2008)

Other Regulations and Districts - Town Regulations addressing Private Docks and Piers (Ch. 703) contain a section that deals with the issue of "nutrient-laden sediment" (§703-1. E.). Several additional Overlay Districts are in place to protect resources: Dock and Pier Overlay District (Ch. 240, §37) and Temporary Recreational Shellfish Area and Shellfish Relay Overlay District (Ch. 240, §37.1), which went into effect on 4/3/2008 and will be in effect for 18 months during which time the 1990 Coastal Resource Management Plan will be updated.

The Town of Barnstable Regulations are listed on the town's website as Ordinances/E-Code. The site is searchable using key words or Article number references.

5.2.2.3 Planning

District of Critical Planning Concern - A town-wide DCPC was adopted in February 2001 by the Town Council in support of a resolution to manage residential growth and to encourage affordable housing over nearly 60 square miles. The nomination stated as a goal: "to address the rate of residential development", which, if continued at its present growth rate "would have serious consequences for municipal infrastructure" and would "move the town further away from its goal of affordable housing stock." The intent of a DCPC, as described in the Cape Cod Commission's Regional Policy Plan, is to provide a "time out" from development, in order for a town to prepare and implement new measures that address its stated purpose for the DCPC. In Barnstable's case, the suggested guidelines for development included an annual residential building permit cap ordinance with a preference for affordable housing, and a general ordinance and board of health regulation "limiting nitrogen discharged from new residential subdivisions (e.g. shared denitrifying system requirements)" needed to maintain good water quality." The Barnstable DCPC was designated, among other reasons, to protect the local and regional water supply, and the sole source aquifer, from contamination occurring from excessive development (specifically, from associated nitrogen contamination primarily caused by septic systems), and also to protect coastal embayments (from nitrogen contamination), which threatens to adversely impact local shellfishing in the embayments. The nomination also supported the need to remediate water quality in [coastal] embayments. For more information on this DCPC, please consult http://www.capecodcommission.org/DCPC/designated.htm

Capital Improvement Plan Barnstable's 2008 Capital Improvement Plan includes a commitment by the Town to fund nitrogen management planning and a nitrogen management program over five years. In 2004, the Town received State Revolving Fund (SRF) funding to cover approximately 2/3 of the estimated cost ($3.1M) of the Nutrient Management Plan (NMP). Town Council appropriations to pay back the SRF Loan were $200,000 in 1998; $250,000 in 2001; and $1,700,000 in 2002. In August 2008, the Town submitted a 2009 Project Evaluation Form (PEF) to the SRF for future funding.

Wastewater Management Planning - The town's Comprehensive Wastewater Facilities Plan (CWFP) was approval by MEPA and the Cape Cod Commission in October 2007. The CWFP addressed the Town's immediate wastewater concerns, and future needs, to protect and restore resources using the Nutrient Management Program. The adaptive implementation management approach is a key factor in dealing with long-term environmental restoration programs; this allows the use of the newest research and technology available. Information is available on the following websites:

- http://town.barnstable.ma.us/PublicWorks/WaterPollutionControl/Final%20Wastewater%20Facilities%20Plan/ExecutiveSummary.pdf
- http://www.capecodcommission.org/regulatory/DRIdecisions/BarnstableWWFPfinaldecis.pdf

Barnstable Local Comprehensive Plan (LCP)

Relevant goals and action items in the Local Comprehensive Plan for Barnstable are listed below.

> *Goal: Improve the shellfishing and recreational uses of the Bays*. To achieve this objective the LCP calls for the implementation of the Nitrogen TMDL's developed for Three Bays by MA DEP, and calls for Town of Barnstable to work with the Towns of Mashpee and Sandwich to implement necessary shared watershed wastewater management and other nitrogen reduction policies.
>
> > *Strategy:* Improve flushing at the bays. Action: Dredge the area in Barnstable southern embayments (North, West and Cotuit Bays) and inlets to improve the flushing in the bays.
> >
> > *Action:* Limit new piers, especially in the Cotuit Narrows, to prevent reduction of flushing flow and impacts on shellfishing.
>
> *Goal 2.2.3 Maintain and improve coastal water quality to allow shellfishing and recreation as appropriate, and to protect coastal ecosystems which support shellfish and finfish habitat with the ultimate goal of restoring and maintaining ecological integrity in our coastal waters.*
>
> *Action 2.2.3.1* Continue, through the Massachusetts Estuaries Program (MEP), Town, County and Commonwealth mapping of recharge areas for all major estuaries and embayments to

identify areas where development and land use have the most impact on coastal water quality. This information is available through the Town's GIS system as it is developed.

Strategies:
Through the MEP, a long-term coastal resource water quality monitoring program is underway in Barnstable. The Town will continue to participate through the completion of the project in Barnstable.

The Town should determine a course of action to comply with the Total Maximum Daily Loads (TMDLs) established as part of the Massachusetts Estuaries Program (MEP).

Action 2.2.3.2 Protect environmentally fragile areas and reduce nitrate nrogen loading in marine recharge areas.

Strategies
Reduce impacts in FEMA A and V zones by amending the Zoning Ordinance to require floor area ratio requirements and impervious area limitations to allow development and redevelopment that does not create large impervious areas that interfere with the flood mitigating function of natural resources.

Adopt a town-wide regulation to limit impervious surface area.

Goal 2.6.1 Minimize wastewater contamination of water resources from private or public wastewater management systems to improve drinking water quality, with the ultimate goal of achieving an untreated water supply, and to improve the ecological integrity of streams, ponds and coastal embayments using all available data including Massachusetts Estuaries Program (MEP) data.

The Local Comprehensive Plan can be downloaded from the Internet.

5.2.3 Town of Sandwich

Water Quality Advisory Committee - During the final year of the Pilot Project, the town representative from Sandwich was successful in having the Town recognize its responsibility to address the nitrogen load from Sandwich, as identified in the TMDL report, affecting the Popponesset Bay. As a result, the Water Quality Advisory Committee (WQAC) was appointed in 2007 to review and provide its recommendations to the Board of Selectmen on all MEP-related matters. This committee includes a member from the Board of Health, Planning Board, Conservation Commission, and the Board of Selectmen. Prior to this endeavor, the Sandwich Health Director role at Pilot Project meetings was limited. The WQAC is currently taking the lead and is currently in the process of hiring a consultant with its reviews and recommendations of the Pilot Project.

5.2.4 Town of Brewster

In 2007, Brewster for the first time officially joined the Pleasant Bay Alliance and entered-up a membership assessment to address water quality related issues that have affected Pleasant Bay from its town borders. It also appropriated funds to contract with professionals to initiate water-planning efforts and assist in the development of a CWMP.

5.2.4.1 Zoning

Water Quality Protection Bylaw (Chapter 170) - Brewster is proposing revisions to its Ground Water Protection District Overlay zoning bylaw to restrict hazardous land uses and tighten permitting processes. Among this bylaw's many purposes, is to "complement the Commonwealth's Department of Environmental Protection regulations governing groundwater protection and the Commonwealth's efforts to protect surface and coastal waters and to prevent temporary and permanent contamination of the water resources of the Town." This bylaw has reserved an undefined section for the protection of Pleasant Bay for future consideration by the Town (Revised 7/26/2008).

5.2.4.2 Planning

Nomination of a District of Critical Planning Concern - To prevent grandfathering and further development within the watershed until a new bylaw is adopted and approved by the Cape Cod Commission for the protection of groundwater as drinking water and for the protection of Pleasant Bay. Nomination accepted by the Cape Cod Commission.

5.2.5 Town of Chatham

5.2.5.1 Zoning

The Town of Chatham Protective (Zoning) Bylaw contains several Overlay Regulations that address the issue of nutrient impacts on the environment. They are listed below.

Conservancy Districts – "Conservancy Districts are overlay districts intended to:

- Preserve and maintain the ground water supply on which inhabitants depend;
- Protect the purity of coastal and inland waters for the propagation of fish and shellfish and for recreational purposes;
- Protect the public health and safety;
- Protect persons and property from the hazards of flood and tidal waters which may result from unsuitable development in or near swamps, ponds, bogs and marshes, along watercourses or in areas subject to flooding, extreme high tides and rising sea level;
- Preserve the amenities of the Town and to conserve natural conditions, wildlife and open space for the education and general welfare of the public."

Flood Plain District – "The purposes of the Flood Plain District are to protect the public health, safety, and general welfare, to protect human life and property from the hazards of periodic flooding, to preserve the natural flood control characteristics, and the flood storage capacity of the flood plain, and to preserve and maintain the ground water table and water recharge areas within the flood plain."

Water Resource Protection District – "The purpose of the Water Resource Protection District (WRPD) is:

- To promote the health, safety, and general welfare of the community by ensuring an adequate and quantity of drinking water for the residents, institutions, and businesses of the town of Chatham;
- To preserve and protect existing and potential sources of drinking water supplies;
- To conserve the natural resources of the Town; and
- To prevent temporary and permanent contamination of the environment."

The full text of these regulations is available on the Chatham Community Development website

5.2.5.2 Regulations

Board of Health - Nitrogen Loading Regulation The Chatham Board of Health enacted an Interim Nitrogen Loading Regulation in 1991, this regulation limited nitrogen loading on a parcel to 10 ppm. This regulation has undergone a number of subsequent revisions, the most recent in 2006, including a shift away from the 10 ppm standard as being none protective for estuarine systems. In 2004, the Board of Health voted to declare the entire Town an "Area of Nitrogen Concern". The current regulation limits the flow of wastewater to no more than 440 gallons per acre of lot area (excluding wetlands). The regulation applies to new commercial development under 10,000 gpd (Title 5 flow); existing commercial development with a total Title 5 sewage flow of under 10,000 gallons per day where an addition or a change in use is proposed that will increase the sewage flow over the existing flow but still be less than 10,000 gallons per day; subdivisions or Open Space Residential Developments (i.e. so-called "cluster" subdivisions) creating three (3) or more parcels, regardless of existing dwelling units; construction of multi-family and single family dwellings; and alterations or additions to existing dwellings where a new bedroom is being added.

Additional provisions:

- This regulation shall not prohibit the construction of a two (2) bedroom house on any vacant lot providing said lot is not in a nitrogen Sensitive Area, as defined in 310 CMR 15.215.
- No building permit, foundation permit, special permit, or plumbing permit shall be issued for any of the projects described in Section 4 above until a Sewer Entrance Permit or Disposal System Construction Permit has first been obtained, unless the Board of Health, or its agent, determines that the existing sewage disposal system is adequate, including that the system is designed to receive or shall receive four hundred forty (440) gallons per day or less per forty thousand square feet (40,000 sq. ft.) of lot area.
- On-site subsurface sewage disposal systems for single-family dwellings shall be designed for the actual number of bedrooms present or by that number determined by the Board of Health or its Agent. On-site subsurface sewage disposal systems designed for less than 3 bedrooms shall cause a deed restriction to be placed on the property limiting the number of bedrooms to those present.
- The creation of a subdivision or Open Space Residential Development (OSRD) of three (3) or more lots shall be serviced by a shared or common on-site subsurface sewage disposal system that provides nitrogen removal technology.
- A division of land, involving existing dwelling units, resulting in the creation of parcels which are not in compliance with Section 5.1 of this regulation shall cause each parcel to install an on-site subsurface sewage disposal system that provides nitrogen removal technology. Each parcel affected by this section may be allowed one additional bedroom upon approval by the Board of Health.
- For residential applications the Board may allow, by variance, one (1) additional bedroom over the number allowed by Sections 5.1 or 5.2 with the use of an innovative/Alternative Technology on-site subsurface sewage disposal system.

The entire regulation can be downloaded from the Chatham Board of Health website.

Rules and Regulations of the Sewer Department - In 2005 Chatham Town Meeting adopted a new Article to the *Town of Chatham Rules and Regulations of the Sewer Department* which were initially adopted in 1972 and revised in 2004. The new Article II, *Regulation of Sewer Flow*, was adopted in response to concerns that future sewering could lead to increased development. The basic premise of the regulation is to limit sewage flow from a property to that allowed under Title 5 and Local Board of Health Regulation, which ever is lower (i.e. so-called "flow neutral"). Key provisions of the regulation include:

- Existing Structures - "Any structure in existence on May 10, 2005 regardless of its flow, may maintain that flow. No person shall modify an existing structure or change its use so as to increase its sewage flow…."
- Determination of Present Sewage Flow - "Sewage flow to the municipal sewer shall be determined using provisions set forth in 310 CMR 15.203: Sewage Flow Design Criteria, and any local board of Health Regulation modifying such in effect on May 10, 2005."
- Undeveloped Parcels – "For the purpose of determining sewage flow, any existing lot, otherwide qualified, may be permitted for that sewage flow as determined under the Board of Health's Regulations in affect on May 10, 2005 or 310 CMR 15.00 et seq, whichever is less."
- Rebuilding – "A property owner may rebuild a structure destroyed by fire, flood, storm or other acts of nature as a matter of right provided that the new structure does not exceed the sewage flow of the structure being replaced."
- Variances – there is a variance provision allowing sewage flow beyond that discussed above following a public hearing process.

Wetlands Protection - In 2004 the Chatham Wetlands Protection Bylaw was amended to include the Adjacent Upland Resource Area (AURA) (i.e. the so-called buffer zone) as a resource area to be protected and defined a No-Disturb Zone. The No-Disturb Zone is defined as the first fifty (50) feet of the AURA in which "…no substantial activity (other than maintenance of an already existing structure), which will result in the building within or upon, filling, removing, or altering of land, shall be permitted by the Commission, except for that which is allowed under a conservation variance". Regulations subsequently adopted by the Commission for the AURA speak clearly to the importance of vegetated buffer strips in addressing nutrient runoff. In addition, the 2004 amendments expanded the area of jurisdiction under the Bylaw to include "Within the boundaries of any area of critical environmental concern".

The full text of the Bylaw and regulations are available at the Chatham Conservation Division website.

5.2.5.3 Planning

Wastewater Management Planning - Chatham began its Comprehensive Wastewater Management Planning in 1997 with the formation of a Citizens Advisory Committee (CAC) to work with town staff (Technical Advisory Group, TAG) and the Town's consultants. Chatham's town-wide DRAFT CWMP/DRAFT Environmental Impact Report (EIR) was completed in April of 2008 and was submitted to the Commonwealth's MEPA unit and Cape Cod Commission (CCC) for approval. The town received the Secretary of Energy and Environmental Affairs Certificate in June 2008 with a determination that the Draft "adequately and properly complies" with the MA Environmental Policy Act. The town is currently in the process of responding to comments made on the Draft CWMP/Draft EIR during the MEPA review. The town expects to file a FINAL CWMP/FINAL EIR with MEPA and the CCC in late 2008 or early 2009.

In addition, the Town has completed preliminary design of an upgraded, expanded wastewater treatment facility (WWTF) and a town-wide sewering master plan in accordance with the recommendations of the DRAFT CWMP. The Town has secured funding for next step of final design of the new WWTF from local appropriation and the USDA Rural Utilities Program. The town expects to begin final design in 2009. The Town has also submitted a 2009 Project Evaluation Form as the initial step in obtaining project funding from the State Revolving Fund.

The CWMP webpage is available at: http://www.chatham-ma.gov/public_documents/ChathamMa_CWMPlan/CWMP.

5.2.5.4 Capital Improvement Planning

Section 6-2, Capital Improvements Program, of the Town of Chatham Charter states: "The town manager shall submit a five-year capital improvement program to the board of selectmen at the date fixed by bylaw for the submission of the proposed operating budget unless some other time is provided by bylaw."

5.2.5.5 Local Comprehensive Plan

The Town of Chatham Comprehensive Plan, adopted by town meeting in 2003, contains a number of provisions relative to nutrient management. A significant number of the recommendations had been implemented or are in process. Examples include, but are not limited to:

- Density limits (dwelling units per acre) should be established consistent with the character of each Neighborhood Center. A limit on commercial density/intensity should also be set. (LU2)
- Allow Open Space Residential development in all zoning districts with minimum lot sizes appropriate to each district. Require residential subdivisions to submit Open Space Residential as an alternative to a standard subdivision. (LU 15)
- The Town should establish and fund a program to acquire property to create and maintain open space. Private entities also should acquire property to preserve it as open space. (LU16)
- Institute a phased program for the construction of public restrooms which are environmentally friendly. (CF8)
- Develop a wastewater sustainability goal for 2020. (CF25)
- Complete the town-wide Wastewater Management Plan by the end of 2005. (CF26, NR1)
- Implement the recommendations of Wastewater Management Plan and establish a mechanism for ensuring that recommendations of the Plan are moved forward through the regulatory and financing process with public and private cooperation. (CF27)
- Continue the policy of upgrading catch basins on town roadways during repaving and reconstruction projects I order to reduce stormwater pollutants reaching the towns ponds, streams, and groundwater. (CF30)
- Designate nitrogen sensitive areas as appropriate, through the processes outlined in state environmental and Chatham Board of Health regulations. (NR2)
- Support research, evaluation, and approval of alternative septic system technology aimed at nutrient reduction (nitrogen and phosphorus), especially on systems appropriate for seasonal use. (NR3)
- Reduce the nitrogen load to impacted embayments or freshwater bodies through the purchase of, or seek donation of land. (NR4)
- Educate the public to the benefits of, and encourage the use of, native, low maintenance landscaping to minimize the use of fertilizers. (NR5)
- Continue the town's Coastal Water Nutrient monitoring Program and freshwater pond monitoring programs to ensure the availability of sound scientific data upon which to evaluate the condition of Chatham's waters and to guide management decisions. (NR9)

The complete Comprehensive Plan is available at: http://www.chatham-ma.gov/Public_documents/chathamma_planning/CLRPTOC.

5.2.6 Town of Harwich

5.2.6.1 Regulations

Board of Health Regulation – As an interim measure prior to the development and implementation of a Comprehensive Wastewater (nitrogen) Management Plan (CWMP) for Pleasant Bay, any development of a subdivision, re-subdivision, or ANR creating five lots or more that is located in whole or in part within the watershed of Pleasant Bay as defined in said (TMDL) report shall be served by a shared septic system that provides nitrogen removal technology. Removal limits shall be those approved by MassDEP for the technology proposed. The system may be located anywhere within the subdivision, including on open space, if any, subject to all applicable rules, regulations and laws (Approved 3/15/2007).

5.2.6.2 Planning

Wastewater Management Planning Harwich established a Water Quality Task Force in September 2007 to initiate development of a CWMP.

5.2.7 Town of Orleans

5.2.7.1 Zoning

Wetlands Bylaw The Orleans Conservation Commission has designated three setback zones within the 100 foot wetlands buffer (0-25 feet, 25-50 feet, and 50-100 feet), each with more stringent requirements for the protection of resource as the applicant approaches the wetlands resource. This bylaw states that: “Wetlands within the Pleasant Bay ACEC watershed and its embayments are protected by a provision that defines nutrient control as a high priority and a “no adverse impact.” This standard also affects the regulation of septic systems and other nutrient sources under their jurisdiction.

5.2.7.2 Regulations

Board of Health Regulations – Specific areas of Orleans are designated as Nitrogen Sensitive Areas where limits are placed on the flow of wastewater from depending on the use of the structure - residential buildings can have no more than 110 gallons/bedroom or no more than 440 gallons per acre; existing commercial development with a total Title 5 sewage flow of under 10,000 gallons per day can expand or a change the use as long as increase the sewage flow remains less than 10,000 gallons per day; subdivisions creating three (3) or more parcels, regardless of existing dwelling units; construction of multi-family and single family dwellings; alterations, additions or changes in use to existing dwellings that would increase the calculated sewage design flow. As defined in this provision, a dwelling on a 10,000 square foot parcel lot is not allowed to have more than one bedroom or a flow that exceeds 110 gallons/day and a dwelling on a 40,000 sq.ft lot, not more than four bedrooms (Adopted 5/1/2008).

Site Plan Review - The Site Plan Review Committee reviews and approves all Special Permit Applications that appear before the Zoning Board of Appeals (ZBA) before the ZBA makes its final ruling. Because the Conservation Commission is a member of this Committee, the wastewater management strategies that have the potential of affecting sensitive natural receptors, such as Pleasant Bay, will be considered prior to the ZBA’s approval.

5.2.7.3 Wastewater Management Planning

In 2000, the Orleans Board of Selectmen appointed members to the newly formed Wastewater Management Steering Committee with representation from the Planning Board, Conservation Commission, and Board of Water Commissioners

CWMP Citizens Advisory Committee - the comprehensive wastewater management plan is in its final stages, completing Phase IV

Wastewater Outreach/Public Education website: Wastewater Frequently Asked Questions (FAQs)

5.3 Regional Accomplishments: Barnstable County

At the county level, the Barnstable County Assembly of Delegates and the Cape Cod Commission have been leaders in recognizing the economic and environmental health implications of nitrogen pollution to the Cape's coastal estuaries; seeking regional and local solutions to address the reductions needed.

5.3.1 Cape Cod Commission's Regional Policy Plan: No-Net Nitrogen

Since its implementation, the NNN policy has been applied to about ten developments in Mashpee (not all in the Popponesset Bay watershed). The usual approach is to require a higher level of nitrogen treatment, either through a small treatment plant for commercial projects or onsite denitrifying systems for residential development. An additional offset method commonly applied is funding for open space land purchases or contributions to an escrow account, which will be used in future efforts to reduce nitrogen pollution. Mashpee currently holds over $300,000 in escrow for this purpose.

Mashpee Commons: As a DRI the Mashpee Commons project was required by the Cape Cod Commission to comply with its "No Net Nitrogen increase" policy to offset each increment in nitrogen loading from its project through a reduction elsewhere within the Popponesset Watershed. This requirement was the basis for the expansion of the Mashpee Commons treatment plant to provide that offset capacity. While this privately owned wastewater treatment plant has the capacity of hooking up privately owned properties to offset its increase in nitrogen loading, the Town of Mashpee is the only entity with the legal authority to require area homes to hook up. Therefore, to accomplish this offset the municipality needs to establish a relationship with the Commons to require these connections. The legal implications have yet to be defined.

5.3.2 Cape Cod Commission's 2008 Draft Regional Policy Plan

The full text of the2008 Draft Regional Policy Plan is available on the Internet. Pertinent components of the RPP that pertain to the role of the Cape Cod Commission in the MEP and the support provided to the Cape's communities regarding wastewater management planning is provided below.

Water Resources Goal – WR3: Marine Water Embayments and Estuaries: *To preserve and restore the ecological integrity of marine water embayments and estuaries.*

> "Cape Cod has at least 59 estuary systems that have the potential to be significantly impacted by excessive nitrogen loads from development in their watersheds. Excessive nitrogen leads to fundamental changes in these coastal ecosystems. Deterioration can affect the use and aesthetics of these resources and potentially lower property values. On-site septic systems are the primary source of nitrogen in most estuary watersheds, generally accounting for at least 75 percent of the nitrogen load.

To address these concerns, the Cape Cod Commission and Barnstable County have been partners for the last six years in the Massachusetts Estuaries Project (MEP). The county has provided more than $600,000 of funding to the project; these funds have allowed the Commission to provide technical expertise toward the development of watershed nitrogen-loading models. The MEP, which is led by the School of Marine Science and Technology (SMAST) at the University of Massachusetts–Dartmouth, assesses the health of each embayment/estuary system and determines an appropriate nitrogen limit or threshold for each individual estuary. The thresholds, officially known as Total Maximum Daily Loads or TMDLs, are adopted by the Massachusetts Department of Environmental Protection and the US Environmental Protection Agency and are enforceable under the federal Clean Water Act. Town Comprehensive Wastewater Management Plans and local, regional, and state regulations are being developed to meet these limits. Incorporating the TMDLs into regional and local regulations and supporting management solutions will help restore and protect coastal embayments by reducing nitrogen loading from existing and proposed land uses."

Cape Cod Commission Actions**:**
WR3-C1. Regional Participation in the MEP: The Cape Cod Commission will continue to participate as a technical partner in the Massachusetts Estuaries Project by providing nitrogen-loading thresholds. The Commission will assist in the maintenance of the linked watershed/estuary models developed through the MEP and assist with the completion of model scenario runs for wastewater planning and evaluation of wastewater alternatives for specific embayments.

WR3-C2. Technical Assistance about Embayments and Estuaries: The Cape Cod Commission will continue to assist the towns, region, and state in the development and implementation of appropriate management solutions for protecting, remediating, and monitoring nitrogen-sensitive embayments and estuaries.

WR3.2 Maintain or Improve Nitrogen Loading In watersheds to estuaries/embayments where there are documented marine water quality problems and a critical nitrogen load has not been developed, including, but not limited to, those embayments shown on the Cape Cod Water Resources Classification Map, development and redevelopment shall maintain or improve existing levels of nitrogen loading, except as provided in WR3.3 and WR3.1.

WR3.3 Local Management Plans. In watersheds with Commission-approved watershed nutrient management plans, or comprehensive wastewater management plans, nitrogen loading from development and redevelopment shall attain the nitrogen loading limit specified by the plan.

WR3.4 Nitrogen Offset Contribution In watersheds to estuaries/embayments where development and redevelopment must meet either WR3.1 or WR3.2, development and redevelopment may meet these standards by providing an equivalent nitrogen offset contribution to be used toward meeting the intent of WR3.1 or WR3.2. The load requirements of WR3.1 and WR3.2 above may be achieved by providing wastewater treatment for the development or redevelopment and additional treatment capacity for nearby land uses, installation of alternative denitrifying technologies for existing septic systems in the same Marine Water Recharge Area, and/or an equivalent contribution of $1,550 per kg/yr of nitrogen towards a municipal or watershed effort that achieves the intent of WR3.1 and WR3.2.

WR3.5 Monetary Contribution. In watersheds where the critical nitrogen load has not been determined, development and redevelopment may be required to make a monetary contribution toward the development or implementation of appropriate nitrogen management strategies not to exceed $20 per gallon of design flow of wastewater per day.

WR3.1 Critical Nitrogen Load Standard for Development. In watersheds to estuaries/embayments where a critical nitrogen load has been determined, through either a Total Maximum Daily Load (TMDL), or a Massachusetts Estuaries Project-accepted technical report, development and redevelopment shall not exceed the identified critical nitrogen loading standard for impact on marine ecosystems, except as provided in WR3.3. The Commission shall maintain a list and map of estuary/embayment critical nitrogen loading standards; the list and map will be updated on a regular basis as TMDLs are approved by the Massachusetts Department of Environmental Protection and the US Environmental Protection Agency.

Recommended Town Actions:
WR3-T1. Local Participation in the MEP: The towns should continue to participate in the Massachusetts Estuaries Project, obtain Total Maximum Daily Loads for their coastal embayments and estuaries, and work to develop and implement solutions to meet TMDLs.

WR3-T2. Regional Solutions for Shared Watersheds: The towns should consider regional solutions for shared watersheds to marine embayments, such as planning, infrastructure, and management.

5.3.3 Cape Cod Commission Wastewater Planning Conferences and Publications

Conference: Restoring and Protecting Coastal Waters, November 16, 2006

Publication: Enhancing Wastewater Management on Cape Cod: Planning, Administrative, and Legal Tools . Released July 2004

Publication: Cape Cod Comprehensive Regional Wastewater Management Strategy Development Project Final Report: June 2003)

5.3.4 Cape Cod Water Protection Collaborative

The Massachusetts Clean Water Act

This legislation was spear headed by the Cape Cod Water Protection Collaborative, submitted by Senator Robert O'Leary and approved by Governor Deval Patrick in August 2008 - the same year it was presented to the General Court (Appendix X). This legislation now provides zero interest State Revolving Loan funding to municipalities that have completed the CWMP process with a MassDEP approved Comprehensive Wastewater Management Plan. Funding under this program expires in ten years.

CapeKeepers – CapeKeepers promotes public education on wastewater issues

FY08 Grant Programs - Grant funding supports municipal efforts to address multi-town water quality issues allocated through the County budget with the primary source of revenue to fund these projects was from the Registry of Deeds.

- Grant 1 - $75,000 to enhance local planning efforts, especially those focused on cross municipal borders. The grant would award 3-5 grants ranging from $25,000 to $50,000. Funded projects must be able to demonstrate the involvement and support of an adjoining community even if that community is not participating in the funding of the project.
- Grant 2 -$95,000 to support completion of MEP alternative model runs where more than one community is involved.
- $34,275 to the Town of Falmouth to work with Mashpee to evaluate wastewater disposal sites to accept wastewater disposal sites to accept wastewater removed from the Waquoit Bay watershed.
- $48,900 awarded to the Town of Orleans Economies of Scale Proposal to quantify the potential cost savings associated with regional wastewater treatment and disposal facilities.
- $40,000 awarded to the Pleasant Bay Alliance to develop a fertilizer management strategy
- $35,000 awarded to the Pleasant Bay Alliance to study restoration of the Muddy Creek as a freshwater system that will remove nitrogen before it impacts the Bay.
- "Eutrophication and You: The Future of Cape Cod" – A public outreach document describing the effects of nitrogen enrichment on Cape Cod waters.
- (7/24/07) "Request for Proposals from Consultants to Assist Barnstable County Water Protection Collaborative in Identifying Growth Impacts Resulting From Sewering and Creating Smart Growth Tools to Proactively Manage these Growth Impacts".
- RFP for the Regional Wastewater Plan. Members of the board worked with Senator Robert O'Leary and his Legislative Aide, Nate Mayo, on the RFP for Barnstable County Wastewater Management Plan Development.
    - Phase 1: Synopsis of problem, including a public relations strategy.
    - Phase 2: Distribute to decision makers and a plan on how it will be distributed.
    - Phase 3: Technical proposal that integrates 15 local plans.

5.4 Massachusetts DEP Accomplishments

5.4.1 Inter-Municipal Wastewater Management Planning

The Assabet River Consortium - When the NPDES permits to four treatment plants on the Assabet River NPDES permits were due to be renewed the MassDEP required each of the communities served by the plants to study regional wastewater treatment issues. As a result, the six communities entered into an inter-municipal agreement that legally bound to prepare and cover the cost of a joint prepared CWMP, including additional inter-municipal agreements to finance and carryout its requirements to restore water quality to the Assabet River from a variety of nonpoint sources in the Assabet River Watershed and the point discharges from the four wastewater treatment facilities serving their six communities – Hudson, Marlborough, Maynard, Northborough, Shrewsbury, and Westborough. The consortium brought them together to leverage their resources and share information and expertise as they worked on a watershed-based plan to meet the anticipated future needs of each community for the protection of the Assabet River. It was estimated that 80 percent of the river's flow during extreme summer lows were comprised of treated wastewater from the four facilities. The CWMP prepared by the Consortium to upgrade the four treatment plants evaluated the cost-effectiveness, environmental impact, and ability to achieve ground and surface water quality standards. The preparation of the CWMP required that it undergo four phases, prior to its submittal to the Environmental Protection Agency and MassDEP.

The EPA/MassDEP NPDES permit that was drafted in June 2004 represented an 87% phosphate load reduction from the four major wastewater treatment plants during April 1 - October 31 (the vegetative growing season of river weeds nourished by phosphorus). While consortium communities maintain their independence, this collaborative, regional, watershed-based approach has expanded the universe of possibilities for each community's wastewater treatment plans. For more on the Assabet Consortium go to: http://www.epa.gov/ncei/stategrants/PDFs/AssabetRiverWorkplanpdf.pdf http://www.epa.gov/ncei/stategrants/PDFs/MAUpdate.pdf

5.4.2 Nitrogen Trading

5.4.2.1 Wayland Business Center - This office building complex sought to discharge effluents from its wastewater treatment plant into the Sudbury River. The facility had been operated by the Raytheon Corporation, and the new owners originally sought to renew and transfer the existing permit. The Massachusetts Department of Environmental Protection and the U.S. EPA ruled that the Raytheon permit could not be transferred to the new owners of the Wayland Business Center, and hence the facility's discharge was to be construed as a new discharge.

As a condition for allowing the discharge, the NPDES permit specified that the Raytheon facility needed to obtain an offsetting reduction in phosphorus. The facility is obtaining offsets by connecting neighboring properties to the plant. Approximately 33 septic systems that are in a high water table area and/or are failing will be connected to the private sewer system.

5.4.2.2 Edgartown **-** WWTP was upgraded in 1996 to meet Class I Ground Water Discharge Standards, with a goal of limiting the annual nitrogen loading to 2200 kilograms. Although the facility is designed for 750,000 gallons per day (gpd), the groundwater discharge permit limits the flow initially to 500,000 gpd until actual performance data is available. To date, the facility has exceeded expectations with an average total nitrogen discharge below 5 mg/L. Approximately 300 additional residences in the recharge area will be connected to the facility, but there is no current timetable for this phase of the project. Dentrifying on-site treatment systems will be encouraged elsewhere within the watershed.

5.4.2.3 Falmouth - WWTP is being upgraded from a Class III to a Class I ground water discharge. Construction of the new facility is expected to begin in the Spring of 2003. More than 400 additional connections will be made to the treatment plant from homes and businesses in the watershed west of Route 28; there is no current timetable for this phase of the project. Dentrifying on-site treatment systems will be installed at sites east of Route 28, and will be centrally managed. A management plan still needs to be implemented to oversee this work.

The treatment plant will be designed at 1.2 MGD to meet a 3 mg/L total nitrogen discharge at a maximum rate of 1 MGD within the watershed. Any additional discharge will have to occur outside the watershed.

5.4.3 Natural Attenuation of Nitrogen in Wetlands and Surface Waters

In response to the use of natural attenuation as an alternative to wastewater treatment, MassDEP initiated the scientific and regulatory work to govern this strategy. Massachusetts has some of the most protective wetland regulations in the U.S. to implement the Wetlands Protection Act. 310cmr10 (part a) and 310cmr10 (part b).

The Wetlands Protection Act does have room for projects that impact a wetland resource but they must provide for overall resource enhancement. Existing examples include the installation of fish ladders for the migration of anadromous fish and the management of invasive species within its impacted lakes and ponds. MassDEP's Guidance for Aquatic Plant Management in Lakes and Ponds describes the Department's approach to resource enhancements.

Extending this approach to projects that enhance natural attenuation of nitrogen will require balancing the various interests of the WPA. For example, alterations could negatively impact a freshwater wetland (e.g., destruction of bordering wetlands vegetation) in order to improve water quality downstream to the estuary.

Key elements of the Guidance are already clear:

1. Enhanced natural attenuation cannot be the only method used for attenuating nitrogen in a watershed, but must be considered in conjunction with another strategy that includes wastewater treatment, stormwater and fertilizer controls, and water conservation. Enhanced natural attenuation may be useful in combination with other attenuation alternatives such as wastewater treatment and stormwater management.
2. Alterations in different resource types will raise different issues with the WPA. The following list ranks protected resources in increasing order of concern:
    a. Creation of constructed wetlands raise the fewest concerns
    b. Wetlands systems which have already been altered, e.g., recently abandoned cranberry bogs
    c. Resources which have been altered, but are long-standing (e.g., long-abandoned cranberry bogs)
    d. Conversion of one type of resource to a different type
    e. Alteration of pristine, well-functioning wetlands would raise the most concerns. Salt marshes are of particular concern because of their limited scope and high ecological value. Although the WPA does not have a resource enhancement exemption for coastal habitat, projects that enhance the salt marsh are allowed under 310 CMR 10.32 (5).
3. Alterations must demonstrate a positive impact on interests of the Act. Stronger cases for alteration will have the following characteristics:
    a. Larger number of interests supported (e.g., pollution prevention, fish habitat, preventing erosion and siltation)
    b. Documentation of negative impacts and efforts to minimize them
    c. Higher percentage of nitrogen attenuation
    d. Ability to predict and measure attenuation.

5.4.3.1 Natural Attenuation Literature Review

The first step in the use of Enhanced Natural Attenuation for reducing nitrogen loads was to fund a search of scientific literature, with funding from the EPA Cooperative Agreement. These case studies, mined by the contractor, the Woods Hole Group and its subcontractor, Teal Partners, provide the Department's policy and regulatory staff and the Massachusetts Estuaries Project (MEP) with the following:

- The current state of our knowledge concerning the attenuation/cleanup of nitrogen contaminated ground and storm water by both natural and constructed wetlands
- The effectiveness of natural wetland system processes for removing nitrogen contaminated groundwater by wetland ecosystems
- Optimal designs and site modifications of wetlands to enhance nitrogen removal by natural attenuation
- Reports on the benefits and detriments of nitrogen attenuation in wetland ecosystems
- MassDEP data needs for the review of natural attenuation project proposals

This research was a first step in the policy development process for external and internal discussion concerning the effectiveness, limitations in use, and applicability under existing state statutes and regulations of nitrogen attenuation. The findings of this review of the literature would allow the MassDEP to consider the effectiveness of nitrogen attenuation as a treatment option to reduce impacts from nitrogen-contaminated groundwater that would otherwise contribute to estuarine eutrophication.

This literature search confirmed that natural attenuation, via bacterial denitrification, is an effective mechanism for the treatment of nitrogen-contaminated groundwater. Vegetative uptake was reported as having a minor role in nitrogen removal. The most important physical characteristics that promote nitrogen removal are the groundwater nitrate concentrations, the detention treatment time within the pond and/or wetland system, the anoxic zones, organic carbon, temperature and pH. Specifically, the conditions that were identified to maximize nitrogen removal include the following: a nitrate loading rate of ~ 2 to 3 mg/l, a detention time of about one day in anoxic zones with labile organic carbon, near neutral pH, and temperatures ~ 10° C. The role of climate (wind, rain, season, air and water temperature) was also explored. Finally, wetland modifications that may enhance nitrogen removal from ground and surface waters in Massachusetts are described.

5.4.3.2 Literature Review Key Findings

The state of the literature and research on natural bogs and fens was determined as not sufficient for use in promoting techniques to use these wetlands as natural nitrogen attenuators without endangering either the resource itself or the downstream resources. The investigators reported that the data required was currently insufficient to making modifications to natural bogs and fens; recommending that natural bogs not be used for natural attenuation projects at this time.

For all other water bodies and wetlands (streams, rivers, lakes and ponds; wet meadows/ freshwater emergent/constructed wetlands; cranberry bogs; woody and open wetlands/riparian zones; salt marshes, ponds and mud flats), the study reported the following data needs prior to reviewing and permitting natural attenuation projects.

- Nitrate Concentration: Measure *in situ* nitrogen up and down gradient to confirm that the proposed site is not already over burdened with N. If the site is acceptable, measure nitrate concentration in ground or surface water proposed for diversion into the site. Try to determine the source of nitrate and estimate whether it is consistent, seasonal or event driven. Higher influent nitrate concentrations are preferred because the microbial biomass thrives at higher concentrations, leading to better denitrification rates. In addition, from a cost/benefit perspective, the outcome (impact on the receiving water) is likely to be measurable if you choose to treat higher concentrations. If nitrate concentrations are below 3 mgl^{-1}, longer detention times are needed. Moreover, if ground and/or surface flows to the wetland or waterbody have periods with no nitrate, then several hours additional detention time at ~10°C is necessary to reactivate denitrification.
- pH: near neutral is best -- 6.5 to 7.5 units
- Anoxic conditions: required. This can be measured with a redox electrode.
- Temperature: best denitrification occurs when water temperature is 10°C or above. Some denitrification occurs at temperatures > 4°C.
- Detention time in sediment is estimated from soil samples and dependent on its permeability. A minimum of 12 hours detention time in the anoxic zone of the wetland is required. A detention time of two to three days is preferred in lakes and ponds (Fleischer et al. 1994, Ahlgren et al. 1994).
- Labile organics: The nature of the substrate, the detention time in the anoxic substrate and the labile organic content affect the rate of denitrification. The labile organic content can be

estimated as chemical oxygen demand (COD), which needs to be more than four times the concentration of the nitrate to be denitrified. Of course, this must be continuously replenished from local sources (decomposition or release from living organisms) for denitrification to continue. For example, sediment with over 15% organic content will probably suffice as will active growth of emergent and submerged herbaceous marsh plants.

Chapter 6: Regulations, Policies, and Guidance Stakeholder Recommendations for Future Planning

The recommendations presented in this chapter reflect the views of the stakeholders throughout Cape Cod – those who have been actively engaged in watershed-based TMDL planning and implementation. They include member of the Popponesset Bay, Three Bays, and the Pleasant Bay Pilot Projects and those representing a working group of the Barnstable County Wastewater Implementation Committee (WIC), as reported to the Cape Cod Commission (Wright-Pierce (2004). On Cape Cod, the nitrogen loads that affect embayment water quality are primarily from unregulated on-site wastewater treatment and discharges, and secondarily from stormwater runoff and fertilizer use. Unlike end of pipe NPDES point source discharges, nonpoint source discharges are dispersed throughout a watershed and not easily removed.

Nitrogen reduction is best achieved when the loads from each community within a watershed have been defined, as has been for several coastal watersheds on Cape Cod by the MEP technical reports. With MEP scenario model runs, it is possible to identify what location(s) within a watershed will achieve quantifiable reductions at an optimal cost and environmental benefit.

The stakeholders whose thoughts are presented below have been addressing watershed-based TMDLs and have become knowledgeable of the MEP approach for defining nitrogen loads and its impact on coastal estuaries but are equally experienced and knowledgeable of the challenges in developing and implementing a CWMP. The categories of discussion topics are listed below as:

- Inter-municipal TMDL planning and implementation
- State Revolving Loan Funding
- State Permitting
- Environmental Planning Requirements
- Wastewater Management Planning and Reporting Requirements

The views presented below will be undergoing evaluation by MassDEP to address the issues that have been identified and will serve as a blueprint for prioritizing and taking action in the future. MassDEP does not necessarily agree with all the recommendations nor is MassDEP committing at this time to implement any of the recommendations.

6.1 Inter-Municipal TMDL Planning and Implementation

If a high percentage of the watershed is in one community, the other communities within the watershed do not feel a sense of responsibility for solving the watershed's water quality impairment. If for other reasons, these communities focus on water quality problems predominantly within their municipal boundaries, they begin to realize that communities need to work together.

6.1.1 Existing Capacity

- MassDEP staff support is available, on a limited consulting basis, to municipalities with willing community partners that have an interest in watershed-based TMDL planning and implementation.

- MassDEP can resolve regulatory and policy barriers as they arise, e.g. nitrogen contributions to an estuary by the towns sharing the watershed.

6.1.2 Defining Future Needs

- MassDEP should allocate town-by-town nitrogen reductions as an incentive for towns to do wastewater management planning (or to sign off on a towns' management proposal once the CWMPs are approved by the MassDEP).
- Towns not engaged in a CWMP should have their nitrogen reduction target assigned by MassDEP.
- MassDEP should be open to pilot projects and new methods for towns to demonstrate the impact of innovative approaches on nitrogen reduction (e.g. fertilizer reduction, stormwater treatment, enhanced natural attenuation, among others).
- Traditionally, MassDEP has limited its involvement to CWMP review/approval and permitting. Under the inter-municipal collaborative approach, the MassDEP should assist MEP communities, on an ongoing basis, with their planning and implementation decision making; which include:
  - Calculation of municipal ni:rogen load contributions
  - Guidelines for inter-municipal collaboration
- Nitrogen contributions and allocations: Towns need nitrogen concentration as early as possible and some way to allocate the target kilograms.
- SMAST Linked Model Peer Review. SMAST should publish the Linked Model in a referred ecological modeling journal to validate its applicability for the nitrogen reduction scenarios it prepares for use by towns. If not, MassDEP should pursue this review and decide how this could be accomplished, by whom, and with what funding.
- Clarification on the nature of approving CWMPs would be helpful; specifically regarding the level of detail that should be provided for a groundwater discharge permit to a town or district.
- Policy guidance is needed on whether TMDLs may be modified in light of changes to the Pleasant Bay inlet and barrier beach configuration. It also would be important to know if a town's CWMP can be approved without a model run scenario that showed concentrations being met throughout the system.
- To guide nitrogen reduction implementation activities in watersheds of impaired embayments, MassDEP should identify measures to balance nitrogen load increases from new development during the time period between EPA approval of the TMDL to completion of the CWMP.
- To require or encourage the multiple towns sharing a coastal watershed to coordinate their planning, additional MEP Linked Model runs should provide the nitrogen reductions that must be achieved at the time of submission of their proposals for a CWMP.
- In view of the MEP model run results, the towns within the same watershed should coordinate and identify the best option for reducing nitrogen loads within their town borders that is both environmentally and cost effective. The CWMPs that the MassDEP approves should identify how those watershed load reductions are allocated among the towns to achieve the threshold concentration in the watershed they share.
- MassDEP should provide guidance on long-term habitat and water quality compliance monitoring protocols for use by towns during CWMP implementation.
- Early in the MEP process (before the TMDL is submitted by the MassDEP for EPA approval), MassDEP should provide workshops to educate municipal decision-makers about the environmental impacts of nitrogen and wastewater management planning and implementation.
- Water Quality Offsets and Trading. Towns engaged in watershed-based collaborative problem solving should consider trading as a tool to defray CWMP implementation costs and to identify the most cost effective remedies. As a result, towns furthest from the shoreline could contribute to the cost of sewering locations closer to the shoreline where the nitrogen reductions have the greatest impact. However, water quality trading should begin only after the towns agree on the amount of nitrogen each town is responsible for reducing. Trading could engage the services of an outside party to monitor process and results. This could be a regional agency or MassDEP.

6.1.3 Rationale

- Massachusetts TMDL implementation plans have focused on watersheds with NPDES (point source) permits.
- MEP coastal watersheds are affected primarily from nonpoint source discharges. Mitigation of these nitrogen loads frequently require reductions by more than one community through TMDL related CWMP planning and implementation.
- TMDL planning and implementation is addressed through town specific, state regulated groundwater discharge permits. Watershed-based, multi-town permits have not been pursued.
- Other States, Oregon, California, and North Carolina, establish a state role in developing and carrying out implementation plans.

6.1.4 Key Elements of a Watershed-Based Wastewater Management Plan

- Below are the local or regional obstacles to implementing a watershed-based TMDL:
  - All towns sharing a nitrogen-sensitive embayment must coordinate efforts and all have some level of responsibility to restore the embayment habitat.
  - Funding of implementation projects, including the cost of sewers, is dependent on community-based outreach and planning. If the towns cannot convince its residents that implementation is a needed then funding will not be provided. Must win over elected officials to support sewering projects and other nutrient treatment programs (NDA, stormwater/road work, etc.). A Citizen Advisory Committee (CAC) can be the bridge between the town's technical staff and the community when proposing projects for funding.
- Locating sites for wastewater treatment and effluent discharge
- Watershed-Wide, Coordination and Planning by Communities Sharing the Watershed Resource through a memorandum of understanding or other legal arrangement.
- Watershed-Wide Nitrogen Reduction Planning, via MEP scenario runs, for the identification of a plan that addresses the nitrogen threshold concentration in the estuary for TMDL compliance when implemented.
- Timeframe for actions and expected timeframe for CWMP development and TMDL implementation
- Reasonable assurances and margins of safety: amplify what's in the TMDL

- With the assistance of MassDEP, develop an acceptable plan that monitors the improvements in water quality following CWMP implementation of the capital improvements toward the TMDL and adaptive management

6.2 State Revolving Loan Funding (SRF)

6.2.1 Existing Capacity

- Financing is available for town and watershed planning and implementation of many nitrogen-reducing alternatives. MassDEP reviews plans and can place conditions on their approval.

- As described earlier in section 5.3.4 and detailed in Appendix X, the Environmental Bond Bill that was approved by Governor Deval Patrick in August 2008 (that includes The O'Leary Bill) (outside Sec.5) created a category of projects for which 0% SRF financing is available. Proponents meeting the following requirements would be eligible for 0% CWSRF loans:
  - The project is primarily intended to remediate or prevent nutrient enrichment of a surface water body or a source of water supply;
  - The applicant is not currently subject, due a violation of a nutrient-related total maximum daily load standard or other nutrient based standard, to a department of environmental protection enforcement order, administrative consent order or

unilateral administrative order, enforcement action by the United States Environmental Protection Agency or subject to a state or federal court order relative to the proposed project;
- The applicant has a Comprehensive Wastewater Management Plan approved pursuant to regulations adopted by the Department of Environmental Protection;
- The project has been deemed consistent with the regional water resources management plans if one exists;
- The applicant has adopted land use controls, subject to the review and approval of the department of environmental protection in consultation with the department of housing and economic development and, where applicable any regional land use regulatory entity, intended to limit wastewater flows to the amount authorized under zoning and wastewater regulations as of the date of the approval of the CWMP.

6.2.2 Defining Future Needs (includes MassDEP comment to these recommendations)

- MassDEP should investigate the feasibility of providing incentives to SRF applicants to promote intermunicipal collaboration for towns sharing a watershed resource. In many instances, intermunicipal TMDL planning and implementation can be the most cost and environmentally effective approach. (DEP cannot affect any SRF incentives. SRF Interest Rates are set by the Massachusetts Legislature)
- MassDEP should explore the benefits of requiring SRF recipients to complete the projects as specified in their CWMP. (The SRF program has no legal authority to require completion of projects in a CWMP. That ‘completion’ would have to result from enforcement by the waste water program, if necessitated by environmental or public health conditions. This bullet should not fall under the SRF heading, since MassDEP cannot obligate any community to borrow SRF funds to institute a project.)
- MassDEP should (continue to) ensure its SRF funding program supports MEP work, and should link towns and watershed organizations to other funding sources.
- While MassDEP in the past has “set aside” funds for certain categories of projects, MEP communities will have to compete with other projects statewide. However, the fact that the projects are based on TMDL reports and are regional based should help in receiving priority. (The O’Leary Bill effectively did establish a set-aside for nutrient mitigation projects, so this bullet point is no longer relevant.)
- MassDEP should reconcile expending SRF funds with the delays in the MEP process. It is critical that towns know SRF funds will be available when they have all the other pieces in place to move forward. (SRF financing has been available to, and used by, MEP communities throughout the MEP “delay.” This point is irrelevant.)
- MassDEP, thru its SRF, should assist towns with the financing to acquire private wastewater treatment facilities. (If it is the desire of any community to acquire private WWTF’s, the acquisition is eligible.)
- Waste Water Districts should be considered as an efficient and cost saving management option for preparing and implementing a CWMP. The key question to resolve among the affected communities is the allocation of watershed nutrient loads and costs between communities.
- Escrow accounts. Rather than implementing enhanced treatment for individual homes prior to developing an area-wide CWMP solution, the cost of enhanced treatment should be placed in escrow and later used to offset a homeowner’s share of implementing the overall wastewater management plan. (The Environmental Bond Bill (outside Sec.10) contained language allowing communities to elect to adopt this approach.)
- Amend MGL C.83 §3 to allow “checkerboard” sewer systems without requiring individual communities to file special legislation. (The Environmental Bond Bill (outside Sec.10) contained language allowing communities to elect to adopt this approach.)

6.3 State Permitting

6.3.1 Existing Capacity

- MassDEP's has the authority to permit existing groundwater and surface water discharges
- MassDEP promoting a collaborative voluntary approach to CWMP planning in recognition that towns are the decision makers on CWMP implementation.

6.3.2 Defining Future Needs

- There is consensus that local decisions will not happen without knowledge of a potential state action if towns do not act. The MassDEP should set criteria for deciding when an enforcement action should be pursued when CWMP implementation is not making adequate progress.
- Codification of point of compliance – through the Working Group, the Pleasant Bay Alliance communities have learned about the policy direction under discussion by MassDEP regarding point of compliance. MassDEP's codification of this approach through a policy guidance or similar document has been requested.
- MassDEP should evaluate its authority to promote a voluntary approach for the mitigation of nonpoint sources discharges to TMDL listed waters.
- MassDEP should clarify its regulatory role, particularly regarding enforcement. Early successes with a voluntary approach will demonstrate value of this approach. Given its ultimate regulatory role, MassDEP is not a neutral party in planning and implementation. The MassDEP should acknowledge its position and work with towns and regional groups; using neutral parties as facilitators and mediators.
- Towns should collaborate with each other to identify cost-effective and effective solutions that best fit with local needs and resources. When Towns consider a range of specific solutions based on Town-specific concerns, taxpayers in the watershed should have access to a wide range of alternatives, including those that are most cost-effective for residents of the watershed as a whole.
- If the towns choose not to coordinate their planning, the MassDEP approval of a CWMP should be conditioned for the towns to demonstrate that they have identified the load reductions, via Linked MEP Modeling, that they are responsible for reducing on their own for restoring water quality in the embayment. This approach should encourage the towns to coordinate their planning for the load reduction throughout the coastal watershed.
- Monitoring protocol and reporting procedures – The Pleasant Bay Alliance has requested clarification on MassDEP's monitoring requirements, protocols and reporting procedures necessary to demonstrate TMDL compliance.
- MassDEP Wetlands Program should decide if credit should be given for projects that increase existing natural attenuation and should provide guidance to Conservation Commissions when these projects come for their review under the Wetlands Protection Act. These two efforts need to proceed in tandem.
- MassDEP should allow Towns to use different permitting approaches to achieve the required nitrogen reductions, so long as they meet MassDEP's standards of success. The MassDEP should formalize this approach through existing policies and regulations).
- Existing policy and regulatory tools are blunt, and not the best for towns to use.
- When two or more communities share a coastal watershed, the MassDEP should adopt a local/regional/state joint review of a town's proposed CWMP, prior to the MassDEP's approval.
- MassDEP should adopt interim measures for use in determining when a MassDEP approved CWMP is making adequate progress toward water quality improvement.

6.4 Environmental Planning Requirements

6.4.1 Existing Capacity

- Projects that trip certain development thresholds are required by the Massachusetts Environmental Policy Act and the Cape Cod Commission's Regional Policy Plan (RPP) to undergo a review processes when they are located in state designated nitrogen sensitive watersheds. Below are answers to some common questions on MEPA and RPP Developments of Regional Impact (DRI).
  - Projects that meet or exceed a MEPA Threshold. For example, direct alteration of 25 acres or more; a new Waste Water Treatment Plant for 100,000 gpd or more; expansion of an existing WWTP by 100,000 gpd or 10%; construction of one or more sewer mains.
  - MEPA/DRI Interface: According to the CCC website, "Projects requiring review under the Massachusetts Environmental Policy Act (MEPA) may also require DRI review. An applicant may request a joint review process with the state and the Cape Cod Commission."
  - The process: "Whenever a developer files an Environmental Notification Form (ENF) with MEPA for a project in Barnstable County, it triggers a DRI application with the CCC.
    - The Commission, through a subcommittee, advises MEPA. The Commission and MEPA hold joint public hearings on the proposal and the subsequent Draft EIR.
    - MEP tells the developer what issues should be addressed. The applicant submits a final EIR. Another joint public hearing is held.
    - The commission and MEPA review that report. MEPA decides whether to issue a certificate allowing the developer to proceed.
    - If MEPA issues the certificate, the commission begins its DRI review process within 45 days.
  - When Cape Cod Commission DRI thresholds are met:
    - subdivisions of 30 acres or more
    - development of 30 or more residential lots or dwelling units
    - development of 10 or more business, office, or industrial lots
    - commercial development or change of use for buildings greater than 10,000 square feet
    - transportation facilities for passage to or from Barnstable County
    - demolition or major changes to some national- or state-recognized historic structures
    - bridge, ramp, or road construction providing access to several types of water bodies and wetlands
    - new construction or change of use involving outdoor commercial space greater than 40,000 square feet
    - construction of any wireless communication tower exceeding 35 feet in height
    - site alterations or site disturbance greater than two acres without a valid local permit
    - mixed use residential and non-residential developments with a floor area greater than 20,000 square feet
  - DRIs that are planned for locations within nitrogen sensitive watersheds with a nitrogen TMDL are governed by the Cape Cod Commission's RPP's No-Net Nitrogen provisions. In watersheds to coastal embayments, projects must conform to watershed-specific critical nitrogen loads. Where existing nitrogen loads exceed critical loads, or where there is demonstrated water quality impairment, the Plan requires no net nitrogen increase. As presented in the Draft RPP's Water Resources Section WR#.3.1: "In watersheds to estuaries/embayments where a critical nitrogen load has been determined, through either a Total Maximum Daily Load (TMDL), or a Massachusetts Estuaries Project-accepted technical report, development and redevelopment shall not exceed the identified critical

nitrogen loading standard for impact on marine ecosystems, except as provided in WR3.3."
- MassDEP comments during the MEPA review.

6.4.2 Future Needs Defined

- MassDEP should integrate its inter-municipal, watershed-wide planning concepts when revising its CWMP guidelines.
- Cape Cod Commission Developments of Regional Impact (DRI) are less common as the larger parcels on the Cape have already been developed. DRIs require application of the County's No Net Nitrogen regulations, under which developers must offset increases in nitrogen flows.
- Towns should address the growth impacts to coastal watersheds from the controllable loads of nitrogen resulting from the installation of on-site wastewater treatment and disposal, fertilizer use, and stormwater runoff separately and as part of TMDL planning and implementation.
- MassDEP should explore the feasibility, through its regulations and policies, concerning the potential of natural attenuation as treatment option for use by cities and town in the CWMPs they are under taking for the removal of nitrogen from nitrogen contaminated groundwater plumes.

6.5 Wastewater Management Planning and Reporting

6.5.1 The Problem Defined

The Clean Water Act does not explicitly require implementation of CWMPs as a TMDL requirement. However, state and local permits are ultimately affected by TMDL compliance requirements; including the groundwater discharge permits the Commonwealth issues and the local Board of Health approvals for the installation of on-site wastewater treatment and disposal systems. The following identifies implementation challenges for the Towns as well as MassDEP particularly as it relates to the implementation of nonpoint source control reductions and watershed-based solutions.

6.5.2 Challenges to Watershed-Wide Planning and TMDL Implementation

6.5.2.1 Massachusetts Towns

- Inter-municipal collaboration on CWMP planning and implementation on a watershed basis.
- Follow through on MassDEP approved CWMPs: Some towns fail to complete their plans, or to modify them without MassDEP consultation or consult with the towns sharing the watershed.
- MassDEP should provide greater clarity in its expectations for all levels of CWMP planning, implementation, water quality monitoring, and adaptive management.
- Concern that towns should be doing more locally, using their permitting, licensing, and enforcement authority to control existing and future NPS discharges to nitrogen-sensitive embayments.

6.5.2.2 MassDEP

- Tracking Progress of TMDL Implementation Plans
- Enforcement of TMDLs for nonpoint sources, as TMDLs are federal Clean Water Act requirements for point source discharges, via NPDES permits, and the Commonwealth's powers under the Clean Waters Act.
- Promoting proactive voluntary actions through encouragement, financial support, and guidance.

6.5.2.3 Proposed Solutions

- MassDEP should provide cities and towns guidelines that promote coordinated watershed-wide planning and reporting among multiple towns sharing a coastal watershed.
- MassDEP should consider revising its requirements for a MassDEP approved CWMP that the applicants demonstrate intermunicipal collaboration and problem solving for the nitrogen reductions required from the coastal watershed.
- The Nitrogen Sensitive Area designation under Title 5 should be revised to address the specific coastal watershed load and the needs for estuarine water quality restoration. Currently Title 5 is a blunt instrument that may not fully address specific local conditions and needs.
- MassDEP should consider using the groundwater discharge permit program for the implementation of the approved CWMPs that address nitrogen load reductions in nitrogen sensitive estuaries. Provisions should be provided that define specific reporting requirements that track and report watershed-wide improvements, and the water quality improvements that have been monitored in the estuary through an approved water quality monitoring and reporting program.
- MassDEP should require more Nutrient Management Plans. One was required for the groundwater discharge permit that was issued to the new wastewater treatment facility for the Town of Plymouth in the Eel River Watershed – a coastal watershed to Plymouth Harbor. This requirement was in response to citizen concerns about the discharge's impacts to the Eel River. As a result, Plymouth was required to develop a nutrient management plan as a condition of the town's wastewater treatment plant permit.
- Towns that are undergoing the CWMP process should address the nitrogen load reductions that have been defined on the MEP Technical and TMDL Reports for the targeted threshold concentration that should be achieved in the estuary's sentinel station. This is best accomplished inter-municipally, as all towns are equally responsible for reducing the loads affecting the embayment. Identifying a scenario that best achieves the nitrogen reduction from a cost and environmental perspective is one that cities and towns understand, especially when the scenario that best achieves the required reduction is the most cost effective.
- MassDEP should consider a voluntary approach to wastewater management planning for cash strapped communities, by allowing them to become engaged as part of a step-by-step process, with MassDEP technical assistance and oversight.
- MassDEP should consider the development of simplified plans that address the required load reductions that could be prepared at low cost by regional environmental or planning associations.

6.5.4 Suggested Elements of a Watershed Based CWMP

- Watershed Coordination and Planning
    - Coordination of planning with other towns, regional entities, private stakeholders, and MassDEP to ensure public involvement and intermunicipal coordination).
    - Local decisions on allocation of assimilative capacity and final TMDLs for subembayments
- Actions to meet the TMDL
    - List of actions to be taken individually or jointly; i.e., elements of town CWMP that impact the specific estuary
    - Identification of responsible parties
    - Actions should include both voluntary and regulated
- Timeframe for actions and expected timeframe for meeting TMDLs
- Monitoring progress toward the TMDL and adaptive management
    - Responsibility for water quality and other monitoring

- Schedule for distributing results to stakeholders and to MassDEP
- Steps to be taken if plan or TMDL need revisiting

Chapter 7: Inter-municipal, Watershed-Wide Comprehensive Wastewater Management Planning Process

Nitrogen pollution is a major environmental and economic problem for Massachusetts's estuaries. MassDEP believes that when people understand the seriousness of the problem, they will work together on solutions. The MassDEP is convinced that the most cost-effective way to make progress is for towns to work together, voluntarily, to develop and implement inter-municipal watershed-based solutions.

Water quality impaired estuaries have one feature in common. Most watershed pollutant loads originate from more than one town. MassDEP encourages towns sharing a watershed to establish a working group to identify and address the watershed loads that have been defined for reduction by the MEP Technical Reports. Once these technical reports are prepared, the Massachusetts MassDEP of Environmental Protection (MassDEP) will develop a Total Maximum Daily Load (TMDL) that will establish limits on the total amount of nitrogen that may be discharged directly or indirectly into each estuary in order to restore these estuaries and return them to compliance with the state's water quality standards.

A watershed-wide CWMP is the ideal option for coordinated planning and implementation (Appendix W). It might be structured in one of several ways listed below.

- A watershed-based plan written specifically for a group of towns
- One document that pulls together relevant information from several towns' plans.
- One town's plan that addresses watershed-wide issues and contains input from other towns in the watershed.

The issues addressed in a watershed CWMP are the same as those addressed in town plans: current and future conditions of water resources, identification of key problems and possible solutions, and recommendation of the preferred alternative. These are discussed in greater detail in the following MassDEP guidance documents:

- Comprehensive Waste water Management Plans
  http://www.mass.gov/dep/water/laws/wwtrfpg.pdf

- Water Resource Management Planning
  http://www.mass.gov/dep/water/laws/iwrmp.pdf

Although shared planning is easiest for towns starting their planning at the same time, most MEP towns are at different stages. In these cases, coordination is even more important. Towns can take the following steps:

- Initiate discussions with neighboring communities and identify a consultant when the MEP Technical and TMDL have been completed. Also retain the services of a consultant to provide the support needed to explain the meaning of these documents and their linkage to the preparation of a CWMP (Appendix F). Towns should begin the process by jointly reviewing the MEP Technical TMDL reports to identify the reduction levels required by the towns. Discuss shared concerns, and submit joint comments on the MEP Technical Report. Discussions and decisions concerning cost-sharing will take place regardless of engagement in the formal planning process.

- Schedule inter-municipal briefings on the MEP and Technical Reports which includes MEP's presentations of findings and recommendations for inter-municipal planning.
- Recommend that the MEP Technical Reports include a town-by-town break down of the unattenuated and attenuated nitrogen loads at current and future build-out conditions within its town borders (Table 3.8). This information will be helpful when deciding how to share the responsibility of reducing watershed-based nitrogen loads.
- Discuss role of natural attenuation as part of the planning process for nitrogen removal.
- Based on the nitrogen load for each sub-watershed (Appendix E), identify the wastewater treatment options and locations that best achieves the threshold concentration at the sentinel station in the embayment that is the most cost and environmental effective for the participating communities. Several scenarios should be identified until one is chosen that takes into account the role of natural attenuation, an appropriate mix of centralized, decentralized and on-site treatment, appropriate occasions, minimal extent of required treatment and potential discharge locations that are the most cost and environmental effective. This coordinated approach that engages towns to identify solutions that are mutually beneficial prevents redundancy in planning, unnecessary treatment when a mutual agreement could be an option where treatment in the adjoining community is the most cost effective, and locating treatment options only where needed to restore water quality to the threshold concentration at the sentinel station(s).
- Following these scenario runs that define the best nitrogen removal options and locations for the required reductions, prepare and establish a formal working relationship through a memorandum of understanding (MOU) if it's in your community's financial interest to jointly submit joint CWMP proposal to MassDEP for SRF funding support.
- Coordinate formal planning and construction schedules where possible, or at least share information on individual plans.
- When formal planning begins, appoint Citizens' Advisory Committee (CAC) members from other towns that share the estuary, as Mashpee has done.
- Create a joint written record of mutual decisions and a schedule of key points down the road at which coordination will be needed.
- For towns with two or more sub-embayments within its town borders, a town-wide plan should be pursued for implementation. In these cases, communities should delay any final decision for shared-watershed planning.
- In conjunction with wastewater management planning, towns should also adopt zoning and regulatory controls to address nitrogen load reductions for coastal groundwatersheds with a TMDL and for the protection of those that have not been impaired (Appendices R-V).

Towns that are ready to initiate their planning should not have to wait for the communities within the same watershed that are not ready. Towns that are unable to collaborate in the planning process when their neighbors are able may find that their planning and cost-saving options may be limited by the decisions made by the towns that began working together early in the process.

Finally, all plans when completed must undergo a public process prior to their adoption and funding. The actions identified in a CWMP to mitigate the impacts affecting our coastal embayments will require an unprecedented education and outreach campaign to address the required nitrogen load reductions: the largest remaining water quality problem in much of unsewered southeastern Massachusetts. The public process will need to address public perceptions of the problem while promoting the proposed management activities and informing or motivating stakeholders.

As described earlier, the NPS impact from residential onsite wastewater systems is substantial; in excess of 70 percent from all sources and greater than 80 percent of all controllable sources within a coastal watershed, but also from the daily use lawn fertilizers, or the manner in which stormwater is channeled offsite.

Several sources of information exist for use by local governments and watershed and citizen groups to assist them maximize the effectiveness of their public education and outreach campaigns, these include the following:

"Priorities for Coastal Ecosystem Science" by the Committee to Identify High-Priority Science to Meet National Coastal Needs, National Research Council (1994). This book provides additional supporting information – describing the critical environmental issues that face coastal ocean and Great Lakes areas, including eutrophication, habitat modification, hydrologic and hydrodynamic disruption, exploitation of resources, toxic effects on ecosystems and humans, introduction of non-indigenous species and global climate change, among others.

"Getting in Step: A Guide for Conducting Watershed Outreach Campaigns" (EPA 2003) is designed to walk watershed groups, municipalities, etc., through the process of developing and implementing a watershed outreach campaign. The guide takes people through a comprehensive six-step outreach process, from establishing goals to project evaluation. http://www.epa.gov/owow/watershed/outreach/documents/getnstep.pdf

"Getting Your Feet Wet with Social Marketing: Steps for Promoting Behavior Change in Water Programs" (Utah Department of Agriculture 2006) by Jack Wilbur should be required reading for any group working on an issue where awareness of the problems and solutions by the target audiences is minimal. http://ag.utah.gov/conservation/GettingYourFeetWet1.pdf

The Color of Water: Bring Back the Blue, by the Cape Cod Water Protection Collaborative http://www.capekeepers.org/images/educ_materials/barnstableworkingdraft-1.pdf

What does your septic system do? What doesn't it do and why does it matter? http://www.capekeepers.org/images/educ_materials/capekeepersepticbrochure.pdf

Also consult EPA NonPoint Source Outreach Toolbox Website for many others sources of information: http://www.epa.gov/owow/nps/toolbox/#toolbox

Individually, towns have lower priority points for SRF funding. However, when towns plan a joint proposal for TMDL related planning and implementation they will always rank higher on the SRF priority list. MassDEP awards SRF funds for both local and watershed-wide planning.

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