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Massachusetts Estuaries Project

Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Edgartown Great Pond System, Edgartown, Massachusetts

Executive Summary

1. Background

This report presents the results generated from the implementation of the Massachusetts Estuaries Project's Linked Watershed-Embayment Approach to the Edgartown Great Pond embayment system, a coastal embayment within the Town of Edgartown, Massachusetts on the Island of Martha's Vineyard. Analyses of the Edgartown Great Pond embayment system was performed to assist the Town with up-coming nitrogen management decisions associated with the Towns' current and future wastewater planning efforts, as well as wetland restoration, anadromous fish runs, shell fishery, open-space, and Pond maintenance programs. As part of the MEP approach, habitat assessment was conducted on the embayment based upon available water quality monitoring data, historical changes in eelgrass distribution, time-series water column oxygen measurements, and benthic community structure. Nitrogen loading thresholds for use as goals for watershed nitrogen management are the major product of the MEP effort. In this way, the MEP offers a science-based management approach to support the Town of Edgartown resource planning and decision-making process. The primary products of this effort are: (1) a current quantitative assessment of the nutrient related health of the Edgartown Great Pond embayment, (2) identification of all nitrogen sources (and their respective N loads) to embayment waters, (3) nitrogen threshold levels for maintaining Massachusetts Water Quality Standards within embayment waters, (4) analysis of watershed nitrogen loading reduction to achieve the N threshold concentrations in embayment waters, and (5) a functional calibrated and validated Linked Watershed-Embayment modeling tool that can be readily used for evaluation of nitrogen management and Pond opening alternatives (to be developed by the Town) for the restoration of the Edgartown Great Pond embayment system.

Wastewater Planning: As increasing numbers of people occupy coastal watersheds, the associated coastal waters receive increasing pollutant loads. Coastal embayments throughout the Commonwealth of Massachusetts (and along the U.S. eastern seaboard) are becoming nutrient enriched. The elevated nutrients levels are primarily related to the land use impacts associated with the increasing population within the coastal zone over the past half-century.

The regional effects of both nutrient loading and bacterial contamination span the spectrum from environmental to socio-economic impacts and have direct consequences to the culture, economy, and tax base of Massachusetts's coastal communities. The primary nutrient causing the increasing impairment of our coastal embayments is nitrogen, with its primary sources being wastewater disposal, and nonpoint source runoff that carries nitrogen (e.g. fertilizers) from a range of other sources. Nitrogen related water quality decline represents one of the most serious threats to the ecological health of the nearshore coastal waters. Coastal embayments, because of their shallow nature and large shoreline area, are generally the first coastal systems to show the effect of nutrient pollution from terrestrial sources.

In particular, the Edgartown Great Pond embayment system within the Town of Edgartown is at risk of eutrophication (over enrichment) from enhanced nitrogen loads entering through groundwater from the increasingly developed watershed to this coastal system. Eutrophication is a process that occurs naturally and gradually over a period of tens or hundreds of years. However, human-related (anthropogenic) sources of nitrogen may be introduced into ecosystems at an accelerated rate that cannot be easily absorbed, resulting in a phenomenon known as cultural eutrophication. In both marine and freshwater systems, cultural eutrophication results in degraded water quality, adverse impacts to ecosystems, and limits on the use of water resources.

The Town of Edgartown, relatively early on, recognized the severity of the problem of eutrophication and the need for watershed nutrient management and as such has over the years embarked on coordinated data gathering efforts with the Martha's Vineyard Commission and SMAST scientists. This local concern has led to the conduct of several studies of nitrogen loading to the system. Key in these efforts has been the Edgartown Great Pond Water Quality Monitoring Program, spearheaded by the MVC and supported by private, municipal, county and state funds (most recently Massachusetts 604(b) grant program) with technical assistance by the Coastal Systems Program at SMAST-UMD. This effort provided the quantitative watercolumn nitrogen data (1996-2006) required for the implementation of the MEP's Linked Watershed-Embayment Approach used in the present study.

Since the initial results of the Water Quality Monitoring Program and the land-use studies indicated that parts of the Edgartown Great Pond system were presently impaired by land-derived nitrogen inputs, the Town of Edgartown and Martha's Vineyard Commission (MVC) undertook additional site-specific data collection that has served to support MEP's ecological assessment and modeling project. The effort was associated with the Town's Wastewater Treatment Facility upgrade effort. The common focus of the Town of Edgartown - MVC efforts in the Edgartown Great Pond system has been to gather site-specific data on the current nitrogen related water quality throughout the pond system and determine its relationship to watershed nitrogen loads. All the historic efforts to begin to understand the nutrient over-enrichment threat to the Edgartown Great Pond system serve as a foundation to the current MEP Nutrient Threshold Analysis that incorporates pertinent elements of previous work with high level hydrodynamic and water quality modeling in order to determine appropriate restoration targets for this coastal system.

The Town of Edgartown, the Martha's Vineyard Commission and other working groups have recognized that a rigorous scientific approach yielding site-specific nitrogen loading targets was required for decision-making and alternatives analysis. The completion of this multi-step process has taken place under the programmatic umbrella of the Massachusetts Estuaries Project, which is a partnership effort between all MEP collaborators and the Town. The modeling tools developed as part of this program provide the quantitative information necessary for the Towns' nutrient management groups to predict the impacts on water quality from a variety of proposed management scenarios.

Nitrogen Loading Thresholds and Watershed Nitrogen Management: Realizing the need for scientifically defensible management tools has resulted in a focus on determining the aquatic system's assimilative capacity for nitrogen. The highest-level approach is to directly link the watershed nitrogen inputs with embayment hydrodynamics to produce water quality results that can be validated by water quality monitoring programs. This approach when linked to state-of-the-art habitat assessments yields accurate determination of the "allowable N concentration increase" or "threshold nitrogen concentration". These determined nitrogen concentrations are then directly relatable to the watershed nitrogen loading, which also accounts for the spatial distribution of the nitrogen sources, not just the total load. As such, changes in nitrogen load from differing parts of the embayment watershed can be evaluated relative to the degree to which those load changes drive embayment water column nitrogen concentrations toward the "threshold" for the embayment system. To increase certainty, the "Linked" Model is independently calibrated and validated for each embayment.

Massachusetts Estuaries Project Approach: The Massachusetts Department of Environmental Protection (DEP), the University of Massachusetts – Dartmouth School of Marine Science and Technology (SMAST), and others including the Cape Cod Commission (CCC) have undertaken the task of providing a quantitative tool to communities throughout southeastern Massachusetts (the Linked Watershed-Embayment Management Model) for nutrient management in their coastal embayment systems. Ultimately, use of the Linked Watershed-Embayment Management Model tool by municipalities in the region results in effective screening of nitrogen reduction approaches and eventual restoration and protection of valuable coastal resources. The MEP provides technical guidance in support of policies on nitrogen loading to embayments, wastewater management decisions, and establishment of nitrogen Total Maximum Daily Loads (TMDLs). A TMDL represents the greatest amount of a pollutant that a waterbody can accept and still meet water quality standards for protecting public health and maintaining the designated beneficial uses of those waters for drinking, swimming, recreation and fishing. The MEP modeling approach assesses available options for meeting selected nitrogen goals that are protective of embayment health and achieve water quality standards.

The core of the Massachusetts Estuaries Project analytical method is the Linked Watershed-Embayment Management Modeling Approach, which links watershed inputs with embayment circulation and nitrogen characteristics.

The Linked Model builds on well-accepted basic watershed nitrogen loading approaches such as those used in the Buzzards Bay Project, the CCC models, and other relevant models. However, the Linked Model differs from other nitrogen management models in that it:

- requires site-specific measurements within each watershed and embayment;
- uses realistic "best-estimates" of nitrogen loads from each land-use (as opposed to loads with built-in "safety factors" like Title 5 design loads);
- spatially distributes the watershed nitrogen loading to the embayment;
- accounts for nitrogen 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 nitrogen regenerated within the embayment;
- is validated by both independent hydrodynamic, nitrogen concentration, and ecological data;
- is calibrated and validated with field data prior to generation of "what if" scenarios.

The Linked Model Approach's greatest assets are its ability to be clearly calibrated and validated, and its utility as a management tool for testing "what if" scenarios for evaluating watershed nitrogen management options.

For a comprehensive description of the Linked Model, please refer to the *Full Report: Nitrogen Modeling to Support Watershed Management: Comparison of Approaches and Sensitivity Analysis*, available for download at http://www.state.ma.us/dep/smerp/smerp.htm. A more basic discussion of the Linked Model is also provided in Appendix F of the *Massachusetts Estuaries Project Embayment Restoration Guidance for Implementation Strategies*, available for download at http://www.state.ma.us/dep/smerp/smerp.htm. The Linked Model suggests which management solutions will adequately protect or restore embayment water quality by enabling towns to test specific management scenarios and weigh the resulting water quality impact against the cost of that approach. In addition to the management scenarios modeled for this report, the Linked Model can be used to evaluate additional management scenarios and may be updated to reflect future changes in land-use within an embayment watershed or changing embayment characteristics. In addition, since the Model uses a holistic approach (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. Unlike many approaches, the Linked Model accounts for nutrient sources, attenuation, and recycling and variations in tidal hydrodynamics and accommodates the spatial distribution of these processes. For an overview of several management scenarios that may be employed to restore embayment water quality, see *Massachusetts Estuaries Project Embayment Restoration Guidance for Implementation Strategies*, available for download at http://www.state.ma.us/dep/smerp/smerp.htm.

Application of MEP Approach: The Linked Model was applied to the Edgartown Great Pond embayment system by using site-specific data collected by the MEP and water quality data from the Water Quality Monitoring Program conducted by the Town of Edgartown and the Martha's Vineyard Commission, with technical guidance from the Coastal Systems Program at SMAST (see Chapter II). Evaluation of upland nitrogen loading was conducted by the MEP, data was provided by the Town of Edgartown and the Martha's Vineyard Commission, and watershed boundaries delineated by USGS, the SMAST-MEP Technical Team and the Martha's Vineyard Commission. This land-use data was used to determine watershed nitrogen loads within the Edgartown Great Pond embayment system and each of the systems sub-embayments as appropriate (current and build-out loads are summarized in Chapter IV). Water quality within a sub-embayment is the integration of nitrogen loads with the site-specific estuarine circulation. Therefore, water quality modeling of this tidally influenced estuary included a thorough evaluation of the hydrodynamics of the estuarine system as defined by the pond breaching regime. Estuarine hydrodynamics control a variety of coastal processes including tidal flushing, pollutant dispersion, tidal currents, sedimentation, erosion, and water levels. Once the hydrodynamics of the system was quantified, transport of nitrogen was evaluated from tidal current information developed by the numerical models and changes is groundwater levels once breaches were closed.

A two-dimensional depth-averaged hydrodynamic model based upon the tidal currents, water elevations and pond openings was employed for the Edgartown Great Pond embayment system. Once the hydrodynamic properties of the estuarine system were computed, two-dimensional water quality model simulations were used to predict the dispersion of the nitrogen at current loading rates. Using standard dispersion relationships for estuarine systems of this type, the water quality model and the hydrodynamic model was then integrated in order to generate estimates regarding the spread of total nitrogen from the site-specific hydrodynamic properties. The distributions of nitrogen loads from watershed sources were determined from land-use analysis. Boundary nutrient concentrations in Atlantic Ocean source waters were taken from water quality monitoring data. Measurements of current salinity distributions throughout the estuarine waters of the Edgartown Great Pond embayment system was used to calibrate the water quality model, with validation using measured nitrogen concentrations (under existing loading conditions). The underlying hydrodynamic model was calibrated and validated independently using water elevations measured in time series throughout the embayments.

MEP Nitrogen Thresholds Analysis: The threshold nitrogen level for an embayment represents the average water column concentration of nitrogen that will support the habitat quality being sought. The water column nitrogen level is ultimately controlled by the watershed nitrogen load and the nitrogen concentration in the inflowing tidal waters (boundary condition). The water column nitrogen concentration is modified by the extent of sediment regeneration. Threshold nitrogen levels for the embayment systems in this study were developed to restore or maintain SA waters or high habitat quality. High habitat quality was defined as supportive of eelgrass and infaunal communities. Dissolved oxygen and chlorophyll a were also considered in the assessment.

The nitrogen thresholds developed in Section VIII-2 were used to determine the amount of total nitrogen mass loading reduction required for restoration of eelgrass and infaunal habitats in the Edgartown Great Pond system. Total nitrogen thresholds derived in Section VIII.1 were used to adjust the calibrated constituent transport model developed in Section VI. Watershed nitrogen loads were sequentially lowered using: 1) reductions in septic effluent discharges, 2) reduction in nitrogen loading from the WWTP due to recent plant upgrades and 3) modified breaching schedules, until the nitrogen levels reached the threshold level at the sentinel stations chosen for the Edgartown Great Pond system. It is important to note that load reductions can be produced by reduction of any or all sources or by increasing the natural attenuation of nitrogen within the freshwater systems to the embayment. The load reductions presented below represent only one of a suite of potential reduction approaches that need to be evaluated by the community. The presentation is to establish the general degree and spatial pattern of reduction that will be required for restoration of this nitrogen impaired embayment.

The Massachusetts Estuaries Project’s thresholds analysis, as presented in this technical report, provides the site-specific nitrogen reduction guidelines for nitrogen management of the Edgartown Great Pond embayment system in the Town of Edgartown. Future water quality modeling scenarios should be run which incorporate the spectrum of strategies that result in nitrogen loading reduction to the embayment. The MEP analysis has initially focused upon nitrogen loads from on-site septic systems and the WWTP as a test of the potential for achieving the level of total nitrogen reduction for restoration of each embayment system. The concept was that since septic system and WWTP nitrogen loads generally represent 80% of the controllable watershed load to the Edgartown Great Pond embayment system and are more manageable than other of the nitrogen sources, the ability to achieve needed reductions through this source is a good gauge of the feasibility for restoration of these systems.

2. Problem Assessment (Current Conditions)

A habitat assessment was conducted throughout the Edgartown Great Pond 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 Edgartown Great Pond System is generally showing moderately to significantly impaired habitat for infauna with the lower basin also supporting moderately impaired eelgrass habitat. There is a slight gradient in the infaunal habitat quality with the upper basin and its tributary coves showing greater impairment than he large lagoonal basin running parallel to the barrier beach. All of the habitat indicators are consistent with this evaluation of the whole of system as presented in Chapter VII.

The effect of nitrogen enrichment is to cause oxygen depletion; however, with increased phytoplankton (or epibenthic algae) production, oxygen levels will rise in daylight to above atmospheric equilibration levels in shallow systems (generally ~7-8 mg L^{-1} at the mooring sites). Overall, Edgartown Great Pond is showing a moderate level of habitat impairment (eelgrass and infaunal animals) from summer oxygen depletion and organic enrichment primarily from phytoplankton production, parameters directly related to nutrient inputs. The level of oxygen depletion and the magnitude of daily oxygen excursions and chlorophyll-a levels indicate moderately nutrient enriched waters and impaired habitat quality within the upper and lower basins of the system. The oxygen data is consistent with organic matter enrichment, primarily from phytoplankton production as seen from the parallel measurements of chlorophyll-a. The periodic elevated oxygen levels observed in Edgartown Great Pond provides additional evidence that this system is presently receiving nitrogen inputs above the threshold required to maintain high quality estuarine habitat.

The measured levels of oxygen depletion in the bottom waters of Wintucket Cove and the lower main basin to Edgartown Great Pond indicate that this Great Salt Pond is currently organic matter enriched, primarily through in situ production by phytoplankton. Moreover, the system periodically experiences moderate levels of oxygen stress, consistent with nitrogen enrichment.

At present, eelgrass beds are not present in the Edgartown Great Pond System, although sparse patches of eelgrass can still be observed within the lower basin. The current lack of eelgrass beds and the remaining sparse patches are consistent with the elevated chlorophyll-a concentrations, the low dissolved oxygen levels and water column nitrogen concentrations within this system. That the remaining patches are found within the shallow margins versus within the "deeper" regions of the lower basin (1951 versus 1997-2002) also supports the contention that the mechanism of loss is nitrogen enrichment.

While water quality parameters, primarily related to nitrogen, chlorophyll and oxygen are the major factors causing shifts in eelgrass habitat quality within this system, water depth is also important in determining potential habitat locations for restoration. All of the locations with eelgrass (1951-2006) are <1.5 meter depth. The more recent field observations suggest eelgrass at depths of 0.5 - 1.0 meters, with the shallower depth potentially related to low water stand when the inlet is opened and the deeper depth being determined by light penetration when the inlet is closed. The depth of the upper main basin (above Swan Neck) appears to have historically limited eelgrass colonization of this basin. The absence of eelgrass within the Coves, most likely relates to their shallow depth, organic rich sediments and periodic salinity declines.

The overall results of the MEP analysis indicate that eelgrass habitat within Edgartown Great Pond is presently impaired and the eelgrass coverage has declined. While it is not possible to determine the density of the eelgrass beds in 1951 (historic benchmark used in all MEP analyses), it does appear the coverage has declined and that recent eelgrass areas support only sparse colonization by eelgrass plants. The decline of eelgrass beds relative to historical distributions is expected given the elevated nitrogen levels and resulting chlorophyll a and dissolved oxygen depletions within this embayment system.

Overall, the infauna survey indicated that most areas within Edgartown Great Pond are supporting moderate nutrient related infaunal habitat quality. It appears that the upper main basin (above Swan Neck) supports the poorest habitat, moderately to significantly impaired, with similar impairment in the major tributary coves (Janes Cove, Wintucket Cove, Mashacket Cove). The lower large lagoonal basin and one of the small associated tributary coves (Jobs Neck Cove) supported slightly higher quality habitat, although moderate impairment by nitrogen and organic enrichment was clearly observed in these basins as well. Both of the lower eastern coves (Turkeyland Cove and Slough Cove) support infaunal animal habitats of intermediate quality between upper and lower basin conditions.

The underlying structure of Edgartown Great Pond and its watershed supports the observed spatial variation in infaunal habitat quality. Moreover, the infaunal habitat quality was consistent with the gradients in dissolved oxygen, chlorophyll, nutrients and organic matter enrichment in this system. The results of the MEP analysis indicate that the nitrogen management threshold analysis (Chapter 8) needs to include a lowering of the level of nitrogen enrichment throughout this salt pond for restoration of nitrogen impaired benthic habitats. However, it is important to note that the non-tidal nature of this embayment and the depositional nature of the upper main basin (deep) make benthic habitat within that region of the system particularly sensitive to nitrogen enrichment.

3. Conclusions of the Analysis

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

Threshold nitrogen levels for this embayment system were developed to restore or maintain SA waters or high habitat quality. In this system, high habitat quality was defined as possibly supportive of eelgrass and supportive of diverse benthic animal communities. Dissolved oxygen and chlorophyll *a* were also considered in the assessment.

Watershed nitrogen loads (Tables ES-1 and ES-2) for the Town of Edgartown Great Pond embayment system was comprised primarily of wastewater nitrogen. Land-use and wastewater analysis found that generally about 80% of the controllable watershed nitrogen load to the embayment was from wastewater.

A major finding of the MEP clearly indicates that a single total nitrogen threshold can not be applied to Massachusetts' estuaries, based upon the results of the Great, Green and Bournes Pond Systems, Popponesset Bay System, the Lewis Bay system, the Hamblin / Jehu

Pond / Quashnet River analysis in eastern Waquoit Bay, the analysis of the Sesachacha Pond and Nantucket Harbor systems as well as the Pleasant Bay and other Nantucket Sound embayments associated with the Town of Chatham. This is almost certainly going to be true for the other embayments within the MEP area, including those on Martha's Vineyard.

The threshold nitrogen levels for the Edgartown Great Pond embayment system in Edgartown were determined as follows:

Edgartown Great Pond Threshold Nitrogen Concentrations

- Following the MEP protocol, the restoration target for the Edgartown Great Pond system should reflect both pre-degradation habitat quality and be reasonably achievable. Based upon the assessment data provided in Chapter VII and since the Edgartown Great Pond System does not support strong horizontal gradients (range in total nitrogen levels from 0.58 mg N L^{-1} in the lower basin to <0.63 mg N L^{-1} in the coves, with 0.65 mg N L^{-1} in upper Mashacket Cove), the MEP Technical Team decided to use the average of the five long-term water quality stations to determine a pond-wide threshold (EGP 2,3,5,6,9). This distributed "location" for the threshold stems from the variability at individual sites and the non-tidal nature of this system. These stations are presently showing an average TN level of 0.596 mg N L^{-1} (range = 0.587-0.613 mg N L^{-1}).

- While it is certain that historic eelgrass habitat (1951 or earlier) was of a higher quality than at present, it was likely not a high quality habitat due to the systems periodic tidal exchange and "naturally" nitrogen enriched condition. Routine opening of this salt pond was initiated in the 1940's and would have been required for habitat maintenance at that time as well as today. Therefore, habitat restoration in this nutrient enriched system should focus on improving eelgrass habitat within the lower main basin and on full restoration of infaunal habitat quality pond-wide.

- Since the infaunal community at all sites with the Pond are either dominated by organic matter enrichment species or are depleted, comparisons to the muddy basins of other estuarine systems in the MEP study region were relied upon. This type of comparative analysis suggests that a healthy infaunal habitat would clearly be achieved at an average nitrogen level of TN <0.5 mg TN L^{-1}. This level was found for Popponesset Bay, where based upon the infaunal analysis coupled with the nitrogen data (measured and modeled), nitrogen levels on the order of 0.4 to 0.5 mg TN L^{-1} were found to be supportive of high infaunal habitat quality in that system. Similarly, in the deeper basins of Three Bays System, healthy infaunal areas are found at nitrogen levels of TN <0.42 mg TN L^{-1} (Cotuit Bay and West Bay) and in Eel Pond (Bourne) at a TN level of 0.45 mg TN L^{-1}. Conversely, moderate impairment of infaunal habitat has routinely been documented by the MEP in areas where nitrogen levels of TN >0.5 mg TN L^{-1} were observed

- The MEP Technical Team determined that infaunal habitat quality within Edgartown Great Pond is responding to nitrogen levels in a manner consistent with other embayments within the MEP study region, as seen by the present TN level of ~0.6 mg TN L^{-1} translating to a moderately impaired infaunal community. The integration of all information available clearly supports a nitrogen threshold for restoration of healthy infaunal habitat within Edgartown Great Pond of 0.5 mg N L^{-1} (time averaged). The modeling simulations in Section VIII-3 targeted the 0.5 mg TN L^{-1} for healthy habitat.

This significant lowering of average TN levels within the lower basin of Edgartown Great Pond will also improve eelgrass habitat within the historic 1951 coverage area and likely in the western portion of the lower basin as well.

It is important to note that the analysis of future nitrogen loading to the Edgartown Great Pond estuarine system focuses upon modification of pond breaching practices as well as additional shifts in land-use and associated nutrient loading to the pond. However, the MEP analysis indicates that significant increases in nitrogen loading can occur under present land-uses, due to shifts in occupancy, shifts from seasonal to year-round usage and increasing use of fertilizers (presently less than half of the parcels use lawn fertilizers). This is besides the fact that based on the MEP analysis, overall, buildout additions within the entire Edgartown Great Pond System watershed will increase the unattenuated nitrogen loading rate to the pond by 44%. Therefore, watershed-estuarine nitrogen management must include management approaches to prevent increased nitrogen loading from both shifts in land-uses (new sources) and from loading increases of current land-uses. The overarching conclusion of the MEP analysis of the Edgartown Great Pond estuarine system is that restoration will necessitate a reduction in the present nitrogen inputs, modifying breach schedule and management options to negate additional future nitrogen inputs.

Table ES-1. Existing total and sub-embayment nitrogen loads to the estuarine waters of the Edgartown Great Pond system, observed nitrogen concentrations, and sentinel system threshold nitrogen concentrations. Loads to estuarine waters of the Great Pond system include both upper watershed regions contributing to the major surface water inputs.

	Natural Background Watershed Load [1] (kg/day)	Present Land Use Load [2] (kg/day)	Present Septic System Load (kg/day)	Present WWTF Load [3] (kg/day)	Present Watershed Load [4] (kg/day)	Direct Atmospheric Deposition [5] (kg/day)	Present Net Benthic Flux (kg/day)	Present Total Load [6] (kg/day)	Observed TN Conc. [7] (mg/L)	Threshold TN Conc. [8] (mg/L)
Edgartown Great Pond System Total	2.759	8.537	15.167	6.586	30.282	11.445	20.445	62.172	**0.58-0.71**	**0.500**

[1] assumes entire watershed is forested (i.e., no anthropogenic sources)
[2] composed of non-wastewater loads, e.g. fertilizer and runoff and natural surfaces and atmospheric deposition to lakes
[3] existing unattenuated wastewater treatment facility discharge to groundwater (Mashacket Cove)
[4] composed of combined natural background, fertilizer, runoff, and septic system loadings
[5] atmospheric deposition to embayment surface only.
[6] composed of natural background, fertilizer, runoff, septic system atmospheric deposition and benthic flux loadings
[7] average of data collected between 2003 and 2006, ranges show the upper to lower regions (highest-lowest) of the system.
[8] average TN concentration of whole system through summer months.

Table ES-2. Present Watershed Loads, Thresholds Loads, and the percent reductions necessary to achieve the Thresholds Loads for the Edgartown Great Harbor system.

	Present Watershed Load [1] (kg/day)	Target Threshold Watershed Load [2] (kg/day)	Direct Atmospheric Deposition (kg/day)	Benthic Flux Net [3] (kg/day)	TMDL [4] (kg/day)	Percent watershed reductions needed to achieve threshold load levels
Edgartown Great Pond System Total	30.282	21.058	11.445	13.559	46.062	-17.8%

(1) Composed of combined natural background, fertilizer, runoff, and septic system loadings.
(2) Target threshold watershed load is the load from the watershed needed to meet the embayment threshold concentration identified in Table ES-1.
(3) Projected future flux (present rates reduced approximately proportional to watershed load reductions).
(4) Sum of target threshold watershed load, atmospheric deposition load, and benthic flux load.