Action Plan 1 Managing Nitrogen Sensitive Embayments

Problem

Impairments to water quality and living resources caused by excessive nitrogen inputs to Buzzards Bay are one of the most pressing issues identified in this Buzzards Bay CCMP. Nitrogen total maximum daily load (TMDL) studies have not been completed for all embayments, but impairments are apparent in all the somewhat less well-flushed embayments that fringe Buzzards Bay. Loss of eelgrass beds, accumulation of benthic algae smothering shellfish beds, and low oxygen concentrations and resulting fish kills are among the impacts that must be remedied. Elimination of excessive nitrogen loads will ensure that all designated uses for those embayments are met[47]. Wastewater discharges are typically the largest source in most watersheds. While state and federal agencies regulate permitted discharges like outfall pipes, some sources of pollution like cumulative loadings from septic systems are difficult to regulate. Solutions typically focus on municipal sewer expansion or nitrogen removing onsite systems, both of which have high costs.

Goals

Goal 1.1. Ensure that no designated uses will be lost, nor ecosystems adversely affected by excessive contributions of nitrogen to any area of Buzzards Bay.

Goal 1.2. Restore lost designated uses and adversely affected ecosystems impaired by the excessive contribution of nitrogen to any area within Buzzards Bay.

Objectives

Objective 1.1. To develop and adopt scientifically based nitrogen total maximum daily loads (TMDLs) for nitrogen impaired areas of Buzzards Bay.

Objective 1.2. To reduce the amount of nitrogen currently entering nitrogen-impacted embayments, including all areas identified on 303(d) and Integrated Lists, according to limits specified in approved TMDLs.

Objective 1.3. To ensure new additions of nitrogen to coastal waters do not cause, or contribute to, a violation of state surface water quality standards, or exceed federally approved TMDLs.

Objective 1.4. To ensure that state and federal discharge permits meet nitrogen loading limits and waste load allocations specified in approved TMDLs.

Objective 1.5. To promote the development and implementation of local plans to manage nitrogen sources to meet TMDLs and waste load allocations.

Objective 1.6. To promote the development and support the use of alternative and advanced nitrogen reducing wastewater treatment technologies at all scales of flow.

Objective 1.7. Monitor water quality and natural resources like eelgrass beds at a sufficient frequency to document management needs, assess the effectiveness of actions taken, and to document ongoing changes and variability in water quality and ecosystems health.

Approaches

Municipalities should take action to reduce nitrogen inputs to impaired waters. In most watersheds, sewering with disposal at centralized or satellite wastewater treatment systems with nitrogen removal will often be the most viable solution for reducing wastewater nitrogen inputs from areas with dense development. In less developed areas, advanced nitrogen removal onsite systems and small community scale systems may be part of a solution, as well non-structural alternatives. To ensure action, it is imperative that DEP develop, and for the U.S. EPA to adopt TMDL nitrogen limits and waste load allocations for all impaired areas. These limits only directly affect discharges requiring a federal permit, so municipalities must develop comprehensive strategies to manage all nitrogen sources to meet adopted TMDLs.

In some watersheds, better management of agricultural fertilizer release or manure management is needed. In the case of the cranberry bogs, nitrogen reductions can be achieved in part through various water use BMPs. Although typically a secondary source, stormwater discharges and residential fertilizer use can be locally important. All stakeholders should work closely with municipalities to reduce nitrogen to meet TMDLs, and implement comprehensive strategies, including managing or offsetting nitrogen inputs from new development.

Costs and Financing

Preliminary estimates by the Buzzards Bay NEP suggest that sewer expansion in the Buzzards Bay watershed may exceed $2 billion. Because of the costs and scale of the effort, meeting TMDLs will remain one of the most formidable political, financial, and management challenges facing municipalities in this CCMP. Implementation will likely take decades and require more state and federal support.

Measuring Success

The issuance of TMDLs, compliance with loading limits, and the area of impaired waters will be the management measures tracked. Restoring water quality and recovery of habitat will be the long-term tracking measure. These will be assessed through the Coalition's Water Quality Monitoring Program and the state's eelgrass mapping and listings of impaired waters.

[47] Unless additional impairments are caused by other pollutants. "Designated Uses" are those listed in Massachusetts Water Quality Standards, see entry in Glossary.

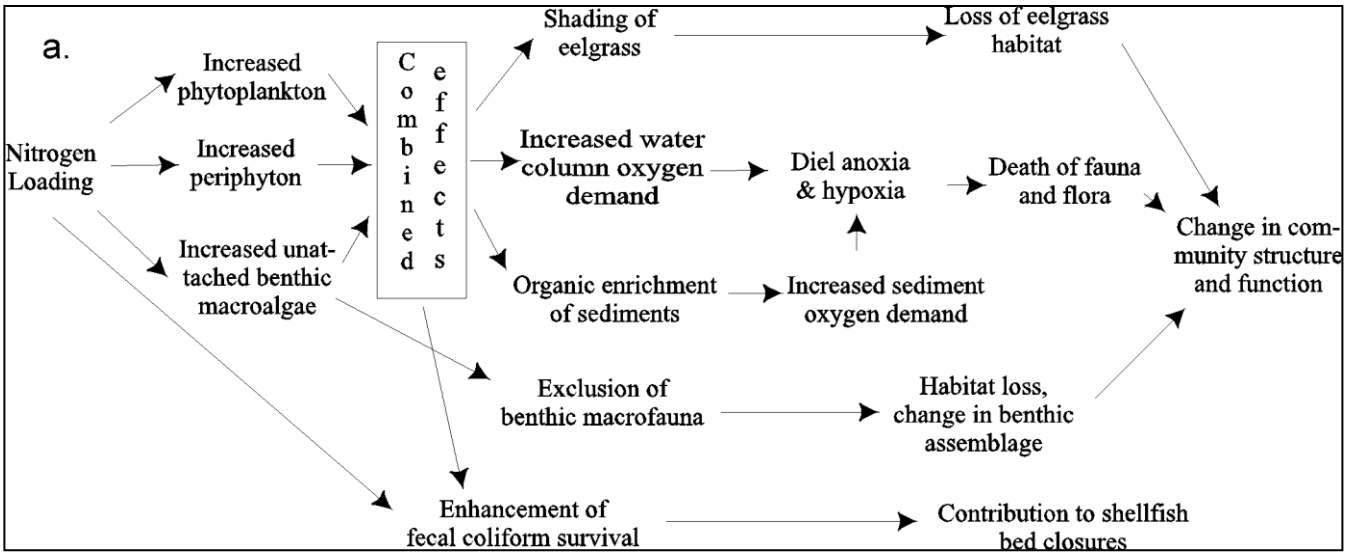

Figure 38. Generalized ecosystem response of a shallow embayment to nitrogen loading.

From Costa et al., 1992.

Background

As summarized in Chapter 3, and as articulated in the Massachusetts DEP's Integrated List of Impaired Waters, many areas of Buzzards Bay are impaired by excessive inputs of nitrogen[48]. In Buzzards Bay, as in most coastal waters, nitrogen, which is an essential nutrient, typically limits the growth of algae. Algae, which include macroalgae or "seaweeds" and microalgae that live in the water (phytoplankton) or grow on surfaces (periphyton), form the base of many marine food webs. Increased inputs of nitrogen from human activities threaten many embayments in Buzzards Bay by stimulating excessive growth of both microalgae and macroalgae (Figure 38 and Figure 39).

This increased production and accumulation of micro- and macroalgae can result in many adverse changes to coastal ecosystems, in a process called "coastal eutrophication" or "nutrient enrichment." For example, increased abundance of algae can limit the transmission of light reaching eelgrass leaves, resulting in the loss of eelgrass beds that provide habitat for shellfish and other animals. The loss of eelgrass because of eutrophication has occurred in many parts of Buzzards Bay, as has happened at the north end of Buzzards Bay in the Wareham River estuary (Figure 40), one of the more eutrophic areas of Buzzards Bay.

Dense layers of macroalgae can also accumulate on the bottom of some shallow bays, which destroys valuable habitat for shellfish and other invertebrates. In addition, decay of macroalgae depletes oxygen in the water and causes unpleasant odors. Severe oxygen depletion can kill fish and shellfish. There is also evidence that excess nitrogen promotes, directly and indirectly, the survival of coliform bacteria, which contributes to closures of shellfish areas. Algae blooms and accumulation of macroalgae may also cause aesthetic problems and inhibit typical recreational uses of the water such as swimming and boating. Overall, the addition of excess nitrogen is one of the most serious long-term problems threatening many embayments around Buzzards Bay.

The response of coastal ecosystems to excessive anthropogenic (human generated) contributions of nitrogen is complex and varied but most pronounced in embayments with restricted water exchange or where the amount of nitrogen added is large as compared to the volume of the receiving water (Figure 41). Perhaps the most overriding feature that defines the response of coastal ecosystems to nitrogen loading is the bathymetry of the receiving waters, particularly the area of bottom within the photic zone; that is where there is enough light for either seagrasses or algae to grow on the bottom.

Photo by Joe Costa.

Figure 39. Excessive algal growth shading out eelgrass (here green algae is rafting on eelgrass leaves) is one of the many adverse impacts of nitrogen pollution.

[48] This action plan principally targets management of point and nonpoint sources of nitrogen at an embayment level, rather than bay-wide. This Buzzards Bay CCMP addresses nitrogen loading from sewer outfalls in more detail in the Sewage Treatment Facilities action plan.

Table 16. Summary of subwatershed loading reaching the estuary and total loadings to Buzzards Bay from various sources.

Embayment	Existing N Load (kg/y)	Note
Allens Pond	5,707	(1)
Apponagansett Bay	24,213	(1)
Aucoot Cove	10,574	(1)
Brant Island Cove	1,225	(1)
Buttermilk Bay	33,175	(1)
Clarks Cove	30,813	(1)
Hen Cove	5,244	(1)
Little Bay	31,192	(1)
Little River	4,225	(2)
Mattapoisett Harbor	51,071	(1)
Megansett / Squeteague Harbor	31,168	(1)
Little Bay / Nasketucket Bay	31,192	(1)
New Bedford Harbor (=Acushnet River, includes Fairhaven WWTF)	89,633	(3)
Onset Bay	20,169	(1)
Phinneys Harbor / Back River	19,704	(1)
Pocasset Harbor	5,555	(1)
Pocasset River	9,417	(1)
Quisset Harbor	1,722	(1)
Red Brook Harbor	9,474	(1)
Sippican Harbor	17,175	(1)
Slocums River	51,562	(3)
Wareham River (includes WWTF)	51,489	(2)
Weweantic River	160,509	(1,4)
West Falmouth Harbor (includes Falmouth WWTF)	15,234	(2)
Widows Cove	2,016	(1)
Wild Harbor	9,772	(1)
Wings Cove	4,199	(1)
Westport Rivers	212,963	(2)
Non-embayment watersheds	108,832	(1)
Buzzards Bay, atmos.	785,258	(5)
New Bedford Wastewater Outfall	368,214	(6)
Dartmouth Wastewater Outfall	97,892	(6)
Mass Maritime Academy Outfall	3,864	(7)
Grand Total	2,304,452	

(1) Buzzards Bay NEP estimates are approximations from MassGIS land use and MEP loading assumptions, with 50% average attenuation above first river impoundments. These estimates will be superseded by better estimates from MEP studies.
(2) MEP draft or final report, includes precipitation to estuary areas.
(3) Buzzards Bay NEP estimate from parcel data and other sources.
(4) Calculation using MEP 2000-2010 cranberry bog loading rates.
(5) Atmospheric loading to entire bay surface in the NEP study area (MA waters to RI border), but does not include estuary surface waters in embayment watersheds (total=162,429 acres), times the MEP loading rate of 4.41 kg per acre.
(6) Outfall loadings as reported to EPA, July 2010 to June 2011, at echo.epa.gov/?redirect=echo.
(7) Based on 2012 average daily flows × 30-ppm TN (assumed conc.)

Sources of anthropogenic nitrogen reaching coastal waters (also defined here as embayment "nitrogen loading") include sewage treatment facilities, septic systems, atmospheric deposition, and fertilizer used on lawns, golf courses, and agricultural land. Atmospheric loading to Buzzards Bay as a whole is quite large, accounting for about one-third of total loadings reaching the bay (Table 16). However, atmospheric loadings to individual embayment watersheds only averages 15% of total loadings among publicly available MEP studies, with wastewater disposal averaging 57% of estuary watershed loading (Table 17). These values do not include watershed attenuation as Table 16 does, and the relative contribution of septic loads actually reaching each estuary is greater than shown.

The relative importance of other nitrogen sources varies among watersheds. For example, agriculture sources are important in some watersheds. In the Westport Rivers, agriculture, mostly related to dairy farm animal waste accounted for 57% of the controllable unattenuated watershed nitrogen loading, whereas septic systems accounted for only 34% (Howes et al., 2012). In the Weweantic River and Wareham River watersheds, loadings from cranberry bogs account for a large portion of watershed nitrogen loadings. In the Wareham River estuary system as a whole, cranberry bogs contribute 20% of the watershed controllable nitrogen load, whereas in the Agawam River/Mill Pond subwatershed, cranberry bogs account for 57% of the watershed controllable loading (Howes et al., 2013). In these same systems, septic systems accounted for 43% and 20% respectively of the controllable unattenuated watershed nitrogen loading.

Nitrogen from watershed sources enters the bay via streams, groundwater, direct rain deposition, stormwater runoff, and by effluent discharge. Cumulatively, the single largest sources of nitrogen entering Buzzards Bay are discharges from sewage facilities; with the next largest amount derived from home septic systems (see Chapter 3, Table 13).

This overview of nitrogen sources in approved MEP reports does not adequately reflect loadings in many Buzzards Bay watersheds. Draft reports for Westport and Wareham show agricultural sources as large as (Wareham) or exceeding septic system discharges (Westport). In New Bedford Harbor, the watershed is mostly sewered, so the Fairhaven wastewater facility discharge is one of the largest sources, although stormwater and CSO discharges are also significant. As noted in the original 1991 CCMP, even a discharge from a large sewage treatment such as New Bedford's, primarily affect waters close to the outfall. The MEP findings continue to affirm both the localized nature of coastal eutrophication, variability among watersheds sources, and the need for watershed-specific strategies to manage nitrogen inputs.

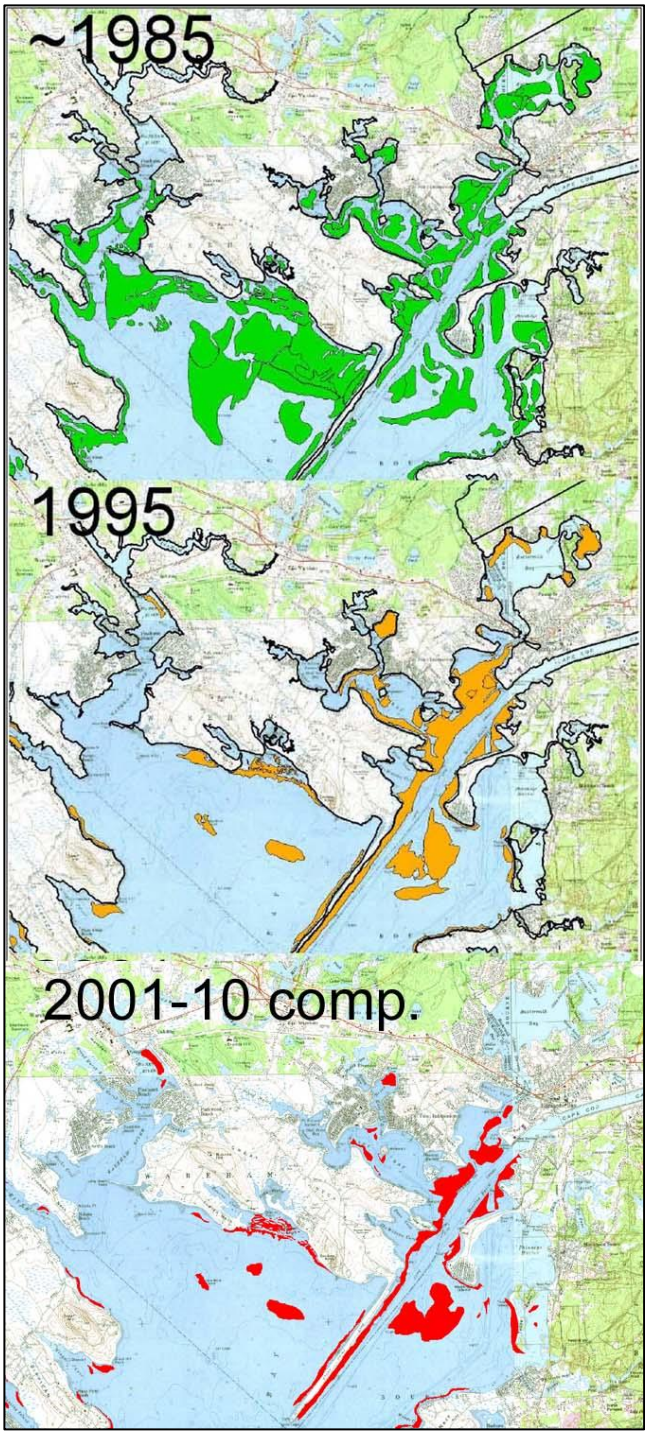

Figure 40. Recent losses of eelgrass in northern Buzzards Bay.

Top panel from data in Costa 1988a,b (posted at buzzardsbay.org/eelgrass.htm), middle panel from DEP eelgrass surveys, data posted at MassGIS, bottom from DEP 2001, 2006, and 2010 maps and Buzzards Bay NEP additional data combined to create a composite of the most recent data (2001 was the date of the last complete survey of Buzzards Bay).

Table 17. Relative contribution of septic system, atmospheric, and wastewater facility loading to watershed loading in various published MEP studies.

Studies of Buzzards Bay embayments are mostly incomplete as of 2013. Most Buzzards Bay embayments will have a lower proportional septic load than on Cape Cod. Because population and septic systems are clustered near the coast, their % contributions reaching the bay relative to other watershed sources are greater than the percentages shown because of watershed attenuation losses.

Estuary System	septic system load	wastewater facility load	atmospheric to estuary surface
Rock Harbor	84%	1%	1%
Centerville River System	80%	0%	2%
Green Pond	78%	6%	7%
Taylors Pond	77%	0%	3%
Bournes Pond	74%	0%	11%
Great Pond (Falmouth)	72%	3%	6%
Oyster Pond (Falmouth)	68%	0%	15%
Three Bays System	68%	0%	11%
Popponesset Bay	66%	0%	11%
Farm Pond	63%	6%	8%
Lagoon Pond	63%	0%	15%
Stage Harbor System	62%	0%	21%
Phinneys Harbor System	62%	0%	18%
Sulphur Spring System	59%	13%	2%
Sengekontacket Pond	58%	0%	23%
Lewis Bay System	55%	20%	11%
Little Pond	53%	0%	3%
Great Pond (Edgartown)	36%	16%	27%
Wareham River Estuary	33%	12%	16%
West Falmouth Harbor	23%	49%	6%
Slocums River	14%	0%	4%
Nantucket Harbor	8%	0%	71%
Average	**57%**	**6%**	**15%**

Although such discharges are important, and managers may limit their nitrogen discharge, Buzzards Bay as a whole has a large well-flushed volume of water relative to nitrogen inputs so that human activity has not yet appreciably affected the central portion of the bay to the same degree that small embayments along the periphery of the bay have been affected. In Buzzards Bay, shallow, less well-flushed embayments are most sensitive to nitrogen additions and are most likely to exhibit the symptoms and impacts described above. The Buzzards Bay NEP coined the terms "Nitrogen sensitive Embayments" and "Nitrogen-Impacted Embayments" to describe these systems in the 1991 Buzzards Bay CCMP.

Evolving Management Approach

Since the 1980s, the U.S. EPA has required that states that list waters as impaired by contaminants (on their "303 (d)" or "Integrated Lists)," develop a Total Maximum Daily Load for that contaminant to mitigate those impairments (see Figure 42 for current listed embayments in Buzzards Bay). However, in 1991, the Commonwealth had not yet adopted a methodology to

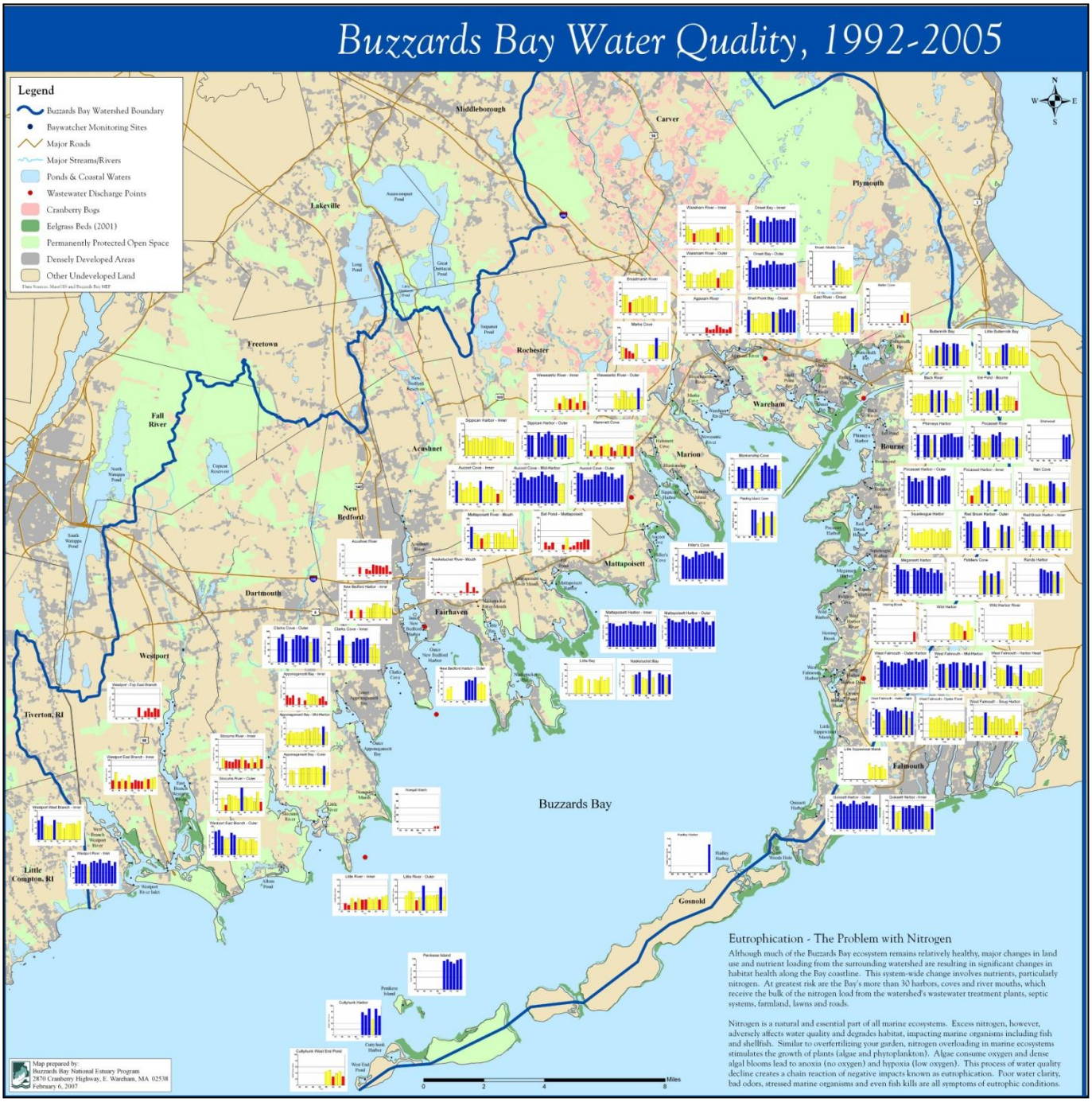

Figure 41. Summary of 13 years of coastal monitoring data collected by the Buzzards Bay Coalition.

Graphic of eutrophication index trends was from a poster prepared by the Buzzards Bay NEP for the Buzzards Bay Coalition water quality monitoring outreach program

define nitrogen TMDLs for coastal waters. The 1991 CCMP sought to address this problem by suggesting the use of parcel level data[49] to calculate watershed nitrogen loading and to set watershed nitrogen loading limits by considering the relationship between watershed loading and total nitrogen concentrations and eelgrass loss relationship to define embayment specific TMDLs[50].

[49] "To calculate anthropogenic nitrogen loads, a parcel level land-use analysis is required using a well defined set of nitrogen loading assumptions." [pg 45].

[50] In the 1991 CCMP the TMDLs were defined as Total Maximum Annual Loads because it was felt that it was impractical to determine the actual loading to an estuary from groundwater and river water on a daily basis, however a subsequent legal ruling (U.S. Court of Appeals for the D.C. Circuit in Friends of the Earth, Inc. v. EPA et al., No. 05-5015, April 25, 2006) determined that TMDLs must be expressed as daily loads, because that is the precise term used in the Clean Water Act.

The proposed strategy attempted to integrate classifications of surface water quality so that degraded systems (SB waters) had higher acceptable thresholds than SA waters or Outstanding Resource waters (ORWs). To set the appropriate watershed mass-loading standard for each of these coastal systems, the Buzzards Bay NEP examined the empirical relationship between theoretical nitrogen loading (based on land use loading models) and ecosystem response, based on available eelgrass distribution information, and limited water quality data. The estimated nitrogen loading was scaled to the degree of tidal flushing of each embayment, based on the established principle that well flushed embayments have less eutrophication impacts than otherwise similar, but less well-flushed systems (see also Costa et al., 1992).

At the time the 1991 CCMP was developed, data to evaluate and model water quality in embayments was lacking, and existing embayment modeling was quite challenging. Consequently, the Buzzards Bay NEP in 1991 adopted a simple tiered system of recommended loadings based on the empirical response between nitrogen loading and various ecosystem measures like eelgrass cover, and assigning loading standards that corresponded to state water quality classifications. Our approach was used for setting or initiating watershed-loading targets in several estuaries during the 1990s, including the upgrade of the Wareham wastewater treatment facility, planned originally in the late 1990s.

In the 1991 CCMP the Buzzards Bay NEP recognized the limitations of its approach and noted,

"Future nitrogen management strategies may be based on embayment-specific nitrogen limits determined from computer models based on a large number of variables. This approach has not yet been developed and the proposed tiered approach is the most practical strategy based upon existing scientific understanding of coastal ecosystem response to nitrogen loading. Nonetheless, the proposed loading rates in table 5.1 should not be used if it can be well documented that a more appropriate limit be selected. For example, if it has been documented that an embayment showed catastrophic decline of eelgrass habitat or shellfish abundance at a certain time in its recent history -- and that it has been demonstrated that this loss was due to nitrogen loading, then an appropriate loading limit goal for remediation activities should be set for nitrogen impact rates before the catastrophic degradation."

The Buzzards Bay NEP also recognized that for nitrogen management actions to be justified, it was important to collect water quality data in all of Buzzards Bay's more than 30 embayments. This data was essential to justify the costs of remediating impacts to coastal embayments already degraded. Because of this need, and because volunteer based water monitoring programs had proved effective on Cape Cod, in 1992, the Buzzards Bay NEP set up a water quality monitoring program with the Buzzards Bay Coalition called Baywatchers. By 1996, the Coalition assumed all management aspects of this program, and provided most of the funding for the effort. The effort led to important insights into water quality conditions in Buzzards Bay embayments (Figure 41) and began raising public awareness of the problem. This water quality data also demonstrated that the 1991 approach for setting limits for coastal embayments was simplistic and often too lenient. In the late 1990s, the Buzzards Bay NEP attempted to revise downward the recommended limits based on the findings of the monitoring program, then in 2000, the program also proposed nitrogen water quality standards for classified surface waters based on this data (see footnote 53).

The original recommendations to manage nitrogen in Buzzards Bay met with some successes (changes in zoning in some municipalities, adoption of the most stringent nitrogen loading limits in the state for the Wareham sewage treatment facility[51], DEP action to require TMDL studies and an upgrade of the Falmouth wastewater facility, see also Table 18). However, ultimately, the methodology did not meet the site-specific rigor needed by DEP, when the agency planned a statewide program to establish watershed nitrogen TMDLs for Massachusetts coastal estuaries in the late 1990s. By 2000, DEP developed an initiative to meet their needs called the Massachusetts Estuaries Project (MEP) that would incorporate embayment-specific water quality hydrodynamic models that would be linked and build upon existing nitrogen loading models.

The MEP effort represents fulfillment of one of the goals of the original Buzzards Bay CCMP to identify embayment specific nitrogen loading limits based on sound science. The key elements of the MEP effort are defined by several documents. Howes et al. (2000) evaluated nitrogen management approaches, including the one defined by the Buzzards Bay NEP in the 1991 Buzzards Bay CCMP and subsequent documents, and settled upon an approach they had developed to evaluate loading in other Cape Cod embayments (e.g. Howes et al., 1997).

Specifically, the MEP would employ what they called a "Linked Watershed-Embayment Model" for their evaluations of 89 embayments. This approach linked a water quality circulation model[52] to a parcel based watershed loading model, a conventional nitrogen loading spreadsheet uses loading coefficients quite similar to those used by the Buzzards Bay NEP and Cape Cod Commission. This linked approach enabled the in-

[51] A 4-ppm total nitrogen discharge limit 7 months of the year.

[52] The water quality and loading software used by the MEP were proprietary customizations of the SMS, WMS, RMS software packages produced by BOSS International. These software packages allow the user to import GIS shapefiles, bathymetric data, and site-specific tidal elevation data to model the embayment's circulation patterns.

vestigators to predict for each embayment concentrations of compounds that act conservatively with mixing (e.g. salinity), or near conservatively (total nitrogen, with adjustments made for benthic flux of nitrogen from sediments) at any location within an embayment. It is the linkage between the water quality and circulation models and the watershed nitrogen loading model (including groundwater and surface flow pathways and attenuation estimates) that represent the core predictive modeling approach used by the MEP for recommended loadings for the TMDLs.

Among other elements included in the MEP model was the use of municipal water use records to estimate septic system loadings in seasonal and intermittently occupied vacation communities common on Cape Cod. The adoption of upper subwatershed attenuation coefficients based on differences between stream loadings and the watershed-loading model added additional watershed specificity to each analysis.

The MEP approach is used to calculate load reductions to achieve embayment-specific target total nitrogen concentrations at sentinel stations within each estuary. Because the Commonwealth of Massachusetts had not adopted numeric criteria in its water quality standards, which were narratives of water quality goals, the MEP presented the basis for site-specific nitrogen thresholds in Howes et al. (2003). This approach allowed for embayment-specific water quality standards at sentinel stations in order to identify appropriate watershed nitrogen TMDLs, which in turn, would become the basis for identifying corrective actions needed to achieve the water quality narrative.

As noted in the supporting documentation, "as a nutrient specific watershed management tool, the nitrogen thresholds and the process by which they are developed help communities focus implementation strategies on manageable (anthropogenic and subject to TMDL allocation process) sources of nutrients versus those that are naturally occurring." The MEP further states that the approach helps "bridge the gap in the existing water quality standards by providing a translator between the current narrative standard and nitrogen thresholds (as they relate to the ecological health of each embayment)." In 2003, DEP released a guidance document as to how municipalities may comply with TMDLs (DEP, 2003; c.f. EPA 1999,2000).

A fundamental first step in developing a recommended TMDL for an estuary in the MEP approach is to select a location for a sentinel monitoring station and to establish a threshold target total nitrogen concentration for that station. Typically the MEP selects a sentinel station of around 0.4 ppm or less total nitrogen, if the water quality goal is to restore or protect eelgrass, and 0.5 ppm or higher, if the goal is only to protect or restore benthic habitat like shellfish beds[53].

Table 18. Some successes and timeline related to the 1991 Buzzards Bay CCMP Nitrogen Management action plan.

- In 1991 Wareham, Plymouth, and Bourne adopt zoning changes to manage future nitrogen inputs to Buttermilk Bay.
- In 1992, in partnership with the Buzzards Bay Coalition, the Buzzards Bay NEP creates a volunteer-based water quality monitoring program to collect eutrophication related water quality data in order to justify management action.
- In 1993, the Buzzards Bay NEP creates the eutrophication index in an effort to simplify and communicate the results of the water quality monitoring program to residents and town officials.
- In 1995-1997, reports and analysis from the Buzzards Bay NEP of nitrogen loading impacts of the Falmouth wastewater facility to West Falmouth Harbor initiated further studies that lead to the construction, in 2002, of an upgraded facility to achieve high levels of nitrogen removal and a groundwater discharge limit of 5 ppm.
- In 1996, DEP adopts "nitrogen sensitive area" standards in the 1996 Title 5 onsite system regulations.
- In 1998, the Buzzards Bay NEP revises downward its recommended nitrogen loading limits based on the results of the monitoring program.
- In 1999, EPA uses Buzzards Bay NEP loading analyses and recommended limits, and the Buzzards Bay Coalition water quality data to justify Best Available Technology upgrades at the Wareham Wastewater Treatment Facility and an NPDES discharge limit of 4-ppm nitrogen during seven critical months of the year.
- In 2000, DEP recognizes the need to limit nitrogen to coastal embayments but realizes the Buzzards Bay NEP's tiered nitrogen loading strategy developed in 1991 is too simplistic to meet the development of TMDLs. Instead, they establish an ambitious 10-year effort to evaluate 89 Massachusetts. embayments using a linked watershed loading-water quality model approach as the basis of the program. Work in West Falmouth Harbor becomes a model for the program. The Buzzards Bay Volunteer Water Quality Monitoring Program data becomes the basis for evaluating the ecosystem response and nitrogen loading models.
- In 2006, the Massachusetts MEP completes the first TMDL for a Buzzards Bay embayment.

[53] The BBNEP proposed similar water quality standards in 2000 correspondence to DEP, Managing anthropogenic nitrogen inputs to coastal embayments: BBNEP (2000), Technical basis and evaluation of a management strategy adopted for Buzzards Bay. Supplementary information on water quality and habitat goals.

Table 19. Status of linked watershed-embayment model to determine critical nitrogen loading thresholds reports for Buzzards Bay embayments and approval date of the TMDL.

Town	Estuary (ies)	Report Status	TMDL Issued
Bourne/ Wareham	Buttermilk Bay	not scheduled	
Bourne	Red Brook Harbor	no report	
Bourne	Megansett/Squeteague Harbors	no report	
Bourne	Pocasset River	no report	
Bourne	Phinneys Harbor/Eel Pond/ Back River System	Final 2006	November 2007
Dartmouth	Slocums River	revised final 2012*	
Dartmouth	Little River	revised 2012*	
Dartmouth	Apponagansett Bay	draft 2013	
Fairhaven	Little Bay/Nasketucket Bay	draft 2013	
Falmouth	West Falmouth Harbor	Final 2006	November 2007
Falmouth	Fiddlers Cove	draft 2012*	
Falmouth	Rands Harbor	draft 2012*	
Falmouth	Quissett Harbor	draft 2012*	
Gosnold	Cuttyhunk Harbor	no report	
Gosnold	West End Pond	no report	
Marion/Matt	Aucoot Cove	no report	
Marion	Sippican Harbor	no report	
Mattapoisett	Mattapoisett Harbor/Eel Pond	no report	
Mattapoisett	Mattapoisett Harbor	no report	
New Bedford	Acushnet River/ New Bedford Inner Harbor	revised 2012*	
Wareham	Agawam/Wareham/Broad Marsh Rivers/Marks Cove	final 2013*	
Wareham/ Marion	Weweantic River	not scheduled	
Westport	Westport Rivers	final 2012	

Retrieve from www.oceanscience.net/estuaries/. Last accessed July 17, 2012. Other information from DEP. Other notes: *= drafts under review.

The placement of the sentinel station, and the selection of a target total nitrogen concentration, affects the recommended limits contained in the TMDL for the estuary, and thus, how much watershed nitrogen loading must be reduced. The actual selection of the specific TN concentration at a sentinel station in an estuary, and the location of that station, is based on a reference condition approach using a comparison with healthy sites in each system or similar systems with observed nitrogen concentrations. The location is chosen based on past observations of where healthy eelgrass beds were previously observed and best professional judgment. The MEP then extrapolates the results of their water quality models to determine what amount of watershed nitrogen loading reduction would result in the proposed target concentration at the sentinel station. Small changes in the nitrogen concentration targets can appreciably affect loading reduction targets.

The MEP reports are not TMDLs, but recommendations to the state and the U.S. EPA as to what the appropriate TMDL is for the estuary. After considering the information in the report, and if it is determined to be acceptable, the Massachusetts DEP will extract the core MEP findings, maps, and recommended limits, including any warranted margins of safety for the protection of the environment, and write a TMDL document, and submit this information to the U.S. EPA. The receipt of the TMDL will be noticed in the Federal Register, and the public will have 90 days to comment on the TMDL.

The Massachusetts Estuaries Project was originally estimated to cost $12.5 million in state, federal, and local funds to evaluate 89 Massachusetts embayments over 8 years. The complexity of analysis along with the availability of local match and escalating costs over time has resulted in delays and the reduction in the number of estuaries to be evaluated to 70. Due to the delays identified above, as of June 2012 only two Buzzards Bay embayments, Phinneys Harbor/Back River system and West Falmouth Harbors, had final reports and approved TMDL reports (see Table 19). However, DEP remains committed to completing the effort for many of the remaining systems originally planned for evaluation within Buzzards Bay.

With delays in the MEP program, some municipalities have sought to pass interim measures to limit nitrogen. The most notable of these efforts were the repeated attempts and failures of town officials in Wareham to pass bylaws in 2006, 2007, 2008, and 2012 to require nitrogen reducing septic systems. Eventually in 2013, the Board of Health adopted regulations requiring nitrogen removal septic systems within 500 feet of any surface water or wetland. Due to the extensive areas of wetlands and water bodies in the town, this requirement affects about 90% of the developable land in the town. All these efforts were prompted by a desire to address the poor water quality in the community, a recognition that the ongoing sewer expansion initiative will take years to complete, and that the town was unlikely to adopt new sewer expansion programs in the near future.

From TMDLs to Management Action

All conventional septic systems release nitrogen as ammonia that converts rapidly to nitrate in soils above the water table. Whether a system is properly operating, or fails to meet Title 5 standards, it is presumed to contribute the same amount of nitrogen to the environment[54]. Nitrate in groundwater flows great distances without attenuation and with little chance of uptake by plants, except in upper watershed areas, where ground-

[54] The exception may be those cesspools located in saturated soils close to water bodies. Properly designed leach fields help remove some nitrogen, and these processes do not occur when an anaerobic effluent plume is discharged directly to the water table close to a water body. See Costa et al., 2002.

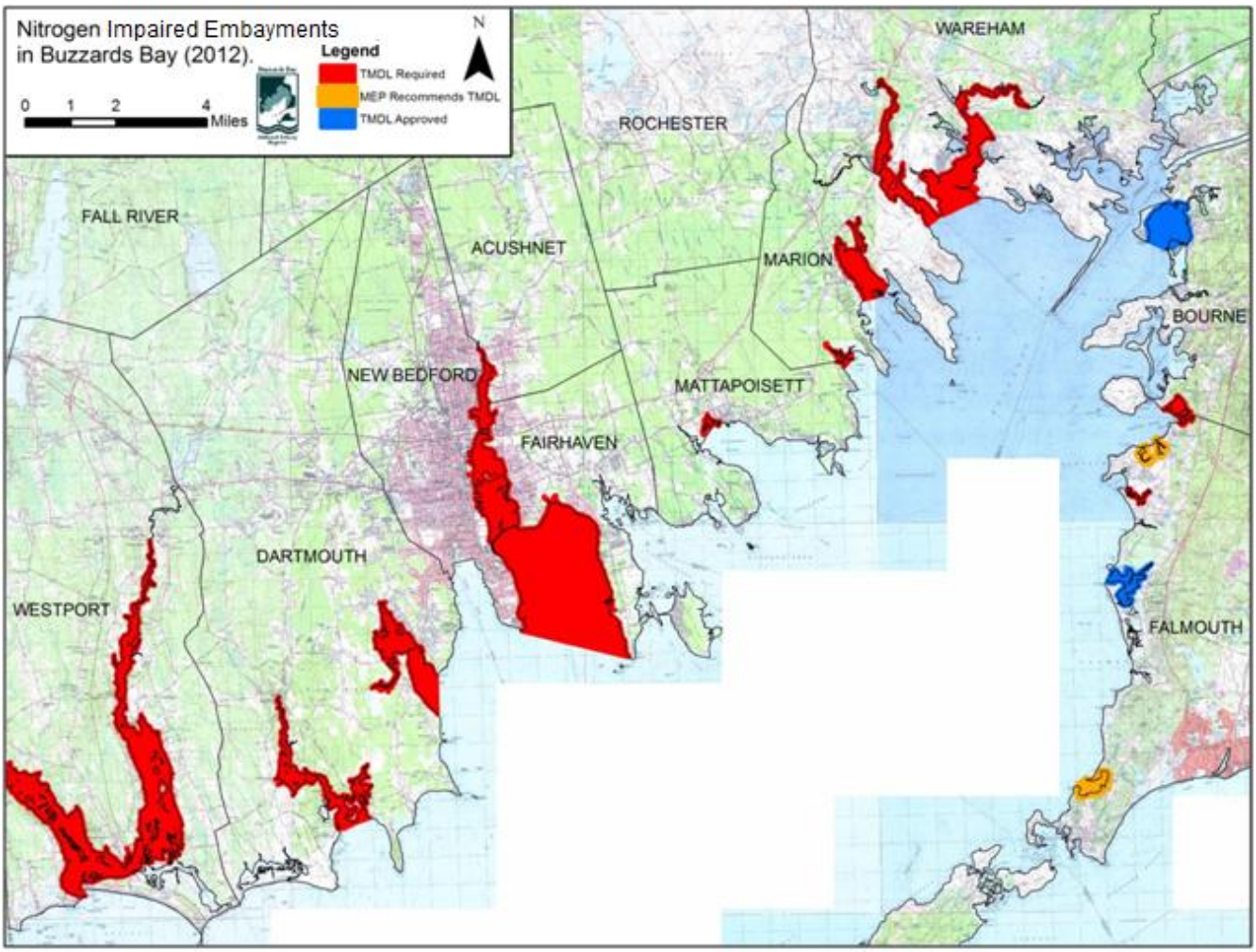

Figure 42. Coastal embayments impaired for nitrogen in Buzzards Bay.

Based on DEP's *Massachusetts Year 2012 Integrated List of Waters, Proposed Listing of the Condition of Massachusetts' Waters Pursuant to Sections 305(b), 314 and 303(d) of the Clean Water Act*, and a companion MassGIS coverage. Note that on Cape Cod, TMDLs have been set based on MEP reports even though they are not listed as Category 5 waters (TMDL Required) on the state's Integrated List. Consequently, the number of embayments where a TMDL will be developed will be greater than the number shown in red on this map. Additional TMDLs will likely include areas where draft MEP reports recommend nitrogen control (shaded orange), and areas where assessments may be conducted in the future (e.g., Buttermilk Bay, Onset Bay).

water may be intercepted by wetlands and fresh surface waters. Still, in the MEP loading models, in many river and upper watershed areas, net nitrogen transmission to coastal waters may still typically equal 50 to 70% of the presumed loading to groundwater in the watershed. Given the large number of septic systems in most watersheds, it is not surprising that septic systems typically account for 40-80% of the nitrogen entering coastal watersheds (averaging 57% as per Table 17), and after attenuation of upper watershed sources, account for a higher percentage of nitrogen actually reaching coastal waters.

Not all parts of Buzzards Bay have these suburban residential patterns of development. In some rural agricultural areas like Westport, Carver, and Middleborough, fertilizer on agricultural lands, or wastes from livestock[55], may be significant contributors of anthropogenic nitrogen. In many instances, these agricultural sources exceed septic system discharges. In an urban area like New Bedford, the Fairhaven wastewater facility and New Bedford CSOs and stormwater are the principal sources of nitrogen to the harbor. Because each embayments has its own specific sources of nitrogen, management strategies will be specific to those watersheds.

Whether or not septic systems are the largest single source, they are viewed as one of the easiest sources to control. Even in the 1991 CCMP, septic systems were viewed as one of the primary problems and sewering was identified as a solution, as was the allowance and use of

[55] This appears to be true for the East Branch of the Westport River according to a 2012 draft MEP report.

nitrogen removing onsite systems, which at the time were a novel idea[56]. Twenty-one years later, and after a decade of work, most MEP reports in support of DEP's TMDL program, identify elimination of septic loads as the modeled scenario to reduce nitrogen. Only in a handful of TMDL reports is improved tidal flushing a viable management option to meet a TMDL reports. Alternative strategies such as aquaculture have not been considered as general options, but given the weight of nitrogen in a clam or oyster, and the amount of nitrogen reduction required in some embayment, large areas of the embayments would need to be dedicated to aquaculture.

Restoration strategies in the original CCMP relied upon voluntary action by municipalities to expand sewer systems or take other measures. With the ongoing TMDL effort by the MEP, a far more scientifically defensible basis for watershed nitrogen TMDLs is now available. However, while existing permitted discharges must comply with the maximum extent feasible, actions by municipalities to expand sewer systems and eliminate septic system nitrogen discharges largely remains a voluntary action. Federal, state, and municipal governments have authority under various laws and regulations to control these discharges of nitrogen, but these powers have not yet been exerted to address watershed TMDLs. For example, DEP has broad authority to enforce the federal Clean Water Act under Massachusetts law[57], but these authorities have not been utilized.

DEP's development and EPA's approval of the TMDLs developed by the MEP are actions within the framework of Section 303(d) of the Clean Water Act. Although these new limits are also just mass loading limits based on best available science, once adopted as TMDLs, they are enforceable by state and federal agencies for regulated (permittable) discharges. However, efforts to solve the problem have been delayed and become more intractable because of the immense cost of sewering. Many state and local regulators do not view the widespread use of nitrogen removing onsite systems as a panacea because of costs and implications of possibly managing hundreds or thousands of these systems. While our scientific understanding and capacity to model nitrogen impacts have vastly improved since 1991, regulatory tools to deal with the problem, within either local bylaws or state regulations, have changed little during the same period, often resulting in continued inaction.

The failure of federal, state, or local government to meet these TMDLs can also be the subject of lawsuits under the Clean Water Act by members of the public and citizen groups. This fact led to the Buzzards Bay Coalition and the Conservation Law Foundation filing a citizen lawsuit, that among other things, challenged the EPA's policies and rules that groundwater discharges were not part of a TMDL's "waste load allocation"; that is, not a regulated discharge under the Clean Water Act. In 2013, this lawsuit was dismissed.

Major Issues

As described in the preceding section, several major issues have hindered progress on this issue since the adoption of the 1991 CCMP. Around the start of the program in 2002, the Massachusetts Estuaries Project and others had encouraged municipalities to delay adopting comprehensive nitrogen management strategies until final watershed nitrogen TMDLs were developed for the affected embayment. Some municipal boards have also felt they should delay action until the MEP reports are finalized. However, due to delays, cost overruns, and insufficient funding, as of June 2013 only two TMDLs have been approved for Buzzards Bay, so most communities continue to defer taking management action, all the while development continues, and sites for treatment solutions diminish.

Each TMDL notes that cost effective solutions can be explored and defined by municipalities to meet water quality targets at the sentinel site during the CWMP development process. On Cape Cod, in most cases, the only practical solution for reducing nitrogen appears to be the construction of new sewage treatment facilities and creation of or expansion of sewer networks (CCC, 2009a). However, some residents and municipal officials have expressed concerns that alternative approaches have not been fully investigated. Elimination of septic system loads can be achieved with alternative nitrogen removing onsite systems instead of sewers. Other proposed alternatives include treatment options rather than source reduction. These include shellfish and algal culture, installation of permeable reactive barriers, dredging, wetland creation and restoration, stormwater BMPs, and channel widening. Increasingly, towns are mandating that these alternative approaches be included in feasibility studies, including their potential environmental impacts. In 2013, the Cape Cod Commission completed a regional wastewater plan study that included an assessment of green infrastructure and alternative approaches addressing some of these issues (CCC, 2013). Despite the interest in these approaches, no town has yet presented a comprehensive wastewater strategy with these alternative approaches combined to meet a TMDL. They thus remain alternatives to be investigated.

Based on town estimates and press reports, these costs will likely total billions of dollars for Buzzards Bay

[56] A specific recommendation in the 1991 action plan was that "DEP will actively promote the development and acceptance of cost-effective alternative technologies for wastewater denitrification by assigning additional personnel to overview pilot projects."

[57] MGL c. 21, Sections 26 through 53 directs DEP to "take all action necessary or appropriate to secure to the Commonwealth the benefits of the Clean Water Act, 33 U.S.C. §1251 et seq."

watershed communities[58]. In some towns, betterments just for sewer tie-ins, have in some cases, exceeded $40,000 per home. This does not include the cost of new or expanded treatment facilities, annual sewer fees, or connection costs. These cost concerns have prompted financial studies of alternative approaches (e.g., Barnstable County Wastewater Cost Task Force, 2010). Such high costs, and the absence of federal grants and limited availability of SRF funds have made these management solutions politically unsellable to large sectors of the population if all the costs are borne locally.

Finally, because septic systems discharge to groundwater, they have not been regulated by the federal government under the Clean Water Act, and have been designated part of the watershed waste load nonpoint source pollution. Therefore, ultimately there has been no effort by the federal government to require municipalities to connect septic systems in the watershed to wastewater facilities to meet a TMDL for nitrogen. Thus for the foreseeable future, unless DEP exerts its authorities under state law, or federal jurisdiction is clarified, municipalities will only make progress toward reducing nitrogen discharges to coastal waters in a time frame defined by decisions and votes driven by politics and costs alone.

Management Approaches

The Buzzards Bay Coalition's water quality monitoring program and DEP's eelgrass mapping program have clearly documented which embayments in Buzzards Bay are impaired. The MEP studies on Cape Cod have resulted in the adoption of TMDLs in nearly every system where eelgrass loss or habitat degradation has occurred, so it is likely that most Buzzards Bay embayments, and many more than those shown in Figure 42, will have a TMDL.

The primary state-local planning tool to implement these TMDLs will be the Comprehensive Wastewater Management Plan (CWMP). The goal of the CWMP process is to make environmentally sound and cost effective decisions on the planning, design, construction, and maintenance of wastewater facilities, and reflect the collective input of residents, local officials and other interested stakeholders. The adoption of CWMPs that address watershed nitrogen TMDLs also makes communities eligible for 0% interest SRF loans.

The outcome of the CWMP process will vary from town to town. Even before a TMDL is approved for the Wareham River estuary, strict nitrogen limits were required for the Wareham wastewater facility based on recommended limits by the Buzzards Bay NEP and water quality data from the Buzzards Bay Coalition's Baywatchers Program. This translated to 4 ppm for 7 months (April through October) of the year, a performance standard that was incorporated into a past CWMP. An updated CWMP for Wareham will need to incorporate any newly adopted TMDLs.

In most watersheds, further reductions in watershed loading must focus principally on onsite septic systems discharges; although manure and agricultural fertilizer use can also be a major source in some watersheds (see additional discussion of sources in Chapter 3 Characterization of Pollution Sources). To reduce these agricultural nitrogen discharges, various best management practices (BMPs) can be implemented depending on the type of agriculture.

In the case of dairy farms (which are the largest source of watershed loading in the Westport rivers), farmers can better manage manure to ensure that less nitrogen reaches streams and the groundwater. These BMPs include maintaining fenced buffers to streams and wetlands, building manure storage structures to prevent runoff and discharge to groundwater, and even changing feed formulations[59].

In the case of agricultural fertilizer use or manure management, some normal farm practices are exempt from local control and are little regulated or exempt from state and federal environmental laws as well. This situation means that agriculture fertilizer management will focus on voluntary and collaborative work with farmers. Fertilizer use on residential and active recreational lands will also depend on voluntary efforts, but more opportunities for regulation of turf fertilizer exist[60].

With respect to cranberry bogs, how water is managed can greatly affect nutrient release, with older flow-through bogs releasing the most nutrients (Demoranville and Howes, 2005; Demoranville, 2010). How floodwater is managed is especially important (Demoranville et al., 2009). For example, flooding time, floodwater retention time, and discharge rates are important factors affecting phosphorus release from bogs (DeMoranville, 2006). New bogs constructed on mineral soils without confining layers are much more prone to release fertilizer and pesticides to groundwater (DeMoranville and Sandler, 2000). Practices, such as the construction of tailwater recovery ponds, bypass canals, and laser leveling of bogs

[58] On Cape Cod, where there is far less existing sewering than in the Buzzards Bay watershed, costs to comply with TMDLs will likely cost between $4 and $8 billion dollars (see Cape Cod Times, *Nonprofit groups hash out wastewater issues*, 28 September 2012, Retrieved from (last accessed October 17, 2012): www.capecodonline.com/apps/pbcs.dll/article?AID=/20120928/NEWS/209280336/-1/SPECIAL25. In contrast, the total cost to meet subwatershed nitrogen TMDLs in the Buzzards Bay watershed is likely to be only $2 billion (see calculations in the Financial Approaches section below).

[59] A more complete list of nutrient management related BMPs is found in Agricultural Best Management Practices Task Force and USDA NRCS (2011).

[60] The Massachusetts Legislature passed in the Acts of 2012 a law that enabled the state Department of Agriculture to "promulgate regulations that specify when plant nutrients may be applied and locations in which plant nutrients shall not be applied." As of June 2013, these regulations have not been promulgated.

can greatly assist in both reducing water use and contaminant release (NRCS, 2011).

To reduce these discharges, growers should continue to utilize best management practices in retrofitting existing bogs and constructing new ones, and for managing water, especially harvest water. Many growers have already installed tailwater recovery ponds, bypass canals, and implemented other water management and conservation measures. Growers should also continue to develop and implement farm plans with these and other beneficial fertilizer and water management practices. USDA and the Massachusetts Department of Agriculture should continue to work with the cranberry industry and its grower community to educate about the environmental and economic benefits of water management. These efforts will require continued technical and financial support from the USDA Natural Resource Conservation Service's Environmental Quality Incentives Program and the Massachusetts Department of Agricultural Resource's Agricultural Environmental Enhancement Program, among others. These needs include support for conservation farm plans and continued research into new and improved fertilizer and water management practices.

For the relatively few embayments that are nitrogen sensitive, but not yet nitrogen impacted, managers can implement a combined strategy of managing nitrogen from new growth through sewering, nitrogen removing community scale package plants, or advanced onsite systems. However, given that nearly all embayments studied on Cape Cod require nitrogen reductions, so too it is likely that all embayments in Buzzards Bay will require TMDLs and loading reductions, not just the impaired systems identified in Figure 42[61].

Separate from efforts to better manage nitrogen from wastewater, local legislative bodies and regulators have initiated other supporting measures to protect or restore estuaries. To reduce fertilizer impacts, municipalities can change fertilizer use on public lands, or require vegetative buffers between turf and wetlands in local wetland regulations. Applications of fertilizer can sometimes be addressed during the permitting process for new development and redevelopment[62]. Wetland regulations are also a mechanism to better treat stormwater, which can convey fertilizer, atmospheric nitrogen, and other sources. Some communities have adopted fertilizer ordnances that control the type and period of use of fertilizer. However, attempts to pass new fertilizer bylaws have now been blocked by the Attorney General because of the passage of a 2012 law that limited the authority for the control of fertilizer to the state and county government[63]. Barnstable County Assembly of Delegates approved the development of a Cape Cod-wide fertilizer regulation[64]. Ultimately these measures are only part of a broader management solution because in most estuary watersheds, fertilizer use and stormwater combined typically account for 20% or far less of the controllable load entering the estuary watersheds, and only somewhat more of the attenuated nitrogen load entering the estuaries.

Other tools municipalities could adopt to manage nitrogen sources include requirements of "nitrogen neutrality" or no net nitrogen for new development, minimum town-wide nitrogen standards for new development (which also become a negotiating point for new Chapter 40B projects), and Transfer of Development rights with elements to allow nitrogen trading. Zoning changes can also support these efforts (nitrogen overlay districts, minimum lot size), although these tools will be used primarily to manage new sources of nitrogen. It is important to coordinate TDR bylaw development between municipal environmental boards. Care must also be taken in developing these strategies to ensure that density bonuses or other incentives do not negate the environmental benefits of the strategy. Guidance on the development of TDRs and comparable strategies can be found in the state's Smart Growth Toolkit[65].

The localized nature of coastal eutrophication and watershed loading limits were novel to local officials when the Buzzards Bay CCMP was adopted in 1991. Today, the public is far more conversant with the seriousness of the problem, and the science defining coastal eutrophication is now widely accepted. Nonetheless, because of the high cost of solving the problem, the restoration of impaired estuaries seems far off. The loading analyses of the MEP and earlier assessments by the Buzzards Bay NEP point to common outcomes and needs. Even where TMDLs have not yet been developed, it is clear that wastewater management must be the primary

[61] Even Quissett Harbor, Falmouth, which has some of the best water quality conditions in the Buzzards Bay Coalition's Baywatchers program, has a documented eelgrass loss and recommended load reductions according to an MEP 2012 draft TMDL report.

[62] The state Wetlands Protection Act regulates activities in a buffer zone with the goal of protecting adjoining wetlands, not to protect or maintain a buffer zone. Through some municipal bylaws, the buffer zone may itself be a resource area to protect, or a no-build buffer is enforced. See Action Plan 7 Protecting and Restoring Wetlands for recommendations on this topic.

[63] A bylaw passed by Falmouth town meeting in 2012 to regulate fertilizers was disapproved by the Massachusetts Attorney General's office (Falmouth Annual Town Meeting of November 13, 2012 - Case # 6565) because it was inconsistent with the state law giving that authority to the Department of Agricultural Resources under Chapter 262 of the Acts of 2012. The Legislature subsequently inserted an exception for towns that had passed ordinances or bylaws on nutrient or fertilizer management in the past year.

[64] Driscol, S. F. Barnstable assembly OKs plan to limit fertilizer use on Cape. Cape Cod Times September 20, 2013, Retrieved from: www.capecodonline.com/apps/pbcs.dll/article?AID=/20130920/NEWS/309200321.

[65] Retrieved from www.mass.gov/envir/smart_growth_toolkit/pages/mod-tdr.html.

focus in every community, and it is imperative that municipalities begin the wastewater planning process.

Financial Approaches

The main financial support offered by the federal and state government is the federally funded State Revolving Fund (SRF) program, which is jointly administered by the DEP Division of Municipal Services and the Massachusetts Water Pollution Abatement Trust. For municipalities with an approved CWMP, SRF offers loans with as low as 0% interest loan, for 20- to 30-year loan periods. In today's financial climate, these loans represent a cost saving on projects of 18-28% (Barnstable County Wastewater Cost Task Force, 2010). However, there is far more demand for the loan program than there are funds available. This means most of the costs of meeting TMDLs will be borne through local property taxes, betterment fees, and sewer fees.

On Cape Cod, estimated costs to comply with watershed nitrogen TMDL are high. Falmouth has estimated sewering costs at $650 million[66], Chatham $350 million, and Bourne $300 million. These are the costs to sewer only the densest developed portions of their communities, and may not cover the costs of sewage treatment upgrades. These costs translate into $40,000 to $100,000 per home connected. Some managers have criticized these projections as over-estimates (and in fact, the State Revolving Loan [SRF] program can reduce per unit costs), but a consensus is developing among municipal and state officials that Cape Cod sewering will in fact total four to eight billion dollars[67].

For the Town of Falmouth, most of the estimated $650 million price tag to comply with nitrogen TMDLs will be associated with projects outside of the Buzzards Bay watershed. However, some areas of West Falmouth Harbor and Quisset Harbor will need to be sewered, and the town's wastewater facility, which is in the Buzzards Bay watershed, may need to be expanded, with a new discharge outside of the West Falmouth Harbor watershed. These costs will likely exceed many tens of millions of dollars to $100 million.

Actual costs will be defined by the specific solutions or strategies a municipality adopts, and reports by the Barnstable County Wastewater Cost Task Force (2010) and Wright-Pierce et al. (2005) provide excellent summaries relevant to southeastern Massachusetts and Cape Cod. For most Buzzards Bay watershed communities, sewering costs may be ameliorated by the fact that many densely developed areas are already sewered, so most towns are merely facing sewer expansion, not the construction costs of new wastewater facilities. However, major expansions of sewer systems typically also require expensive upgrades or expansions of existing systems, so savings are not always realized. Still, upgrading existing facilities to meet more stringent discharge limits is sometimes also required. In the less densely developed areas, sewer tie-in costs per home can increase dramatically.

On top of these costs are connection fees and septic removal costs ($4,000 to $8,000 per home), household plumbing retrofit costs if the septic is located behind the home ($1,000 to $2,000 per home), sewer fees ($400 to $650 per year in Buzzards Bay communities), and hundreds of millions of dollars to upgrade the capacity and performance of existing wastewater facilities generally charged to sewer ratepayers. Thus, the unsubsidized 20-year cost for sewering will likely average between $50,000 and $110,000 per home connected for many areas of the watershed.

In the U.S. 2010 Census, in the Buzzards Bay watershed, there are 116,205 residential units[68]. Of these, 64,335 are sewered[69]. If 60% of the 51,870 estimated units served by septic systems in the Buzzards Bay watershed needed to be sewered[70], the cost of wastewater facility upgrades and betterments, system removals and house tie-ins could total $1.9 billion[71]. Thus, the total costs to comply with nitrogen TMDL in the Buzzards Bay watershed will likely exceed $2 billion dollars when other incidental costs are factored in.

For some embayments, simpler and less costly solution may be available. Dredging harbor entrances to increase flushing rates may be a viable option in only a few small systems. However, even when dredging is a potential solution, it may be controversial because enlarging channels may increase tidal ranges, change salinities, transfer nitrogen pollution elsewhere, or result in significant changes in sediments deposition; these changes could have significant impacts on the distribu-

[66] See archive.capenews.net/communities/falmouth/news/442. Last accessed October 11, 2013.

[67] Cape Cod Times, February 27, 2011, Wastewater: Cape Faces Costly Cleanup at: www.capecodonline.com/apps/pbcs.dll/article?AID=/20110227/NEWS/102270320/-1/SPECIAL25. Last accessed October 11, 2013.

[68] Based on a Buzzards Bay NEP analysis using U.S. Census GIS data. For census blocks that were bisected by the watershed, the population and housing units were assumed to be directly proportional to the percent of the area of the block within the watershed. In specific cases, this may over or underestimate units, but given that there were only 391 of 8,950 census blocks clipped by the Buzzards Bay watershed boundary, the calculations presented here are likely to be a good approximation.

[69] Same methodology applied using the sewered areas map in Figure 32. This calculation is based on a larger proportion of split census blocks and likely has a greater uncertainty in the estimate.

[70] This totals 31,122. In the draft Westport, New Bedford Harbor, and Wareham River TMDL reports, nearly 20,000 homes will need to be sewered alone.

[71] Calculation: 31,100 systems x $60,000 average total cost per unit; cost includes betterment ties, facility construction costs and upgrades, homeowner tie costs, system removal and plumbing expenses. 20 years of sewer fees may add an additional $12,000 to homeowner costs.

tion and abundance of many species. At this time, dredging appears to be an option for only one small embayment (Eel Pond, Mattapoisett).

Some communities, like Wareham, have been considering requiring individual onsite or community nitrogen removal septic systems as an alternative to wide scale sewer expansion. The motivation for adopting this strategy is partly the result of the high costs of their wastewater facility upgrade ($30 million), and the cost of sewer expansion and septic system removal. For example, in the early 2000s, sewer expansion resulted in betterments of $12,000 to $15,000 per home. Because of distance from the wastewater facility and the lesser density of some planned sewered areas, future betterments are expected to range from $20,000 to $40,000 per residence, and possibly higher. In 2011, Wareham residents were challenging a sewer expansion that would have required a betterment totaling $32,000 per home[72]. These costs do not include $640 annual sewer fees, the cost of tying into the sewer system, or costs of removing abandoned septic tanks that may cumulatively exceed $4,000 to $8,000 per home, and are directly paid by the homeowner.

Similarly, betterments for sewer expansion in neighboring Marion in 2008 cost $30,000 per home. In 2010, a Mattapoisett sewer expansion that would cost $32,000 per home in betterments passed town meeting[73]. In all these communities, most of the expansion of sewering served parcels less than a quarter acre, and in some villages, parcels to a tenth of an acre. Small densely clustered parcels create an economy of scale and service costs in sewering, and efforts to expand sewering into less densely developed areas will result in dramatically higher costs.

In Wareham, the prospect of having to sewer 70% of the remaining existing homes[74] (to achieve a 50% septic reduction as proposed in their draft MEP report), not to mention the costs of sewering another 4,000 potential units in the Wareham portion of the Wareham River watershed has worried local officials about the capacity of communities to assimilate these costs. Consequently, the alternate strategy of adopting local regulations and standards requiring individual and community-scale wastewater systems[75] is attractive to some.

Such a strategy would entail requiring new construction and the retrofit of old construction with nitrogen removal septic systems. Local regulations could also require community scale plants for large new subdivisions. Such a strategy faces several obstacles. First, even for new construction the cost of adding a minimum-performing (19 ppm) nitrogen removal septic system will add an average of $10,000 over the costs of a conventional septic system already averaging close to $15,000, plus annual operation, maintenance, and monitoring costs. Second, a municipality would require a program to oversee these systems to ensure they are properly operated and maintained. Finally, the state minimum standard of 19-ppm total nitrogen discharge concentration is far greater than what is possible with a large-scale nitrogen removal facility (4 ppm 7 months a year). It is possible for the town to require better performing nitrogen removing septic systems, but more advanced residential nitrogen removal systems (10 ppm) might add $15,000 to $20,000 over the cost of a conventional system for new construction. Such solutions have been proposed in Articles at Wareham Town meeting, but all have been rejected.

A municipal oversight program to oversee advanced alternative onsite systems is achievable, and on Cape Cod, Barnstable County has implemented a program to require operation and maintenance contracts for onsite nitrogen removal systems. This program oversees 3,000 units on Cape Cod through a web based reporting system. At a cost of $15,000, Barnstable County created a website where vendors and operators of nitrogen removal septic systems can report on the existence of an operation and maintenance contract and submit data on discharge testing. One staff person oversees this reporting, and prepares correspondence based on reports from the software when systems do not comply with county regulations.

Regulators do not favor the widespread use of denitrifying onsite wastewater systems because those systems now allowed under general permitting under the state Title 5 regulations do not achieve the same high level of nitrogen removal as centralized advanced treatment municipal wastewater systems. Moreover, there are concerns that it may be difficult for government to track large numbers of alternative systems to ensure that they are properly maintained and performing well. These issues would need to be overcome, and more effective and reliable alternatives required, if alternative nitrogen re-

[72] New Bedford Standard Times June 30, 2011 article retrieved from www.southcoasttoday.com/apps/pbcs.dll/article?AID=/20110630/NEWS/106300345.

[73] On the third attempt, see the Mattapoisett 2010 Town Report retrieved from www.mattapoisett.net/Pages/MattapoisettMA_annualtownreports/2010TRArchives/W-STownReport2010.pdf.

[74] If 3,000 homes were sewered, tie-in costs, plus betterments and sewer fees spread over 20-years to pay for capital costs, the 20 year cost per homeowner could range from $40,000 to $60,000 per unit, and possibly more. The cost of sewering 3,000 existing homes to meet a TMDL might cost $120-180 million. Estimates for towns with no existing sewage infrastructure, like Westport, will be considerably higher.

[75] Community scale systems are generally defined as having a discharge exceeding 10,000 gpd (roughly 23 homes) and requiring a state groundwater discharge permit. Shared systems are generally described as systems servicing two or more homes, but under 10,000 gpd, and are permitted by municipal boards of health under the Title 5 regulations.

moval onsite systems were to become a viable widespread mechanism to comply with watershed nitrogen TMDLs.

Financial obstacles are not the only impediments, and establishing waste load allocations for meeting TMDLs is another problem that must be worked out. Some Buzzards Bay embayments will require management of sources from outside their watershed. This is because in a few instances a neighboring more eutrophic embayment system is dominating water quality in what would be a system with good water quality. This situation exists for Marks Cove in Wareham (nestled between the Wareham and Weweantic Rivers), and Little River in Dartmouth, with its small watershed at the confluence of the mouth of the larger eutrophic Slocums River.

Monitoring Progress

The development, issuance of, and compliance with TMDLs will be the principal management measures tracked to evaluate the success of this management plan. This will be accomplished by tracking embayments on the state's Integrated List of impaired waters.

At the local level, the adoption and implementation of specific milestones in CWMPs, together with adoption of companion regulations such as zoning and health regulations will be the principal tracking measures.

Restoring water quality and recovery of habitat is the goal of this action plan. These measures will also be used for long-term environmental assessment. Water quality and total nitrogen concentrations will be tracked by the ongoing Buzzards Bay Coalition Volunteer Water Quality Monitoring program. In some instances, the Coalition will need to add an estuary monitoring station to match the TMDL sentinel station defined by the MEP.

Eelgrass will be the principal habitat tracked for evaluating the success of nitrogen control measures. DEP must continue to monitor eelgrass cover at a frequency of no less than 5 years.

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