Chapter 4

Massachusetts Estuaries Project Evaluations and Findings

CHAPTER 4

MASSACHUSETTS ESTUARIES PROJECT EVALUATIONS AND FINDINGS

4.1 INTRODUCTION

The Massachusetts Estuaries Project (MEP) was established to "provide water quality, nutrient loading, and hydrodynamic information for 89 estuaries in Southeastern Massachusetts" (MEP, 2003). The project has created a linked watershed/estuary model that is used to predict the water quality changes in an estuary using nitrogen loading inputs from the embayment's watershed. The purpose of the project is to evaluate each of the 89 estuaries identified, and establish nitrogen loading thresholds that can be used as management goals in the respective watersheds. These thresholds become the basis for generating Total Daily Maximum Loads (TMDLs) that can be used for watershed permitting. As generally defined in the Clean Water Act, TMDLs establish the threshold value for a particular pollutant in a water body, and this threshold is to be consistent with State water quality standards (WQS). The TMDLs developed by the Massachusetts Department of Environmental Protection (MADEP) serve as a guide for implementation activities aimed at reducing nitrogen loadings. In the case of Waquoit Bay, Popponesset Bay, and other coastal embayment watersheds, the pollutant of interest is most often nitrogen. Due to the non-point source nature of nitrogen loadings, it is appropriate to base the TMDL on annual average loadings instead of on daily average loadings.

As part of the MEP, the health of the estuarine habitat is also evaluated and this information is used to establish the water-quality threshold to maintain or improve the habitat. Threshold nitrogen levels are defined by MEP as "the average water column concentration of nitrogen that will support the habitat quality being sought."

The MEP is a collaborative effort by two state agencies, the Executive Office of Environmental Affairs (EOEA) (through the MADEP) and the University of Massachusetts Dartmouth's School

of Marine Science and Technology (SMAST), with contributions from the United States Geological Survey (USGS), Cape Cod Commission (CCC), and Applied Coastal Research and Engineering, Inc (ACRE).

The following reports relating to the Waquoit Bay East and Popponesset Bay watersheds were produced:

- "Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for Popponesset Bay, Mashpee and Barnstable, Massachusetts" Final Report – September 2004.
- "Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Quashnet River, Hamblin Pond, and Jehu Pond, in the Waquoit Bay System of the Towns of Mashpee and Falmouth, MA" Final Report – January 2005.
- "FINAL: Popponesset Bay total Maximum Daily Loads for Total Nitrogen" April 10, 2006.
- "FINAL DRAFT: Quashnet River, Hamblin Pond, Little River, Jehu Pond, and Great River in the Waquoit Bay System Total Maximum Daily Loads for Total Nitrogen" October 14, 2005.

4.2 SUMMARY OF MEP APPROACH FOR ESTUARIES IN THE PROJECT AREA

The nitrogen thresholds for each embayment system were developed to restore or maintain SA water quality or to support high habitat quality with the following basis:

- 310 CMR 4.05 defines SA waters as "suitable for shellfish harvesting without depuration; an excellent habitat for fish, other aquatic life and wildlife, and for primary and secondary contact recreation," and having "excellent aesthetic value."
- MEP defines high habitat quality as "supportive of eelgrass and infaunal communities."

Watershed specific information was obtained to determine the nitrogen loads resulting from the various nitrogen sources within the watersheds – wastewater, fertilizers, runoff from impervious surfaces, and atmospheric deposition. Natural attenuation and nitrogen recycling estimates were obtained from previous regional studies and from measurements within each watershed. Existing and future nitrogen loadings were established for each subwatershed and, through the use of the "Linked Watershed-Embayment Model," reductions in nitrogen loadings were evaluated to see if the nitrogen thresholds could be met.

The analysis of parcels located in Mashpee was done with land use information from 2001. Water data (for properties with public water supply) from 1997 through 1999 was used to estimate water flows throughout the watersheds. For properties with water use data, the average water use over the three year period was used. However, not all of the properties in Mashpee use the public water supply. As a result, assumptions had to be made by MEP for water use on the properties that did not have water use information. The following assumptions were used based on average water use for similar land use categories:

- Average water use – residential: 154 gallons per day (gpd)
- Average water use – commercial/industrial: 81.5gpd/1000 ft^2 of building

Some of the parcels within the watersheds are connected to private wastewater treatment facilities (WWTFs). Wastewater flow and effluent quality for the WWTFs was obtained, and the properties that are connected to the WWTFs were included in the actual measurements, rather than estimating flows. Determination of the nitrogen loads within the watersheds was done using the estimated and actual water flows. The following assumptions were used in the nitrogen loading analysis for the properties not connected to WWTFs:

- Wastewater generation = 90% of water consumption
- Wastewater nitrogen concentration ≈ 35 mg/L (with approximately 25% nitrogen reduction within the septic tank and soil adsorption system)

A build-out analysis was performed to estimate the future wastewater nitrogen loading. For this analysis, assumptions similar to the existing use analysis were used, including average water use for residential and commercial properties. Building areas for determination of wastewater generation in commercial and industrial areas were provided by the Mashpee Planning Department.

The following assumptions were made for other nitrogen sources:

- Nitrogen concentration in road runoff = 1.5 mg/L
- Nitrogen concentration in roof runoff = 0.75 mg/L

Septic system nitrogen is the largest source of controllable nitrogen; therefore, the focus of reductions concentrated on this source.

4.3 SUMMARY OF FINDINGS FOR POPPONESSET BAY

The final MEP report for Popponesset Bay was released in September 2004, and the Final TMDL report was released in April 2006. The results of the evaluation are summarized in the following sections.

A. MEP STUDY RESULTS

Nitrogen loading estimates were developed for each subwatershed within Popponesset Bay. Nitrogen inputs from wastewater, stormwater runoff, fertilizer, and natural sources were estimated as described in previous sections. These estimated values are shown as "Present Load" in the following table. The "Build-out Load" is the nitrogen load based on the same inputs, but at the potential future conditions. In order to compare these nitrogen loads to naturally occurring nitrogen levels, estimates were made of what the nitrogen loads would be if there were no human sources. This analysis assumed only atmospheric deposition, with natural

forests occupying the watershed area. The "No Load" column summarizes these loads for each subwatershed.

TABLE 4-1

POPPONESSET BAY NITROGEN LOADS

	Present Load (kg/day)	Build-out Load (kg/day)	Build-out (% Change)	No Load (kg/day)	No Load (% Change)
Sub-Embayment					
Popponesset Bay	1.82	1.98	8.9%	0.08	-95.6%
Popponesset Creek	4.94	5.35	8.4%	0.1	-97.9%
Pinquickset Cove	0.76	0.98	28.7%	0.11	-85.7%
Ockway Bay	3.15	4.25	35.0%	0.24	-76.0%
Mashpee River	12.11	17.57	45.1%	0.62	-79.4%
Shoestring Bay	9.21	11.47	24.5%	0.34	-75.5%
Surface Water Sources					
Mashpee River	15.56	37.15	138.7%	4.68	-69.9%
Santuit River (Shoestring Bay)	15.58	21.46	37.7%	1.27	-91.8%
Quaker Run River (Shoestring Bay)	5.98	6.62	10.6%	0.24	-96.0%

Source: Table VI-4 of MEP's *Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for Popponesset Bay, Mashpee and Barnstable, Massachusetts*, September 2004

The analyses described above aid in estimating the impact of future growth and human activity on the nitrogen load entering each subwatershed. Based on these analyses, the MEP determined that much of the watershed was already moderately to significantly impaired. In addition, the MEP developed a "target nitrogen concentration," a concentration at one point in the system (a "sentinel station") that would aid in restoration of eelgrass to the system. The target concentration for the sentinel station was determined to be 0.38 milligrams of Total Nitrogen per liter. Table 4-2 presents one nitrogen reduction scenario presented by MEP that could achieve the target nitrogen concentration. As stated by MEP, this scenario is only one of many possible ways to achieve the target concentration. This analysis provides a general guideline for nitrogen management. It should be noted that these nitrogen loads are *only* the septic nitrogen loads.

TABLE 4-2

POPPONESSET BAY THRESHOLD SEPTIC LOADS (1)

	Present Septic Load (kg/day)	Threshold Septic Load (kg/day)	Threshold Septic Load % Change
Sub-Embayment			
Popponesset Bay	1.58	1.58	0%
Popponesset Creek	4.00	0.00	-100%
Pinquickset Cove	0.58	0.58	0%
Ockway Bay	2.39	0.00	-100%
Mashpee River	9.61	0.00	-100%
Shoestring Bay	6.94	0.00	-100%
Surface Water Sources			
Mashpee River	16.85	8.63	-48.8%
Santuit River (Shoestring Bay)	11.69	7.58	-35.2%
Quaker Run River (Shoestring Bay)	4.37	4.37	0%

Source: Table VIII-1 of MEP's *Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for Popponesset Bay, Mashpee and Barnstable, Massachusetts*, September 2004

(1) MEP reports use the term "septic load" to include septic system and wastewater treatment facility loads.

The percent change as shown in Table 4-2 represents the percent of the nitrogen contributed to the watershed by wastewater that needs to be removed in order to achieve the stated threshold. For example "-100%" indicates that 100 percent (or all) of the nitrogen currently being contributed by septic systems and wastewater treatment facilities needs to be removed from the watershed to achieve the stated threshold.

B. TMDL DEVELOPMENT

TMDLs were developed for Popponesset Bay as part of the federal Clean Water Act (CWA). Compliance with section 303(d) of the CWA results in the identification of water bodies that do not meet the water quality standards for the designated uses, therefore requiring a TMDL.

Popponesset Bay, Shoestring Bay, and the Mashpee River were identified as requiring nutrient TMDLs.

The MEP work assessed the water quality and determined the loading capacity of the water body (described above). The loading capacities were developed by setting water quality conditions that would:

- restore the natural distribution of eelgrass because it provides valuable habitat for shellfish and finfish;
- prevent algal blooms;
- protect benthic communities from impairment or loss; and
- maintain dissolved oxygen concentrations that are protective of the estuarine communities.

Although the conditions listed above are the objectives of the TMDLs, these conditions will not be observed in all subembayments by achieving the TMDL. For example, benthic infauna will be the only restored condition in certain subembayments.

Achieving the target concentration at the sentinel station can be accomplished in a variety of ways. The MEP report and the TMDL report both present one scenario that will achieve that goal. The following table summarizes the loading capacities (Target Threshold Watershed Load) for the various subwatersheds based on the one scenario that was used in the reports. Also listed are the controllable watershed loads, which are a combination of fertilizer, runoff, wastewater treatment plant effluent, and septic system loadings.

TABLE 4-3

POPPONESSET BAY LOADING CAPACITIES

Sub-Embayment	Present Controllable Watershed Load (kg/day)	Target Threshold Watershed Load (kg/day)	Percent Watershed Load Reductions Needed to Achieve Threshold Loads
Mashpee River	34.15	16.17	52.7
Shoestring Bay	31.24	19.72	36.9
Ockway Bay	3.15	0.76	75.9
Pinquickset Cove	0.77	0.76	1.3
Popponesset Bay	6.75	2.77	59.0

Note: This represents the load reductions necessary for *one* scenario (of many potential scenarios) that will achieve the target nitrogen concentration at the sentinel station.

Source: Table 4 of *Final Popponesset Bay Total Maximum Daily Loads for Total Nitrogen*, April 10, 2006.

Similar to Table 4-2, this table shows the percent of nitrogen that needs to be removed from each watershed; however, unlike table 4-2, the watershed load shown here includes all nitrogen sources, not just nitrogen from wastewater.

Consideration of the natural background nitrogen levels and the nitrogen loading allocated to point and nonpoint loads led to the development of TMDLs. The background levels were developed as discussed in section 4.3.A. The following table lists the TMDLs for the Popponesset Bay subwatersheds.

TABLE 4-4

POPPONESSET BAY TMDLS

Sub-Embayment	TMDL (kg/day)
Mashpee River	26
Shoestring Bay	13
Ockway Bay	3
Pinquickset Cove	1
Popponesset Bay	1
Note: This represents the load reductions necessary for *one* scenario (of many potential scenarios) that will achieve the target nitrogen concentration at the sentinel station. Source: Table 5 of *Final Popponesset Bay Total Maximum Daily Loads for Total Nitrogen*, April 10, 2006.	

The TMDL is the sum of the target threshold watershed load, atmospheric deposition load, and benthic flux load. For some subwatersheds, the TMDL is less than the target threshold watershed load. This is due to the negative load contributed by the benthic flux.

4.4 SUMMARY OF FINDINGS FOR WAQUOIT BAY EAST

Waquoit Bay East was the second coastal embayment in the PPA to be evaluated. The eastern portion of the Waquoit Bay watershed, which includes Quashnet River, Hamblin Pond, and Jehu Pond, was prioritized for analysis prior to the remaining portions of the Waquoit Bay watershed in order to assist in Mashpee's nitrogen management planning. Therefore, this section deals only with the reports for that portion of the Waquoit Bay watershed. The final MEP report was released in January 2005, and the Final TMDL report was released in October 2005. It should be noted that the recommendations resulting from this analysis will be revisited and may change when the entire Waquoit Bay system evaluation is completed.

A. MEP STUDY RESULTS

Nitrogen loading estimates were developed for each subwatershed identified above within Waquoit Bay. Nitrogen inputs from wastewater, stormwater runoff, fertilizer, and natural

sources were estimated as described in previous sections. These estimated values are shown as "Present Load" in the table below. The "Build-out Load" is the nitrogen load based on the same inputs, but at the potential future conditions. In order to compare these nitrogen loads to naturally occurring nitrogen levels, estimates were made of what the nitrogen loads would be if there were no human sources. This analysis assumed only atmospheric deposition, with natural forests occupying the watershed area. The "No Load" column summarizes these loads for each subwatershed.

TABLE 4-5

WAQUOIT BAY NITROGEN LOADS

	Present Load (kg/day)	**Build-out Load (kg/day)**	**Build-out (% Change)**	**No Load (kg/day)**	**No Load (% Change)**
Sub-Embayment					
Hamblin Pond	3.84	4.84	26.1%	0.13	-96.7%
Upper Hamblin Pond	1.54	2.10	36.4%	0.06	-96.3%
Little River	1.11	1.27	14.4%	0.02	-98.1%
Lower Great River	2.95	3.37	14.3%	0.07	-97.8%
Upper Great River	0.68	1.58	132.1%	0.22	-67.1%
Jehu Pond	3.61	4.01	11.1%	0.12	-96.8%
Upper Quashnet River	2.16	3.03	39.9%	0.13	-94.0%
Lower Quashnet River	0.79	0.89	12.5%	0.02	-97.2%
Surface Water Sources					
Red Brook	3.88	7.29	59.9%	0.42	-94.9%
Quashnet River (1)	23.00	46.82	103.6%	4.16	-81.9%

Source: Table VI-5 of MEP's *Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Quashnet River, Hamblin Pond, and Jehu Pond in the Waquoit Bay System of the Towns of Mashpee and Falmouth, MA*, January 2005.

(1) MEP report lists this as Moonakis River. However, based on information provided by the Mashpee Town Planner, Moonakis River is only the lower, brackish portion of this river.

Based on these analyses, the MEP determined that the eastern subwatersheds are "generally showing impaired habitat quality resulting from nitrogen enrichment." The overall habitat health assessments ranged from moderate impairment to severe degradation.

As with the Popponesset Bay analysis, the MEP developed a "target nitrogen concentration" that would aid in restoration of habitat quality throughout the system. The target concentration was determined to be 0.38 mg Nitrogen/Liter for Hamblin Pond, 0.446 mg Nitrogen/Liter for Jehu Pond, and 0.50 mg Nitrogen/Liter for the Quashnet River.

As noted previously, the watersheds analyzed for this MEP report are subwatersheds of the main Waquoit Bay system. As a result, the threshold nitrogen concentrations are dependent on the incoming water quality (the water from the main basin of Waquoit Bay). Therefore, the technical report presented two potential scenarios to achieve the target nitrogen concentrations, one (Scenario A) on the assumption that no nitrogen reductions are achieved in the other portions of the watershed (resulting in nitrogen concentration in the incoming water remaining at its existing levels) and one (Scenario B) on the assumption that there are nitrogen reductions throughout the other subwatershed (with a resultant lower nitrogen concentration in the incoming water). The following table summarizes the necessary nitrogen reductions for these two scenarios. Scenario A is the assumption of existing nitrogen concentrations (0.38 mg N/L) and Scenario B is the reduced nitrogen concentration (0.35 mg N/L).

TABLE 4-6

WAQUOIT BAY THRESHOLD SEPTIC LOADS [1]

	Present Septic Load (kg/day)	Scen. A Septic Load (kg/day)	Scen. A Septic Load % Change	Scen. B Septic Load (kg/day)	Scen. B Septic Load % Change
Sub-Embayment					
Hamblin Pond	3.36	0.00	-100%	0.87	-74%
Upper Hamblin Pond	1.26	0.00	-100%	0.33	-74%
Little River	0.92	0.00	-100%	0.24	-74%
Lower Great River	2.35	0.00	-100%	0.00	-100%
Upper Great River	0.36	0.00	-100%	0.00	-100%
Jehu Pond	2.65	0.00	-100%	0.00	-100%
Upper Quashnet River	1.80	0.00	-100%	0.59	-67%
Lower Quashnet River	0.57	0.00	-100%	0.19	-67%
Surface Water Sources					
Red Brook	3.24	0.00	-100%	0.81	-75%
Quashnet River [2]	12.59	0.00	-100%	4.16	-67%

Source: Tables VIII-2 and VIII-7 of MEP's *Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Quashnet River, Hamblin Pond, and Jehu Pond in the Waquoit Bay System of the Towns of Mashpee and Falmouth, MA*, January 2005.

(1) MEP reports use the term "septic load" to include septic system and wastewater treatment facility loads.

(2) MEP report lists this as Moonakis River. However, based on information provided by the Mashpee Town Planner, Moonakis River is only the lower, brackish portion of this river.

B. TMDL DEVELOPMENT

Loading capacities and TMDLs were developed as discussed in the TMDL Development section for Popponesset Bay.

The following table summarizes the loading capacities (Target Threshold Watershed Load) for the various subwatersheds. Also listed are the controllable watershed loads, which are a combination of fertilizer, runoff, wastewater treatment plant effluent, and septic system loadings. It should be restated that this represents *one of many* potential scenarios that will achieve the target nitrogen concentration at the sentinel station.

TABLE 4-7

WAQUOIT BAY LOADING CAPACITIES

Sub-Embayment	Present Controllable Watershed Load (kg/day)	Target Threshold Watershed Load (kg/day)	Percent Watershed Load Reductions Needed to Achieve Threshold Loads
Upper Great River	0.68	0.32	52.9
Lower Great River	2.95	0.60	79.7
Upper Hamblin Pond	5.42	2.06	62.0
Hamblin Pond	3.84	1.34	65.1
Jehu Pond	3.61	0.96	73.4
Little River	1.11	0.43	61.3
Upper Quashnet River	25.16	15.51	38.4
Lower Quashnet River	0.79	0.41	48.1

Note: This represents the load reductions necessary for *one* scenario (of many potential scenarios) that will achieve the target nitrogen concentration at the sentinel station.

Source: Table 4 of *Final Draft Quashnet River, Hamblin Pond, Little River, Jehu Pond, and Great River in the Waquoit Bay System Total Maximum Daily Loads for Total Nitrogen*, October 14, 2005.

The following table lists the TMDLs for the Waquoit Bay subwatersheds.

TABLE 4-8

WAQUOIT BAY TMDLS

Sub-Embayment	TMDL (kg/day)
Great River/Jehu Pond	25
Little River/Hamblin Pond	2
Quashnet River	27

Note: This represents the load reductions necessary for *one* scenario (of many potential scenarios) that will achieve the target nitrogen concentration at the sentinel station.

Source: Table 5 of *Final Draft Quashnet River, Hamblin Pond, Little River, Jehu Pond, and Great River in the Waquoit Bay System Total Maximum Daily Loads for Total Nitrogen*, October 14, 2005.

The TMDL is the sum of the target threshold watershed load, atmospheric deposition load, and benthic flux load. For some subwatersheds, the TMDL is less than the target threshold watershed load. This is due to the negative load contributed by the benthic flux.

4.5 SUMMARY OF TMDL REQUIREMENTS

The following table summarizes the percent of septic load reductions that will be necessary to achieve the target nitrogen concentration requirements based on the one scenario that was used as the basis of these reports. These percentages represent the reductions necessary if only septic systems loads were removed and all other sources were ignored.

The findings outlined in Table 4-9, representing one scenario, will be the starting point for evaluating the project areas and in the development of alternatives in the next phase of the Project.

TABLE 4-9

EMBAYMENT SEPTIC PERCENT NITROGEN REMOVALS [1]

Embayment System	Embayment	Percent Removal to Meet Threshold [2]
Popponesset Bay System	Popponesset Bay	0%
	Popponesset Creek	100%
	Pinquickset Cove	0%
	Ockway Bay	100%
	Mashpee River	100%
	Shoestring Bay	100%
	Mashpee River [3]	49%
	Santuit River [3]	35%
	Quaker Run River [3]	0%
Waquoit Bay System	Hamblin Pond	75%
	Upper Hamblin Pond	75%
	Little River	75%
	Lower Great River	100%
	Upper Great River	100%
	Jehu Pond	100%
	Upper Quashnet River	67%
	Lower Quashnet River	67%
	Red Brook [3]	75%
	Quashnet River [3, 4]	67%

(1) Source: Table B-1 of *Final Popponesset Bay Total Maximum Daily Loads for Total Nitrogen*, April 10, 2006 and Table B-1 of *Final Draft Quashnet River, Hamblin Pond, Little River, Jehu Pond, and Great River in the Waquoit Bay System Total Maximum Daily Loads for Total Nitrogen*, October 14, 2005.

(2) Based on *one of many* potential scenarios to achieve the target concentration.

(3) Indicates a surface water source.

(4) MEP report lists this as Moonakis River. However, based on information provided by the Mashpee Town Planner, Moonakis River is only the lower, brackish portion of this river.