VIII. CRITICAL NUTRIENT THRESHOLD DETERMINATION AND DEVELOPMENT OF WATER QUALITY TARGETS

VIII.1. ASSESSMENT OF NITROGEN RELATED HABITAT QUALITY

Determination of site-specific nitrogen thresholds for an embayment requires integration of key habitat parameters (infauna and eelgrass), sediment characteristics, and nutrient related water quality information (particularly dissolved oxygen and chlorophyll-a. Additional information on temporal changes within each sub-embayment and its associated watershed nitrogen load further strengthen the analysis. These data were collected to support threshold development for the West Falmouth Harbor System by the MEP Team and were discussed in Chapter VII. Nitrogen threshold development builds on this data and links habitat quality to summer water column nitrogen levels obtained from the water quality baseline established by the Falmouth PondWatch and BayWatcher Water Quality Monitoring Program.. At present, West Falmouth Harbor, is showing a strong gradient in habitat quality from severely degraded (Oyster Pond) to significantly impaired (Snug Harbor, Harbor Head) transitioning to less impaired (South Basin) to moderately impaired (Outer/Mid Basin) to healthy (basin nearest inlet). The Snug Harbor shows significant impairment based upon all 3 parameters (eelgrass, infauna, D.O.), while the outer/mid basin was moderately impaired in spite of its proximity to the tidal inlet and high quality waters of Buzzards Bay. All of the habitat indicators show consistent patterns of habitat quality in each of the major subembayments and those habitat impairments are consistent with nitrogen enrichment (Chapter VII).

Eelgrass: The West Falmouth Harbor Estuary is moderately deep compared to others along the south shore of Cape Cod from Falmouth to Barnstable (Chapter V). However, water depths are well within the range for eelgrass growth in Massachusetts, given suitable conditions of light penetration.

There has been a clear and ecologically significant alteration of eelgrass distribution within West Falmouth Harbor within the past 15 years. The first available quantitative mapping of eelgrass is for 1979 (Costa, 1988). This study documented eelgrass throughout the Harbor, with beds in the outer basins, South Basin and Snug Harbor. The 1979 distribution is similar to the 1951 historic analysis by DEP and is supported by a qualitative mapping effort conducted in 1985, as part of a food preference study on geese (Buchsbaum, 1985). While this latter study is only approximate, it clearly shows eelgrass within both South Basin and Snug Harbor, as in the 1979 and 1951 map (Chapter VII). This is important as it helps to constrain the timing of eelgrass loss in these basins. The later maps (1995, 1999, 2001) show generally similar distributions, but very different from the pre-1985 eelgrass distributions. Detailed mapping and validation by MA DEP in 1995 (Costello, 1999) indicated that eelgrass had been lost from the inner basins over the previous decade and that decline continued through the 2001 survey. The level of decline is even more significant than recorded by DEP in that the SMAST field survey of 1999 recorded both presence/absence of eelgrass and density of plants. This survey confirmed the DEP coverages, but indicated that Snug Harbor no longer supported functional eelgrass beds, but rather very sparse eelgrass in the outer region that ranged from small patches to 5%-15% coverage and in the inner region <5% coverage.

Analysis of the mapping data is consistent with a real change in eelgrass coverage. Comparison of inner versus outer Harbor areas indicates only a small decline in eelgrass area in the outer Harbor region from 1979 to 1999 (and 1995, 2001 data). This indicates that although three different groups conducted sampling, consistent results could be achieved. In contrast, the inner areas appear to have lost there functional eelgrass habitat, with only sparse coverages remaining in a small fraction of the area that historically supported eelgrass.

The large reduction in eelgrass distribution within West Falmouth Harbor represents a significant decline in habitat quality and a major shift in ecological structure. Analysis of the distribution maps indicates the following changes:

- major loss (ca. 2/3) of eelgrass from inner basin areas (South Basin and Snug Harbor), between 1985-1996,
- only sparse coverage remains within the colonized areas of the inner basins in 1999,
- decreasing coverage within the inner portions of the outer Harbor from 1979-1999, particularly from outer/mid basin (Field Cove) in the outer Harbor between 1985-1996.

This pattern of loss of eelgrass coverage from the inner-most Harbor regions and gradually expanding toward the tidal inlet is symptomatic of nutrient enrichment. In the absence of other system-wide disturbances which would have been noted by the PondWatch and BayWatcher Monitoring Programs, it is reasonable to conclude that the shift in Harbor health that occurred between 1985-1996 was associated with the entry of the Falmouth WWTF nitrogen plume into the Snug Harbor/Mashapaquit Creek area circa 1994).

The presence of remaining sparse eelgrass within the inner harbor is consistent with the relatively recent (more than 2 fold) increase in nitrogen loading. That nitrogen from the watershed and particularly the WWTF plume is affecting the Harbor is also supported by the observation of dense concentrations of macroalgae, *Ulva lactuca*, in Snug Harbor adjacent the inlet to Mashapaquit Creek. In the outer portion of Snug Harbor, eelgrass is still visible, but covered with invading algae. Eelgrass was almost totally absent in the inner portions of Snug Harbor and in its place the bottom was dominated by invading *Ulva* and other macroalgae.

It should be noted that the loss of eelgrass from the inner reaches of South Basin may have also been partially associated with overwash associated with Hurricane Bob in 1991. Evidence of overwash was found in cores from that basin collected by MEP. However, the subsequent loss of eelgrass from the outer reach of South Basin clearly follows the pattern of nutrient enrichment effects.

The pattern of eelgrass loss is fully consistent with the pattern of nitrogen levels throughout the Harbor and with the dissolved oxygen and chlorophyll data. As discussed below, infaunal communities also reflect a pattern of stress correlated with nitrogen levels. Tidally averaged TN is 0.46 mg/L in Snug Harbor declining to 0.38 in South Basin, with the Outer Harbor being significantly lower 0.31-0.33 mg/L. This nitrogen gradient is clearly seen in the gradient in oxygen depletion and infaunal habitat health, as well as in the eelgrass distribution data.

The surveys indicate that both the inner and outer Harbor basins are capable of supporting eelgrass when the watershed nitrogen loading rates are at the 1979-1985 levels. The current absence of functional eelgrass beds within the inner basins and the fact that these areas supported eelgrass in the recent past classifies the Snug Harbor and South Basin eelgrass habitat as “significantly impaired”. The presence of significant eelgrass beds within the mid/outer basin (Field Cove) coupled with recent declines in the uppermost portion classifies this basin’s eelgrass habitat as “moderately impaired”, while the outermost basin nearest the inlet still supports healthy eelgrass beds and garners a “healthy” classification. There is no evidence that the small tributaries to the main estuary (Mashapaquit Creek, Harbor Head and

Oyster Pond) have supported eelgrass and therefore restoration of eelgrass habitat in these basins is not a management goal (although infaunal habitat should be, see below).

Nitrogen management of this system is likely to restore eelgrass beds to the coverage of 84 acres observed in 1951 (Table VII-3). As noted above, this will restore on the order of 40 acres of eelgrass beds as the inner basin eelgrass distribution noted in Table VII-3 includes sparse coverages (<5%). Note that restoration of this habitat will necessarily result in restoration of other resources throughout the West Falmouth Harbor System Eelgrass recovery following nitrogen management would likely follow the pattern of beds first being re-established in the marginal areas in the lower basins and move to the deeper regions and the margins of the upper subembayments. Based upon the above analysis, eelgrass habitat was a primary nitrogen management goal for the West Falmouth Harbor System and was the focus of the management alternatives analysis (Chapter 9).

Water Quality: The dissolved oxygen records, based upon both continuous measurement and grab samples indicate that Snug Harbor, South Basin and outer/mid Harbor are currently under periodic oxygen stress during summer, consistent with nitrogen enrichment (Figure VII-2, Table VII-1). The deep salt pond, Oyster Pond, is periodically hypoxic/anoxic. However, within the main Harbor, the Snug Harbor sub-embayment clearly showed the highest level of oxygen stress. That the cause is nitrogen enrichment is supported by parallel observations of chlorophyll a (Table VII-2) and total nitrogen levels (Snug Harbor>South Basin>Outer Harbor). Oxygen conditions and chlorophyll a levels generally improved with decreasing distance to the tidal inlet. The results of the summer oxygen and chlorophyll a studies are consistent with the pattern of eelgrass loss within the West Falmouth Harbor System and the pattern of infaunal communities, where opportunistic species dominate the more nitrogen enriched basins. These observations are consistent with a classification of the inner basins of Snug Harbor and Oyster Pond as significantly impaired and severely degraded, respectively, and in South Basin and the outer/mid Harbor as moderately impaired.

Dissolved oxygen levels near atmospheric equilibration are important for maintaining healthy animal and plant communities. Short-duration oxygen depletions can significantly affect communities even if they are relatively rare on an annual basis. For example, for the Chesapeake Bay it was determined that restoration of nutrient degraded habitat requires that instantaneous oxygen levels not drop below 3.8 mg L^{-1}. Massachusetts State Water Quality Classification indicates that SA (high quality) waters maintain oxygen levels above 6 mg L^{-1}. The tidal waters of the Three Bays System are currently listed under this Classification as SA.

The level of oxygen depletion and the magnitude of daily oxygen excursion and chlorophyll a levels indicate nutrient enriched waters and impaired habitat quality, particularly in Snug Harbor. The oxygen data throughout the estuary is consistent with elevated organic matter loads from phytoplankton production (chlorophyll a levels) indicative of nitrogen enrichment and eutrophication of these estuarine systems. The oxygen records further indicate that the upper tidal reaches of each estuary have the largest daily oxygen excursion, with daily excursions in excess of >4 mg L-1 common. This further supports the assessment of a high degree of nutrient enrichment..

The use of only the duration of oxygen below, for example 4 mg L^{-1}, can underestimate the level of habitat impairment in these locations. 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). This was periodically seen in Snug Harbor and the mid/outer Harbor. The oxygen and chlorophyll data also shows a gradient of impairment with high levels in the inner sub-embayments (Oyster Pond, Snug Harbor) and better conditions in the lower basins (Outer Harbor). The primary cause of the severely degraded habitat in Oyster Pond is that the Pond is deep (>8 m) with a very shallow tidal channel. In addition it has fringing salt marsh which contributes detritus to its sediments. The physical structure of Oyster Pond results in it stratifying and periodically becoming hypoxic. Attempts to restore this habitat will have to address the natural structural issues of this salt pond. Overall, there was clear oxygen depletion at all mooring sites within the main Harbor basins indicating that additional nitrogen loading will cause further habitat decline at all sites.

Infaunal Communities: The Infauna Study indicated that most of the Harbor habitat is presently impaired by nitrogen enrichment (Table VII-4). The gradient in habitat impairment followed the gradient in tidally averaged total nitrogen levels, eelgrass loss and oxygen depletion and chlorophyll levels. Assessing the overall quality of the benthic infaunal habitat within the basins of West Falmouth Harbor was based upon the types of species present, the numbers of individuals and species and the diversity and evenness indices. It must be kept in mind that large numbers of stress indicator species does not indicate a healthy environment, while moderate numbers of species indicative of low organic matter loading generally does indicate habitat health.

The Infaunal study indicated that most of the Harbor basins have nutrient related impairment of benthic habitat, although it appears that near the inlet habitat quality remains high. However, the level of impairment varied greatly between sub-embayments. Within the main Harbor, Snug Harbor was found to support patchy habitat dominated by stress indicator (opportunistic) species such as *Capitella*. Harbor Head was very similar to Snug Harbor in numbers of individuals and species and dominance by stress indicator species. The infaunal habitat in these basins appears to be “significantly impaired” by organic matter enrichment stemming from nitrogen overloading. In contrast, South Basin was not dominated by opportunistic species but by species indicative of lower organic enrichment with deeper burrowers and mollusks, although the numbers of individuals and species were similar to Snug Harbor and Harbor Head. This indicates a less stressed habitat. However, South Basin’s moderate number of species (11) indicates a “moderately impaired” community when compared to healthy embayments where >20 species is typical (Table VII-4). Similar to the gradient found in the other health indicators, the Outer Harbor sites showed less stress overall than the inner basins. The outer basins generally supported almost double the numbers of individuals and more species that the inner Harbor sites. However, the Outer Harbor basins had patches of stress indicator species and lower numbers of species that would be indicative of a fully healthy habitat. Overall, the outer harbor appears to range from Healthy conditions to moderately impaired conditions when moving from the inlet toward the inner Harbor. The drown kettle pond, Oyster Pond, was not found to support benthic infaunal habitat throughout most of the basin. At all 3 sampling sites, less than 10 individuals per sample were found. This system clearly is supporting “severely degraded” infaunal habitat, although some portion of the poor conditions results from the physical structure of this drown kettle pond.

Overall, the pattern of infaunal community quality is consistent with the pattern of oxygen depletion and chlorophyll a during summer and eelgrass habitat quality. Almost all sites showed some level of degradation, either in number of individuals, diversity or the presence of stress indicator species. Lowering nitrogen inputs to this system should allow a relatively rapid recovery of communities in the mid/outer Harbor and South Basins, with higher levels of nitrogen management required to restore benthic habitat to Snug Harbor and Harbor Head. Creation of Oyster Pond infaunal habitat (there is no viable bottom habitat at present) may not be possible by nitrogen management alone and would need to focus on the physical and biological processes controlling stratification and seasonal hypoxia. It appears that implementation of watershed nitrogen management to reduce loading to the Harbor should restore infaunal habitat first throughout the outer harbor and then South Basin followed by Snug Harbor and Harbor Head. It is anticipated that habitat restoration will be relatively rapid following a reduction in nitrogen load.

Table VIII-1. Summary of Nutrient Related Habitat Health within the West Falmouth Harbor Estuary on the Buzzards Bay coast of Falmouth, MA., based upon assessment data presented in Chapter VII.

Health Indicator	West Falmouth Harbor Estuary						
	Mashap Creek Marsh	Snug Harbor	South Basin	Harbor Head	Oyster Pond	Outer Harbor	
						Mid	Outer
Dissolved Oxygen	--	SI	MI[3]	--	SD[1]	MI/SI[2]	--
Chlorophyll	--	SI/MI	MI	--	--	H	--
Macroalgae	SI	SD[4]	--	--	MI	MI[5]	H
Eelgrass	--[8]	SI	SI	--[8]	--[8]	MI	H
Infaunal Animals	--	SI[9]	MI	SI[9]	SD[7]	MI	H/MI
Overall:	**SI**	**SI**	**MI/SI**	**SI**	**SI/SD**	**MI**	**H**

1 – periodic oxygen depletions to <2 mg/L and frequently <4 mg/L, grab data only
2 – infrequent oxygen depletions to 3-4 mg/L, periodic 4-5 mg/L., generally >5 mg/L.
3 – generally >5 mg/L..
4 – high macroalgal accumulations during summer
5 – moderate macroalgal accumulations or patches on bottom.
6 – modest numbers of individuals dominated by stress indicator species.
7 – absence of infaunal community (<15 individuals/grab).
8 – no evidence this basin is supportive of eelgrass.
9 – infaunal community dominated by opportunistic species.

H = healthy habitat conditions; MI = Moderate Impairment; SI = Significant Impairment; SD = Severe Degradation; -- = not applicable to this estuarine reach

VIII.2. THRESHOLD NITROGEN CONCENTRATIONS

The approach for determining nitrogen loading rates, which will maintain acceptable habitat quality throughout and embayment system, is to first identify a sentinel location within the embayment and second to determine the nitrogen concentration within the water column which will restore that location to the desired habitat quality. The sentinel location is selected such that the restoration of that one site will necessarily bring the other regions of the system to acceptable habitat quality levels. Once the sentinel site and its target nitrogen level are determined, the Linked Watershed-Embayment Model is used to sequentially adjust nitrogen loads until the targeted nitrogen concentration is achieved.

Determination of the critical nitrogen threshold for maintaining high quality habitat within West Falmouth Harbor is based primarily upon the nutrient and oxygen levels, temporal trends in eelgrass distribution and current benthic community indicators. Given the database it is possible to develop a site-specific threshold, which is a refinement upon general threshold analysis frequently employed in other approaches.

Given the importance of eelgrass to the habitat quality of West Falmouth Harbor, a target nitrogen concentration within the inner Harbor waters supportive of eelgrass habitat will provide for a high level of overall habitat health. Selection of the sentinel station in Snug Harbor will support restoration of the various sub-basins (except possibly Oyster Pond). Snug Harbor is presently the most nitrogen enriched of the West Falmouth Harbor sub-embayments (Snug Harbor, South Basin, Harbor Head, Outer Basins). Consequently, Snug Harbor is showing the highest level of habitat impairment of these basins. Restoration of the Snug Harbor basin to be supportive of eelgrass beds will necessarily result in lower nutrient concentrations in the outer, better flushed basins and the South Basin such that eelgrass habitat will be supportable.

At present, the healthy eelgrass beds within the Outer Harbor are at tidally averaged total nitrogen levels of 0.33-0.31 mg N/L. Total nitrogen levels in the upper and lower reach of Snug Harbor where sparse eelgrass is still found are 0.46 (<5% cover) and 0.37 (5-15% cover and patches), respectively. South Basin does not currently have eelgrass and has a tidally averaged total nitrogen level of 0.38 mg N/L. Note that the background total nitrogen in the inflowing Buzzards Bay waters is 0.296 mg N L^{-1}. The average measured mid-ebb tide total nitrogen level in the outer harbor, which currently supports eelgrass beds is 0.345 mg N L^{-1}, which compares well with the 0.353-0.356 mg N L^{-1} ebb tidal maximum from the MEP water quality module (Chapter VI). In addition, measured mid-ebb tide total nitrogen levels in the inner basins in 1992-93, when eelgrass habitat was still presumably relatively healthy (pre-WWTF plume discharge to Harbor) were 0.34-0.36 mgN/L^{-1}. These data argue for a tidally averaged total nitrogen level <0.37 N/L^{-}1 and mid-ebb concentration <0.36 mg N/L^{-1} to support high quality eelgrass habitat. Given all of the above data the tidally averaged total nitrogen threshold at the sentinel station in Snug Harbor was set at 0.35 mg N L^{-1}. This threshold is also consistent with previous analyses of this system (Eichner et al. 1998, Howes et al. 2000), targeted at restoration of high quality estuarine habitats throughout the West Falmouth Harbor System. A nitrogen threshold greater than 0.35 mg N L^{-1} is likely to result in some loss of eelgrass habitat. It should be noted that this is a best estimate of the upper boundary of nitrogen. It should be emphasized that eelgrass coverage declined in Old Field Cove at total nitrogen levels less than 0.35 mg N L^{-1}, although this may have resulted from macroalgal transport from the inner harbor interfering with eelgrass survival. However, a threshold of 0.35 N/L^{-1} for Snug Harbor, would ensure that most of the other regions of the Harbor would have lower average total nitrogen concentrations, and commensurate levels of environmental health.

Although a single sentinel station (Snug Harbor) was selected, secondary criteria relating to infaunal habitat must be achieved at other locations (e.g. Harbor Head). The secondary criteria serve only as checks to make sure that the targets are achieved when the nitrogen threshold at the sentinel station has been reached. The historical analysis did not indicate that Harbor Head is supportive of eelgrass habitat and therefore eelgrass was not used to evaluate habitat health. In these cases, as discussed previously, the MEP focuses on maintenance of a high quality infaunal habitat as the restoration objective. At present, the infaunal habitat within the Harbor Head basin is significantly impaired. The present tidally averaged total nitrogen level is 0.44 N/L^{-1} and the measured mid-ebb average is 0.48 N/L^{-1}. This contrasts with South Basin which shows only a modest level of impairment to infaunal habitat at 0.38 N/L^{-1}. The secondary criteria relating to Harbor Head infaunal habitat would then require tidally averaged total nitrogen level between 0.35 and 0.38 N/L^{-1} when the nitrogen level at the sentinel station is achieved.

The target nitrogen concentration (tidally averaged TN) for restoration of eelgrass at the sentinel location within the West Falmouth Harbor System was determined to be 0.35 mg TN L^{-1}. This nitrogen level is lower than found for other complex systems such as Stage Harbor (0.38 N/L^{-1}) and analysis of nitrogen levels within the eelgrass bed in Waquoit Bay, near the inlet (measured TN of 0.395 mg N L^{-1}, tidally corrected <0.38 mg N L^{-1}), and (3) a similar analysis in Bournes Pond. The sentinel station under present loading conditions supports a tidally corrected average concentration of 0.46 mg TN L^{-1}, therefore a watershed nitrogen management will be required for restoration of the estuarine habitats within this system.

It must be stressed that the nitrogen threshold for the West Falmouth Harbor System is at the sentinel location. The secondary criteria should be met when the threshold is met at the sentinel station used for setting the nitrogen threshold and serves as a "check" on the threshold established for the system. The nitrogen loads associated with the threshold concentration at the sentinel location are discussed in Section VIII.3, below.

VIII.3. DEVELOPMENT OF TARGET NITROGEN LOADS

The nitrogen thresholds developed in the previous section were used to determine the amount of total nitrogen mass loading reduction required for restoration of eelgrass and infaunal habitats in the West Falmouth Harbor system. Tidally averaged 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 reductions in septic effluent discharges only, until the nitrogen levels reached the threshold level at the sentinel station chosen for West Falmouth Harbor. 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. However, the recent upgrade to the WWTF allowed streamlining of the target nitrogen loads to West Falmouth Harbor, since this upgrade significantly reduced the total nitrogen entering the estuarine system.

The initial development of nitrogen load reductions needed to meet the threshold concentration of 0.35 mg/l in Snug Harbor was based on the Town of Falmouth moving forward with sewer upgrades in West Falmouth. In addition, full build-out of the watershed was assumed, since this only generates a small increase in overall nitrogen load, much of which will be sent to the WWTF. Table VIII-2 shows the septic load reductions modeled for this scenario. These nitrogen load reductions are a result of (a) the recently upgraded WWTF and (b) development of the currently planned sewer system in the West Falmouth Harbor watershed. In general, the greatest reduction in septic load is from the upper parts of the estuarine system including Oyster Pond, Harbor Head, Snug Harbor, and Mashapaquit Creek.

Tables VIII-3, VIII-4, and VIII-5 provide additional loading information associated with the thresholds analysis. Table VIII-3 shows the change to the total watershed loads, based upon the removal of septic loads depicted in Table VIII-2. For Example, removal of 61% of the septic load from Harbor Head sub-watershed results in a 45% reduction in total nitrogen load. For Mashapaquit Creek, septic load reduction of 45% resulted in total attenuated watershed load reduction of over 61%. The reason that the total load reduction in Mashapaquit Creek is actually larger than the reduction in septic load is due to the WWTF. Since the majority of the existing nitrogen load entering Mashapaquit Creek is from the WWTF, the recent upgrade will cause a large-scale reduction in nitrogen entering the estuary at this location. Table VIII-4 illustrates the significant reduction in total nitrogen load resulting from the WWTF upgrade, even considering the additional load associated with build-out.

Table VIII-5 shows the breakdown of threshold sub-embayment and surface water loads used for total nitrogen modeling. In Table VIII-5, loading rates are shown in kilograms per day, since benthic loading varies throughout the year and the values shown represent 'worst-case' summertime conditions. The benthic flux for this modeling effort is reduced from existing conditions based on the load reduction and the observed particulate organic nitrogen (PON) concentrations within each sub-embayment relative to background concentrations in Buzzards Bay.

Model results for the build-out scenario with the upgraded WWTF achieve the target TN concentrations at the sentinel station, as shown in Table VIII-6 and Figure VIII-1. To achieve the threshold nitrogen concentrations at the sentinel station, a reduction in TN concentration of greater than 20% is required for Snug Harbor, with TN reduction levels decreasing toward the inlet. The maximum reduction in TN levels occurs in Mashapaquit Creek, where TN levels drop more than 30%. The basis for the watershed nitrogen removal strategy utilized to achieve the embayment thresholds has merit, since it follows the existing WWTF upgrade and sewer construction plan developed by the Town of Falmouth.

Table VIII-2. Comparison of sub-embayment watershed ***septic loads*** (attenuated) used for modeling of present and threshold loading scenarios of the West Falmouth Harbor system. These loads do not include direct atmospheric deposition (onto the sub-embayment surface), benthic flux, runoff, or fertilizer loading terms.

sub-embayment	present septic load (kg/day)	threshold septic load (kg/day)	threshold septic load % change
Outer West Falmouth Harbor	1.274	0.942	-26.0%
Inner West Falmouth Harbor	2.085	1.901	-8.8%
Harbor Head	0.811	0.318	-60.8%
Oyster Pond	0.984	0.342	-65.2%
Snug Harbor	1.912	0.589	-69.2%
Mashapaquit Creek	2.975	1.650	-44.5%

Table VIII-3. Comparison of sub-embayment ***total watershed loads*** (including septic, runoff, and fertilizer, and the WWTF) used for modeling of present and threshold loading scenarios of the West Falmouth Harbor system. These loads do not include direct atmospheric deposition (onto the sub-embayment surface) or benthic flux loading terms.

sub-embayment	present load (kg/day)	threshold load (kg/day)	threshold % change
Outer West Falmouth Harbor	1.690	1.359	-19.6%
Inner West Falmouth Harbor	10.386	5.301	-49.0%
Harbor Head	1.085	0.592	-45.5%
Oyster Pond	1.359	0.718	-47.2%
Snug Harbor	9.570	3.715	-61.2%
Mashapaquit Creek	17.649	6.844	-61.2%

Table VIII-4. Comparison of Falmouth WWTF loads to West Falmouth Harbor for present and build-out.		
watershed	Present WWTF load kg/day	Buildout WWTF load kg/day
Inner West Falmouth Harbor	7.118	2.216
Snug Harbor	6.584	2.052
Mashapaquit Creek	13.731	4.251
Total	27.432	8.519

Table VIII-5. Threshold sub-embayment loads used for total nitrogen modeling of the West Falmouth Harbor system, with total watershed N loads, atmospheric N loads, and benthic flux			
sub-embayment	watershed load (kg/day)	direct atmospheric deposition (kg/day)	benthic flux net (kg/day)
Outer West Falmouth Harbor	1.359	0.921	-2.895
Inner West Falmouth Harbor	5.301	0.866	-4.949
Harbor Head	0.592	0.153	-0.372
Oyster Pond	0.718	0.079	0.000
Snug Harbor	3.715	0.455	-2.892
Mashapaquit Creek	6.844	0.019	0.000

Table VIII-6. Comparison of model average total N concentrations from present loading and the threshold scenario, with percent change, for the West Falmouth Harbor system. Loads are based on atmospheric deposition and a scaled N benthic flux (scaled from present conditions). The threshold station is shown in bold print.				
Sub-Embayment	monitoring station	present (mg/L)	threshold (mg/L)	% change
Mashapaquit Cr., Nashawena Rd.	PWF1	0.627	0.412	-34.3%
Harbor Head, Chappaquoit Rd.	PWF2	0.437	0.353	-19.1%
Chappaquoit Basin	PWF3	0.382	0.326	-14.8%
Inner West Falmouth Harbor	PWF4	0.370	0.320	-13.5%
Snug Harbor	**PWF5**	**0.464**	**0.353**	**-24.0%**
Outer West Falmouth Harbor	PWF6	0.327	0.306	-6.5%
Outer West Falmouth Harbor	PWF7	0.312	0.301	-3.6%
Oyster Pond	PWF8	0.534	0.407	-23.8%

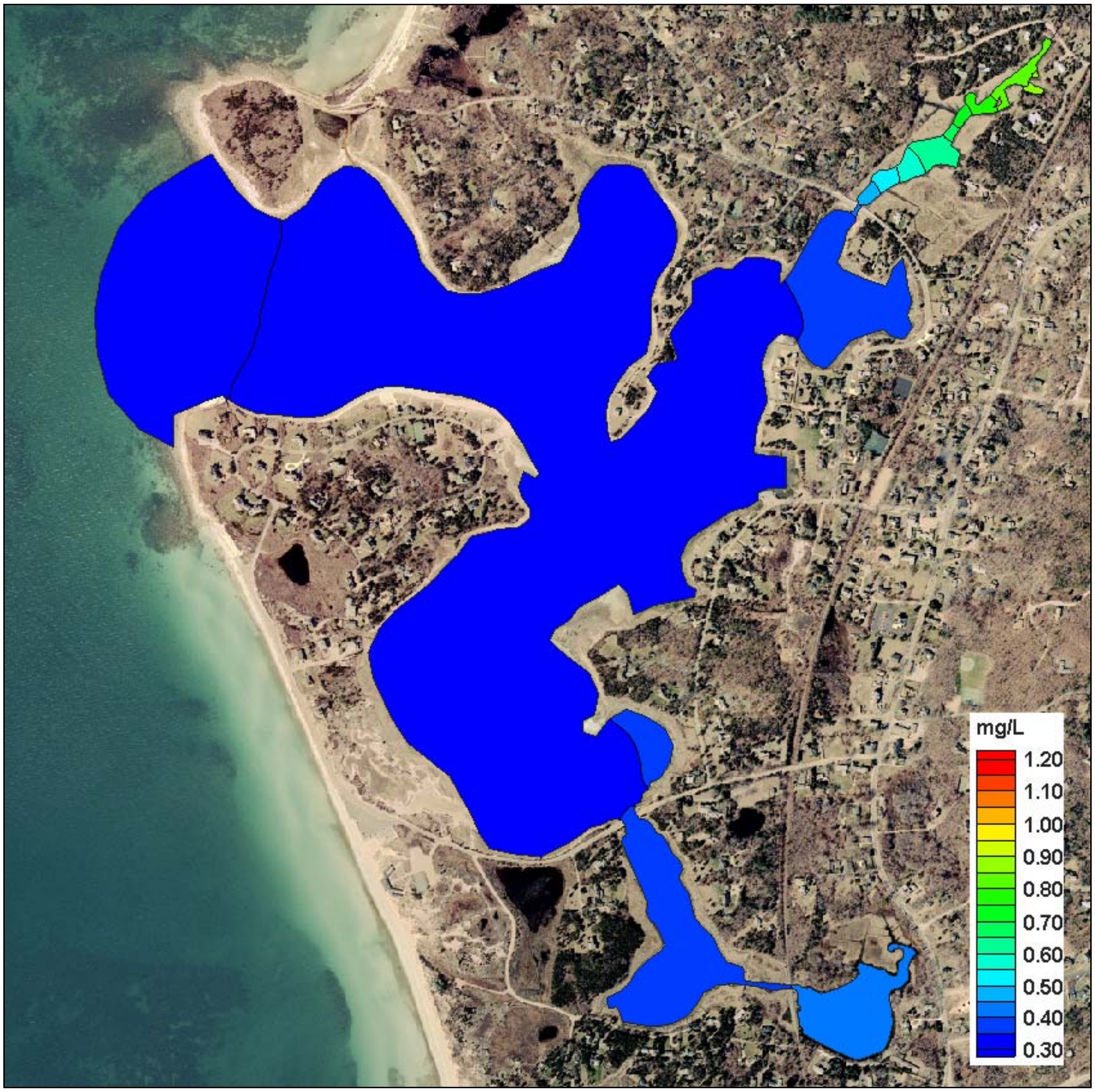

Figure VIII-1. Contour plot of modeled total nitrogen concentrations (mg/L) in the West Falmouth Harbor system, for threshold conditions (0.35 mg/L in Snug Harbor).