

Analysis of Nitrogen Loads to Pleasant Bay

Background

Pleasant Bay is within the Towns of Brewster, Chatham, Harwich, and Orleans and all four towns have watersheds draining to the Bay. The eastern edge of the Bay is a narrow barrier beach and the outlet to the ocean is at the southernmost part of the Bay. Pleasant Bay is comprised of large open water areas as well as many small sub-embayments. These small sub-embayments are poorly flushed by tidal action and are at risk of eutrophication (accelerated aquatic plant growth from excessive nitrogen) if they receive high nitrogen loads from the contributing watersheds.

Description of MEP and TMDL reports

The Massachusetts Department of Environmental Protection (MassDEP) through its Massachusetts Estuaries Project (MEP), commissioned a comprehensive study of land loading and flushing on the nitrogen concentrations in the Bay. This study divided the Bay into 95 contributing sub-watersheds and 22 receiving sub-embayments. The study modeled the annual nitrogen loading from individual sub-watersheds, routed the attenuated load to the downstream sub-embayments, and accumulated the total annual load to each sub-embayment. Sources of nitrogen that are problematic for Pleasant Bay are septic systems, urban runoff, and fertilizer use on residential, agricultural, or golf course land. Significant attenuation of nitrogen loads occurs when the water flows through a series of ponds.

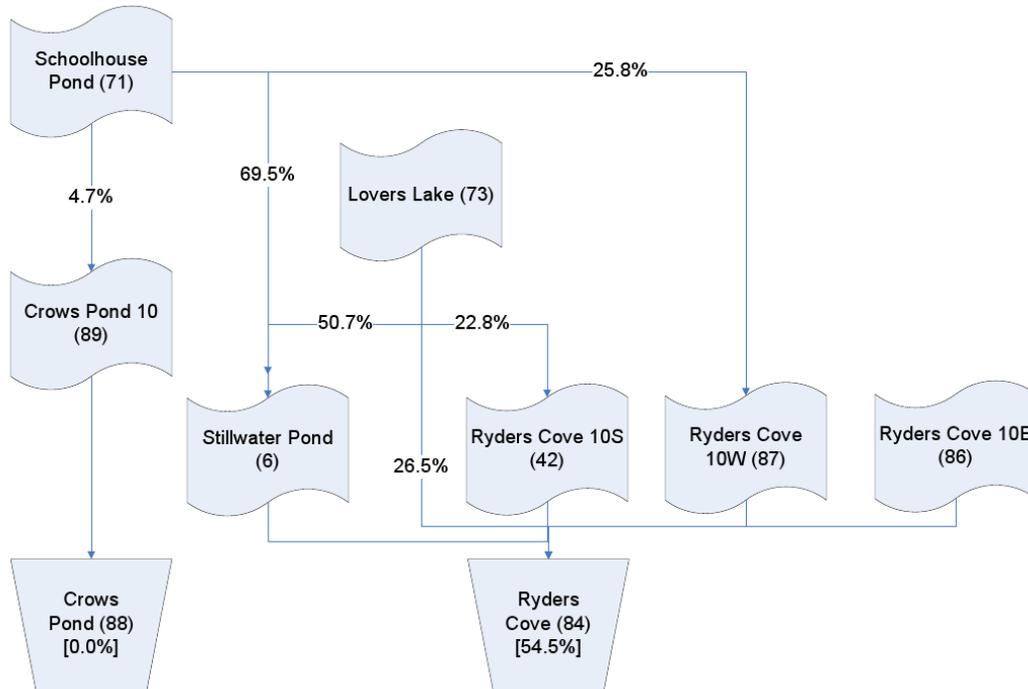
A tidal hydraulic model was then used to mix the loads appropriately throughout the waters of the Bay and estimate nitrogen concentrations in the Bay. Sentinel or reference stations were used to set the target nitrogen concentration to maintain a healthy bed of eel grass in each sub-embayment. By varying the contributing source loads, the maximum acceptable loads that meet the target concentrations were determined. The final MEP report was completed in 2007.

Subsequent to the MEP report, MassDEP issued a Total Maximum Daily Load (TMDL) report in 2007. A TMDL report identifies the sources of pollution that are causing the existing water quality problems and sets limits on these sources so that over time the end result is an acceptable improvement in water quality. The TMDL used the MEP reports as its basis and simplified results to 19 sub-embayments. The required TMDL reductions for the manageable (land plus septic) attenuated loads to the sub-embayments varied from 0 to 100% depending on the degree of nitrogen loading and flushing.

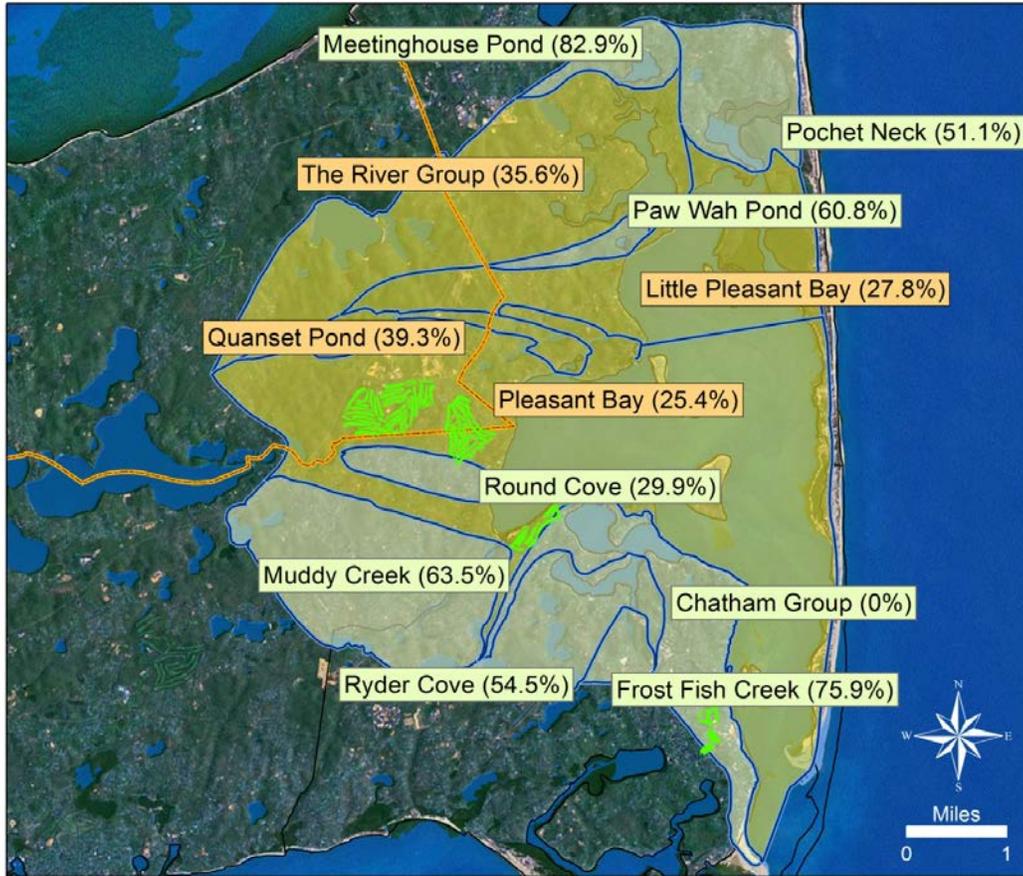
Development of Planning Units

In order to trace the required TMDL reductions from the embayments back to the originating land there needs to be a one-to-one correspondence between watersheds and sub-embayments. A peculiarity of this groundwater-driven system is that water from an upstream

sub-watershed can drain into a pond, then exit from the pond into multiple downstream sub-watersheds, which in turn might split again at the next pond. The result is a convoluted stream pattern with one sub-watershed possible contributing to multiple sub-embayments (see figure below).



HW developed a grouped watershed approach to solve this problem. We traced the flow of groundwater throughout the watershed and developed flow diagrams for the complete systems. These flow diagrams allowed us to identify groups of sub-watersheds and sub-embayments that function together, resulting in 12 planning units for Pleasant Bay, four of which are related to Brewster (see orange labels in figure below).



Using this approach, we were able to appropriately transfer the TMDL nitrogen reductions from the sub-embayments to the correct land areas. The TMDL nitrogen reduction rates for manageable loads in the four planning units associated with the Town of Brewster are given in the table below.

Planning Unit	Current Reduction (%)
The River Group	35.6
Quanset Pond	39.3
Little Pleasant Bay	27.8
Pleasant Bay	25.4
Average	28.8

Analysis of Nitrogen loads to Brewster's Sub-embayments

HW then used a memo prepared by the Cape Cod Commission by Ed Eichner (September 25, 2007) on the Town's relative nitrogen contributions to Pleasant Bay to estimate the unattenuated manageable loads. The unattenuated loads are used because these are the actual loads applied to the land and required reductions must be quantified in those terms.

Attenuation through the pond-river system is assumed to remain the same as that used in the MEP study. The appropriate reduction percentages were then applied to compute the load reductions for each Town contributing to each planning unit (see table below).

Sub-embayment /Town	Current Reduction (lb/yr)				TOTAL
	Brewster	Chatham	Harwich	Orleans	
The River Group	672	0	0	4,146	4,818
Quanset Pond	239	0	0	506	744
Little Pleasant Bay	141	0	0	1,678	1,819
Pleasant Bay	3,240	625	1,532	980	6,378
TOTAL	4,291	625	1,532	7,310	13,759

From this table one can see that the reductions required for each town within these four planning units varies. For the River Group and Little Pleasant Bay, most of the reductions must come from Orleans. For Quanset Pond, the reductions are split between Brewster and Orleans. For the main part of Pleasant Bay, all towns are responsible, with Brewster having the largest reductions.

Potential Solutions for Brewster

Using the required reductions for Brewster, the table below provides an estimate of the number of single-family homes requiring advanced septic treatment or at a wastewater treatment facility (WWTF). Because the MEP study was based on an effluent concentration for septic system nitrogen of 26.25 mg/L, each treatment option in the table only claims credit for the reduction from 26.25 mg/L to its effluent concentration (say 19 mg/L for advanced septic). This conservative assumption could be relaxed in favor of a strict percent reduction approach, which would give greater reductions and fewer homes treated. Discussions with MassDEP on this issue are ongoing on this approach.

Treatment of Brewster's Unattenuated Loads for Current Conditions	Number of Single Family Homes			
	Existing	Adv Septic @ 19 mg/L	Regular WWTF @ 10 mg/L	Adv WWTF @ 5 mg/L
The River Group	229	228	102	78
Quanset Pond	48	81	36	28
Little Pleasant Bay	12	48	21	16
Pleasant Bay	351	1,099	490	375
Pleasant Bay (w/ Captains)	351	336	150	115
Total	641	1,455	649	496

The table for current conditions shows that only in the River Group only the advanced septic option feasible, since there are enough existing homes. If the Captains Golf Course can claim a nitrogen credit of 2,250 lb/yr for improved fertilizer practices since the MEP study (need ref?),

then the second line for Pleasant Bay shows that the advanced septic option is also feasible. For Quanset Pond and Little Pleasant Bay, some more advanced treatment of nitrogen will probably be required. Alternatively, trading between Brewster and Orleans might be possible. If Orleans treated some or all of the load reductions in these two planning units, then Brewster could possibly do more in the Pleasant Bay unit.

These kinds of calculations are also being developed for buildout conditions. Discussions with other adjoining towns on joint management strategies for reducing nitrogen in wastewater are ongoing.