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***** **Technical Memorandum** *****

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RE: Scenarios 1, 2, 3, 4 of Nantucket Harbor MEP Linked Model

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The present Technical Memorandum details the results of four (4) Scenario Runs completed using the MEP Linked Watershed-Embayment Model developed for the Nantucket Harbor System. Development of the model and establishment of the nitrogen thresholds for the Nantucket Harbor System are described in the MassDEP/SMAST MEP Nitrogen Threshold Report for the Nantucket Harbor Estuary¹. These Scenarios are the initial planning runs for this system for the Town of Nantucket. The scenarios focus on nitrogen management strategies within the watershed (scenario 1 and 2), increasing tidal flushing (scenario 3 which elevates the jetties) and a combination of increasing tidal flushing and nitrogen management within the watershed (scenario 4 elevates the jetties and utilizes watershed loading developed for scenario 2). The effects of the watershed and flushing alterations on nitrogen levels throughout the waters of the Nantucket Harbor System are compared to the MEP target nitrogen levels (thresholds) needed to achieve restoration. The scenarios were developed by the Town of Nantucket in order to provide guidance to municipal officials, private citizens and environmental groups to support decisions regarding the nitrogen management planning and load allocation related to the stewardship of this critical coastal system.

At present, historic eelgrass and benthic animal habitat within Nantucket Harbor is showing impairment in the Head of the Harbor and Polpis Harbor sub-basins, although most of the estuary is generally supporting high quality habitat. Impairment stems from nitrogen enrichment due to watershed nitrogen inputs that exceed this estuary's assimilative capacity under its present hydrodynamic regime. As part of nitrogen management planning, the Town of Nantucket is working with the MEP Technical Team (through SMAST) in the use of the MEP Linked Model developed for this estuary.

¹ Howes, B.L., S.W. Kelley, J.S. Ramsey, R.I. Samimy, D.R. Schlezinger, E. Eichner. 2006. Linked Watershed-Embayment Modeling Approach to Determine Critical Nitrogen Loading Thresholds for Nantucket Harbor, Town of Nantucket, MA. Massachusetts Estuaries Project Final Report to Massachusetts Department of Environmental Protection, Boston MA. 168pp.

The two sewerage scenarios assume that wastewater is collected in two areas within the Harbor watershed and is then treated and discharged at the existing Town Waste Water Treatment Facility. The third modeling run (scenario 3) focuses on tidal flushing by elevating the main jetties at the Harbor inlet. The fourth modeling run combines the wastewater loading reduction from scenario 2 with the tidal flushing alteration in scenario 3. Details of the scenarios are as follows:

Scenario 1, Monomoy:

The MEP Nantucket Harbor linked model was used to evaluate the extent of improvement in nitrogen related water quality that would be achieved by lowering nitrogen loading to the watershed from septic systems through the extension of sewer lines into the Monomoy area (Figure 1) and connecting all dwellings possible. This scenario is based on existing, not buildout, watershed nitrogen loading and model output was assessed relative to the MassDEP TMDL targets for Nantucket Harbor.

Scenario 2, Monomoy / Shimmo:

The MEP Nantucket Harbor linked model was used to evaluate the extent of improvement in nitrogen related water quality that would be achieved by lowering nitrogen loading to the watershed from septic systems through the extension of the sewer lines into both the Monomoy and Shimmo areas (see Figure 1) and connecting all dwellings possible. This scenario is based on existing, not buildout, watershed nitrogen loading and model output was assessed relative to the MassDEP TMDL targets for Nantucket Harbor.

Scenario 3, Elevate jetties:

The MEP Nantucket Harbor linked model was used to evaluate the extent of improvement in nitrogen related water quality that would be achieved by elevating the jetties to the main tidal inlet of the Harbor to at or above high tide (full tide jetty). This scenario is based on existing watershed nitrogen loading documented in the MEP threshold report and model output was assessed relative to the MassDEP TMDL targets for Nantucket Harbor.

Scenario 4, Monomoy / Shimmo + elevate jetties:

The MEP Nantucket Harbor linked model was used to evaluate the extent of improvement in nitrogen related water quality that would be achieved by the combined actions of (a) lowering nitrogen loading to the watershed from septic systems through the extension of sewer lines into Monomoy and Shimmo areas (Scenario 2) plus (b) increased tidal flushing by elevating the jetties to the main tidal inlet of the Harbor to at or above high tide (full tide jetty; Scenario 3). This scenario is based on existing watershed nitrogen loading modification developed in Scenario 2 and model output was assessed relative to the MassDEP TMDL targets for Nantucket Harbor.

Scenario Results:

As part of the development of the Monomoy and Shimmo sewerage scenarios, MEP staff noted the following watershed/sewer district characteristics:

1. Monomoy sewerage scenario (Scenario 1) has 181 new properties to be seweraged, all are in the Harbor subwatershed, some are also within the existing sewer district but not connected (see figure 1).

2. Monomoy/Shimmo scenario (Scenario 2) has 443 new properties to be sewered (including the properties in the Monomoy sewerage scenario above); 369 are in the Harbor subwatershed & 74 are in the Quaise subwatershed.
3. In the Monomoy scenario (Scenario 1) there are 1,014 properties that remain unsewered in the Town subwatershed, 716 of which are developed or developable.
4. Among the remaining 716 developed or developable properties in the Town subwatershed, 666 are in the existing town sewer district and have either a listing in the database we received from the town as using a septic system (262 parcels)² or no listing of wastewater treatment type (404 parcels).
5. Among the 404 properties within the existing sewer district that have no wastewater classification type, 106 of them have town assessor-assigned land use codes that would indicate that they are developed and would need a septic system or sewer connection.
6. Review of the town-supplied databases used in the MEP N loading model indicates that some of the properties with land use classifications that would not automatically mean they have a wastewater system have buildings on them. Adjusting the count with these properties, indicates that the number of potential septic systems inside the sewer district would be close to 400.
7. Connecting the ~400 properties already inside the existing town sewer district would have approximately the same watershed nitrogen loading reduction as the proposed combined sewerage of Monomoy/Shimmo. The caveat to this is the need to confirm the listings in the Town database, which might be a useful next step if the Town opts to move in this direction at some time in the future.

The effect of extending the sewer lines into the Monomoy area (Scenario 1) and the combined Monomoy and Shimmo area (Scenario 2) to remove nitrogen loads from existing on-site wastewater septic systems was to lower the watershed nitrogen load to the Nantucket Harbor Town basin (Scenario 1: Table 1) and Town and Quaise basins (Scenario 2: Table 2), respectively. No changes in the watershed nitrogen loads occurred in Scenario 3, only tidal flushing was effected (Table 3). Scenario 4 was the combination of the septic effluent removal in Monomoy and Shimmo (Scenario 2) plus the tidal flushing enhancement (Scenario 3). All scenarios resulted in lower nitrogen levels within the receiving waters of the Harbor (Table 4).

The resulting nitrogen levels within the waters of Nantucket Harbor and its tributary basin, Polpis Harbor, were lower compared to present conditions in all scenarios, with resulting TN levels in:

Scenario 1 > Scenario 2 > Scenario 3 > Scenario 4.

Scenario 4, the combined effect of extending sewers to Monomoy and Shimmo plus elevating the main inlet jetties, results in the greatest level of improvement throughout Nantucket Harbor relative to the TMDL. However, Scenario 3 yields nearly identical results, indicating that almost all of the improvement in the combined Scenario 4 results were due to the increase in tidal flushing resulting from the modification of the jetties. Both Scenario 3 and Scenario 4 attain the threshold nitrogen level/TMDL

² Note that connecting these 262 parcels within the existing sewer district (according to the Town database), would have a similar effect on lowering watershed wastewater nitrogen as the reductions proposed in Scenario 1.

(0.350 mg/L TN) at the sentinel station within the Head of the Harbor and both are extremely close to the threshold level/TMDL (0.355 mg/L TN) at the secondary sentinel station within Polpis Harbor. It should also be noted that all of the scenarios (1,2,3,4) are based upon existing, not build-out, conditions, the Town must mitigate any new loads from new development to sustain the improvements in any of the scenarios.

These results indicate that sewer extension to Monomoy and Shimmo areas, alone, is insufficient to meet the threshold targets for restoring Nantucket Harbor's impaired resources. The elevation of the jetties provides more improvement in nitrogen levels, but also is insufficient on its own to meet the threshold nitrogen level/TMDL at *both* sentinel stations. Both sewer extension and alteration of hydrodynamics had positive effects on nitrogen levels. It should also be noted that the parcel analysis conducted within the existing Town sewer area indicated that a large number of parcels may not presently be connected to the existing sewer system presenting an opportunity for additional removal of septic nitrogen (if the town database can be confirmed).

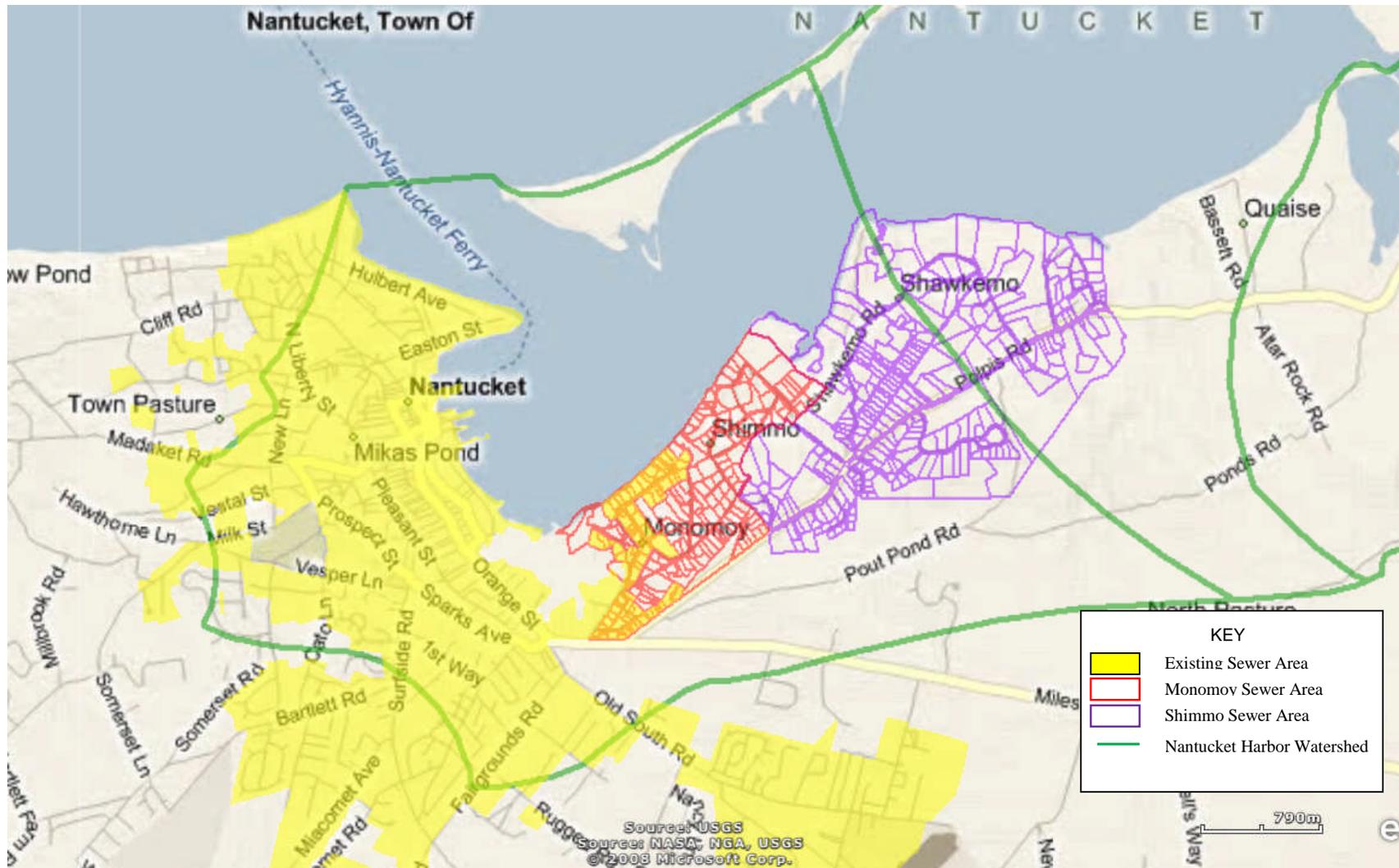


Figure 1. Nantucket Harbor Existing and Proposed Wastewater Collection Areas. The area colored yellow indicates the existing sewer collection area, while the parcels outlined in red are in the Scenario 1/Monomoy collection area and the parcels outlined in purple are in the Shimmo collection area. Scenario 2 combines the Monomoy and Shimmo collection areas. Subwatershed boundaries for Nantucket Harbor are shown in green. Scenario 3 uses existing nitrogen loads and elevates the inlet jetties, increasing tidal flushing. Scenario 4 combines the results of Scenario 2 with elevating the main jetties to the Harbor.

Table 1. Nitrogen loads used for Scenario 1. The difference between the present watershed load and Scenario 1 stems from the removal of septic system wastewater nitrogen load from the Monomoy area (Figure 1).

Subwatershed Area	Present Watershed (kg/day)	Scenario 1 Watershed (kg/day)	Atmospheric (kg/day)	Benthic (kg/day)
Head of the Harbor	1.858	1.858	22.239	-17.082
Polpis Harbor	3.529	3.529	2.190	27.370
Quaise	2.123	2.123	20.126	43.643
Town	15.901	15.208	13.888	-2.775

Table 2. Nitrogen loads used for Scenarios 2 and 4. The difference between the present watershed load and Scenario 1 stems from the removal of septic system wastewater nitrogen load from the Monomoy and Shimmo areas (Figure 1).

Subwatershed Area	Present Watershed (kg/day)	Scenarios 2 & 4 Watershed (kg/day)	Atmospheric (kg/day)	Benthic (kg/day)
Head of the Harbor	1.858	1.858	22.239	-16.953
Polpis Harbor	3.529	3.529	2.190	27.335
Quaise	2.123	1.962	20.126	43.517
Town	15.901	14.784	13.888	-2.775

Table 3. Nitrogen loads used for Scenarios 3. Since this scenario only involves the elevation of the jetties, the present watershed nitrogen load, atmospheric load, and benthic flux is the same as used in the MEP Threshold Report assessment of existing conditions.

Subwatershed Area	Present Watershed (kg/day)	Scenarios 3 Watershed (kg/day)	Atmospheric (kg/day)	Benthic (kg/day)
Head of the Harbor	1.858	1.858	22.239	-17.211
Polpis Harbor	3.529	3.529	2.190	27.441
Quaise	2.123	2.123	20.126	43.896
Town	15.901	15.901	13.888	-2.793

Table 4. Results of watershed loading reductions and elevation of jetties detailed as Scenarios 1-4 above. Total nitrogen concentrations at each water quality station under present conditions and for each scenario are presented in mg/L. Sentinel stations (stations 2.1 and 4) are shown in bold. TN threshold levels at the respective sentinel stations are 0.350 and 0.355 mg/L.						
Station	Station ID	Present TN mg/L	Scenario 1 mg/L	Scenario 2 mg/L	Scenario 3 mg/L	Scenario 4 mg/L
Head of the Harbor-Upper	2	0.397	0.396	0.396	0.395	0.394
Head of the Harbor- Mid	2.2	0.390	0.389	0.388	0.387	0.387
Head of the Harbor- Lower	2.1	0.353	0.352	0.352	0.350	0.349
Pocomo Head	3	0.340	0.339	0.339	0.336	0.336
Quaise Basin	3.1	0.325	0.325	0.324	0.321	0.321
East Polpis	4	0.361	0.361	0.360	0.357	0.357
West Polpis	4.1	0.371	0.370	0.370	0.367	0.367
Abrams Point	5	0.296	0.296	0.296	0.292	0.292
Monomoy	6	0.291	0.290	0.290	0.287	0.286
Mooring Area	7	0.285	0.284	0.284	0.281	0.281