

IX. ALTERNATIVES TO IMPROVE WATER QUALITY

At the request of Town of Barnstable and Town of Yarmouth staff, MEP staff completed six additional scenarios in July of 2007. Through a current Comprehensive Wastewater Management Planning process, the Town of Yarmouth delineated a potential sewer district (Section IV, Figure IV-6). Both town staffs agreed to the following scenarios: A) collection of wastewater within the proposed district and removal of wastewater loads from Lewis Bay watershed, B) collection of wastewater within the proposed district and treatment and discharge at the Hyannis WPCF, and C) collection of wastewater within the proposed district, treatment at the Hyannis WPCF, and discharge within an abandoned bog system to the east of Cape Cod Hospital. Wastewater flows were developed under both current and buildout conditions. It should be noted that in subsequent 18-months since the original six scenarios were run, the water quality models have been further developed and improved upon, thus there may be slight changes in the base loading for the watersheds. However, since these scenarios did not meet the threshold requirements, they were not revisited.

MEP staff developed a separate “sewershed” module for the proposed district, which cuts across six sub-watersheds. The sewershed module contains all the properties in the proposed district according to their current sub-watershed assignments. Just as in the standard nitrogen loading analysis, staff determined water use for all developed properties within the sewershed and potential future water use at buildout based on a review of developable land and additional development on existing developed properties. Total existing wastewater load within the whole sewershed is 7,792 kg/yr and buildout will add 2,486 kg/yr.

Under scenario A, the existing and buildout loads from the sewershed are removed from the respective sub-watersheds. Under scenario B, wastewater flows are assumed to be discharged at the Hyannis WPCF and redistributed to various sub-watersheds based on the analyses described above. Under scenario C, the WPCF-treated effluent from the sewershed is discharged at the abandoned bogs in the Inner Harbor Creek sub-watershed. The scenario C loads receive an additional 30% attenuation from the bog system. Overall impacts on all loads are shown in Table IV-5.

Six additional scenarios were provided to the MEP in the Fall of 2008, by Town of Barnstable and Town of Yarmouth staff. The new scenarios evolved out of the water quality results from the original six scenarios (A through C). Both town staffs agreed to the following scenarios: D) collection of wastewater within the proposed district and removal of wastewater loads from Lewis Bay watershed and discharge outside the watershed, E) collection of wastewater within the proposed district and treatment and discharge at the Hyannis WPCF, and F) collection of wastewater within the proposed district, treatment at the Hyannis WPCF, and discharge within an abandoned bog system to the east of Cape Cod Hospital. Wastewater flows were developed under both current and buildout conditions.

Under scenario D, the existing and buildout loads from the sewershed are removed from the respective sub-watersheds. Under scenario E, wastewater flows are assumed to be discharged at the Hyannis WPCF and redistributed to various sub-watersheds based on the analyses described above. Under scenario F, the WPCF-treated effluent from the sewershed is discharged at the abandoned bogs in the Inner Harbor Creek sub-watershed. The scenario F loads receive an additional 30% attenuation from the bog system.

IX.1 EXISTING LOADING SCENARIO A

Based on the potential sewer district developed by the Town of Yarmouth under their ongoing CWMP process, a set of scenarios were developed to be modeled by the MEP. Both the Towns of Barnstable and Yarmouth were in agreement about the types of scenarios to be modeled and worked together to develop them. Scenario A as developed jointly by the two Towns is based on collection of wastewater within the proposed district and removal of wastewater loads from Lewis Bay watershed. Wastewater flows were developed under both current as presented herein and buildout conditions provided below (Section IX.4). Table IX-1 and Table IX-2 illustrate the overall change to septic and watershed loads resulting from this alternative. Septic removal from potential Lewis Bay sewer district results in significant reductions in the watershed loads in specific sub-embayments, particularly the Mill Creek and Hyannis Inner Harbor sub-watersheds. Based on the assumptions developed for this alternative, Table IX-3 presents the various components of nitrogen loading for the Lewis Bay system. Despite the reductions in load related to the modeled sewer district, the threshold target (0.38 mg/L TN at BHY-3) is approached (0.391 mg/L TN at BHY-3) but not reached at the sentinel station. The load reduction associated with this scenario did yield water column concentrations that were <0.5 mg/L TN (infaunal threshold) at 2 of 3 locations selected as check stations. Concentrations at MC-1 and BH-2 were 0.472 mg/L and 0.486 mg/L respectively, slightly less than the 0.5 mg/L infaunal target.

Table IX-1. Comparison of sub-embayment watershed <i>septic loads</i> (attenuated) used for modeling present loading conditions for Existing Scenario A. 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)	scenario septic load (kg/day)	threshold septic load % change
Lewis Bay	26.490	21.647	-18.3%
Uncle Roberts Cove	0.214	0.214	+0.0%
Mill Creek	13.570	1.923	-85.8%
Hyannis Inner Harbor	6.847	4.663	-31.9%
Snows Creek	7.970	7.970	+0.0%
Stewarts Creek	21.564	21.564	+0.0%
Surface Water Sources			
Chase Brook	2.488	2.463	-1.0%
Mill Pond	10.425	10.003	-4.0%
Hospital Creek/Hyannis Inner	1.907	0.326	-82.9%

Table IX-2. Comparison of sub-embayment **total attenuated watershed loads** (including septic, runoff, and fertilizer) used for modeling of present conditions for Existing Scenario A. These loads do not include direct atmospheric deposition (onto the sub-embayment surface) or benthic flux loading terms.

sub-embayment	present load (kg/day)	scenario load (kg/day)	threshold % change
Lewis Bay	30.855	26.011	-15.7%
Uncle Roberts Cove	0.540	0.540	+0.0%
Mill Creek	15.964	4.318	-73.0%
Hyannis Inner Harbor	12.153	9.970	-18.0%
Snows Creek	15.115	15.115	+0.0%
Stewarts Creek	38.992	38.992	+0.0%
Surface Water Sources			
Chase Brook	3.345	3.321	-0.7%
Mill Pond	15.038	14.616	-2.8%
Hospital Creek/Hyannis Inner	1.907	0.326	-82.9%

Table IX-3. Sub-embayment loads used for total nitrogen modeling of the Lewis Bay system for present loading scenario with present loading conditions for Existing Scenario A, with total watershed N loads, atmospheric N loads, and benthic flux.

sub-embayment	scenario load (kg/day)	direct atmospheric deposition (kg/day)	benthic flux net (kg/day)
Lewis Bay	26.011	13.507	24.872
Uncle Roberts Cove	0.540	0.759	11.940
Mill Creek	4.318	0.627	-1.208
Hyannis Inner Harbor	9.970	0.633	18.990
Snows Creek	15.115	-	-4.533
Stewarts Creek	38.992	0.236	-9.683
Surface Water Sources			
Chase Brook	3.321	-	-
Mill Pond	14.616	-	-
Hospital Creek/Hyannis Inner	0.326	-	-

Table IX-4. Comparison of model average total N concentrations from present loading scenarios (with and without the reduction of septic loads for Existing Scenario A), with percent change, for the Lewis Bay system. The threshold station is shown in bold print.

Sub-Embayment	monitoring station	present (mg/L)	scenario (mg/L)	% change
Hyannis Inner Harbor	BH-1	0.549	0.535	-2.5%
Hyannis Inner Harbor	BH-2	0.496	0.486	-2.0%
Hyannis Inner Harbor	BH-3	0.440	0.422	-4.1%
Snows Creek	BH-4	1.638	1.626	-0.7%
Lewis Bay	BH-5	0.387	0.375	-3.1%
Lewis Bay	BH-6	0.368	0.359	-2.4%
Stewarts Creek	BH-7	1.374	1.372	-0.1%
Lewis Bay	BHY-1	0.384	0.372	-3.0%
Lewis Bay	BHY-2	0.414	0.394	-4.8%
Lewis Bay	BHY-3	0.407	0.391	-4.0%
Uncle Roberts Cove	BHY-4	0.431	0.414	-3.9%
Mill Creek	MC-1	0.531	0.472	-11.1%
Mill Creek	MC-2	0.473	0.433	-8.6%

IX.2 EXISTING LOADING SCENARIO B

Scenario B as developed jointly by the two Towns is based on collection of wastewater within the proposed district and treatment and discharge at the Hyannis WPCF. Wastewater flows were developed under both current conditions presented herein and buildout conditions provided below (Section IX.5). Table IX-5 and Table IX-6 illustrate the overall change to septic and watershed loads resulting from this alternative. Septic removal from potential Lewis Bay sewer district results in significant reductions in the watershed loads in specific sub-embayments, particularly the Mill Creek and Hyannis Inner Harbor sub-watersheds. Unlike Scenario A that showed no change in the septic loads (present vs. scenario) for the Snows Creek and Stewarts Creek sub-watershed, under Scenario B septic loads increase in Snows Creek and decrease in Stewarts Creek. Based on the assumptions developed for this alternative, Table IX-7 presents the various components of nitrogen loading for the Lewis Bay system. Despite the reductions in load related to the modeled sewer district, the threshold target (0.38 mg/L TN at BHY-3) is approached (0.391 mg/L TN at BHY-3) but not reached at the sentinel station. The load reduction associated with this scenario did yield water column concentrations that were <0.5 mg/L TN (infaunal threshold) at 2 of 3 locations selected as check stations. Concentrations at MC-1 and BH-2 were 0.472 mg/L and 0.488 mg/L respectively, slightly less than the 0.5 mg/L infaunal target.

Table IX-5. Comparison of sub-embayment watershed **septic loads** (attenuated) used for modeling present loading conditions for Existing Scenario B. 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)	scenario septic load (kg/day)	threshold septic load % change
Lewis Bay	26.490	21.647	-18.3%
Uncle Roberts Cove	0.214	0.214	0.0%
Mill Creek	13.570	1.923	-85.8%
Hyannis Inner Harbor	6.847	4.899	-28.5%
Snows Creek	7.970	9.088	+14.0%
Stewarts Creek	21.564	13.775	-36.1%
Surface Water Sources			
Chase Brook	2.488	2.463	-1.0%
Mill Pond	10.425	10.003	-4.0%
Hospital Creek/Hyannis Inner	1.907	0.326	-82.9%

Table IX-6. Comparison of sub-embayment **total attenuated watershed loads** (including septic, runoff, and fertilizer) used for modeling of present conditions for Existing Scenario B. These loads do not include direct atmospheric deposition (onto the sub-embayment surface) or benthic flux loading terms.

sub-embayment	present load (kg/day)	scenario load (kg/day)	threshold % change
Lewis Bay	30.855	26.011	-15.7%
Uncle Roberts Cove	0.540	0.540	0.0%
Mill Creek	15.964	4.318	-73.0%
Hyannis Inner Harbor	12.153	10.205	-16.0%
Snows Creek	15.115	16.233	+7.4%
Stewarts Creek	38.992	31.203	-20.0%
Surface Water Sources			
Chase Brook	3.345	3.321	-0.7%
Mill Pond	15.038	14.616	-2.8%
Hospital Creek/Hyannis Inner	1.907	0.326	-82.9%

Table IX-7. Sub-embayment loads used for total nitrogen modeling of the Lewis Bay system for present loading scenario with present loading conditions for Existing Scenario B, 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)
Lewis Bay	26.011	13.507	25.067
Uncle Roberts Cove	0.540	0.759	11.980
Mill Creek	4.318	0.627	-1.208
Hyannis Inner Harbor	10.205	0.633	19.173
Snows Creek	16.233	-	-4.533
Stewarts Creek	31.233	0.236	-10.402
Surface Water Sources			
Chase Brook	3.321	-	-
Mill Pond	14.616	-	-
Hospital Creek/Hyannis Inner	0.326	-	-

Table IX-8. Comparison of model average total N concentrations from present loading scenarios (with and without the reduction of septic loads for Existing Scenario B), with percent change, for the Lewis Bay system. The threshold station is shown in bold print.

Sub-Embayment	monitoring station	present (mg/L)	scenario (mg/L)	% change
Hyannis Inner Harbor	BH-1	0.549	0.538	-2.1%
Hyannis Inner Harbor	BH-2	0.496	0.488	-1.7%
Hyannis Inner Harbor	BH-3	0.440	0.422	-3.9%
Snows Creek	BH-4	1.638	1.754	+7.1%
Lewis Bay	BH-5	0.387	0.375	-3.1%
Lewis Bay	BH-6	0.368	0.359	-2.5%
Stewarts Creek	BH-7	1.374	1.074	-21.9%
Lewis Bay	BHY-1	0.384	0.372	-3.1%
Lewis Bay	BHY-2	0.414	0.394	-4.9%
Lewis Bay	BHY-3	0.407	0.391	-4.1%
Uncle Roberts Cove	BHY-4	0.431	0.414	-4.0%
Mill Creek	MC-1	0.531	0.472	-11.2%
Mill Creek	MC-2	0.473	0.432	-8.7%

IX.3 EXISTING LOADING SCENARIO C

Scenario C as developed jointly by the two Towns is based on Collection of wastewater within the proposed district, treatment at the Hyannis WPCF, and discharge within an abandoned bog system to the east of Cape Cod Hospital. Wastewater flows were developed under both current conditions presented herein and buildout conditions provided below (Section IX.6). Table IX-9 and Table IX-10 illustrate the overall change to septic and watershed loads resulting from this alternative. Septic removal from potential Lewis Bay sewer district results in significant reductions in the watershed loads in specific sub-embayments, particularly the Mill Creek and Hyannis Inner Harbor sub-watersheds. Unlike Scenario B that showed change in the septic loads (present vs. scenario) for the Snows Creek and Stewarts Creek sub-watershed,

under Scenario C septic loads did not change from present conditions for both Snows Creek and Stewarts Creek (similar to Scenario A results). As would be expected, loads to Hospital Creek/Hyannis Inner Harbor go up dramatically over present conditions. Based on the assumptions developed for this alternative, Table IX-11 presents the various components of nitrogen loading for the Lewis Bay system. Despite the reductions in load related to the modeled sewer district, the threshold target (0.38 mg/L TN at BHY-3) is approached less so than under Scenario A and B (0.399 mg/L TN at BHY-3) but not reached at the sentinel station. The load reduction associated with this scenario did yield water column concentrations that were <0.5 mg/L TN (infaunal threshold) at 1 of 3 locations selected as check stations. Concentrations at MC-1 was 0.480 mg/L, slightly less than the 0.5 mg/L infaunal target but not as low as under Scenario A and B.

Table IX-9. Comparison of sub-embayment watershed **septic loads** (attenuated) used for modeling present loading conditions for Existing Scenario C. 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)	scenario septic load (kg/day)	threshold septic load % change
Lewis Bay	26.490	21.647	-18.3%
Uncle Roberts Cove	0.214	0.214	+0.0%
Mill Creek	13.570	1.923	-85.8%
Hyannis Inner Harbor	6.847	4.663	-31.9%
Snows Creek	7.970	7.970	0.0%
Stewarts Creek	21.564	21.564	0.0%
Surface Water Sources			
Chase Brook	2.488	2.463	-1.0%
Mill Pond	10.425	10.003	-4.0%
Hospital Creek/Hyannis Inner	1.907	3.753	+96.8%

Table IX-10. Comparison of sub-embayment **total attenuated watershed loads** (including septic, runoff, and fertilizer) used for modeling of present conditions for Existing Scenario C. These loads do not include direct atmospheric deposition (onto the sub-embayment surface) or benthic flux loading terms.

sub-embayment	present load (kg/day)	scenario load (kg/day)	threshold % change
Lewis Bay	30.855	26.011	-15.7%
Uncle Roberts Cove	0.540	0.540	0.0%
Mill Creek	15.964	4.318	-73.0%
Hyannis Inner Harbor	12.153	9.970	-18.0%
Snows Creek	15.115	15.115	0.0%
Stewarts Creek	38.992	38.992	0.0%
Surface Water Sources			
Chase Brook	3.345	3.321	-0.7%
Mill Pond	15.038	14.616	-2.8%
Hospital Creek/Hyannis Inner	1.907	3.753	+96.8%

Table IX-11. Sub-embayment loads used for total nitrogen modeling of the Lewis Bay system for present loading scenario with present loading conditions for Existing Scenario C, 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)
Lewis Bay	26.011	13.507	25.176
Uncle Roberts Cove	0.540	0.759	12.098
Mill Creek	4.318	0.627	-1.208
Hyannis Inner Harbor	9.970	0.633	18.990
Snows Creek	15.115	-	-4.533
Stewarts Creek	38.992	0.236	-9.683
Surface Water Sources			
Chase Brook	3.321	-	-
Mill Pond	14.616	-	-
Hospital Creek/Hyannis Inner	3.753	-	-

Table IX-12. Comparison of model average total N concentrations from present loading scenarios (with and without the reduction of septic loads for Existing Scenario C), with percent change, for the Lewis Bay system. The threshold station is shown in bold print.

Sub-Embayment	monitoring station	present (mg/L)	scenario (mg/L)	% change
Hyannis Inner Harbor	BH-1	0.549	0.552	+0.5%
Hyannis Inner Harbor	BH-2	0.496	0.503	+1.5%
Hyannis Inner Harbor	BH-3	0.440	0.438	-0.3%
Snows Creek	BH-4	1.638	1.635	-0.2%
Lewis Bay	BH-5	0.387	0.384	-0.8%
Lewis Bay	BH-6	0.368	0.365	-0.9%
Stewarts Creek	BH-7	1.374	1.375	+0.1%
Lewis Bay	BHY-1	0.384	0.379	-1.2%
Lewis Bay	BHY-2	0.414	0.403	-2.8%
Lewis Bay	BHY-3	0.407	0.399	-2.0%
Uncle Roberts Cove	BHY-4	0.431	0.422	-2.1%
Mill Creek	MC-1	0.531	0.480	-9.7%
Mill Creek	MC-2	0.473	0.441	-6.9%

IX.4 BUILD-OUT LOADING SCENARIO A

Scenario A (buildout) as developed jointly by the two Towns is based on collection of wastewater within the proposed district and removal of wastewater loads from Lewis Bay watershed. Wastewater flows were developed under both current conditions as presented above (Section IX.1) and buildout conditions herein. Table IX-13 and Table IX-14 illustrate the overall change to septic and watershed loads resulting from this alternative. Based on the assumptions developed for this alternative, Table IX-15 presents the various components of nitrogen loading for the Lewis Bay system. Despite the reductions in load related to the

modeled sewer district, the threshold target (0.38 mg/L TN at BHY-3) is exceeded at the sentinel station and infaunal check stations under build out conditions.

Table IX-13. Comparison of sub-embayment watershed **septic loads** (attenuated) used for modeling present loading conditions for Build-Out Scenario A. 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)	scenario septic load (kg/day)	threshold septic load % change
Lewis Bay	26.490	20.603	-22.2%
Uncle Roberts Cove	0.214	0.340	+59.0%
Mill Creek	13.570	-2.775	-120.5%
Hyannis Inner Harbor	6.847	4.616	-32.6%
Snows Creek	7.970	9.893	+24.1%
Stewarts Creek	21.564	25.307	+17.4%
Surface Water Sources			
Chase Brook	2.488	2.318	-6.8%
Mill Pond	10.425	8.986	-13.8%
Hospital Creek/Hyannis Inner	1.907	0.332	-82.6%

Table IX-14. Comparison of sub-embayment **total attenuated watershed loads** (including septic, runoff, and fertilizer) used for modeling of present conditions for Build-Out Scenario A. These loads do not include direct atmospheric deposition (onto the sub-embayment surface) or benthic flux loading terms.

sub-embayment	present load (kg/day)	scenario load (kg/day)	threshold % change
Lewis Bay	30.855	29.049	-5.9%
Uncle Roberts Cove	0.540	0.715	+32.5%
Mill Creek	15.964	5.721	-64.2%
Hyannis Inner Harbor	12.153	12.690	+4.4%
Snows Creek	15.115	21.529	+42.4%
Stewarts Creek	38.992	53.959	+38.4%
Surface Water Sources			
Chase Brook	3.345	3.896	+16.5%
Mill Pond	15.038	21.074	+40.1%
Hospital Creek/Hyannis Inner	1.907	0.332	-82.6%

Table IX-15. Sub-embayment loads used for total nitrogen modeling of the Lewis Bay system for present loading scenario with present loading conditions for Build-Out Scenario A, 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)
Lewis Bay	29.049	13.507	26.482
Uncle Roberts Cove	0.715	0.759	13.008
Mill Creek	5.721	0.627	-1.437
Hyannis Inner Harbor	12.690	0.633	21.238
Snows Creek	21.529	-	-6.458
Stewarts Creek	53.959	0.236	-13.489
Surface Water Sources			
Chase Brook	3.896	-	-
Mill Pond	21.074	-	-
Hospital Creek/Hyannis Inner	0.332	-	-

Table IX-16. Comparison of model average total N concentrations from present loading scenarios (with and without the reduction of septic loads for Build-Out Scenario A), with percent change, for the Lewis Bay system. The threshold station is shown in bold print.

Sub-Embayment	monitoring station	present (mg/L)	scenario (mg/L)	% change
Hyannis Inner Harbor	BH-1	0.549	0.575	+4.6%
Hyannis Inner Harbor	BH-2	0.496	0.518	+4.3%
Hyannis Inner Harbor	BH-3	0.440	0.442	+0.5%
Snows Creek	BH-4	1.638	2.171	+32.6%
Lewis Bay	BH-5	0.387	0.387	+0.1%
Lewis Bay	BH-6	0.368	0.368	+0.1%
Stewarts Creek	BH-7	1.374	1.767	+28.6%
Lewis Bay	BHY-1	0.384	0.384	-0.1%
Lewis Bay	BHY-2	0.414	0.412	-0.4%
Lewis Bay	BHY-3	0.407	0.406	-0.3%
Uncle Roberts Cove	BHY-4	0.431	0.430	-0.2%
Mill Creek	MC-1	0.531	0.538	+1.2%
Mill Creek	MC-2	0.473	0.468	-1.2%

IX.5 BUILD-OUT LOADING SCENARIO B

Scenario B (buildout) as developed jointly by the two Towns is based on collection of wastewater within the proposed district and treatment and discharge at the Hyannis WPCF. Wastewater flows were developed under both current conditions as presented above (Section IX.2) and buildout conditions herein. Table IX-17 and Table IX-18 illustrate the overall change to septic and watershed loads resulting from this alternative. Based on the assumptions developed for this alternative, Table IX-19 presents the various components of nitrogen loading for the Lewis Bay system. Despite the reductions in load related to the modeled sewer district,

the threshold target (0.38 mg/L TN at BHY-3) is exceeded at the sentinel station and infaunal check stations under build out conditions.

Table IX-17. Comparison of sub-embayment watershed **septic loads** (attenuated) used for modeling present loading conditions for Build-Out Scenario B. 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)	scenario septic load (kg/day)	threshold septic load % change
Lewis Bay	26.490	20.603	-22.2%
Uncle Roberts Cove	0.214	0.340	+59.0%
Mill Creek	13.570	-2.775	-120.5%
Hyannis Inner Harbor	6.847	4.904	-28.4%
Snows Creek	7.970	11.255	+41.2%
Stewarts Creek	21.564	14.203	-34.1%
Surface Water Sources			
Chase Brook	2.488	2.318	-6.8%
Mill Pond	10.425	8.986	-13.8%
Hospital Creek/Hyannis Inner	1.907	0.332	-82.6%

Table IX-18. Comparison of sub-embayment **total attenuated watershed loads** (including septic, runoff, and fertilizer) used for modeling of present conditions for Build-Out Scenario B. These loads do not include direct atmospheric deposition (onto the sub-embayment surface) or benthic flux loading terms.

sub-embayment	present load (kg/day)	scenario load (kg/day)	threshold % change
Lewis Bay	30.855	29.049	-5.9%
Uncle Roberts Cove	0.540	0.715	+32.5%
Mill Creek	15.964	5.721	-64.2%
Hyannis Inner Harbor	12.153	12.978	+6.8%
Snows Creek	15.115	22.890	+51.4%
Stewarts Creek	38.992	42.855	+9.9%
Surface Water Sources			
Chase Brook	3.345	3.896	+16.5%
Mill Pond	15.038	21.074	+40.1%
Hospital Creek/Hyannis Inner	1.907	0.332	-82.6%

Table IX -19. Sub-embayment loads used for total nitrogen modeling of the Lewis Bay system for present loading scenario with present loading conditions for Build-Out Scenario B, 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)
Lewis Bay	29.049	13.507	26.326
Uncle Roberts Cove	0.715	0.759	13.087
Mill Creek	5.721	0.627	-1.437
Hyannis Inner Harbor	12.978	0.633	21.463
Snows Creek	22.890	-	-6.458
Stewarts Creek	42.855	0.236	-14.288
Surface Water Sources			
Chase Brook	3.896	-	-
Mill Pond	21.074	-	-
Hospital Creek/Hyannis Inner	0.332	-	-

Table IX-20. Comparison of model average total N concentrations from present loading scenarios (with and without the reduction of septic loads for Build-Out Scenario B), with percent change, for the Lewis Bay system. The threshold station is shown in bold print.

Sub-Embayment	monitoring station	present (mg/L)	scenario (mg/L)	% change
Hyannis Inner Harbor	BH-1	0.549	0.577	+5.0%
Hyannis Inner Harbor	BH-2	0.496	0.519	+4.6%
Hyannis Inner Harbor	BH-3	0.440	0.442	+0.6%
Snows Creek	BH-4	1.638	2.325	+42.0%
Lewis Bay	BH-5	0.387	0.386	-0.1%
Lewis Bay	BH-6	0.368	0.367	-0.2%
Stewarts Creek	BH-7	1.374	1.349	-1.8%
Lewis Bay	BHY-1	0.384	0.383	-0.3%
Lewis Bay	BHY-2	0.414	0.411	-0.7%
Lewis Bay	BHY-3	0.407	0.405	-0.6%
Uncle Roberts Cove	BHY-4	0.431	0.429	-0.4%
Mill Creek	MC-1	0.531	0.537	+1.0%
Mill Creek	MC-2	0.473	0.467	-1.4%

IX.6 BUILD-OUT LOADING SCENARIO C

Scenario C (buildout) as developed jointly by the two Towns is based on collection of wastewater within the proposed district, treatment at the Hyannis WPCF, and discharge within an abandoned bog system to the east of Cape Cod Hospital. Wastewater flows were developed under both current conditions as presented above (Section IX.3) and buildout conditions herein. Table IX-21 and Table IX-22 illustrate the overall change to septic and watershed loads resulting from this alternative. Based on the assumptions developed for this alternative, Table IX-23 presents the various components of nitrogen loading for the Lewis Bay system. Despite the reductions in load related to the modeled sewer district, the threshold target (0.38 mg/L TN

at BHY-3) is exceeded at the sentinel station and infaunal check stations under build out conditions.

Table IX-21. Comparison of sub-embayment watershed **septic loads** (attenuated) used for modeling present loading conditions for Build-Out Scenario C. 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)	scenario septic load (kg/day)	threshold septic load % change
Lewis Bay	26.490	20.603	-22.2%
Uncle Roberts Cove	0.214	0.340	+59.0%
Mill Creek	13.570	-2.775	-120.5%
Hyannis Inner Harbor	6.847	4.616	-32.6%
Snows Creek	7.970	9.896	+24.2%
Stewarts Creek	21.564	14.203	-34.1%
Surface Water Sources			
Chase Brook	2.488	2.318	-6.8%
Mill Pond	10.425	8.986	-13.8%
Hospital Creek/Hyannis Inner	1.907	4.507	+136.4%

Table IX-22. Comparison of sub-embayment **total attenuated watershed loads** (including septic, runoff, and fertilizer) used for modeling of present conditions for Build-Out Scenario C. These loads do not include direct atmospheric deposition (onto the sub-embayment surface) or benthic flux loading terms.

sub-embayment	present load (kg/day)	scenario load (kg/day)	threshold % change
Lewis Bay	30.855	29.049	-5.9%
Uncle Roberts Cove	0.540	0.715	+32.5%
Mill Creek	15.964	5.721	-64.2%
Hyannis Inner Harbor	12.153	12.690	+4.4%
Snows Creek	15.115	21.532	+42.5%
Stewarts Creek	38.992	42.855	+9.9%
Surface Water Sources			
Chase Brook	3.345	3.896	+16.5%
Mill Pond	15.038	21.074	+40.1%
Hospital Creek/Hyannis Inner	1.907	4.507	+136.4%

Table IX-23. Sub-embayment loads used for total nitrogen modeling of the Lewis Bay system for present loading scenario with present loading conditions for Build-Out Scenario C, 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)
Lewis Bay	29.049	13.507	26.699
Uncle Roberts Cove	0.715	0.759	13.245
Mill Creek	5.721	0.627	-1.437
Hyannis Inner Harbor	12.690	0.633	21.238
Snows Creek	21.532	-	-6.458
Stewarts Creek	42.855	0.236	-14.288
Surface Water Sources			
Chase Brook	3.896	-	-
Mill Pond	21.074	-	-
Hospital Creek/Hyannis Inner	4.507	-	-

Table IX-24. Comparison of model average total N concentrations from present loading scenarios (with and without the reduction of septic loads for Build-Out Scenario C), with percent change, for the Lewis Bay system. The threshold station is shown in bold print.

Sub-Embayment	monitoring station	present (mg/L)	scenario (mg/L)	% change
Hyannis Inner Harbor	BH-1	0.549	0.594	+8.1%
Hyannis Inner Harbor	BH-2	0.496	0.537	+8.2%
Hyannis Inner Harbor	BH-3	0.440	0.461	+4.8%
Snows Creek	BH-4	1.638	2.181	+33.2%
Lewis Bay	BH-5	0.387	0.396	+2.5%
Lewis Bay	BH-6	0.368	0.373	+1.5%
Stewarts Creek	BH-7	1.374	1.352	-1.6%
Lewis Bay	BHY-1	0.384	0.391	+1.7%
Lewis Bay	BHY-2	0.414	0.421	+1.6%
Lewis Bay	BHY-3	0.407	0.414	+1.6%
Uncle Roberts Cove	BHY-4	0.431	0.438	+1.7%
Mill Creek	MC-1	0.531	0.545	+2.6%
Mill Creek	MC-2	0.473	0.476	+0.6%

IX.7 EXISTING LOADING SCENARIO D

Based on the potential sewer district developed by the Town of Yarmouth under their ongoing CWMP process, a second set of six scenarios were developed to be modeled by the MEP. Scenario D as developed jointly by the two Towns is based on collection of wastewater within the proposed district and removal of wastewater loads from Lewis Bay watershed. Wastewater flows were developed under both current as presented herein and buildout conditions provided below (Section IX.10). Table IX-25 and Table IX-26 illustrate the overall change to septic and watershed loads resulting from this alternative. Septic removal from potential Lewis Bay sewer district results in significant reductions in the watershed loads in

specific sub-embayments, particularly the Mill Creek and Hyannis Inner Harbor sub-watersheds. Based on the assumptions developed for this alternative, Table IX-27 presents the various components of nitrogen loading for the Lewis Bay system. The reductions in load related to the modeled sewer district, meet the threshold target (0.38 mg/L TN at BHY-3) at the sentinel station (0.373 mg/L TN at BHY-3). The load reduction associated with this scenario did yield water column concentrations that were <0.5 mg/L TN (infaunal threshold) at all 3 locations selected as check stations. Concentrations at MC-1 and BH-2 were 0.495 mg/L and 0.454 mg/L respectively, for an average concentration of 0.475 mg/L, which is below the 0.5 mg/L infaunal target. At stations BHY-4 and MC-1 concentrations were 0.396 mg/L and 0.449 mg/L respectively, which are below the 0.4 mg/L and 0.5 mg/L infaunal targets.

Table IX-25. Comparison of sub-embayment watershed septic loads (attenuated) used for modeling present loading conditions for Existing Scenario D. 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)	scenario septic load (kg/day)	threshold septic load % change
Lewis Bay	26.490	0.351	-98.7%
Uncle Roberts Cove	0.214	0.214	0.0%
Mill Creek	13.570	1.614	-88.1%
Hyannis Inner Harbor	6.847	4.723	-31.0%
Snows Creek	7.970	7.970	0.0%
Stewarts Creek	21.564	21.564	0.0%
Surface Water Sources			
Chase Brook	2.488	1.077	-56.7%
Mill Pond	10.425	9.427	-9.6%
Hospital Creek/Hyannis Inner	1.907	0.326	-82.9%

Table IX-26. Comparison of sub-embayment total attenuated watershed loads (including septic, runoff, and fertilizer) used for modeling of present conditions for Existing Scenario D. These loads do not include direct atmospheric deposition (onto the sub-embayment surface) or benthic flux loading terms.			
sub-embayment	present load (kg/day)	scenario load (kg/day)	threshold % change
Lewis Bay	30.855	4.715	-84.7%
Uncle Roberts Cove	0.540	0.540	0.0%
Mill Creek	15.964	4.008	-74.9%
Hyannis Inner Harbor	12.153	10.030	-17.5%
Snows Creek	15.115	15.115	0.0%
Stewarts Creek	38.992	38.992	0.0%
Surface Water Sources			
Chase Brook	3.345	1.934	-42.2%
Mill Pond	15.038	14.041	-6.6%
Hospital Creek/Hyannis Inner	1.907	0.326	-82.9%

Table IX-27. Sub-embayment loads used for total nitrogen modeling of the Lewis Bay system for present loading scenario with present loading conditions for Existing Scenario D, with total watershed N loads, atmospheric N loads, and benthic flux.

sub-embayment	scenario load (kg/day)	direct atmospheric deposition (kg/day)	benthic flux net (kg/day)
Lewis Bay	4.715	13.507	23.396
Uncle Roberts Cove	0.540	0.759	10.556
Mill Creek	4.008	0.627	-1.143
Hyannis Inner Harbor	10.030	0.633	11.261
Snows Creek	15.115	-	-4.533
Stewarts Creek	38.992	0.236	-9.750
Surface Water Sources			
Chase Brook	1.934	-	-
Mill Pond	14.041	-	-
Hospital Creek/Hyannis Inner	0.326	-	-

Table IX-28. Comparison of model average total N concentrations from present loading scenarios (with and without the reduction of septic loads for Existing Scenario D), with percent change, for the Lewis Bay system. The threshold station is shown in bold print.

Sub-Embayment	monitoring station	present (mg/L)	scenario (mg/L)	% change
Hyannis Inner Harbor	BH-1	0.549	0.495	-9.8%
Hyannis Inner Harbor	BH-2	0.496	0.454	-8.5%
Hyannis Inner Harbor	BH-3	0.440	0.405	-7.9%
Snows Creek	BH-4	1.638	1.615	-1.4%
Lewis Bay	BH-5	0.387	0.363	-6.1%
Lewis Bay	BH-6	0.368	0.350	-4.8%
Stewarts Creek	BH-7	1.374	1.365	-0.6%
Lewis Bay	BHY-1	0.384	0.361	-6.0%
Lewis Bay	BHY-2	0.414	0.378	-8.8%
Lewis Bay	BHY-3	0.407	0.373	-8.4%
Uncle Roberts Cove	BHY-4	0.431	0.396	-8.1%
Mill Creek	MC-1	0.531	0.449	-15.5%
Mill Creek	MC-2	0.473	0.406	-14.3%

IX.8 EXISTING LOADING SCENARIO E

Scenario E as developed jointly by the two Towns is based on collection of wastewater within the proposed district and treatment and discharge at the Hyannis WPCF. Wastewater flows were developed under both current conditions presented herein and buildout conditions provided below (Section IX.11). Table IX-29 and Table IX-30 illustrate the overall change to septic and watershed loads resulting from this alternative. Septic removal from potential Lewis Bay sewer district results in significant reductions in the watershed loads in specific sub-embayments, particularly the Mill Creek and Hyannis Inner Harbor sub-watersheds. Unlike Scenario D that showed no change in the septic loads (present vs. scenario) for the Snows

Creek and Stewarts Creek sub-watershed, under Scenario E septic loads increase in Snows Creek and Stewarts Creek. Based on the assumptions developed for this alternative, Table IX-31 presents the various components of nitrogen loading for the Lewis Bay system. The reductions in load related to the modeled sewer district, meet the threshold target (0.38 mg/L TN at BHY-3) at the sentinel station (0.374 mg/L TN at BHY-3). In addition, the load reduction associated with this scenario did yield water column concentrations that were <0.5 mg/L TN (infaunal threshold) at all 3 locations selected as check stations. Concentrations at MC-1 and average of BH-1 and BH-2 were 0.450 mg/L and 0.480 mg/L respectively, slightly less than the 0.5 mg/L infaunal target.

Table IX-29. Comparison of sub-embayment watershed **septic loads** (attenuated) used for modeling present loading conditions for Existing Scenario E. 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)	scenario septic load (kg/day)	threshold septic load % change
Lewis Bay	26.490	0.351	-98.7%
Uncle Roberts Cove	0.214	0.214	0.0%
Mill Creek	13.570	1.614	-88.1%
Hyannis Inner Harbor	6.847	5.244	-23.4%
Snows Creek	7.970	10.427	+30.8%
Stewarts Creek	21.564	27.310	+26.6%
Surface Water Sources			
Chase Brook	2.488	1.077	-56.7%
Mill Pond	10.425	9.427	-9.6%
Hospital Creek/Hyannis Inner	1.907	0.326	-82.9%

Table IX-30. Comparison of sub-embayment **total attenuated watershed loads** (including septic, runoff, and fertilizer) used for modeling of present conditions for Existing Scenario E. These loads do not include direct atmospheric deposition (onto the sub-embayment surface) or benthic flux loading terms.

sub-embayment	present load (kg/day)	scenario load (kg/day)	threshold % change
Lewis Bay	30.855	4.715	-84.7%
Uncle Roberts Cove	0.540	0.540	0.0%
Mill Creek	15.964	4.008	-74.9%
Hyannis Inner Harbor	12.153	10.551	-13.2%
Snows Creek	15.115	17.573	+16.3%
Stewarts Creek	38.992	44.737	+14.7%
Surface Water Sources			
Chase Brook	3.345	1.934	-42.2%
Mill Pond	15.038	14.041	-6.6%
Hospital Creek/Hyannis Inner	1.907	0.326	-82.9%

Table IX-31. Sub-embayment loads used for total nitrogen modeling of the Lewis Bay system for present loading scenario with present loading conditions for Existing Scenario E, 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)
Lewis Bay	4.715	13.507	23.434
Uncle Roberts Cove	0.540	0.759	10.715
Mill Creek	4.008	0.627	-1.143
Hyannis Inner Harbor	10.551	0.633	11.538
Snows Creek	17.573	-	-5.272
Stewarts Creek	44.737	0.236	-11.188
Surface Water Sources			
Chase Brook	1.934	-	-
Mill Pond	14.041	-	-
Hospital Creek/Hyannis Inner	0.326	-	-

Table IX-32. Comparison of model average total N concentrations from present loading scenarios (with and without the reduction of septic loads for Existing Scenario E), with percent change, for the Lewis Bay system. The threshold station is shown in bold print.

Sub-Embayment	monitoring station	present (mg/L)	scenario (mg/L)	% change
Hyannis Inner Harbor	BH-1	0.549	0.502	-8.6%
Hyannis Inner Harbor	BH-2	0.496	0.459	-7.5%
Hyannis Inner Harbor	BH-3	0.440	0.408	-7.2%
Snows Creek	BH-4	1.638	1.821	+11.2%
Lewis Bay	BH-5	0.387	0.365	-5.6%
Lewis Bay	BH-6	0.368	0.352	-4.4%
Stewarts Creek	BH-7	1.374	1.516	+10.4%
Lewis Bay	BHY-1	0.384	0.362	-5.6%
Lewis Bay	BHY-2	0.414	0.379	-8.4%
Lewis Bay	BHY-3	0.407	0.374	-8.0%
Uncle Roberts Cove	BHY-4	0.431	0.398	-7.7%
Mill Creek	MC-1	0.531	0.450	-15.2%
Mill Creek	MC-2	0.473	0.407	-13.9%

IX.9 EXISTING LOADING SCENARIO F

Scenario F as developed jointly by the two Towns is based on Collection of wastewater within the proposed district, treatment at the Hyannis WPCF, and discharge within an abandoned bog system to the east of Cape Cod Hospital. Wastewater flows were developed under both current conditions presented herein and buildout conditions provided below (Section IX.12). Table IX-33 and Table IX-34 illustrate the overall change to septic and watershed loads resulting from this alternative. Septic removal from potential Lewis Bay sewer district results in significant reductions in the watershed loads in specific sub-embayments, particularly the Mill Creek and Lewis Bay sub-watersheds. Unlike Scenario E that showed change in the septic loads (present vs. scenario) for the Snows Creek and Stewarts Creek sub-watershed, under

Scenario F septic loads did not change from present conditions for both Snows Creek and Stewarts Creek (similar to Scenario D results). As would be expected, loads to Hospital Creek/Hyannis Inner Harbor go up dramatically over present conditions. Based on the assumptions developed for this alternative, Table IX-35 presents the various components of nitrogen loading for the Lewis Bay system. Despite the reductions in load related to the modeled sewer district, the threshold target (0.38 mg/L TN at BHY-3) is approached (0.390 mg/L TN at BHY-3) but not reached at the sentinel station. The load reduction associated with this scenario did yield water column concentrations that were <0.5 mg/L TN (infaunal threshold) at 1 of 3 locations selected as check stations. Concentrations at MC-1 was 0.465 mg/L, slightly less than the 0.5 mg/L infaunal target.

Table IX-33. Comparison of sub-embayment watershed **septic loads** (attenuated) used for modeling present loading conditions for Existing Scenario F. 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)	scenario septic load (kg/day)	threshold septic load % change
Lewis Bay	26.490	0.351	-98.7%
Uncle Roberts Cove	0.214	0.214	0.0%
Mill Creek	13.570	1.614	-88.1%
Hyannis Inner Harbor	6.847	4.723	-31.0%
Snows Creek	7.970	7.970	0.0%
Stewarts Creek	21.564	21.564	0.0%
Surface Water Sources			
Chase Brook	2.488	1.077	-56.7%
Mill Pond	10.425	9.427	-9.6%
Hospital Creek/Hyannis Inner	1.907	7.863	+312.4%

Table IX-34. Comparison of sub-embayment **total attenuated watershed loads** (including septic, runoff, and fertilizer) used for modeling of present conditions for Existing Scenario F. These loads do not include direct atmospheric deposition (onto the sub-embayment surface) or benthic flux loading terms.

sub-embayment	present load (kg/day)	scenario load (kg/day)	threshold % change
Lewis Bay	30.855	4.715	-84.7%
Uncle Roberts Cove	0.540	0.540	0.0%
Mill Creek	15.964	4.008	-74.9%
Hyannis Inner Harbor	12.153	10.030	-17.5%
Snows Creek	15.115	15.115	0.0%
Stewarts Creek	38.992	38.992	0.0%
Surface Water Sources			
Chase Brook	3.345	1.934	-42.2%
Mill Pond	15.038	14.041	-6.6%
Hospital Creek/Hyannis Inner	1.907	7.863	+312.4%

Table IX-35. Sub-embayment loads used for total nitrogen modeling of the Lewis Bay system for present loading scenario with present loading conditions for Existing Scenario F, 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)
Lewis Bay	4.715	13.507	23.652
Uncle Roberts Cove	0.540	0.759	10.912
Mill Creek	4.008	0.627	-1.143
Hyannis Inner Harbor	10.030	0.633	11.261
Snows Creek	15.115	-	-4.533
Stewarts Creek	38.992	0.236	-9.750
Surface Water Sources			
Chase Brook	1.934	-	-
Mill Pond	14.041	-	-
Hospital Creek/Hyannis Inner	7.863	-	-

Table IX-36. Comparison of model average total N concentrations from present loading scenarios (with and without the reduction of septic loads for Existing Scenario F), with percent change, for the Lewis Bay system. The threshold station is shown in bold print.

Sub-Embayment	monitoring station	present (mg/L)	scenario (mg/L)	% change
Hyannis Inner Harbor	BH-1	0.549	0.532	-3.1%
Hyannis Inner Harbor	BH-2	0.496	0.491	-1.1%
Hyannis Inner Harbor	BH-3	0.440	0.441	+0.4%
Snows Creek	BH-4	1.638	1.634	-0.2%
Lewis Bay	BH-5	0.387	0.383	-1.0%
Lewis Bay	BH-6	0.368	0.362	-1.6%
Stewarts Creek	BH-7	1.374	1.371	-0.2%
Lewis Bay	BHY-1	0.384	0.376	-2.1%
Lewis Bay	BHY-2	0.414	0.396	-4.5%
Lewis Bay	BHY-3	0.407	0.390	-4.2%
Uncle Roberts Cove	BHY-4	0.431	0.413	-4.2%
Mill Creek	MC-1	0.531	0.465	-12.5%
Mill Creek	MC-2	0.473	0.423	-10.6%

IX.10 BUILD-OUT LOADING SCENARIO D

Scenario D (buildout) as developed jointly by the two Towns is based on collection of wastewater within the proposed district and removal of wastewater loads from Lewis Bay watershed. Wastewater flows were developed under both current conditions as presented above (Section IX.7) and buildout conditions herein. Table IX-37 and Table IX-38 illustrate the overall change to septic and watershed loads resulting from this alternative. Based on the assumptions developed for this alternative, Table IX-39 presents the various components of nitrogen loading for the Lewis Bay system. Despite the reductions in load related to the

modeled sewer district, the threshold target (0.38 mg/L TN at BHY-3) is exceeded at the sentinel station and infaunal check stations under build out conditions.

Table IX-37. Comparison of sub-embayment watershed **septic loads** (attenuated) used for modeling present loading conditions for Build-Out Scenario D. 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)	scenario septic load (kg/day)	threshold septic load % change
Lewis Bay	26.490	-3.266	-112.3%
Uncle Roberts Cove	0.214	0.340	+59.0%
Mill Creek	13.570	-2.814	-120.7%
Hyannis Inner Harbor	6.847	4.688	-31.5%
Snows Creek	7.970	9.896	+24.2%
Stewarts Creek	21.564	25.307	+17.4%
Surface Water Sources			
Chase Brook	2.488	0.534	-78.5%
Mill Pond	10.425	9.726	-6.7%
Hospital Creek/Hyannis Inner	1.907	0.332	-82.6%

Table IX-38. Comparison of sub-embayment **total attenuated watershed loads** (including septic, runoff, and fertilizer) used for modeling of present conditions for Build-Out Scenario D. These loads do not include direct atmospheric deposition (onto the sub-embayment surface) or benthic flux loading terms.

sub-embayment	present load (kg/day)	scenario load (kg/day)	threshold % change
Lewis Bay	30.855	5.181	-83.2%
Uncle Roberts Cove	0.540	0.715	+32.5%
Mill Creek	15.964	5.682	-64.4%
Hyannis Inner Harbor	12.153	12.762	+5.0%
Snows Creek	15.115	21.532	+42.5%
Stewarts Creek	38.992	53.959	+38.4%
Surface Water Sources			
Chase Brook	3.345	2.112	-36.9%
Mill Pond	15.038	21.814	+45.1%
Hospital Creek/Hyannis Inner	1.907	0.332	-82.6%

Table IX-39. Sub-embayment loads used for total nitrogen modeling of the Lewis Bay system for present loading scenario with present loading conditions for Build-Out Scenario D, 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)
Lewis Bay	5.181	13.507	24.546
Uncle Roberts Cove	0.715	0.759	11.505
Mill Creek	5.682	0.627	-1.404
Hyannis Inner Harbor	12.762	0.633	12.659
Snows Creek	21.532	-	-6.458
Stewarts Creek	53.959	0.236	-13.489
Surface Water Sources			
Chase Brook	2.112	-	-
Mill Pond	21.814	-	-
Hospital Creek/Hyannis Inner	0.332	-	-

Table IX-40. Comparison of model average total N concentrations from present loading scenarios (with and without the reduction of septic loads for Build-Out Scenario D), with percent change, for the Lewis Bay system. The threshold station is shown in bold print.

Sub-Embayment	monitoring station	present (mg/L)	scenario (mg/L)	% change
Hyannis Inner Harbor	BH-1	0.549	0.531	-3.4%
Hyannis Inner Harbor	BH-2	0.496	0.482	-2.9%
Hyannis Inner Harbor	BH-3	0.440	0.423	-3.7%
Snows Creek	BH-4	1.638	2.160	+31.9%
Lewis Bay	BH-5	0.387	0.374	-3.2%
Lewis Bay	BH-6	0.368	0.359	-2.5%
Stewarts Creek	BH-7	1.374	1.762	+28.2%
Lewis Bay	BHY-1	0.384	0.371	-3.3%
Lewis Bay	BHY-2	0.414	0.395	-4.7%
Lewis Bay	BHY-3	0.407	0.386	-5.1%
Uncle Roberts Cove	BHY-4	0.431	0.410	-4.8%
Mill Creek	MC-1	0.531	0.522	-1.7%
Mill Creek	MC-2	0.473	0.441	-6.9%

IX.11 BUILD-OUT LOADING SCENARIO E

Scenario E (buildout) as developed jointly by the two Towns is based on collection of wastewater within the proposed district and treatment and discharge at the Hyannis WPCF. Wastewater flows were developed under both current conditions as presented above (Section IX.8) and buildout conditions herein. Table IX-41 and Table IX-42 illustrate the overall change to septic and watershed loads resulting from this alternative. Based on the assumptions developed for this alternative, Table IX-43 presents the various components of nitrogen loading for the Lewis Bay system. Despite the reductions in load related to the modeled sewer district, the threshold target (0.38 mg/L TN at BHY-3) is exceeded at the sentinel station and infaunal check stations under build out conditions.

Table IX-41. Comparison of sub-embayment watershed **septic loads** (attenuated) used for modeling present loading conditions for Build-Out Scenario E. 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)	scenario septic load (kg/day)	threshold septic load % change
Lewis Bay	26.490	-3.266	-112.3%
Uncle Roberts Cove	0.214	0.340	+59.0%
Mill Creek	13.570	-2.814	-120.7%
Hyannis Inner Harbor	6.847	5.315	-22.4%
Snows Creek	7.970	12.847	+61.2%
Stewarts Creek	21.564	32.205	+49.3%
Surface Water Sources			
Chase Brook	2.488	0.534	-78.5%
Mill Pond	10.425	9.726	-6.7%
Hospital Creek/Hyannis Inner	1.907	0.332	-82.6%

Table IX-42. Comparison of sub-embayment **total attenuated watershed loads** (including septic, runoff, and fertilizer) used for modeling of present conditions for Build-Out Scenario E. These loads do not include direct atmospheric deposition (onto the sub-embayment surface) or benthic flux loading terms.

sub-embayment	present load (kg/day)	scenario load (kg/day)	threshold % change
Lewis Bay	30.855	5.181	-83.2%
Uncle Roberts Cove	0.540	0.715	+32.5%
Mill Creek	15.964	5.682	-64.4%
Hyannis Inner Harbor	12.153	13.389	+10.2%
Snows Creek	15.115	24.482	+62.0%
Stewarts Creek	38.992	60.858	+56.1%
Surface Water Sources			
Chase Brook	3.345	2.112	-36.9%
Mill Pond	15.038	21.814	+45.1%
Hospital Creek/Hyannis Inner	1.907	0.332	-82.6%

Table IX -43. Sub-embayment loads used for total nitrogen modeling of the Lewis Bay system for present loading scenario with present loading conditions for Build-Out Scenario E, 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)
Lewis Bay	5.181	13.507	24.585
Uncle Roberts Cove	0.715	0.759	11.703
Mill Creek	5.682	0.627	-1.404
Hyannis Inner Harbor	13.389	0.633	12.972
Snows Creek	24.482	-	-7.343
Stewarts Creek	60.858	0.236	-15.215
Surface Water Sources			
Chase Brook	2.112	-	-
Mill Pond	21.814	-	-
Hospital Creek/Hyannis Inner	0.332	-	-

Table IX-44. Comparison of model average total N concentrations from present loading scenarios (with and without the reduction of septic loads for Build-Out Scenario E), with percent change, for the Lewis Bay system. The threshold station is shown in bold print.

Sub-Embayment	monitoring station	present (mg/L)	scenario (mg/L)	% change
Hyannis Inner Harbor	BH-1	0.549	0.538	-2.0%
Hyannis Inner Harbor	BH-2	0.496	0.488	-1.7%
Hyannis Inner Harbor	BH-3	0.440	0.427	-2.8%
Snows Creek	BH-4	1.638	2.408	+47.0%
Lewis Bay	BH-5	0.387	0.377	-2.6%
Lewis Bay	BH-6	0.368	0.360	-2.1%
Stewarts Creek	BH-7	1.374	1.943	+41.5%
Lewis Bay	BHY-1	0.384	0.373	-2.9%
Lewis Bay	BHY-2	0.414	0.397	-4.2%
Lewis Bay	BHY-3	0.407	0.388	-4.7%
Uncle Roberts Cove	BHY-4	0.431	0.412	-4.3%
Mill Creek	MC-1	0.531	0.524	-1.4%
Mill Creek	MC-2	0.473	0.443	-6.5%

IX.12 BUILD-OUT LOADING SCENARIO F

Scenario F (buildout) as developed jointly by the two Towns is based on collection of wastewater within the proposed district, treatment at the Hyannis WPCF, and discharge within an abandoned bog system to the east of Cape Cod Hospital. Wastewater flows were developed under both current conditions as presented above (Section IX.9) and buildout conditions herein. Table IX-45 and Table IX-46 illustrate the overall change to septic and watershed loads resulting from this alternative. Based on the assumptions developed for this alternative, Table IX-47 presents the various components of nitrogen loading for the Lewis Bay system. Despite the reductions in load related to the modeled sewer district, the threshold target (0.38 mg/L TN

at BHY-3) is exceeded at the sentinel station and infaunal check stations under build out conditions.

Table IX-45. Comparison of sub-embayment watershed **septic loads** (attenuated) used for modeling present loading conditions for Build-Out Scenario F. 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)	scenario septic load (kg/day)	threshold septic load % change
Lewis Bay	26.490	-3.266	-112.3%
Uncle Roberts Cove	0.214	0.340	+59.0%
Mill Creek	13.570	-2.814	-120.7%
Hyannis Inner Harbor	6.847	4.688	-31.5%
Snows Creek	7.970	9.896	+24.2%
Stewarts Creek	21.564	25.307	+17.4%
Surface Water Sources			
Chase Brook	2.488	0.534	-78.5%
Mill Pond	10.425	9.726	-6.7%
Hospital Creek/Hyannis Inner	1.907	9.384	+392.1%

Table IX-46. Comparison of sub-embayment **total attenuated watershed loads** (including septic, runoff, and fertilizer) used for modeling of present conditions for Build-Out Scenario F. These loads do not include direct atmospheric deposition (onto the sub-embayment surface) or benthic flux loading terms.

sub-embayment	present load (kg/day)	scenario load (kg/day)	threshold % change
Lewis Bay	30.855	5.181	-83.2%
Uncle Roberts Cove	0.540	0.715	+32.5%
Mill Creek	15.964	5.682	-64.4%
Hyannis Inner Harbor	12.153	12.762	+5.0%
Snows Creek	15.115	21.532	+42.5%
Stewarts Creek	38.992	53.959	+38.4%
Surface Water Sources			
Chase Brook	3.345	2.112	-36.9%
Mill Pond	15.038	21.814	+45.1%
Hospital Creek/Hyannis Inner	1.907	9.384	+392.1%

Table IX-47. Sub-embayment loads used for total nitrogen modeling of the Lewis Bay system for present loading scenario with present loading conditions for Build-Out Scenario F, 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)
Lewis Bay	5.181	13.507	25.067
Uncle Roberts Cove	0.715	0.759	11.980
Mill Creek	5.682	0.627	-1.404
Hyannis Inner Harbor	12.762	0.633	6.937
Snows Creek	21.532	-	-6.458
Stewarts Creek	53.959	0.236	-13.489
Surface Water Sources			
Chase Brook	2.112	-	-
Mill Pond	21.814	-	-
Hospital Creek/Hyannis Inner	9.384	-	-

Table IX-48. Comparison of model average total N concentrations from present loading scenarios (with and without the reduction of septic loads for Build-Out Scenario F), with percent change, for the Lewis Bay system. The threshold station is shown in bold print.

Sub-Embayment	monitoring station	present (mg/L)	scenario (mg/L)	% change
Hyannis Inner Harbor	BH-1	0.549	0.540	-1.8%
Hyannis Inner Harbor	BH-2	0.496	0.502	+1.3%
Hyannis Inner Harbor	BH-3	0.440	0.456	+3.8%
Snows Creek	BH-4	1.638	2.180	+33.1%
Lewis Bay	BH-5	0.387	0.395	+2.3%
Lewis Bay	BH-6	0.368	0.371	+1.0%
Stewarts Creek	BH-7	1.374	1.768	+28.7%
Lewis Bay	BHY-1	0.384	0.387	+0.9%
Lewis Bay	BHY-2	0.414	0.414	+0.0%
Lewis Bay	BHY-3	0.407	0.405	-0.6%
Uncle Roberts Cove	BHY-4	0.431	0.429	-0.5%
Mill Creek	MC-1	0.531	0.540	+1.6%
Mill Creek	MC-2	0.473	0.460	-2.9%