IX. IMPACTS TO WATER QUALITY DUE TO INLET MIGRATION

IX.1 HYDRODYNAMIC EFFECTS FROM ALTERNATE INLET CONFIGURATION

As discussed in Chapter V, Pleasant Bay has a migrating inlet that over time can vary greatly the tidal conditions throughout the estuary. The present inlet configuration is nearly optimal with regard to tidal exchange for Pleasant Bay. In past years, when the inlet was positioned farther south (as it was prior to the 1987 breach) tidal conditions were less than optimal due to the additional hydraulic resistance caused by the longer inlet channel, and also because the tide range at the inlet was less. The tide range decreases as the inlet moves south due to the difference in tide ranges between the Atlantic Ocean offshore Nauset Beach and Nantucket Sound offshore Stage Harbor (southern Chatham). Therefore, as the inlet migrates, the average tide range that drives circulation in the Pleasant Bay system could vary potentially about 4 feet.

An analysis was performed to evaluate water quality conditions for the worst-case flushing scenario for Pleasant Bay. The hydrodynamic model grid of Pleasant Bay was modified to include the inlet as it existed pre-breach. The tidal open boundary condition used to drive the model was developed from a tide record measured offshore Stage Harbor in Nantucket Sound in the summer of 2000. The tide in Nantucket Sound represents the smallest tide that the inlet to Pleasant Bay could be exposed to, which is why it was selected for this worst-cases analysis.

A comparison of present a worst case tidal conditions in Pleasant Bay is presented in Figure IX-1. In this figure, hydrodynamic model output from the simulations of present and worst-case conditions are shown for stations at the inlet, at the fish pier at Chatham Harbor and in Meetinghouse Pond. From the data, the maximum tide range at the inlet is reduced from approximately 10 feet to 6 feet. At the fish pier, the range is reduced from 7 feet to 4 feet, and in Meetinghouse Pond the tide range for the worst case scenario is 2 feet smaller than the 5.5 foot range from present conditions.

Flushing rates for the old inlet scenario were computed based on the mean system volumes and prisms computed from the hydrodynamic model output. The comparison between present flushing conditions and those for the old inlet are presented in Tables IX-1 and XI-2. Generally, the mean volume of all the system sub-embayments changes less than 12%. The mean tide prisms computed for all the sub-embayments decrease more than 34%. The large decrease in tide prism results in greatly impaired flushing conditions for the whole of the Pleasant Bay system as indicated by the residence times shown in Table IX-2, where it can be seen that local flushing times increase between 22% and 44% in the system sub-embayments. By the flushing analysis alone, it is apparent that water quality conditions in Pleasant Bay could be severely impacted by a less than optimal arrangement of the system inlet.

IX.2 WATER QUALITY COMPARISON OF INLET SCENARIOS

Water quality impacts resulting from the worst-case inlet configuration are further investigated through the use of the RMA-4 water quality model created for Pleasant Bay. Using the hydrodynamic model output developed for the old inlet scenario and present nitrogen loading conditions (Table V-2), the RMA-4 model was re-run to quantify how N concentrations in the system would change as a result of impaired tidal flushing.

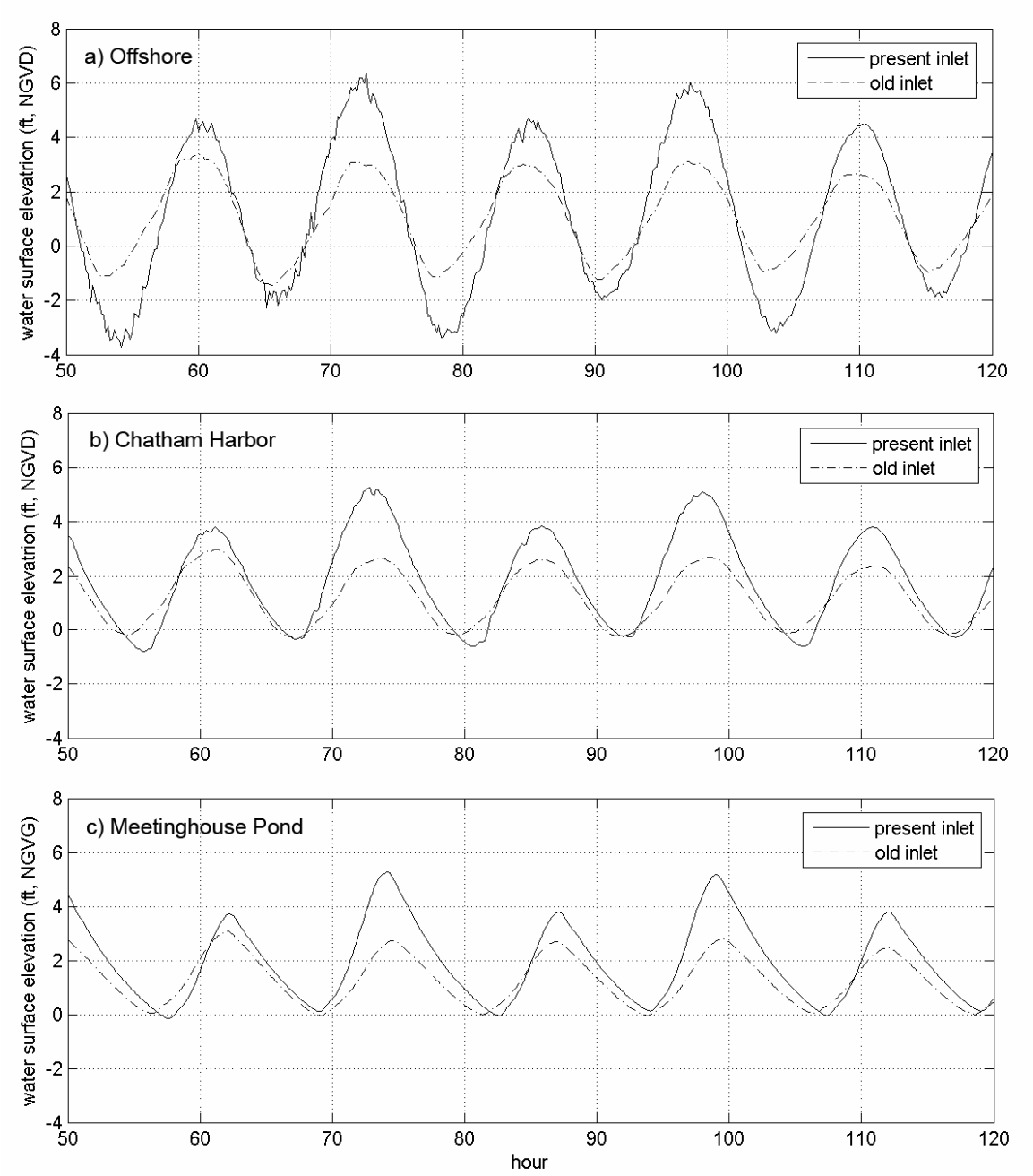

Figure IX-1. Comparison of hydrodynamic model output from simulations of present and historical ("old inlet") configurations of the inlet to Pleasant Bay. The old inlet simulation included a tidal boundary condition developed from a data record measured offshore Stage Harbor in Nantucket Sound, which is considered to be the worst-case tidal condition for Pleasant Bay.

Table IX-1. Embayment mean volumes and average tidal prism during simulation period, for present condition and historical pre-breach inlet configuration with Nantucket Sound tides ("Old Inlet").

Embayment	Present Mean System Volume (ft^3)	Old Inlet Mean System Volume (ft^3)	% change
Pleasant Bay	2,113,621,000	1,941,501,000	-8.1%
Bassing Harbor	109,139,000	97,626,000	-10.5%
Crows Pond	50,208,000	46,482,000	-7.4%
Ryder Cove	18,070,000	15,941,000	-11.8%
Muddy Creek	5,541,000	4,309,000	-22.2%
The River	96,032,000	85,417,000	-11.1%
Round Cove	2,913,000	2,428,000	-16.6%
Paw Wah Pond	2,341,000	2,067,000	-11.7%
Areys Pond	5,474,000	5,013,000	-8.4%
Kescayo Gansett Pond	6,330,000	5,827,000	-7.9%
Meetinghouse Pond	19,406,000	17,974,000	-7.4%
Embayment	Present Tide Prism Volume (ft^3)	Old Inlet Tide Prism Volume (ft^3)	% change
Pleasant Bay	1,207,917,000	789,266,000	-34.7%
Bassing Harbor	66,133,000	42,656,000	-35.5%
Crows Pond	21,898,000	14,124,000	-35.5%
Ryder Cove	12,534,000	8,086,000	-35.5%
Muddy Creek	806,000	515,000	-36.1%
The River	60,199,000	39,384,000	-34.6%
Round Cove	2,738,000	1,777,000	-35.1%
Paw Wah Pond	1,538,000	1,005,000	-34.7%
Areys Pond	2,623,000	1,715,000	-34.6%
Kescayo Gansett Pond	2,864,000	1,874,000	-34.6%
Meetinghouse Pond	8,167,000	5,341,000	-34.6%

A side-by-side comparison of bioactive nitrogen model output from the simulations of present and worst-case inlet conditions is presented in Figure IX-2. The color contour plots emphasize dramatically that there would be a serious degradation in water quality in the whole of the Pleasant Bay system as a result of worst-case flushing conditions at the inlet. The average bioactive N concentration in the main basin of Pleasant Bay increases 50%, from 0.157 mg/L to 0.235 mg/L. The range of concentrations in the main basin for the worst-case would be from 0.146 mg/L at the entrance to Chatham Harbor to 0.279 mg/L at the northernmost reach of Little Pleasant Bay, compared to 0.107 mg/L to 0.184 mg/L for present conditions.

Table IX-2. Computed System and Local residence times for embayments in the Pleasant Bay system, for present conditions and the historical pre-breach inlet configuration with Nantucket Sound tides ("Old Inlet").

Embayment	Present System residence time (days)	Old Inlet System residence time (days)	% change
Pleasant Bay	0.9	1.3	+40.6%
Bassing Harbor	16.5	23.6	+42.4%
Crows Pond	49.9	71.1	+42.4%
Ryder Cove	87.3	124.3	+42.4%
Muddy Creek	1357.1	1950.9	+43.8%
The River	18.2	25.5	+40.4%
Round Cove	399.5	565.4	+41.5%
Paw Wah Pond	711.2	999.7	+40.6%
Areys Pond	417.0	585.8	+40.5%
Kescayo Gansett Pond	381.9	536.1	+40.4%
Meetinghouse Pond	133.9	188.1	+40.5%
Embayment	Present Local residence time (days)	Old Inlet Local residence time (days)	% change
Pleasant Bay	0.9	1.3	+40.6%
Bassing Harbor	0.9	1.2	+38.7%
Crows Pond	1.2	1.7	+43.5%
Ryder Cove	0.7	1.0	+36.7%
Muddy Creek	3.6	4.3	+21.7%
The River	0.8	1.1	+36.0%
Round Cove	0.6	0.7	+28.4%
Paw Wah Pond	0.8	1.1	+35.1%
Areys Pond	1.1	1.5	+40.1%
Kescayo Gansett Pond	1.1	1.6	+40.7%
Meetinghouse Pond	1.2	1.7	+41.6%

An additional comparison of bioactive N model output for the two scenarios is presented in Table IX-3, which shows the difference in N concentrations at each of the water quality monitoring stations (Figure V-1). Increases in bioactive N concentrations range from 30% in Chatham Harbor to 62% at Pochet Neck. With the old inlet hydrodynamics and present loading conditions, the eelgrass threshold sentinel stations at the head of Pleasant Bay (PBA-12) and in Ryder Cove (PBA-03 and CH-13) would not be supportive of even quality benthic infaunal habitat.

The widespread loss of quality eelgrass habitat results from the poor tide flushing of the old inlet configuration run with Nantucket Sound tides. The area coverage of the main basin of Pleasant Bay with a bioactive N concentration less than the eelgrass threshold, discussed in Chapter VIII (0.16 mg/L), would decrease approximately 89% from present conditions.

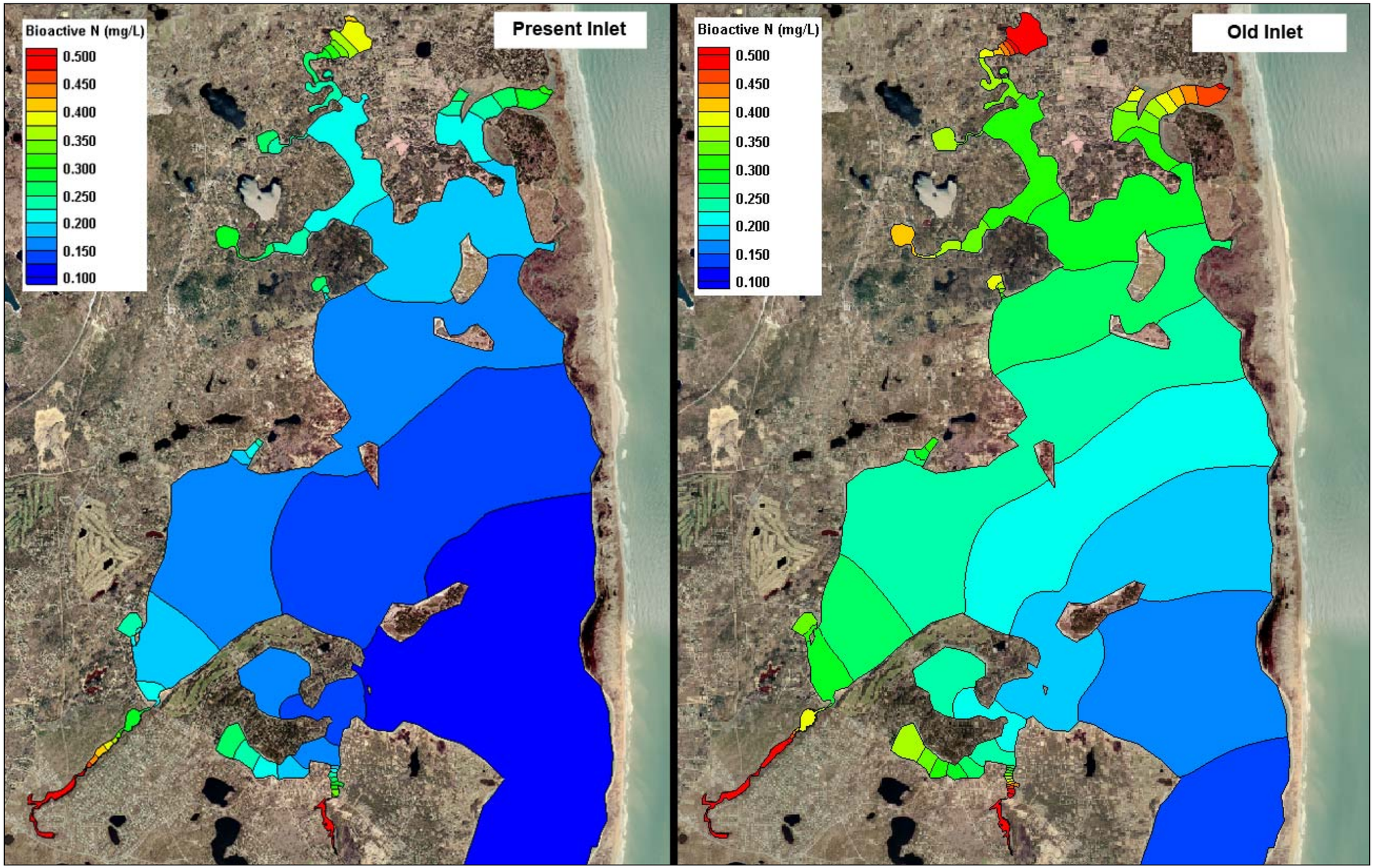

Figure IX-2. Comparison of bioactive N (DIN+PON) model runs for present inlet conditions and historical inlet (pre-breach) configuration for the Pleasant Bay system. Color contours indicate average bioactive nitrogen concentrations resulting from the present conditions loading scenario (Table VI-2).

Table IX-3. Comparison of model average bioactive N (DIN+PON) concentrations from present loading and the historical inlet configuration scenario ("old inlet") driven with Nantucket Sound Tides, with percent change, for the Pleasant Bay system. Loads for both present and "old inlet" bioactive N model runs are based on the present loading scenario (Table VI-2) The threshold stations are shown in bold print.

Sub-Embayment	monitoring station	present (mg/L)	old inlet (mg/L)	% change
Meetinghouse Pond	PBA-16	0.380	0.551	+45.0%
Meetinghouse Pond	WMO-10	0.261	0.372	+42.3%
The River - upper	WMO-09	0.239	0.345	+44.2%
The River – mid	WMO-08	0.211	0.313	+48.2%
Lonnies Pond (Kescayo Ganset Pond)	PBA-15	0.250	0.365	+46.0%
Areys Pond	PBA-14	0.297	0.417	+40.5%
Namequoit River - upper	WMO-6	0.239	0.346	+44.7%
Namequoit River - lower	WMO-7	0.216	0.319	+47.5%
The River - lower	PBA-13	0.195	0.293	+50.6%
Pochet – upper	WMO-05	0.269	0.434	+61.8%
Pochet - lower	WMO-04	0.209	0.322	+54.1%
Pochet – mouth	WMO-03	0.183	0.278	+52.1%
Little Pleasant Bay - head	**PBA-12**	**0.178**	**0.270**	**+51.9%**
Little Pleasant Bay - main basin	PBA-21	0.162	0.247	+53.1%
Paw Wah Pond	PBA-11	0.257	0.380	+47.9%
Little Quanset Pond	WMO-12	0.229	0.320	+39.7%
Quanset Pond	WMO-01	0.191	0.277	+44.9%
Round Cove	PBA-09	0.241	0.337	+40.1%
Muddy Creek - upper	PBA-05a	0.674	0.906	+34.4%
Muddy Creek - lower	PBA-05	0.286	0.387	+35.2%
Pleasant Bay - head	PBA-08	0.149	0.230	+54.3%
Pleasant Bay - off Quanset Pond	WMO-02	0.160	0.242	+51.2%
Pleasant Bay- upper Strong Island	PBA-19	0.117	0.175	+48.6%
Pleasant Bay - mid west basin	PBA-07	0.168	0.251	+48.8%
Pleasant Bay - off Muddy Creek	PBA-06	0.192	0.276	+43.7%
Pleasant Bay - Strong Island channel	PBA-20	0.124	0.186	+49.6%
Ryders Cove - upper	**PBA-03**	**0.250**	**0.360**	**+43.7%**
Ryders Cove - lower	**CM-13**	**0.158**	**0.231**	**+45.8%**
Frost Fish - lower	CM-14	0.243	0.351	+44.1%
Crows Pond	PBA-04	0.162	0.230	+41.7%
Bassing Harbor	PBA-02	0.127	0.191	+50.0%
Pleasant Bay - lower	PBA-18	0.116	0.169	+45.3%
Chatham Harbor - upper	PBA-01	0.104	0.135	+30.2%
Chatham Harbor - lower	PBA-17a	0.099	0.140	+41.3%

The results of this analysis indicate that the natural range of hydraulic conditions at the inlet to the Pleasant Bay system has a much greater potential influence on water quality conditions than anthropomorphic effects, such as those from the projected build-out nitrogen loading scenario. As a suggestion, an inlet management plan should be developed to address possible future water quality problems that could occur as a result of less-than-optimal configurations of the Pleasant Bay inlet.