

## II. PREVIOUS STUDIES RELATED TO NITROGEN MANAGEMENT

Nutrient additions to aquatic systems cause shifts in a series of biological processes that can result in impaired nutrient related habitat quality. Effects include: 1) excessive plankton and macrophyte growth (which leads to reduced water clarity), 2) organic matter enrichment of waters and sediments, with the concomitant resulting increased rates of oxygen consumption and periodic depletion of dissolved oxygen, (especially in bottom waters), and 3) the limitation of the growth of desirable species such as eelgrass. Even without changes to water clarity and bottom water dissolved oxygen, the increased organic matter deposition to the sediments generally results in a decline in habitat quality for benthic infaunal communities (animals living in the sediments). This habitat change causes a shift in infaunal communities from high diversity deep burrowing forms (which include economically important species), to low diversity shallow dwelling organisms. This shift alone causes significant degradation of the resource and a loss of productivity to both the local shellfisherman and to the sport-fishery and offshore fin fishery, all of which are dependent upon these highly productive estuarine systems as a habitat and food resource during migration or during different life cycle phases. This process is generally termed “eutrophication” and in embayment systems, unlike in shallow lakes and pond, it is not a necessarily a part of the natural evolution of a system.

In most marine and estuarine systems, such as the Phinneys Harbor System, the limiting nutrient, and thus the nutrient of primary concern, is nitrogen. In large part, if nitrogen addition is controlled, then eutrophication is controlled. This approach has been formalized through the development of tools for predicting nitrogen loads from watersheds and the concentrations of water column nitrogen that may result. Additional development of the approach generated specific guidelines as to what is to be considered acceptable water column nitrogen concentrations to achieve desired water quality goals (e.g., see Cape Cod Commission 1991, 1998; Howes et al. 2002).

These tools for predicting loads and concentrations tend to be generic in nature, and overlook some of the specifics for any given water body. The present Massachusetts Estuaries Project (MEP) study focuses on linking water quality model predictions, based upon watershed nitrogen loading and embayment recycling and system hydrodynamics, to actual measured values for specific nutrient species. The linked watershed-embayment model is built using embayment specific measurements, thus enabling calibration of the prediction process for specific conditions in each of the coastal embayments of southeastern Massachusetts, including the Phinneys Harbor System. As the MEP approach requires substantial amounts of site specific data collection, part of the program is to review previous data collection and modeling efforts. These reviews are both for purposes of “data mining” and to gather additional information on an estuary’s habitat quality or unique features.

Concern over the health of Buzzards Bay’s tributary embayments have resulted in a number of studies relating to the nutrient related health of the Phinneys Harbor System over the past 2 decades. These investigations include both habitat assessments and studies relating to nitrogen loading, hydrodynamics and habitat health. While none of the previous studies provided a holistic view of the Phinneys Harbor System or its sub-embayments (Phinneys Harbor, Eel Pond, Back River), they provide useful information to the present MEP effort. These earlier efforts were generally survey studies to evaluate this estuary and its watershed within the larger regional system and to evaluate the potential for watershed nitrogen inputs (present and at build-out) to produce habitat declines within the receiving estuary.

An initial watershed land-use and nitrogen loading analysis was conducted by the Buzzards Bay Project (BBP 1996) as part of a survey of all of the tributary embayments to Buzzards Bay. This survey used Mass GIS 1984 coverages and an approximate watershed delineation. The results indicated that the system appeared to be below its nitrogen loading threshold, although it recommended a more detailed analysis due to the complexity generated by the inner versus outer sub-embayments. The Cape Cod Commission, as part of its Coastal Embayment Project (Eichner, *et al.*, 1998), conducted a quantitative watershed delineation of the Back River and Eel Pond sub-embayments. The CCC watershed was defined based on regional water table measurements collected from available wells over a number of years and normalized to average conditions; delineations based on this previous effort were incorporated into the Commission's regulations through the Regional Policy Plan (CCC, 1996 & 2001). The CCC also indicated that these sub-embayments were within the middle range of nitrogen sensitivity and should be given a moderate priority for additional assessment. The MEP watershed analysis builds on these earlier efforts, but uses a refined watershed delineation based upon both updated water table data and groundwater modeling (Chapters III & IV).

While the overall watershed nitrogen loading results of the BBP and CCC studies have held true, the analysis is insufficient to simulate changes in nitrogen within the estuary under different management alternatives. In addition, as the landuse models did not account for nitrogen attenuation by the wetland ecosystems (no data available), it over estimated the role of nitrogen sources in upper (inland most) sub-watersheds compared to the direct groundwater watersheds to the estuary. While watershed delineation and nitrogen loading data from this earlier CCC study was incorporated by the MEP, direct use of the modeling results was problematic. Since the landuse model was based upon the 1996 watershed delineations from well data, rather than the MEP's USGS West Cape Model and expanded water table database (see Chapter III), the contributing areas are slightly different. Due to the difference in watershed areas and the MEP's update and refinements to the watershed nitrogen loading model (e.g. to incorporate attenuation and new nitrogen source information), the results from the MEP are different and supercede the earlier studies.

As part of the earlier efforts a semi-quantitative flushing analysis was conducted of the Phinneys Harbor System based primarily upon basin configuration, assumed generalized tide ranges and tidal prism calculations (ACI 1994). The purpose of this study was to support qualitative nitrogen thresholds for the Buzzards Bay sub-embayments and evaluation of the likelihood of current or future watershed nitrogen loads causing water quality degradation. However, given the refinements to the watershed delineation by the CCC and now MEP, and the need for detailed quantitative hydrodynamic analysis, the results from this previous effort could not be directly integrated into the MEP effort.

The Town of Bourne, as part of its Landfill operations, worked with Applied Coastal Research and Engineering and SMAST to conduct a quantitative hydrodynamic assessment and modeling and nitrogen related water quality modeling study of the Eel Pond and Back River sub-embayments to the Phinneys Harbor System. The study included both hydrodynamic data collection and modeling and measurements of nitrogen regeneration and watershed nitrogen inputs. In addition, groundwater modeling (USGS particle tracking) was employed to determine the coastal site of discharge of any contaminant plume, including nitrogen loads, originating from the Town of Bourne Landfill site. The modeling was based upon recharge to different areas of the Landfill site with emphasis on the historic septage disposal lagoons. The results indicated that any contaminant plume travels along, but outside of the Harbor watershed boundary. While the southernmost portion of the landfill site may contribute to the estuarine reach of Back River, at the time of the analysis, this region had been unused for disposal. In

contrast, the historic septage lagoons located within the northern portion of the site were found to clearly discharge to the Cape Cod Canal (approximately mid-way between the Railroad and Bourne Bridges). As the operating landfill is lined to prevent contamination of groundwater, and since the historic septage disposal lagoon area is the primary potential nitrogen source within the landfill parcel, nitrogen loading to the Phinneys Harbor System from the landfill was deemed to be negligible. The overall results of this investigation were fully integrated into the present effort when the Town of Bourne partnered with the Massachusetts Estuaries Project. This earlier effort provided most of the Town matching funds for the MEP.

The Town of Bourne, as the primary stakeholder to the Phinneys Harbor embayment system, has been concerned over the quality of this significant coastal resource. The community has worked to implement controls on direct stormwater discharges and the Town of Bourne Task Force on Local Pollution has focused on this and other Town embayments for protection and restoration. As part of this effort the Town of Bourne has supported the Coalition for Buzzards Bay's Water Quality Monitoring Program, which has been collecting data on nutrient related water quality within the Phinneys Harbor System since 1992. The Coalition's BayWatcher Program has collected the principal baseline water quality data set necessary for ecological management of Bourne's embayments and harbors. The BayWatchers is a citizen-based water quality monitoring program run by the Coalition for Buzzards Bay (T. Williams, Project Coordination), with technical and analytical assistance from the Coastal Systems Program at SMAST-UMD.

The common focus of the Coalition for Buzzards Bay Baywatcher Water Quality Monitoring Program effort has been to gather site-specific data on the current nitrogen related water quality throughout all the embayments tributary to Buzzards Bay to support evaluations of observed water quality and habitat health. This multi-year effort was initiated in 1992, with significant support from the Buzzards Bay Project. The BayWatcher Water Quality Monitoring Program in Phinneys Harbor developed a data set that elucidated the long-term water quality of this system (Costa et al. 1996. Howes et al. 1999). Additionally, as remediation plans for various systems are implemented, the continued monitoring is planned to provide quantitative information to the Town relative to the efficacy of remediation efforts. The MEP effort builds upon the Coalition for Buzzards Bay water quality monitoring program, and previous hydrodynamic and water quality analyses conducted by Applied Coastal Research and Engineering and SMAST, and includes high order biogeochemical analyses and water quality modeling necessary to develop critical nitrogen targets for the Phinneys Harbor embayment system and its major sub-embayments (Back River and Eel Pond).

The Coalition for Buzzards Bay's BayWatcher Program provided the quantitative watercolumn nitrogen data (1992-2005) required for the implementation of the MEP's Linked Watershed-Embayment Approach. The MEP effort also builds upon the previous watershed delineation and land-use analyses and the embayment water quality and eelgrass surveys. This information is integrated with MEP higher order biogeochemical analyses and water quality modeling necessary to develop critical nitrogen targets for the Phinneys Harbor embayment system. The MEP has incorporated all appropriate data from all previous studies to enhance the determination of nitrogen thresholds for the Phinneys Harbor System and to reduce costs to the Town of Bourne.