MINUTES
Special Meeting
Nantucket Harbor Watershed Work Group
3:00 PM, Thursday, May 1, 2003
Conference Room, Town Hall Annex, 37 Washington St.

Members Present: Don Visco, Mike Glowacki, Dirk Roggeveen

Staff Present: John Pagini, Jeromette Hicks

Audience Present: Chuck Fiegl (I&M), Tracy Sundell, Keith Conant

I. Call to Order The Chairman Don Visco called the meeting to order at 3:00 PM

II. Establishment of Quorum The Chairman declared no quorum was present and the meeting would be a "Sense of those present".

III. Request of Member Michael Glowacki to Incorporate in the Final Report of the Nantucket Harbor Watershed Work Group a Paragraph Inadvertently Omitted from the Last Draft Circulated by Staff.

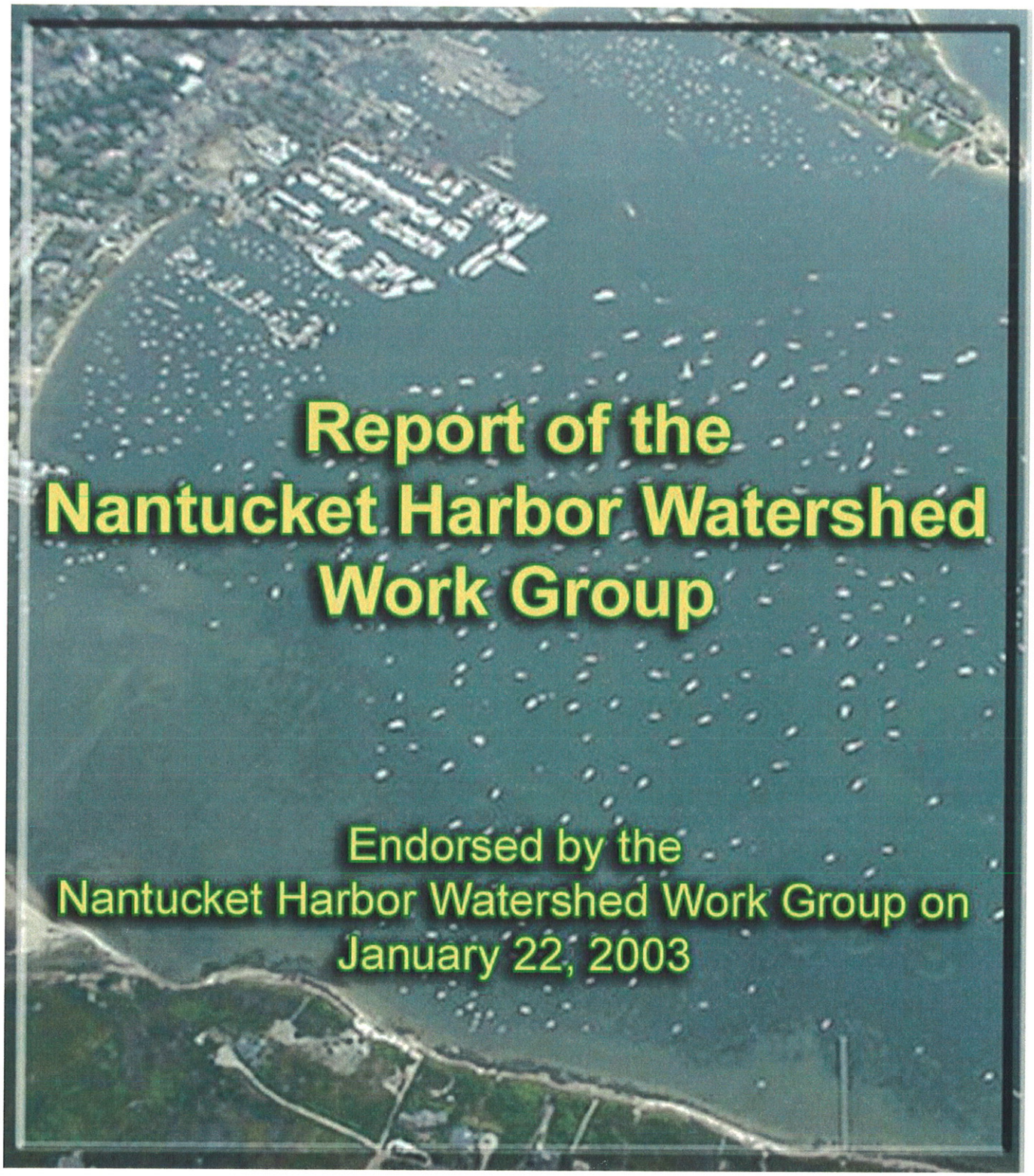
The consensus was to incorporate the paragraph.
Note date of revision, so no confusion with first one.
Have approx 100 copies made for distribution to NP&EDC, BOS, NHWWG the library and then to others.

IV. NP&EDC Request that the NHWWG Serve as its Agent in Facilitating Implementation of the Report Recommendations.

V. Other Business
The NP&EDC will be asked to request new appointments for the Work Group for June 2003.

There might be information meetings this Summer, possibly with the BOS Re: Wastewater Plan.

V. Adjournment The meeting adjourned at 3:20 PM.



Report of the Nantucket Harbor Watershed Work Group

Endorsed by the
Nantucket Harbor Watershed Work Group on
January 22, 2003

Report

of the

Nantucket Harbor Watershed Work Group

Endorsed by the Nantucket Harbor Watershed Work Group
on
January 22, 2003
Final Version – June 1, 2003

Preface

Nantucket Harbor is a product of the last continental glacial advance that occurred more than 10,000 years ago. Blocks of ice from the stagnating glacier created glacial kettle holes – depressions in the unconsolidated sand that were initially freshwater lagoons, but were later occupied by ocean water following dramatic rises in sea level[i]. The barrier beach that is now Coatue is the result of post-glacial reworking of glacial deposits by wind and tides, creating a buffer from the rougher waters of Nantucket Sound, and of the open Atlantic. Since the historic arrival of settlers, the entrance of the Harbor leading to the open ocean has been manipulated to maintain its open connection to the Sound, through the construction of the Jetties, and through periodic maintenance dredging. From time to time, catastrophic events have created new, but always transient, connections between the Ocean and the Harbor, such as the breach that opened at the end of the 19th century at the Haulover. Since then, the tides and winds continue to shape and re-shape the shoreline and ocean bottom beneath it.

The quality of the waters of Nantucket Harbor has always been important to Nantucketers, although the reasons for valuing that quality may have changed through the years, as well as the influences on that quality. Following the decline of whaling in the latter half of the 19th century, fishing and shell-fishing took on greater importance to Nantucketers who no longer had the lucrative whaling trade to support their existence, and the quality of Nantucket's waters spawned healthy crops through the middle of the 20th century. International exploitation of the rich fishing grounds that lie east of Nantucket, and later, regulation, drastically reduced commercial catches, and, consequently, Nantucket's economic reliance on the sea. The latter half of the 20th century brought different values. Not only was the water quality of Nantucket's Harbor valued for its ability to produce fish, but its recreational value and its intrinsic environmental value are now cherished by all. And yet, ironically, in large measure it is new growth that has spawned the current threat to Nantucket's harbor water quality – that threat in the form of growing numbers of boats docked, buoyed and anchored in the Harbor, and the growing numbers of homes that have developed within the Harbor's watershed - the majority of them seasonal residences. These homes and the practices of their occupants have introduced nutrients and pollutants that have had a measurable effect on the quality of the Harbor's waters. Higher nutrient levels, compounded by low rates of tidal flushing, and phytoplankton bloom, have resulted in low concentrations of oxygen – anoxia - in certain Harbor basins. It is the purpose of this report to suggest a strategy to mitigate these impacts, and ensure the quality of Nantucket's waters for future generations. We wish to note, however, that the primary focus of this report is on nutrient impacts, primarily nitrogen, and not on all pollutants.

A. History of Work Group Activities

The Nantucket Harbor Watershed Work Group (the "Work Group") was initially formed in 1997 by the Nantucket Planning and Economic Development Commission (NP&EDC") for the purpose of developing a strategy to address water quality issues in

Nantucket Harbor. The impetus for the formation of the Work Group was the long-awaited issuance in March of 1997 of the ***Nantucket Harbor Study**: A Quantitative Assessment of the Environmental Health of Nantucket Harbor for the Development of a Nutrient Management Plan*, by Woods Hole Oceanographic Institute ("Woods Hole"). That report capped a 10-year collaborative effort between the Town of Nantucket, the Nantucket Land Council, and Woods Hole to study the environmental health of the Harbor, and to make general recommendations. These recommendations included:

- strategic land acquisition;
- extension of sanitary sewers in areas of the watershed with higher density and / or poor soils, thus removing nutrients from the watershed that would otherwise be added through septic systems;
- encouragement of denitrifying systems;
- cessation of direct storm water discharges into the Harbor;
- continuation of harbor pump-out facilities;
- enforcement of the Federal "no-discharge" zone;
- reduction of lawn fertilizer usage;
- determination of the role of eelgrass deposition on oxygen depletion;
- exploring the feasibility of alternative fishing methods to avoid the "mowing" of eelgrass;
- considering further limitation of the commercial harvest season;
- directing runoff to vegetated surfaces, rather than through underground rapid infiltration systems; and,
- maintenance of the Harbor circulation system.

A critique by a subcommittee of the Harbor Watershed Work Group determined that the quantitative assessment contained in the ***Nantucket Harbor Study*** report was flawed in the following manner:

- it failed to include atmospheric deposition sources;
- it used a disproportionately high and non-scientifically based fertilizer leaching rate percent;
- It failed to use Nantucket-based on-site septic system and sewer information;
- It used surface water sampling data (except for Millbrook) of questionable scientific validity; and,
- It failed to highlight the role of education / community participation in addressing harbor needs and in promoting harbor health.

The Work Group at that time consisted of the individuals and groups listed in Exhibit "A" – a collaboration of representatives from government, the private sector, and from the scientific community who were dedicated to one cause – seeking a solution to the water quality problems of the Harbor. The work of the Work Group culminated in a report dated December 1, 1997, that recommended the following:

- a Town Meeting appropriation to fund a Engineering, modeling, and dredging of a channel in the Harbor to enhance circulation in the Harbor;
- an appropriation for the design of sanitary sewers for the Monomoy and Shimmo portions of the watershed;
- an appropriation for the design, engineering, and environmental assessment of improvements to existing storm drainage systems within the watershed;
- the formation of a Harbor Watershed district encompassing Nantucket Harbor;
- adoption of elements of an Open Space Work Group report associated with the development of the Comprehensive Plan related to open space initiatives in the Watershed;
- encouragement of open space acquisition preference to Nantucket Islands Land Bank and non-profit entities; and,
- a public education component that focused on educating the public on prudent application of fertilizers within the watershed.

Of the initiatives requiring Town Meeting action, the following actions took place:

- the appropriation of $50,000 for the study of the circulation patterns in Nantucket Harbor[ii];
- the appropriation of approximately $700,000 for the construction of sewers in Monomoy, recently completed[iii];
- the inclusion in the Department of Public Works Enterprise fund an appropriation to inventory drainage systems in the watershed[iv];
- the adoption of a Harbor Watershed District (Exhibit "B") as a general bylaw in 1999[v].

Of the initiatives not requiring Town Meeting action, the following publicly sponsored actions were initiated:

- The design and construction of a stormwater mitigation area for a stormwater discharge on Washington Street extension;
- the acquisition by the Town, the County, the Land Bank, and environmental organizations of the fee interest conservation restrictions in over 60 acres of land situated in the Harbor Watershed[vi];
- The production of a poster highlighting water quality issues and best management practices, with the funding assistance of the Massachusetts Executive Office of Environmental Affairs.

B. Watershed Nutrient Model / Harbor Nutrient Model; Re-constitutes Harbor Watershed Work Group

The Work Group suspended its meetings pending the completion of a Watershed Nutrient Model and a Harbor Nutrient Model, funded by Article 28, 1998 ATM. The Marine and Coastal Resources Department commenced these studies in late 1999, retaining Applied Science Associates ("ASA"), who subcontracted with the Boston University Marine

Program ("BUMP"), Applied Marine Ecology Lab, and Nucci Vine Associates as consultants to design the models.

In May of 2000, the Watershed Model and report by BUMP were released. The report provided the best information available concerning the contribution of nutrients by sanitary sewers in the Watershed. However, the model did not factor in the 20 +/- year equilibrium rate for on-going and past loading on nutrients already in transit in the watershed system. The model underscored the importance of atmospheric contribution of nutrients into the Harbor. Shortcomings of the model included a failure to factor in the contribution of storm water discharges into the nitrogen load; non-septic-related nitrogen-loading rates (atmospheric, storm water, fertilizers) were not Island-specific, or they were based on disproportionately non-science based leaching rates; and nitrogen loading values attributed by the study were found not to be based on scientific data, although it was found that "hot spot" nitrogen loading areas may exist. Yet, despite some of its drawbacks, the Work Group considers the report as the best information available on Harbor nutrient loading. To the extent that the ***Nantucket Harbor Study*** and the BUMP report conflict, these conflicts will be discussed in the following discussion.

The final results of the Harbor Circulation Model prepared by ASA were released in November of 2000. The model was considered a necessary "first step" – a two-dimensional model that demonstrated the dynamics of tidal flushing in the Harbor. The model allows the user to apply various scenarios, or "solutions" to Harbor circulation problems, and to measure the effectiveness of these solutions in terms of increased circulation. Among the scenarios tested were structural solutions including various dredging scenarios; removal of the jetties; repair of the breach in the east jetty; and the introduction of a man-made connection between the Head of the Harbor and the Atlantic Ocean by creating a connection through the Haulover[vii]. The model concluded that nearly all actions, including dredging scenarios, had a marginal effect on circulation in the Harbor. One solution involving dredging the shoaled areas between the basins yielded decreased circulation. The most effective "solution" was the construction of a breach at the Haulover, but the total effects of such a permanent breach on sediment transport and the overall Harbor ecosystem would have to be carefully studied before it could be considered a viable option[viii].

The Work Group was reconstituted upon the development and release of the models, and in reaction to a citizen-sponsored Article 47 of the 2000 Annual Town Meeting (Appendix "C"). The new Harbor Watershed Work Group consisted of the membership listed in Appendix "D." The Work Group began its activities in earnest in December of 2000, developing a Work Program based on the scope suggested in the Article.

In evaluating the report conclusions, the Work Group found that conclusions based on a two-dimensional model could be considered problematic, because it was the sense of the Work Group that the Harbor was multidimensional in function. The Work Group also concluded that sound judgment should be exercised in the use application, and development of conclusions and / or recommendations reached by employing the model – changing patterns may lead to other adverse effects on the Harbor, such as eel grass

destruction, sediment re-suspension, and effects on navigation. Reliance solely on a water-based solution should not be taken in isolation from watershed-related impacts. The final recommendation of the Work Group was to explore the need for a three-dimensional model, and to implement this model if further tests of the dynamics of the water column support the need for such an advanced model.

II. Assessment of the "State of Nutrient Loading to Nantucket Harbor"

This report attempts to summarize the most current scientific information available concerning the nutrient inputs into Nantucket Harbor. The primary sources of information are the ***Nantucket Harbor Study*** (the "Harbor Study") and ***Land-derived nitrogen loading to Nantucket Harbor*** (the "BUMP Study"). The Harbor Study concludes that "nutrient inputs are necessary for the healthy growth of phytoplankton, macro-algae, and eelgrass within Nantucket Harbor."[ix] However, it is an over-supply of nutrients, both naturally occurring and man-made, that exceeds the assimilative capacity of the harbor system, leading to death of phytoplankton and eelgrass, and the resulting anoxia, particularly at the Head of the Harbor, Quaise, and Polpis Harbor.

The BUMP Study reaches similar conclusions concerning the overall nutrient budget for the Harbor, but the two reports differ in the relative contribution of nutrients from different sources.

In order to manage nutrient inputs, it is also necessary to understand nutrient contributions and loading rates from a number of sources, together with circulation and transport patterns in the Harbor.

A. Sources of Nutrient Loading in Nantucket Harbor

Sources of nutrient inputs that are addressed in this report must include land-based contributions from the Nantucket Harbor Watershed (Exhibit "E"); water-based sources; and atmospheric sources; all of which are addressed in the Harbor Study[x] and the BUMP Study.

1. Land-based Sources:

Because of the predominantly sandy character of the soils within the Harbor watershed, and the relatively high infiltration capacity of these soils, the ground water is the most significant conduit for the transport of nutrients from throughout the watershed. But because the Harbor consists of a series of basins which have differing nutrient levels, the Harbor Study and the BUMP Study divide the overall harbor watershed into sub-watersheds for the purpose of both evaluating and managing nutrient loading. The Harbor Study and the BUMP Study both identify atmospheric sources, stream flow, and groundwater as land-based conduits for nutrient transport, although the BUMP study's estimates of atmospheric contributions to nutrient loads in the watershed is more

comprehensive than the Harbor Study. Although atmospheric sources include wetfall and dryfall sources that add nutrients to the watershed, that discussion is deferred to a section that follows below.

Stream flow from the ten (10) small streams identified in the harbor watershed contributes only an estimated 36 kg of Nitrogen per year, compared to the estimated atmospheric contribution of more than 10,000 kg per year[xi].

Groundwater, by far, contributes the most Nitrogen to the waters of the Harbor. The groundwater nutrient loading model developed specifically for Nantucket Harbor estimates the contributions of nutrients, and Nitrogen in particular, that are transported through groundwater to the Harbor. The following sections of this report examine the relative contributions of a variety of land uses, sources, and other contributors to nutrient loading in the Harbor.

Sewage / Septic System Discharges

Aside from direct atmospheric contributions, septic systems cause one of the greatest contribution of Nitrogen ("N") (over 3,000 KG per year[xii] per the Harbor Study, but only 1201 KG per the BUMP Study[xiii]) loading to groundwater of any other source within the harbor watershed. This discrepancy between the reports may be due to significant differences in the numbers of assumed septic systems actually located within the watershed. The estimate in the Harbor Study is based on the numbers of year-round and seasonal residences in the watershed at the time of the study, adjusted for projected occupancy rates.

Additional development has taken place in the five (5) years since the issuance of the Harbor Study. Based on our review of the building permit records of the Town of Nantucket Building Department, we estimate that of the approximately 160 new dwelling units that have been constructed in the Harbor watershed since 1997, 75 were constructed within the unsewered area, representing a 7.8 % increase in the number of dwelling units on septic systems over the number of dwelling units estimated in that report. Using the same assumptions of the Harbor Study, we estimate that the Nitrogen loading has now increased to approximately 3,300 KG per year. Using the same assumptions under the BUMP study, we conclude that the addition of 75 new septic systems is a nearly 13% increase in the number of septic systems in the watershed, bringing the N load to approximately 1356 KG of N. However, based on the same variables and assumptions, the recent construction of sanitary sewers in Monomoy can result in the reduction of Nitrogen loading by approximately 145 KG (54 KG, under the BUMP Study assumptions) when all the homes served by the sewer abandon their septic systems. The extent of properties serviced by septic systems within the Harbor watershed versus the extent of lots served by sanitary sewer is illustrated in Exhibit "F" (a Geographic Information Systems map of the watershed).

The Comprehensive Wastewater Management Plan ("CWMP"), still in the process of development by Earth Tech under contract with the Town of Nantucket, has identified ten

(10) areas of wastewater need Island-wide, i.e., areas where conventional Title V septic systems would not be effective in disposing of wastewater. The rating criteria established for the purpose of defining need were based on the numbers of actual septic system failures; the numbers of imminent septic system failures; the numbers of septic systems with a high likelihood of failure; and the number of systems that have health or water quality issues[xiv]. This last criterium includes consideration for location of septic systems within the Nantucket Harbor Watershed[xv]. A second stage analytical analysis also identified septic system age, lot size, and severe soils and groundwater as added factors in determining need. Of the ten needs areas identified, five are located within the Nantucket Harbor Watershed (see Exhibit "G"). Three of the areas are based largely on location within the watershed (Monomoy, Shimmo, and Pocomo), while the final two (Polpis and Wauwinet) are based on a series of criteria the importance of which supersedes the watershed inclusion criteria. In terms of need, Wauwinet ranked first, Polpis third, Monomoy seventh, and Pocomo ninth.

The next step in the CWMP planning process is the evaluation of a variety of wastewater solutions to address each area.

b. Storm water runoff / sedimentation

Stormwater runoff from impervious (impermeable) surfaces, according to the Harbor Study, accounts for an estimated N load of 1465 KG per year[xvi], or 19% of all non-atmospheric sources, while the BUMP Study estimates an N load of 583 KG. This amount, according to the Harbor Study, represents the third highest contribution, following septic systems and fertilizers as a principal non-atmospheric contributor of N to the watershed.

Impermeable surfaces take the form of paved roads, driveways, and roofs within the watershed. These surfaces become traps for atmospheric N, as well as pollutants generated by automobiles and animal waste. How these N sources are directed into the ground and eventually to the Harbor determines how much total N is not attenuated, and therefore is contributed to Harbor waters. The following section divides these contributors into point and non-point sources.

i. Point Sources

Point sources may constitute the biggest stormwater runoff threat because nutrients, including N, are discharged directly into the Harbor, or into the underlying soils, usually with little or no attenuation[xvii]. Within the Harbor watershed, the area west of the Creeks and the Rotary consists almost exclusively of a paved road network with a developed storm drainage system, nearly all of which discharges directly into the Harbor, or directly into the ground through leaching catch basins[xviii]. Stormwater discharges from that portion of the historic Nantucket Town often include road and roof runoff combined. These discharges are usually in the form of stormwater outlet pipes that discharge

directly into the Harbor, or in the form of direct discharge to leaching basins from roofs and roads. Because some discharges are often directly through harbor bulkheads, open air or vegetative retrofit is often difficult or impossible. In this dense network of roads, only 3.2 miles of road are unpaved[xix]. This area drains to the extreme west end of the Harbor, which has the greatest degree of tidal flushing. East of the Creeks and the Rotary, it is estimated that there are approximately 36 miles of roads, paved and unpaved, public and private. This number includes approximately 15 miles of unpaved "roads" located within preserved land south of Polpis Road, controlled predominantly by the Nantucket Conservation Foundation. The remaining 21 miles of roads in this part of the watershed serves developed areas, and consists of 11.1 miles of paved roads, and 10 miles of unpaved roads. Of the 11.1 miles of paved roads, approximately 5 ¼ miles, or 47%, have leaching catch basins, and therefore constitute point discharges. An example is all of the paved portion of Pocomo Road. Point discharges often include sediment generated from winter road applications, or from natural erosion, and often contain concentrations of nutrients[xx].

Some point discharges, however, are via specially designed stormwater systems that are designed to filter runoff through vegetated surfaces, or through underground systems that provide some capture and treatment of nutrients.

ii. Non-point Sources (including development activities; agricultural and landscaping practices)

Non-point sources generate nutrients to a lesser extent than point sources, because they are often filtered by vegetation, which has significant attenuation potential. These non-point sources include runoff from roads without storm drainage systems consisting of pipes and catch basins. East of the Creeks and the Rotary, these include the 15 miles of unpaved roads in protected land, 10 miles of unpaved roads in developed areas, and 5.85 miles of paved roads without storm drainage systems. Most of the driveways serving homes in this area of the watershed are unpaved, and therefore non-point sources. West of the Creeks and the Rotary, only 3.2 miles of unpaved roads constitute non-point sources.

Development activities have the potential to contribute sediment to Harbor waters, and associated nutrients borne by sediment, although the general porosity of the soils reduces the risk to a considerable extent. The Conservation Commission, in its capacity as wetlands agency, routinely requires erosion and sedimentation measures to protect adjacent wetlands. The Planning Board and the Zoning Board, through the Site Plan Review process, has the discretion to require similar measures in connection with commercial permits, and the Planning Board can require such measures for Definitive Subdivision Plans. However, lots of record, and lots created by ANR are not subject to erosion control requirements, unless they are otherwise under the jurisdiction of the Conservation Commission. The storm drainage system within the streets of Nantucket

Town can act as a conduit for sediment generated by infill development, transporting it directly to the Harbor.

Agricultural activities are quite limited within the watershed, with the 15 +/- acres of Moors End Farm being the greatest contributor, and Windswept cranberry bog, which has been inactive for several years. Again, the agricultural erosion potential of Moors End is limited, due to the porosity of the soils. Only 1% of the estimated Nitrogen is generated by farming within the watershed, according to the Harbor Study[xxi].

Landscaping practices can contribute nutrients generated by runoff within the watershed by clearing large areas of natural vegetation. Nutrients are generated both during construction, but also as a consequent of increases rates of runoff due to the loss of vegetation that is more efficient at attenuating runoff and nutrients.

c. Landscaping and Agricultural Practices

The most common way that landscaping and agricultural practices contribute nutrients within the Harbor Watershed is through the addition of organic and chemical fertilizers.

i. Agricultural practices

The contribution of fertilizers due to agricultural practices of the two farms (Moors End and Windswept Bog) is estimated by the Harbor Study as contributing only 63 KG of N, or approximately 0.8% of the total N generated in the watershed from non-atmospheric sources[xxii]. With the closure of Windswept bog to active agricultural production since the time of the Harbor Study, it is anticipated that the nutrient generation is at the present time is less than that cited in the Harbor Study.

ii. Landscaping practices

The Harbor Study and the BUMP Study both cite fertilizer as a major non-atmospheric source of N in the watershed.

The 1997 WHOI Harbor Study model included an estimate of 2898 Kg N from lawn fertilizers. The WHOI model assumed that 100% of lawn areas within the watershed are fertilized each year, at a rate of 3 lbs N/ 1,000 sq. ft., and estimated that 20% of the applied nitrogen leached to the groundwater as nitrate[xxiii].

After requesting documentation from WHOI in support of their assumptions[xxiv], the Work Group formed a subcommittee (November, 1997) to review all available scientific literature. The subcommittee was able to identify four factors that most significantly influence the degree of leaching: 1) amount of fertilizer applied, 2) type of fertilizer applied, 3) stage of growth at time of application, and 4) amount of irrigation[xxv].

The August 2000 BUMP Study estimated 1322 Kg N[xxvi], assuming that 61% of applied material leached to the groundwater[xxvii].

In November, 2000, the Massachusetts Executive Office of Environmental Affairs, Watershed Initiative Team, sponsored a forum on Nantucket to bring some clarity to the question of fertilizer leaching, and introduced experts in turf science. Presentations by the speakers documented differences between actual ground testing / monitoring derived data and statistical data compilation modeling approach for evaluation of leaching impacts by:

1. Providing scientific field study data showing actual nitrogen leaching rates.
   a. In glacial outwash soils ranging between 0-6%, and
   b. In glacial and/or lab created soils ranging between 0-12%
2. Providing model-based compiled and/or statistically derived nitrogen leaching rates ranging between 15-20%[xxviiixxix]

The Harbor Watershed Work Group recognizes the need for further science-based research and education, and recommends some specific practices that are scientifically known to reduce the potential for nitrogen loading from lawn fertilizer.

d. Natural Contributions

Natural contributions of N are generated both from portions of developed lots that are naturally vegetated and undeveloped privately owned land, as well as the significant acreage of land preserved. by various public entities, and private environmental organizations. This total contribution is estimated at the time of the Harbor Study at 358 KG of N, or 4.5 % of the non-atmospheric N contribution in the watershed. The BUMP Study disputes this amount, stating that the Harbor Study understates the atmospheric contribution within the watershed. The BUMP Study estimates that between wetlands, freshwater ponds, and natural vegetation, 3,978 KG of non-attenuated N enter the Harbor, their ultimate source being atmospheric deposition[xxxiii]. With the development of 160 new homes in the watershed, the amount of natural N has been modified by N generated by impervious surfaces and septic systems. But converting undeveloped land to open space does not affect the N contribution to the watershed or the Harbor because they were assigned the same rate of contribution on N.

2. Water-based Sources

Water-based sources are not addressed or quantified in the Harbor Study, although there is an acknowledgment that dumping of septage from boats is a factor in determining nutrient loading.

a. Commercial and recreational activities

Commercial activities that are water-based are generally limited to commercial fishing and recreational fishing and scalloping pursuits. The commercial fishing activities contribute little to the contribution of N to the Harbor, since most of these activities are carried on outside of the Harbor, generally. The act of commercial might generate organic material that decays and is arguably a contributor of N to the Harbor waters. The precise effects of scalloping harvest practices are unknown, and require further study.

Despite the designation of the Harbor as a federal "No Discharge" zone, it is acknowledged that some clandestine dumping occurs. The practice of boat washing contributes phosphates, but is also a contributor of N to Harbor waters. Although biodegradable washing products are prescribed, the increasing volume of boats moored, docked, and at anchor make enforcement difficult. An aggressive pump-out program by the Marine Department yields increasing volumes of sewage annually.

b. Natural Contributions

As stated earlier in this report, N generated from streamflow is in the order of 36 KG annually. But if continued development occurs within the watershed, it is anticipated that this contribution will increase.

Atmospheric contributions of N on the water surface of the Harbor is a major contributor of N, as discussed in more detail below.

3. Atmospheric Sources

Deposition of N on the surface waters of the Harbor is estimated in the Harbor Study as over 10,000 KG per year, and is therefore the greatest contributor of N to the Harbor of any source[xxxv]. Because the BUMP Study is a watershed model, and deals only with applications of N from land within the watershed, atmospheric contributions in that report are strictly limited to those contributions on land. If we assume the atmospheric contributions to Harbor waters of over 10,000 KG in the Harbor Study in combination with the BUMP Studies estimates of atmospheric contributions within the watershed, then we might conclude that 83% is ultimately attributable to atmospheric deposition. Only 5 % of that amount is attributable to activities under our control, i.e., deposition on turf, bogs, agricultural areas, roofs, and impervious surfaces.

N deposited on land from atmospheric sources is largely attenuated by the renovation potential of natural vegetation. But the N that falls upon impervious surfaces adds to the regimen of N that is potentially discharged directly to the Harbor or underlying groundwater as a point source[xxxvi].

C. Results - Watershed Nutrient Model / Harbor Nutrient Model

The ASA Harbor Nutrient Model was useful in providing positive flushing rate data affecting the Harbor. The analyses of various structural solutions led the Work Group to conclude that such solutions may not provide the water benefits that it had hoped for. The "solution" of developing a permanent breach in the barrier beach at the Head of the Harbor raises more questions than it answers at the present time, and requires further study if it is to be seriously considered.

The watershed analysis (BUMP Study), although conflicting in some respects with the details of the Harbor Study, still corroborates many of the conclusions of the latter study. The BUMP Study emphasizes the vast contributions of atmospheric N to the problems of the Harbor, and points to fertilizers, septic systems, and roads and other impervious surfaces as the principal non-atmospheric contributors. Based on a presentation by BUMP to the Work Group, the Work Group concludes that, given the large atmospheric contribution that, for the most part, cannot be mitigated, and given the fact that N loading of the Harbor is at a critical juncture, it is logical to conclude that we must manage the sources that we have control over, namely, sources of N from septic systems, fertilizers, storm outfalls, roads, and other impervious surfaces.

D. Physical Characteristics / Limitations of the Harbor

Remediating the concentrations of N in the Harbor is a complex undertaking. Circulation in the Harbor, as attested by the ASA Study, cannot be easily changed, except by radical actions (i.e., breach at the Head of the Harbor) that may have negative effects on the overall environmental health of the Harbor. Some subwatersheds are more critical than others, and because of their unique characteristics, may deserve different solutions. Even if an aggressive watershed management program is implemented, benefits may not seem obvious for decades, because of the lag time in the travel of N through the soils and groundwater within the watershed. These are not reasons not to proceed. The purpose of the recommendations that follow are to ensure the quality of the waters of the Harbor for future generations; we must therefore have a long view. We must also continue to study those issues for which we do not have an adequate understanding, and expand our monitoring and observation of variables that affect Nantucket Harbor water quality so that we can rely in the future on information specific to out own Harbor and watershed, and not on data derived from other sources and extrapolated to fit Nantucket's circumstances.

III. Recommended Strategies and Actions to Limit / Control / Regulate Nutrient Loading of Nantucket Harbor

As stated previously, the Harbor Study and the BUMP Study produced overall results that were roughly consistent in their estimation of total N loads for Nantucket Harbor. However, they differ greatly in the breakdown of the various contributors. Rather than

get hung up on the numbers, the Work Group has looked at the bottom line conclusions of each, which lead to these recommended solutions:

A. Educate the Public on Nutrient Influences on the Harbor, and on Practices to Mitigate those Influences.

The Work Group voted to place this first in order of importance, because it feels strongly that getting stakeholders to understand the problem, and understand that they all must be a part of the solution, is a critical step. Although regulation is an essential part of this overall strategy, not everything can be regulated or practically enforced. Seeking voluntary compliance is therefore an important part of this strategy.

1. **Continue a public education campaign to educate both year-round and seasonal residents concerning responsible nutrient management practices in the Harbor Watershed.**

    a. **Support development and distribution of educational pamphlets concerning Harbor water quality issues, and responsible management actions that homeowners need to engage in.**

    b. **Support development of an "information resource center" on Harbor watershed issues at the library or at select Town Offices.**

    c. **Conduct educational forums on Harbor Watershed issues pertaining to nutrient loading.**

    d. **Provide speakers for civic meetings on Harbor Watershed issues, particularly before Neighborhood Associations whose geographic boundaries fall within the Harbor Watershed.**

B. Public and Private Infrastructure Policy and Improvements

A public-private partnership is required for this program to be successful, because the area of the watershed serviced by the public infrastructure (public roads, sanitary sewers, and storm drainage systems) covers a relatively small part of the watershed. Private roads and their drainage systems fall under the jurisdiction of the Town only insofar as they are subject to jurisdiction of the Planning or the Zoning Board, and, even then, only for new or modified development plans. Septic systems and sanitary sewer extensions, in contrast, fall under the development and regulatory authority of the Town.

1. Septic Systems / Sanitary Sewers

   a. **Support and implement a comprehensive survey and program of inspections of failed or failing septic systems, and enforcement actions.**

   b. **Develop septic system standards for new and replacement septic systems in the Nantucket Harbor Watershed; draft and implement Nantucket Health Code Regulation changes tailored to Nantucket Harbor.**

   c. **Recommend sanitary sewer extensions within the Harbor Watershed in keeping with the recommendations of the CWMP, and provide for funding of these extensions through bonding, loans, and the Town's capital program and enterprise fund accounts.**

   d. **Implement solutions tailored to circumstances of each Priority Area identified in the Town's CWMP.**

   e. **Adhere to the Sanitary Sewer Policy of the Nantucket Board of Public Works, adopted on January 6, 1999 and revised on June 26, 2002.**

2. Storm Drainage Systems

   a. **Conduct a Comprehensive Inventory of Storm Drainage System and Point Source Discharge Points.**

   b. **Mitigate point source discharges (Harbor outfalls and leaching catch basins) on public storm drainage systems by establishing a long-range capital program. Mitigation may include retrofit of storm water discharges which issue directly into the Harbor, or the creation of roadside ditches in lieu of leaching catch basins (i.e., Pocomo Road).**

   c. **Develop a plan to retrofit the storm drainage system throughout the Harbor Watershed, including private systems, such as Quaise Pasture, North Pasture, and Moors End Road. Prioritize improvements through a long-range capital program, and work with Neighborhood and Homeowners Associations to retrofit systems.**

d. **Draft and adopt a Zoning Bylaw amendment and amendments to the Rules and Regulations Governing the Subdivision of Land to implement storm drainage standards consistent with the goal of reducing and attenuating nitrogen within the Harbor Watershed.**

e. **Develop standards for storm drainage systems and improvements to be employed by the Town of Nantucket, Department of Public Works in the construction, maintenance, and retrofit of storm drainage systems.**

f. **Mount a public relations campaign to encourage retrofit of roof drain systems and private storm systems on individual lots to eliminate leaching basins in lieu of discharge onto vegetated areas.**

C. Development Practices

The following measures are meant to close the gap in requirements for erosion and sedimentation measures in the Harbor Watershed:

1. **Amend the Zoning Bylaw, the Rules and Regulations Governing the Subdivision of Land, and the Wetlands Regulations to require more stringent erosion and sedimentation controls within the Nantucket Harbor Watershed.**

2. **Amend the Wetland Regulations to specifically require the reservation of vegetation / vegetated buffers within the Harbor Watershed.**

3. **Amend the Town Code to require Erosion and Sedimentation measures in connection with any Building Permit located in the Harbor Watershed that is not regulated by the Planning Board, Zoning Board, or the Conservation Commission.**

4. **Storm water management (see above).**

E. Agricultural Practices

Although agriculture is a relatively small contributor of nitrogen within the watershed, the following measures can provide incremental benefits to the watershed:

1. **Encourage agricultural businesses within the Harbor Watershed to employ winter cover crops, which attenuate leaching on nitrogen during winter months.**

2. **Encourage agricultural businesses within the Harbor Watershed to use slow-release fertilizers.**

3. **Encourage agricultural businesses within the Harbor Watershed to establish and maintain buffers from the Harbor or its bordering wetlands and streams.**

F. Landscaping Practices

Since nitrogen levels play a key role in the ecological health of all bodies of water, in particular our Harbor on Nantucket *(because of its physical shape and geological history which have resulted in less than optimum circulation and flushing patterns)*, homeowners and lawn care professionals should be encouraged to adopt the following measures to ensure that lawn fertilization practices here, particularly in the Harbor watershed area, are based on the most current accepted practices scientifically known to reduce the potential for nitrogen loading as regards lawn fertilizer:

1. **Educate the landscaping professional and the consumer about best management practices to control and limit nutrients.**

2. **Identify, and encourage use of, slow-release fertilizers by consumers and landscaping professionals. The following measures are based on scientific evidence:**

    a. **A maximum application rate of 3 lbs. Nitrogen per 1,000 sq. ft. per year.**

    b. **The use of lawn fertilizers that contain a high ratio of slow release forms of nitrogen to water soluble forms of nitrogen, which are less likely to leach to ground water.**

    c. **Lawn fertilization only during the active growing season, usually starting in May. Discourage fall applications after growth has slowed. Several lighter applications versus one large dose are preferable.**

3. **Support scientific research to collect and analyze data regarding nitrogen leaching associated with lawns here on Nantucket.**

4. **Educate the landscaping professional and the consumer concerning the value of preserving existing vegetation; the use of indigenous vegetation; the value of buffers; and the use of plant species that are drought-tolerant, and which require little fertilization.**

5. **Educate the landscaping professional, irrigation installers, and the consumer about controlled irrigation and the inclusion of rain gauges on irrigation systems. Careful monitoring and control of irrigation on lawns, as excess irrigation, particularly over sandy soils, contributes to higher losses of nitrogen to leaching before turf grasses can take it up; one inch of water a week should suffice, and lighter watering more frequently to reach the one inch amount is preferable to one heavier dose of water.**

6. **Educate developers, builders, and prospective and existing homeowners concerning best management practices in activities that disturb the soil and remove indigenous vegetation.**

F. Land and Conservation Restriction Acquisition; Deed Restrictions; Tax Incentives

Acquisition of land and easements will have the effect of decreasing future contributions of nitrogen to the Harbor by removing the development potential of land, and therefore the nitrogen associated with septic systems, landscaping practices (application of fertilizers, removal of natural vegetation), and new impervious surfaces (roofs and roads / driveways:

1. **Encourage the Town, the County, the Land Bank, and environmental organizations to acquire land, conservation, and deed restrictions within the Harbor Watershed to control and limit development in the watershed, and manage further nutrient releases into the Harbor. Support tax incentives as an inducement to implementing these mechanisms.**

G. Management of Use of Harbor Waters

The Marine Department has a monumental task during the peak season in regulating and enforcing "no discharge" zone requirements:

1. **Support Marine Department management of Harbor use (boating, dredging), etc. to limit nutrient contributions into the Harbor; support an increase in funding to accomplish these activities, if necessary.**

H. Regulatory Policies and Practices

In addition to the specific recommendations for increased regulatory oversight, implement the following:

1. **Support local regulatory agency implementation of existing regulations and policies that are consistent with best management practices. Assist these agencies with revisions / upgrades of existing regulations and policies affecting the Nantucket Harbor Watershed and Nantucket Harbor including, as appropriate, "basic arguments / support data."**

I. Phase II of Harbor Circulation Model

The ASA Study raised the question of the adequacy of a 2-dimensional model to replicate the dynamics of the Harbor. The following second stage is recommended:

1. **Support preparation of a 3-dimensional model of Harbor circulation only if testing of Harbor circulation warrants further analysis.**

J. Conclusion

These recommendations of the Harbor Watershed Work Group come at a time of increasing evidence of degradation of water quality in Nantucket Harbor. Recent closings of shellfish beds and decreasing yields of scallops are clear signs of this trend. These are not recommendations that should be taken lightly - water quality is important to the well-being of our environment, but is also important to our economic well-being.

K. Bibliography

1. Nantucket Harbor Water Quality Survey: Water Quality Survey Data: Summary of Significant Findings. Prepared by Christine Duerring, Environmental Analyst and Catherine O'Riordan, Environmental Engineer (Massachusetts Department of Environmental Protection - February, 1990).

2. Nantucket and Madaket Harbors Action Plan, Prepared by the Nantucket Harbor Planning Advisory Committee and the University of Rhode Island Coastal Resources Center for the Town of Nantucket, Massachusetts (May, 1993).
3. Nantucket Harbor Study: A Quantitative Assessment of the Environmental Health of Nantucket Harbor for the Development of a Nutrient Management Plan, by Woods Hole Oceanographic Institute (March, 1997).
4. Report of Nantucket Harbor Watershed Work Group (December 1, 1997).
5. Proposed Recommendations to the Nantucket Harbor Watershed Work Group, concerning fertilizer management, dated November 19, 1997, and adopted on March 19, 1998 by the Harbor Watershed Work Group.
6. Land-derived nitrogen loading to Nantucket Harbor, by Ivan Valiela, Marci L. Cole, and Joanna K. York, Boston University Marine program, Marine Biological Laboratory, Woods Hole, MA, Draft Final Report, May, 2000.
7. Computer Modeling of Nantucket Harbor: Project Summary, by Craig Swanson and Matthew Ward, Applied Science Associates, Inc., Narragansett, RI, November 10, 2000.
8. Landscaping Workshop, October, 2000, co-sponsored by the Nantucket Conservation Commission, the NP&EDC, Mass. DEP, and the Nantucket Landscapers Association.
9. Brochure entitled: "Landscaping Practices That Make a Difference," Nantucket Landscape Association, in cooperation with NP&EDC, Harbor Watershed Work Group, the Nantucket Landscape Association, the Nantucket Conservation Commission, and the Nantucket Land Council.
10. Poster entitled: "Nantucket Harbor Watershed: Ours to Enjoy and Protect," 2000, created by Harbor Watershed Work Group, and funded by EOEA.

---

[i] ***Nantucket Harbor Study,*** pp. 10 and 11
[ii] Article 28, 1998 ATM.
[iii] Article 12, 1999 ATM
[iv] Article 10, 1999 ATM
[v] Article 70, 1999 ATM
[vi] Communications with Jim Lentowski, Executive Director, Nantucket Conservation Foundation, and Eric Savetsky, Executive Director, Nantucket Land Bank
[vii] ***Project Summary: Computer Modeling of Nantucket Harbor***, Applied Science Associates, November 10, 2000, pp. 10 and 11
[viii] Idem.
[ix] ***Nantucket Harbor Study*** p. 20
[x] Ibid., pp. 20 through 36
[xi] Ibid., pp. 25 through 27
[xii] Ibid., p. 29
[xiii] ***Land Derived Nitrogen***, pp. 14 through 16
[xiv] ***Comprehensive Wastewater Management Plan and Environmental Impact Report, Phase I, Needs Analysis and Screening of Alternatives***, Nantucket, MA, Earth Tech, Inc., August, 2002; pp. 3-23 through 3-33
[xv] Ibid, p.3-24
[xvi] ***Nantucket Harbor Study***, pp. 32 and 33
[xvii] Ibid., p. 33
[xviii] Field and GIS Analysis by NP&EDC staff, December, 2002
[xix] Idem.
[xx] Idem.
[xxi] ***Nantucket Harbor Study***, p. 31

[xxii] Ibid., p. 30
[xxiii] Ibid., p. 32
[xxiv] Minutes, Harbor Watershed Work Group, October 22, 1997, pp. 1, 7
[xxv] *Report and Recommendations of Harbor Watershed Work Group*, December 1, 1997
[xxvi] ***Land Derived Nitrogen***, p. 14
[xxvii] Valiela, I., et al, *Nitrogen loading from watersheds to estuaries*: Biogeochemistry 49: 277-293
[xxviii] EOEA Landscape Workshop: Branham, Cohen, Nelson, Talbot
[xxix] Collier, Cormac; Fantozzi, Peggy: *Report Summaries: 4/4/2001 Prepared for Nantucket Harbor Watershed Work Group*
[xxxiii] ***Land Derived Nitrogen…***, p. 14
[xxxv] ***Nantucket Harbor Study***, pp. 24 and 25
[xxxvi] ***Land Derived Nitrogen…***, p. 14

Exhibit "A"

NP&EDC

NANTUCKET PLANNING AND ECONOMIC DEVELOPMENT COMMISSION

NANTUCKET HARBOR WATERSHED WORK GROUP

NP&EDC

Donald Visco
Jeffrey Willett

Nantucket Harbor and Shellfish Advisory Board

Tobey Leske
Stephen L. Estabrooks, Ph.D.

Shellfish and Marine Department

David F. Fronzuto

Nantucket Board of Health

Richard L. Ray

Nantucket Land Council, Inc.

Linda S. Holland

Chamber of Commerce / Landscapers

Michael A. Glowacki
Lucinda Young

At Large

Maurice E. Gibbs
Mayer Mann

Ex Officio

Brian L. Howes
Wesley N. Tiffney, Jr., Ph.D.
Donald R. F. Harleman
John D. Pagini, AICP

1 EAST CHESTNUT ST. NANTUCKET, MA 02554
(508) 228-7237

recycled paper

Exhibit "B"

Chapter 99

NANTUCKET HARBOR WATERSHED

§ 99-1. Purpose.
§ 99-2. Definitions.
§ 99-3. Strategies and activities within the watershed.
§ 99-4 Applicability.

[History: Adopted 4-12-1999 Annual Town Meeting, Art. 70, approved 8-10-1999. Amendments noted where applicable.]

§ 99-1. Purpose.

It is hereby resolved and declared that Nantucket Harbor is a valuable environmental, economic, recreational, and aesthetic resource.

§ 99-2. Definitions.

NANTUCKET HARBOR WATERSHED — The area constituting the watershed for Nantucket Harbor, as described in a technical report entitled "Nantucket Water Resources Management Plan," 1990, by Horsley, Witten, Hegemann, Inc., and as delineated on a map entitled "Nantucket Harbor Watershed," Nantucket GIS, dated January, 1999.

§ 99-3. Strategies and activities within the watershed.

The Nantucket Harbor Watershed encompasses that area of the town within which human activities may affect the quality of the waters of Nantucket Harbor.

It is in the public interest to delineate the boundaries of the Nantucket Harbor Watershed, thus providing a frame of reference for diverse, multi-jurisdictional strategies and activities which promote the purposes of this section. In the future, these activities might include structural improvements (i.e., dredging or other activities to enhance water circulation, extension of sanitary sewers to mitigate septic discharges, the retrofit of storm drainage systems to reduce nutrient loading, and the development of planning contingencies and improvements devised to support spill containment), and regulatory activities, such as Public Health Regulations. Open space preservation activities, such as land acquisition and implementation of conservation restrictions, by the Land Bank Commission and other governmental and nonprofit entities are encouraged within the Watershed, because they reduce the land use impacts which can degrade the water quality of the Harbor. It is also important that educational strategies, devised to inform the public of ways to preserve Harbor water quality, have a defined watershed as a frame of reference.

§ 99-4. Applicability.

Nothing in this bylaw shall have any effect upon or applicability to the Zoning Bylaw of the Town of Nantucket (Nantucket Code, Chapter 139), nor shall this bylaw regulate expressly or impliedly any land use or operate in any manner as a land use regulation.

Exhibit "C"

Proposed Amendment to Article 47:
Nantucket Harbor Watershed

Delete the Finance Committee recommendation, and substitute the following:

To see if the Town of Nantucket will recommend to the NP&EDC that it direct its Nantucket Harbor Watershed Work Group to develop a strategy for regulating nutrients within the Nantucket Harbor Watershed following the receipt of a watershed nutrient loading model and recommendations, and Harbor circulation model and recommendations, both as commissioned by the Marine Department and the Shellfish and Harbor Advisory Board. It is further recommended that this strategy should include, but not be limited to, the consideration of the regulation of nutrient loading by storm drainage systems, septic systems, lawn fertilizers, and agricultural activities, among other contributors. It is further recommended that this strategy and associated bylaws should be presented for inclusion in warrant of the 2001 Annual Town Meeting, if the aforementioned reports are delivered to the Work Group in a timely manner. THIS IS A NON-BINDING RESOLUTION.

Exhibit "D"

NP&EDC

NANTUCKET PLANNING AND ECONOMIC DEVELOPMENT COMMISSION

Nantucket Harbor Watershed Work Group

NP&EDC

Donald Visco, Chairman

Nantucket Harbor and Shellfish Advisory Board

Tobey Leske
Stephen L. Estabrooks, Ph.D

Nantucket Shellfish and Marine Department

David Fronzuto

Nantucket Conservation Commission

Dirk Roggeveen

Nantucket Board of Health

Richard L. Ray

Nantucket Land Council, Inc.

Linda S. Holland

Chamber of Commerce / Landscapers

Michael A Glowacki

At Large

Maurice E. Gibbs
Mayer Mann
C.S. Lovelace
Ron Shepherd
Phil Austin

Ex Officio

Donald R. F. Harleman
Jeffrey Willett
John D. Pagini AICP / Matt Young
Revised July 10, 2000

1 EAST CHESTNUT ST. NANTUCKET, MA 02554
(508) 228-7237

recycled paper

Exhibit "E"

Nantucket Harbor Watershed

January, 1999

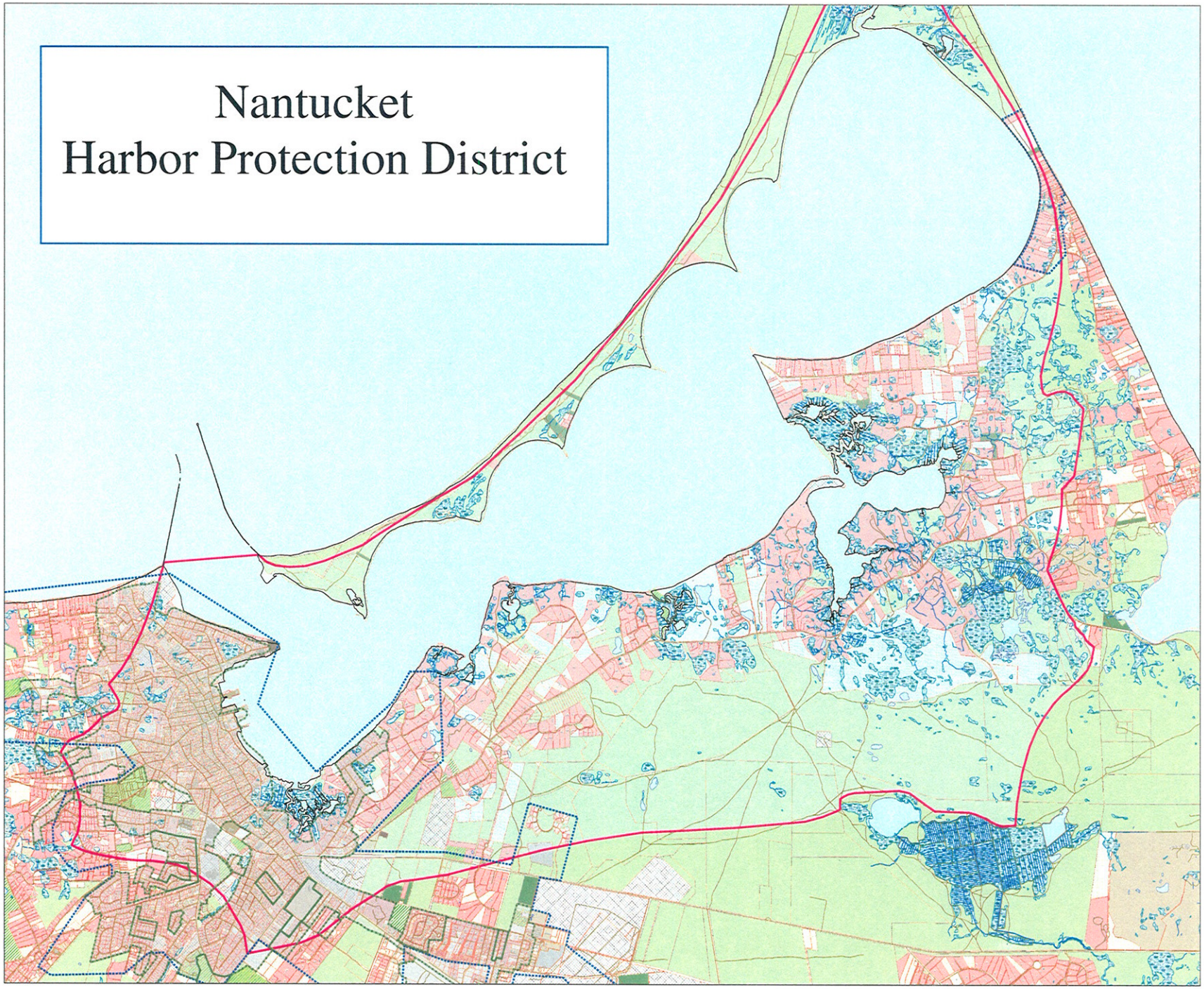
Nantucket Harbor Watershed

Nantucket Planning and Economic Development Commission

Exhibit "F"

Nantucket, MA

Nantucket
Harbor Protection District



Legend

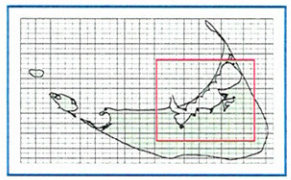
- Water Service Area Bound
- Sewer Service Area Bound
- Sewer Service Areas
- Harbor Protection District
- Openspace

Land Use

- Residential
- Commercial
- Vacant
- Industrial
- Agricultural
- Recreational
- Town
- County
- MA
- US
- Green-Open Space
- Misc Tax Exempt
- Parcels

Hydro

- Pond
- Stream
- Wetland



1 inch equals 1,000 feet N 01/30/2003

Exhibit "G"

FIGURE 7B-1

TOWN OF NANTUCKET
MASSACHUSETTS

COMPREHENSIVE WASTEWATER MANAGEMENT PLAN

AREAS OF WASTEWATER DISPOSAL NEED

Challenge:
Evaluate alternatives for a 20-year solution to wastewater collection, treatment and disposal needs of the Town.

Solution:
An Island-wide study to maintain and/or improve environmental conditions while determining costs, benefits for long-term sustainability, protection of the sole source aquifer and public health, and preservation of Nantucket Harbor, Madaket Harbor, Polpis Harbor and Sesachacha Pond.

Area of Wastewater Disposal Need Based on Wellhead Overlay Protection Zone

Town WPZ
Challenge
- Wellhead Protection Zone
- Private Water Supply & Wastewater Disposal

Solution
- Connect into Existing Wastewater System

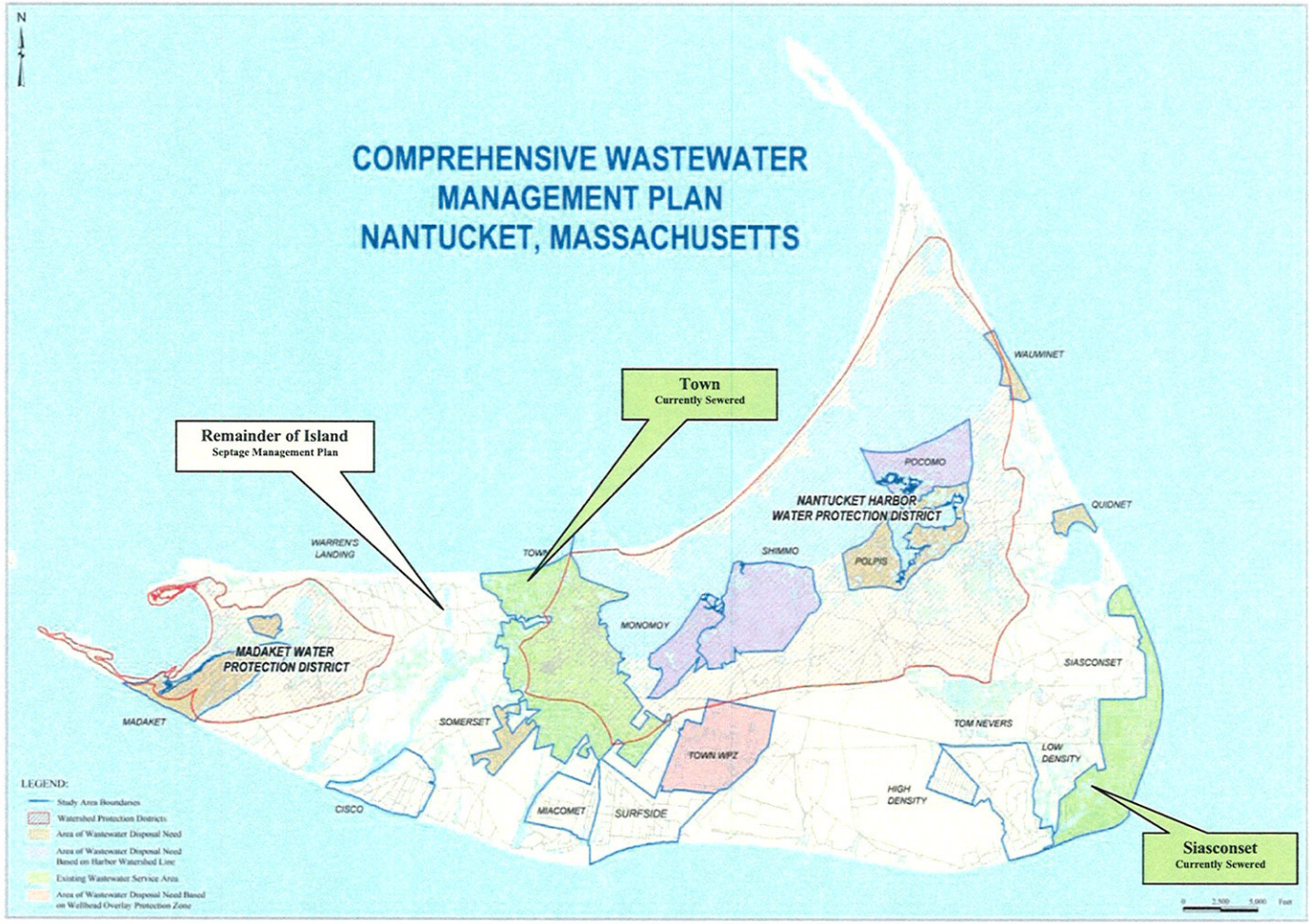
Area of Wastewater Disposal Need Based on Harbor Watershed Line

Pocomo
Challenge
- Nantucket Harbor Watershed
- High Groundwater
- Private Water Supply & Wastewater Disposal

Solution
- Septage Management Plan

Monomoy
Challenge
- Nantucket Harbor Watershed
- Private Water Supply & Wastewater Disposal

Solution
- Connect into Existing Wastewater System



Area of Wastewater Disposal Need

Shimmo
Challenge
- Nantucket Harbor Watershed
- Private Water Supply & Wastewater Disposal

Solution
- Connect into Existing Wastewater System

Madaket
Challenge
- Small Dense Lots
- Madaket Harbor Watershed
- Private Water Supply & Wastewater Disposal

Solution
- Decentralize Wastewater Treatment

Polpis
Challenge
- Nantucket Harbor Watershed
- Degradation of Polpis Harbor
- High Groundwater
- Private Water Supply & Wastewater Disposal

Solution
- Septage Management Plan

Quidnet
Challenge
- Topography
- Small Dense Lots
- Private Water & Wastewater Disposal

Solution
- Septage Management Plan

Somerset
Challenge
- Small Dense Lots
- Private Water & Wastewater Disposal

Solution
- Connect into Existing Wastewater System

Warrens Landing
Challenge
- Madaket Harbor Watershed
- Small Dense Lots
- Private Water Supply & Wastewater Disposal

Solution
- Decentralize Wastewater Treatment

Wauwinet
Challenge
- Small Dense Lots
- Private Water Supply & Wastewater Disposal

Solution
- Septage Management Plan

Prepared For: Town of Nantucket, Department of Public Works, 188 Madaket Road, Nantucket, MA 02554
For Additional Information Contact: Mr. Jeffrey Willett, Director, Department of Public Works, 508-228-7244
Prepared By: Earth Tech, Inc., 196 Baker Avenue, Concord, MA 01742, Contact: Mr. Thomas Parece, P.E., 978-371-4142

Date Prepared: June 2003