July 28, 2000

Dave Pincumbe,
US EPA
Boston, MA 02203
via fax

Mr. Pincumbe,

As you requested, the Buzzards Bay Project has evaluated existing available data relating to nitrogen loading and water quality of New Bedford Inner Harbor (also known as the Acushnet River), especially as it relates to the Fairhaven Wastewater Treatment Facility, and its discharge to that estuary.

Enclosed is our draft report for your consideration, *A Preliminary Evaluation of Nitrogen Loading and Water Quality of New Bedford Inner Harbor (Acushnet River) as it Relates to the Fairhaven Wastewater Treatment Facility.* As noted in the title, we have yet to fully characterize, update, and verify all the information relating to sources of nitrogen. In addition, the Town of Fairhaven has not yet had the opportunity to review this report. Please keep these facts in mind when reviewing the loading analysis contained in the report.

Sincerely,

Joseph E. Costa, Ph.D.
Executive Director

cc. Jeff Osuch, Town of Fairhaven Executive Secretary

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A Preliminary Evaluation of Nitrogen Loading and Water Quality of New Bedford Inner Harbor (Acushnet River) as it Relates to the Fairhaven Wastewater Treatment Facility.

By

Joseph E. Costa, Ph.D.
Buzzards Bay Project National Estuary Program

Draft Report
July 28, 2000

Introduction

The US EPA is expected to soon draft a renewal permit for the Fairhaven Wastewater Treatment facility. When reviewing discharge permit renewals for wastewater treatment facilities to coastal waters, the EPA now considers nitrogen loading from these facilities and their impacts on ecosystem health. This is particularly true in Buzzards Bay, because management of nitrogen sources to sensitive coastal embayments was identified as a priority in the Buzzards Bay Comprehensive Conservation and Management Plan (CCMP), which was approved by the Commonwealth of Massachusetts and the US EPA in 1991 and 1992 respectively. Such a loading evaluation is especially important when those discharges are into a poorly flushed embayment as is the case of New Bedford Harbor (also known as the Acushnet River estuary), where a hurricane barrier connects New Bedford and Fairhaven with only a narrow gate entrance between.

Because the permit renewal of the Fairhaven wastewater treatment plant is pending, the US EPA Region I offices has requested that the Buzzards Bay Project (BBP) conduct a review of available data that relate to nitrogen loading and ecosystem impacts of nitrogen to this estuary. In particular, the US EPA has sought an evaluation as to how nitrogen loading to this estuary compares to recommended nitrogen loading limits using the BBP's nitrogen loading methodologies.

Figure 1. Aerial view, circa 1991, of central New Bedford Harbor, showing the approximate location of the outfall of the Fairhaven Wastewater Treatment Facility.

In response to this request, the BBP has reviewed available land use information, flushing data, and water quality data undertaken by the Buzzards Bay Citizens' Water Quality Monitoring program. We have also evaluated loading with respect to the Buzzards Bay Project's nitrogen loading limit methodology contained in the Buzzards Bay Comprehensive Conservation and Management Plan and revised nitrogen loading recommendations issued by the Buzzards Bay Project in September 1999 and January 2000 (Costa, 1999; 2000). The loading estimates in this report are based on more recent and detailed information than found in the draft 1994 report evaluating loadings in 28 Buzzards Bay embayments.

Methods

Analysis of land use and population was largely based on 1985 MassGIS land use data, and 1990 census data (1995 corrections) provided by ERSI (www.esri.com). Census housing units and population blocks that were bisected by the Acushnet River drainage basin were adjusted by assuming the populations within the basin were overall proportional to the percentage of the census block polygon within the basin. These calculations and polygon clipping calculations were

Table 1. Acushnet River Watershed Land Use

Landuse type	Watershed areas Hectares	% of total
Cropland	170.1	2.5%
Pasture	397.2	5.8%
Forest	2863.7	41.9%
Non-forested wetland	124.9	1.8%
Mining	118.6	1.7%
Open land	233.3	3.4%
Participatory recreation	63.0	0.9%
Spectator recreation	34.1	0.5%
Water based recreation	5.0	0.1%
R0: residential multi-family	24.0	0.4%
R1: Residential - <¼acre lots	756.7	11.1%
R2: Residential - <¼-½acre lots	521.4	7.6%
R3: Residential - <½acre lots	411.2	6.0%
Salt marsh	15.7	0.2%
Commercial	247.2	3.6%
Industrial	232.7	3.4%
Urban open	211.0	3.1%
Transportation (major highways)	155.4	2.3%
Waste disposal	53.1	0.8%
Water (ponds, other freshwater)	98.3	1.4%
Woody perennial (bogs, orchards, etc.)	191.0	2.8%
TOTAL LAND AREA (ha)	6829.4	100.0%

Table 2. New Bedford Harbor and Acushnet River Watershed Features

Main Features		
Land area	16,874	acres
Embayment area	951	acres
Flushing rate	26.5	days
Half Tide Depth	3.8	m
Half Tide Volume	$16x10^6$	m^3
Land Use Summary		
Forest	42	%
Residential	25	%
Total developed	50	%
Agriculture use	11	%
Demographics of Watershed		
Population		
1990 US Census	66,224	
Housing Units		
1990 US Census	28,034	
Occupancy Rate	2.4	/unit

performed within the ArcView™ GIS software program. Because Land use and census statistics are 15 years and 10 years out of date respectively, calculations involving theses statistic are likely to be underestimates by at least 5-10%.

Point source estimates of loading were largely based on estimates of annual flow multiplied by average concentration where data was available. Other sources of data for water quality and loading assumptions are contained within other sections of this report.

Harbor & Watershed Characteristics

The Acushnet River is the most heavily urbanized embayment in Buzzards Bay. More than 20 CSO and other permitted sources (National Pollution Discharge Elimination System outfalls, NPDES) discharge to the Harbor, including the Fairhaven Wastewater Treatment Facility. These sources and generalized land use is shown in Figs. 1 and 2.

New Bedford Harbor sediments are highly contaminated with toxic PCBs and other contaminants, and the harbor has been declared an EPA superfund site. However, in recent years, the cleanup of PCBs has commenced, and is expected to continue until PCB cleanup is complete.

As a result, the embayment's ecosystem and many public uses have been impaired, and many recreational uses have been lost (no swimming, shellfishing, or finfishing is allowed). The Harbor is one of only three Buzzards Bay embayments with an "SB" water quality designation from the Massachusetts DEP.

This industrial urbanized waterfront is also home to one of the largest commercial fishing fleets in the country, and the harbor is used for docking and mooring of many recreational boats. Efforts are underway to reduce oil discharges to the harbor from both commercial and recreational boats.

New Bedford Harbor is an urban harbor with a watershed that includes 35% of the entire Buzzards Bay watershed population. This population resides in the lower part of the watershed, with the uppermost watershed largely forested, and with extensive wetlands. A summary of the major features of the harbor and watershed are shown in Table 1. Other watershed and embayment features are shown in Table 2.

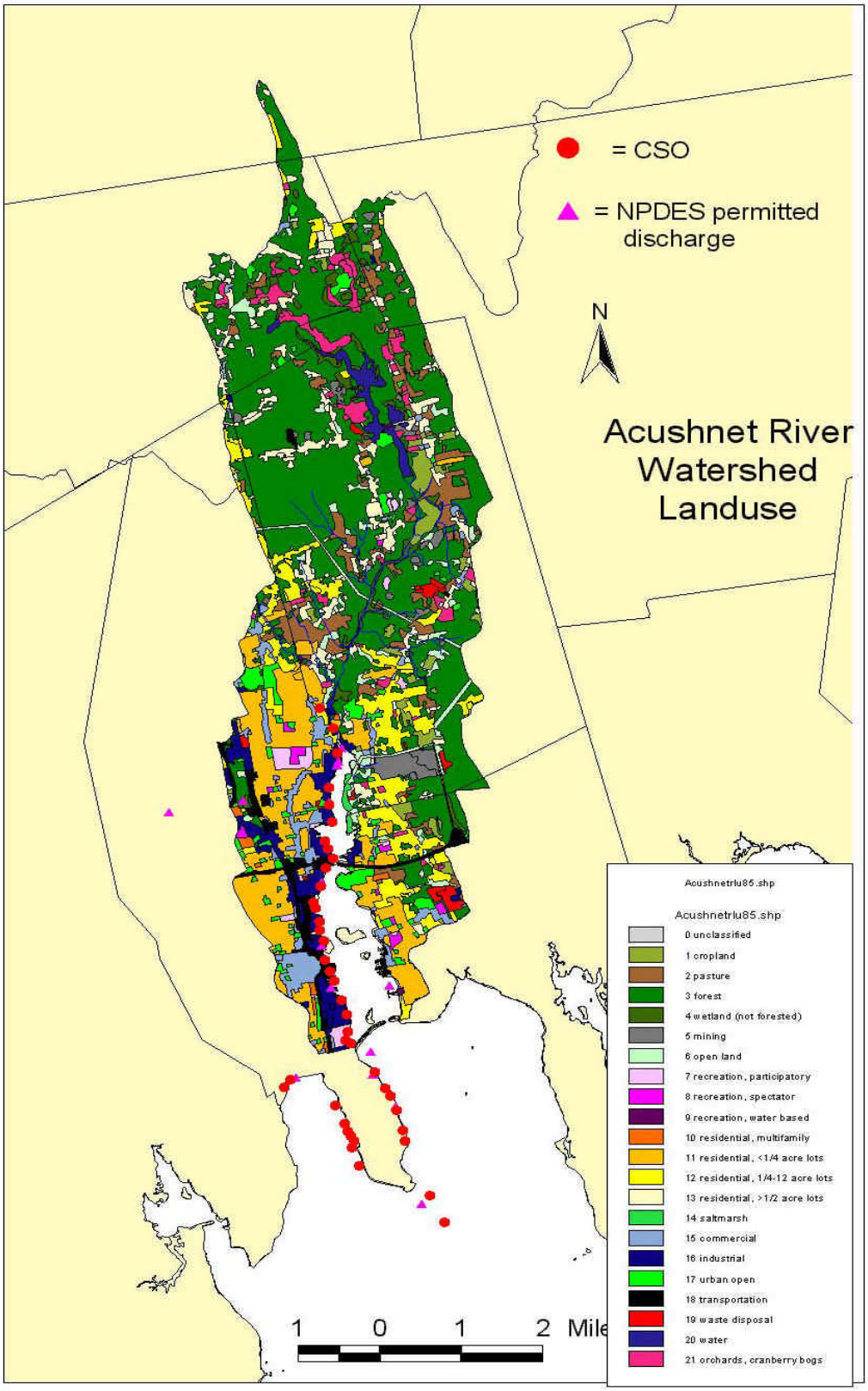

Figure 2. The watershed of the Acushnet River (New Bedford Harbor) showing land use (circa 1985), CSOs, and other NPDES discharges.

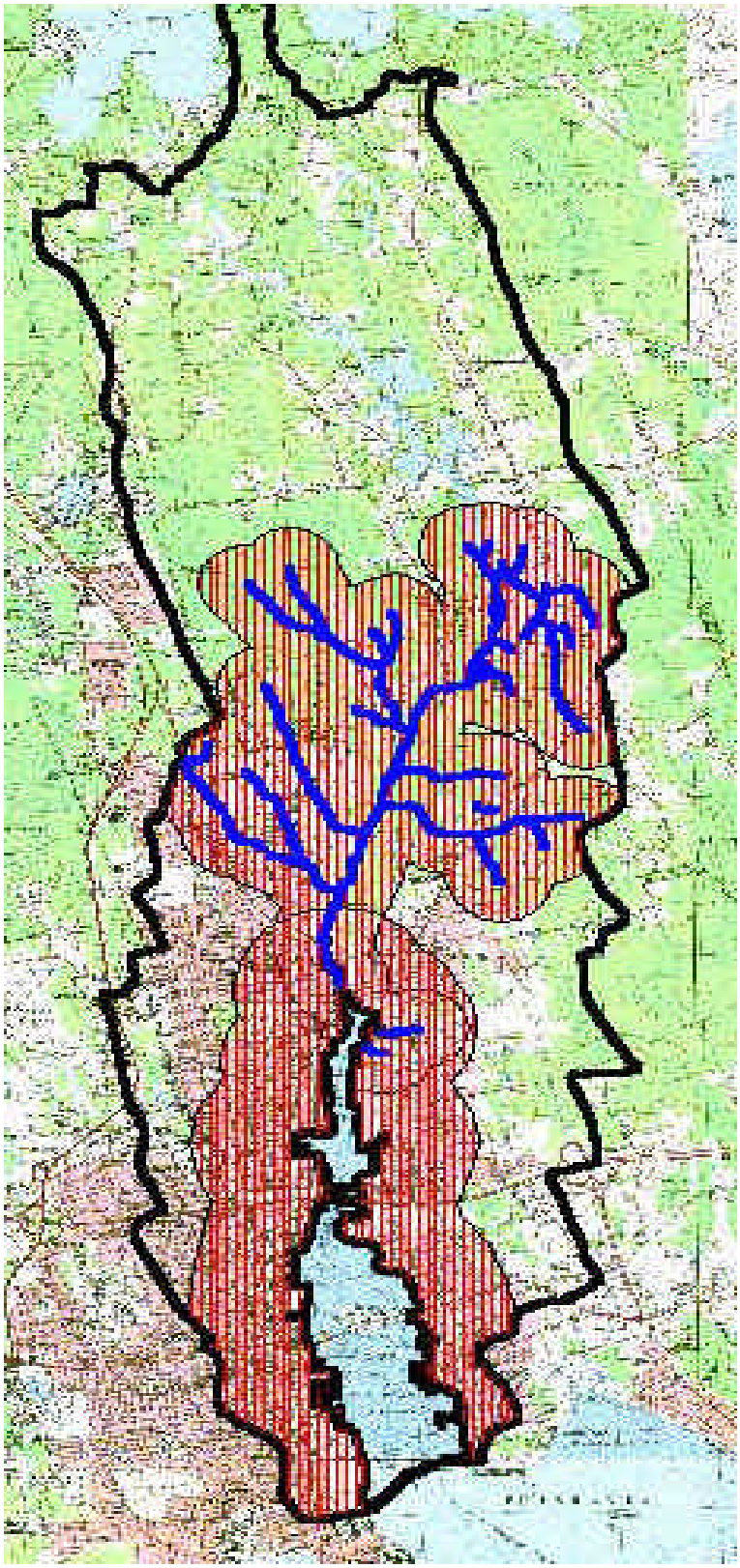

Figure 3. "Lower" watershed or low nitrogen attenuation zone shown by red cross-hatched area.

Only 32 % of the New Bedford Harbor-Acushnet River watershed area is sewered, with most of the sewered development occurring in the lower portion of the watershed, are is located in this sewered portion of the watershed. Most of this sewered area is connected to the New Bedford wastewater facility, which discharges to Buzzards Bay. Previous studies have suggested that this discharge affects water quality in the inner harbor only to a small degree. Rather, it is believed that sources within the harbor such as the Fairhaven sewage treatment facility, New Bedford CSOs, and urban runoff (Fig. 2) are the nitrogen sources that affect most harbor water quality.

Nitrogen Loading Evaluation

In 1994, the Buzzards Bay Project completed a nitrogen loading assessment for 28 Buzzards Bay embayments, including New Bedford Harbor and the Acushnet River watershed (Costa, 1994). There were a number of important assumptions in our 1994 methodology that did not apply well to this urban watershed, and they are worth highlighting. In this report we also present what we believe are more realistic loading assumptions for a number of important sources. The calculations below include new nitrogen loading methodologies recommended by the Buzzards Bay Project in the September 1999 and January 2000 reports (Costa et al., 1999, Costa, 2000). These reports outline proposed revisions to the BBP methodologies, including a 30% nitrogen loss term for the upper watershed (land more than 1 km from the bay or from a direct surface water discharge), and a background precipitation loading coefficient of 0.17 kg per hectare of all drainage basin land types except ponds and wetlands.

There are several difficulties in interpreting nitrogen loading to New Bedford Harbor, especially when trying to relate it to existing water quality. One of the most important of these is that loadings have changed dramatically during the past 10 years. For example, dry weather CSO discharges were prevalent during the early 1990s. The City of New Bedford has corrected this problem, and now only wet weather discharges occur, and then at a smaller volume than previously occurred due to the additional storage capacity of the cleaned in-line settling chambers.

Another nitrogen loading decline has occurred because of expansion of the New Bedford sewer lines into Acushnet. This poses a special problem for interpreting existing water quality, because of the lag time between septic system inputs to groundwater and discharge to coastal waters, which in this case may exceed a decade for neighborhoods more than 1 km from the edge of the river. Thus, for the most recent sewering of Acushnet, the removal of these septic loads was included in “future” loading estimates, but circa 1990 sewer maps were used for estimating existing loading to the harbor. For establishing the appropriate discharge limits for the Fairhaven sewage treatment facility, all existing sewers and projected CSO improvements were included in the analysis.

Fairhaven Wastewater Facility Loadings

The Buzzards Bay Project's 1994 nitrogen subwatershed analysis used design limit flows (5.0 MGD) in the calculation of loading. This approach is appropriate for estimating future worse case conditions and for putting into perspective discharge concentration limits appropriate for a permit. However, estimates of existing loading should be based on existing average annual loads. In 1998, annualized daily flow was 2.3 MGD. In 1999, annualized daily flow was 2.0 MGD. The decline may have been the result of a summertime drought (Osuch, pers. comm.). In Table 3, we calculate total loading based on a presumed current average annualized daily load of 2.2 MGD. In 1994, the BBP used a worse case sewage discharge of 30 ppm. Historically no measurements of total nitrogen were made on the effluent. Two recent tests found 11 and 13 ppm TN. These values are low for a municipal discharge with only secondary treatment levels, and the collection of more data is warranted, especially given the importance of this discharge. In our loading calculations, we use an average annual discharge of 12 ppm. These assumptions suggest that the wastewater treatment facility discharges approximately 36,000 kg N annually (ca. 79,400 lbs/y) to New Bedford harbor.

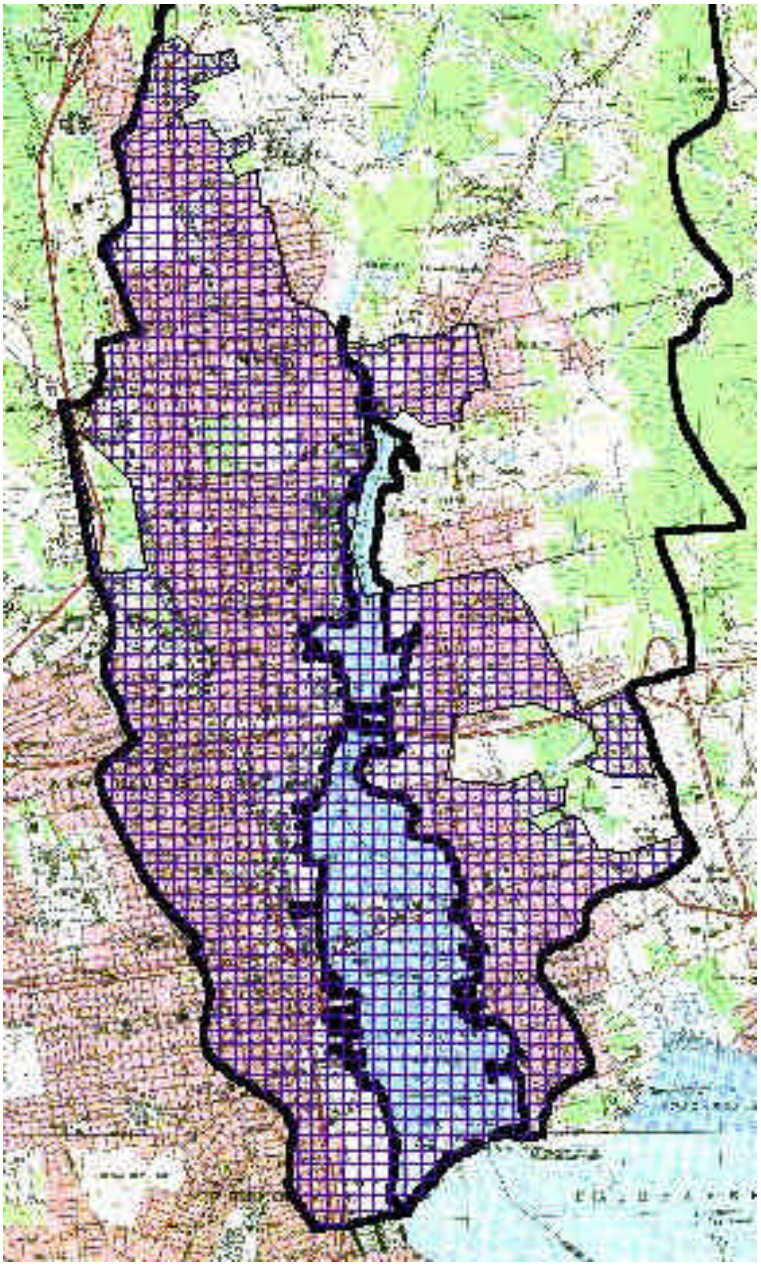

Figure 4. Detail of lower watershed, showing the approximate extant of sewering circa 1990 (purple cross-hatch).

New Bedford CSOs

The nitrogen concentration and average freshwater wet weather flow of CSO discharges is less than the 35 ppm used in our 1994 calculations. The US EPA has recommended that 6.7 mg/l is a more likely annual wet weather average concentration of nitrogen (D. Pincumbe, pers. comm.). The 1991 CSO flows and loads to the inner harbor were estimated to be 595 MG/y, which equals 14,900 kg/y (32,800 lbs/y) nitrogen loading using the presumed 6.7 mg/l average nitrogen concentration. However, with the reduction or elimination of dry weather discharges, CSO discharges are now estimated to be 353 MG/y for CSO discharges in the inner harbor. This implies an existing nitrogen load of 8,850 kg/y (19,500 lbs/y). For future conditions, we presume that after CSO and wastewater line upgrades are completed in the next decade, total CSO discharges (wet only) will equal only 28.2 MG/y, which if the

discharge remains constant in concentration of 6.7 mg/l, would equal 700 kg/y or 1,550 lbs N/yr

Stormwater Discharges

A large portion of this watershed has an impervious surface to rainwater, and this fact results in the discharge of large volumes of stormwater. A large portion of this stormwater is tied into CSOs in New Bedford, some of which may overflow into the harbor through wet weather discharges, but the majority of which are discharged to Buzzards Bay through the New Bedford outfall on Clarks Point. However, there are also many other stormwater-only discharge pipes located in the inner harbor and these are far more numerous than the number of CSO discharges shown in Fig. 2. Unfortunately, little is known of the annual volume of discharge of these pipes into the inner harbor.

In Table 1, all land use in the industrial, commercial, and transportation land use categories were presumed to be sewered, leaving only stormwater discharges as the principal source of nitrogen for these land types. The BBP methodology incorporates these stormwater discharges in the loading coefficients for each land use. Because a portion of stormwater runoff from the commercial, industrial, and transportation (roads) land types is captured by the New Bedford CSO system, these losses need to be accounted for. In the absence of specific data, we assumed that ½ the stormwater from roads, and commercial and industrial properties were captured by the New Bedford wastewater treatment facility and discharged into Buzzards Bay. This assumption reduced annual nitrogen loading to the inner harbor by 3,300 kg annually.

Residential nonpoint sources of pollution

For all census units in the watershed, impervious land area from roofs, driveways, and sidewalks are presumed to cover 1500 square feet, and average lawn size is presumed to be 1000 square feet. In practical terms, many small parcels may have greater impervious surfaces, and have lawns of only 500 square feet. Many other properties, especially in the upper and non-urban portions of the watershed may have lawn far greater than 5000 square feet. To simplify calculations, a 1500 sq. ft impervious, and 1000 sq. ft lawn was assumed to represent average weighted lawn and impervious surface area sizes for the entire watershed. These contributions from the 28,000 units in the watershed (21,400 lower, 6,600 upper watershed) amount to 13,400 kg/y N loading.

Although only 32% of the watershed is sewered, 84% of the wastewater from the 66,200 people and 28,000 units are connected to wastewater facilities. New Bedford and Acushnet residences are tied into the New Bedford Wastewater facility, and Fairhaven Residents are tied into the Fairhaven Wastewater Facility. Based on recent sewer line maps from the City of New Bedford and 1990 US census unit and population statistics, 16% of the population (10,600 people or about 4000 units) in this drainage basin are using septic systems. Most of these systems are within the Town of Acushnet. These septic systems contribute an estimated 24,800 kg N annually to the inner harbor. This is somewhat of an underestimate since additional new subdivisions with septic systems have been built in Acushnet since 1990.

Table 3. Acushnet River Land Use and Loadings	Watershed areas in Hectares			Annual Loading
Land use type	whole	lower	upper	N (kg)
Cropland	170.1	98.4	71.7	2997
Pasture	397.2	233.7	163.5	3540
Forest	2863.7	972.0	1891.7	383
Non-forested wetland	124.9	44.3	80.6	17
Mining	118.6	52.1	66.4	737
Open land	233.3	137.1	96.3	34
Participatory recreation	63.0	52.9	10.2	1767
Spectator recreation	34.1	23.9	10.3	915
Water based recreation	5.0	2.9	2.1	33
R0: residential multi-family	24.0	13.6	10.4	4
R1: Residential- <¼acre lots	756.7	513.2	243.5	126
R2: Residential- <¼-½acre lots	521.4	299.3	222.1	87
R3: Residential- <½acre lots	411.2	155.5	255.7	69
Salt marsh	15.7	15.7	0.0	3
Commercial	247.2	200.5	46.7	1881
Industrial	232.7	181.0	51.7	2528
Urban open	211.0	112.6	98.4	30
Transportation (major highways)	155.4	97.3	58.1	2134
Waste disposal	53.1	15.9	37.1	649
Water (ponds, other freshwater)	98.3	18.3	80.0	0
Woody perennial (bogs, orchards, etc.)	191.0	32.2	158.8	2648
Major road length, km	30.8	14.2	16.6	
Secondary Road length, km	327.8	231.1	96.7	
Road Area (ha)	314.0	208.7	105.2	2062
Embayment area (ha)	240			1752
Total Loading, pre adjustments				**24394**
Area occupancy	2.2	2.2	2.2	
actual units (1990 census)	28034	21429	6605.0	
roof+lawn loading from census units		8073	2372	10446
Unit density (per acre)	0.7	0.9	0.5	
Actual population (1990 Census)	66224	49767	16457	
nonsewer census population septic N	10580	5876	4704	24756
actual occupancy, 1990	2.4	2.3	2.5	
Total Loading, actual units				**59595**
Animal units	0.0	0.0	0.0	0
Fairhaven Wastewater Facility 2.2 MGD, 12 ppm TN				36039
NB CSOs:				8845
Fairhaven Landfill				1300
stormwater losses				-3235
Final Adjusted Loading				**102544**

Fairhaven Landfill

The Fairhaven landfill is located in this drainage basin. This 6.5-hectare (16.1 acres – fill area) site was recently closed and capped, but because it was the site of household and commercial waste, and a septage disposal site, it likely has contributed to groundwater, and hence estuary, nitrogen loads. Because the center of the site is approximately 1400 m (4590 ft) from the Harbor, assuming a groundwater travel time of 1 to 2 feet per day, this plume has a transit time of 6 to 13 years.

Groundwater under landfills tends to be elevated in nitrogen. At the time of the writing of this report, the Buzzards Bay Project was unaware whether groundwater nitrogen concentrations have been monitored under the landfill. In the absence of data, we presume the landfill is comparable to that of the Town of Falmouth, whose landfill also accommodated septage. The non-septage bearing areas had groundwater concentrations of approximately 10 to 15 ppm. In contrast, an area immediately down gradient of septage lagoons had concentrations as high as 120 ppm ammonia (Costa, 1996b). If, for example, the average groundwater concentration under the site is 40 ppm, and assuming a 50 cm rainfall recharge rate (=32.5 x 10^6 liters), annually loading from the landfill would amount to 1,300 kg annually. This plume is still likely to be loading to the harbor but will diminish considerably with time because of landfill capping. This is a preliminary estimate, and actual loadings can only be ascertained with groundwater nitrogen measurements.

A summary of existing nitrogen loads is found in Table 3, and summarized by major source category in Figure 5. As shown, total nitrogen load to the harbor is largely the result of the Fairhaven sewage treatment facility, followed by residential non-point sources of pollution. These loading estimates do not account for new homes built since 1990.

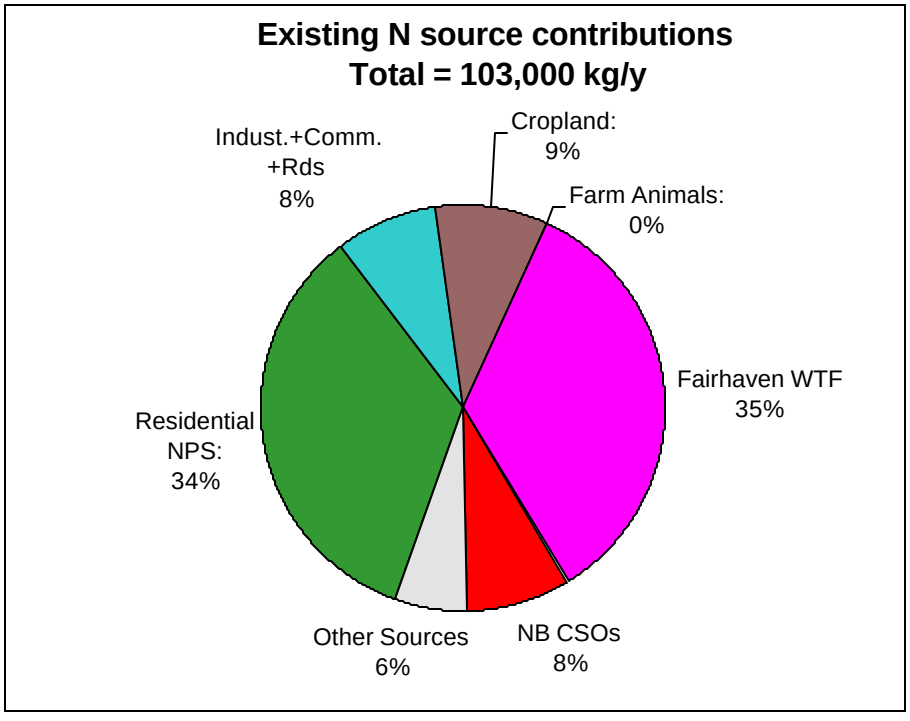

Figure 5. Estimated relative contribution of nitrogen sources to New Bedford Harbor.

Water Quality Monitoring

Water quality in the Harbor was monitored in 1993-1996, and 1998-2000 as part of the Coalition for Buzzards Bay Citizens Water Quality Monitoring Program. Data collected in that program and analyzed for 1993 to 1998 shows that the upper portion New Bedford inner harbor is among the most eutrophic embayments in Buzzards Bay (Figs. 6 and 7, modified for revised loading in this report from Costa 1999 and Costa 2000). Measured Total Nitrogen and the Eutrophication Index score for water quality show that the harbor is well over the proposed target concentrations appropriate for SB waters. By extrapolating along the relationship curves for these data, loadings may need to be reduced by one half to achieve water quality targets.

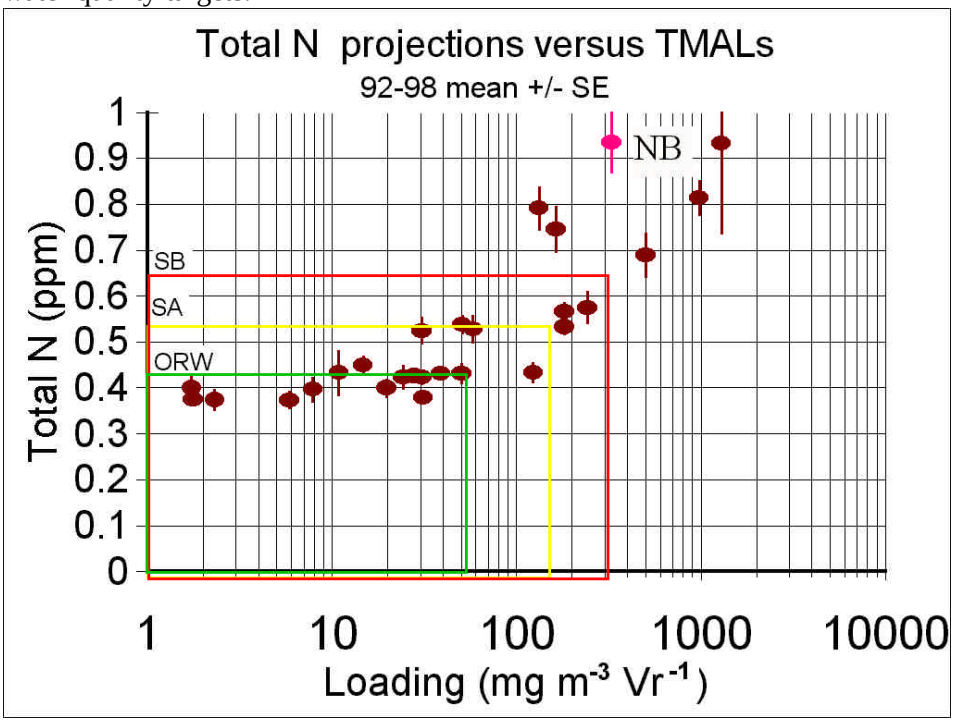

Figure 6. *Total Nitrogen in New Bedford Harbor versus predicted load compared to other Buzzards Bay embayments and proposed revised TMDLs (see Costa, 2000).). New Bedford Harbor is well above the proposed TN standard of 0.65 ppm for SB embayments (shallow).*

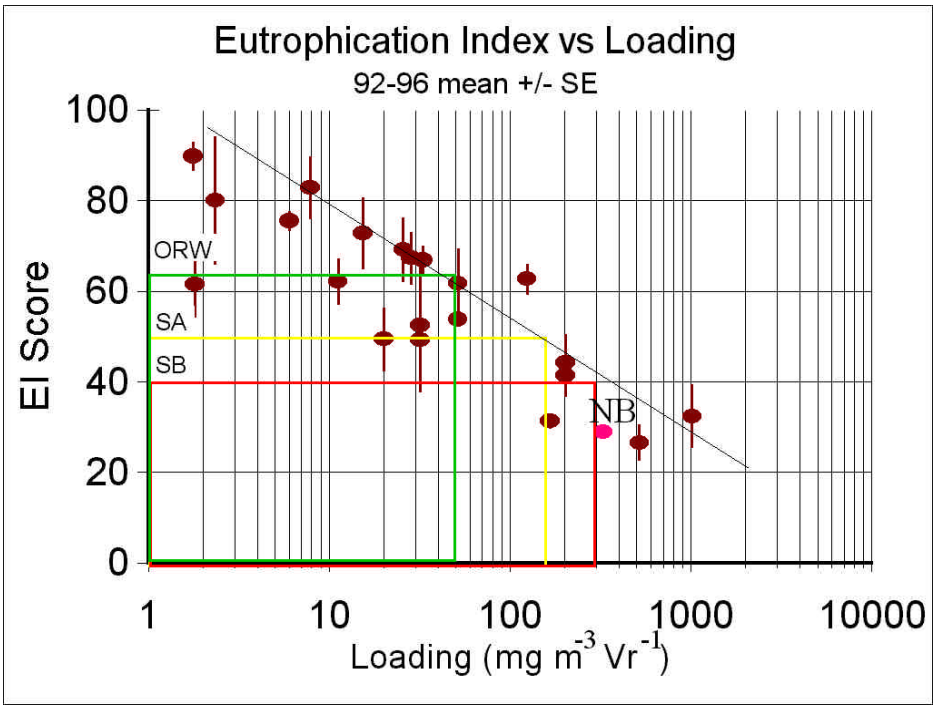

Figure 7. *Buzzards Bay Eutrophication Index in New Bedford Harbor versus predicted load compared to other Buzzards Bay embayments and proposed revised TMDLs (see Costa, 2000). New Bedford Harbor is well below the proposed EI score of 40 for SB embayments (shallow).*

Recommended Nitrogen Limit

To estimate allowable nitrogen loading rates for New Bedford Harbor using the BBP's methodology, estimates of bay volume at half tide, and average flushing or hydraulic turnover time is required. The Buzzards Bay Project estimates of half tide volume and hydraulic turnover time are shown in Table 2. Both estimates were taken from the ACI 1995 report. Harbor area was adjusted to account for islands in the harbor, which were directly digitized in ArcView using USGS quad maps.

In the ACI report, actual flushing rates ranged from 15.5 days to 23.2 days for the upper estuary and 27 to 40 days for the entire system using a dispersion coefficient model (the tidal prism model was not appropriate because of the presence of the hurricane barrier). In addition, ACI used a tidal range of 1.1 m, which is likely the tidal range outside the hurricane barrier, not within the harbor. Because of these complications, we have a selected the upper calculation range for the upper embayment (23.2 days) as the basis for establishing a TMDL limit. However, because of the importance of this term in establishing a nitrogen TMDL, we recommend *in situ* measurements of salinity, tidal exchange, or us of dye release studies to refine this estimate. Some relevant data may have already been collected through the Superfund studies for New Bedford Harbor, and these data should be examined if they exist.

Using the BBP's proposed September 1999 and January 2000 limits for SB waters greater than 2 m in depth (standard = 400 mg per liter during the hydraulic turnover time), the allowable loading to New Bedford is 122,900 kg/y[1]. Using this standard, the harbor is below the recommended limits by 15,000 kg

[1] TMAL standard x volume at half tide (in m3) x (1+ w½)/ w ÷ 1,000,000; where w is the hydraulic turnover time in years.

annually. However, water quality data shows that New Bedford harbor is among the most eutrophic systems in Buzzards Bay. These findings suggest that the proposed BBP SB limits for deep embayments are too lenient and either the SA standard should be used, or the more lenient rates for "deep" embayments should be abandoned.

Application of the BBP methodology is clearly complicated by the fact that water in New Bedford Harbor is worse than expected from loading and hydrological features alone. Either nitrogen inputs were underestimated (e.g. the facility discharges greater than 12 ppm nitrogen), flushing rates overestimated, or the ecosystem response to nitrogen is affected by other factors.

The Buzzards Bay Project is currently reviewing the appropriateness of the proposed SB standards for Buzzards Bay embayments. The surface water standards currently do not establish water quality conditions with respect to the nitrogen loading. The "SA" and "SB" standards as defined in the state's Surface Water Quality Standards differ only in that the SA uses the word "excellent" to describe overall water quality and habitat conditions. In contrast application of the BBP's proposed SB nitrogen standard (Costa, 2000) for New Bedford Harbor results in the existing "poor" water quality conditions that have been documented (e.g. Howes et al, 1999).

Another consideration is that the application of a more lenient loading allowance for deeper embayments is difficult to justify with the Buzzards Bay water quality data since few embayments are classified as "deep", and their ecosystem response is not dissimilar from those classified as "shallow." As currently proposed, deep embayments are allowed 50% to 33% more nitrogen inputs using the BBP nitrogen management methodology on the assumption that they are less sensitive to nitrogen inputs because eelgrass and algae cannot grow on the bottom of these bays. While the depth of these embayments may preclude such shifts in photosynthetic benthic species, there is inadequate data to justify such a large allowable extra load in these embayments. This is particularly true since these systems may show greater concentrations of TN and chlorophyll in the water column than shallow embayments. As a result of this information gap, the Buzzards Bay Project is considering abandoning the "deep bay" standard in favor of a single standard for both shallow and deep bays.

In Table 4 below, we identify potential management loading options for the Acushnet River

Table 4. *Estimated existing nitrogen load versus potential recommended limits.*

SA, shallow standard:	46,100 kg/y
SA, deep standard	61,400
SB, shallow standard:	92,200
SB deep standard	122,900
Estimated Current:	103,000

Management implications for the Fairhaven Wastewater Treatment Facility

There is currently debate among regulatory agencies as to whether the proposed BBP SB standard meets the water quality intent of the Clean Water Act or whether it is too lenient. There is uncertainty whether a separate more lenient standard should be applied to deeper embayments. It is a management decision as to which standard is most appropriate. However, the results of water quality data suggest that either the SA-deep or SB shallow should be applied.

If, for example, the SB water quality standard for shallow bays is applied to this embayment (92,200), then loading to the harbor should be reduced by 11,000 kg annually. If the standard must be met by the wastewater facility at design capacity (5.0 MGD), then it would have to adopt a discharge limit of 3.5 ppm N (Table 5). Of course, with future reductions from groundwater and stream discharges from the

landfill plume and septic systems in Acushnet recent eliminated through sewering, and reductions in CSO wet weather discharges to the Harbor with completion of the New Bedford CSO upgrades, then the discharge target concentration may be closer to 5.0 ppm. Of course, this scenario does not account for future growth potential in the watershed.

Table 5. Fairhaven Wastewater Facility Sensitivity Analysis

	MGD	ppm	kg N/y
existing	2.2	12	36039
worse case	2.2	18	54058
future potential	5	3.5	23889
future potential	5	5	34128
future potential	5	10	68255
future potential	5	12	81906

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