PECONIC ESTUARY PROGRAM

Nitrogen Loading Budget and Trends

Major, External, Anthropogenic Nitrogen Sources:
Groundwater and Duck Farms

Suffolk County Dept. Of Health Services
Office of Ecology

DRAFT

January 15, 1999

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Table of Contents

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ABSTRACT

A total nitrogen (TN) loading budget for the Peconic Estuary was constructed for the time period of 1900 to 2050. The budget considered major, regional, external, locally manageable, anthropogenic nitrogen loads. These include duck farms and groundwater, which integrates nonpoint source pollution from fertilizer, sanitary systems, and other sources. The analysis was performed primarily to:

* provide basic status and trends information to support management efforts;
* verify existing surface water model TN nonpoint source load assumptions; and
* develop preliminary regional estimates for future nitrogen loadings for preliminary surface water model "management alternative runs."

All objectives were successfully accomplished.

The analysis has several management applications. Most profoundly, the study has reaffirmed the feasibility of the PEP approach of "no net increase" of TN loading to the western estuary (with ultimate load reductions targeted), and has underscored the need for the "water quality preservation" in the eastern estuary. For existing land uses, on a regional basis, management of residential and agricultural lands is an obvious priority, since they account for greater than 80% of the groundwater TN load to the estuary. For proposed new development, residential development is the major concern on an estuary-wide basis, particularly in the western estuary and on the South Fork. New industrial and commercial development is an issue prominent mainly in the western estuary, particularly in Riverhead Town.

The value of open space has been quantified in terms of nitrogen loading averted. Several priority investigation needs were also identified, including refinement of Western Peconic River loadings (possibly via a watershed model), as well as improving agricultural TN load budgets.

SUMMARY

Existing Conditions

For existing conditions, duck farms no longer directly discharge waste to the estuary. Nonpoint source loading was evaluated using land use data and pollution loading factors. Overall groundwater total nitrogen loading is approximately 6,500 pounds per day, about 32% of which occurs in the western estuary (Peconic River and Flanders Bay groundwater-contributing area). The dominant sources of total nitrogen to the estuary are agriculture (41% of TN loading) and residential development (40% of TN loading). Agriculture has a per-acre TN loading rate of about double the residential land in the study area. Industrial and commercial uses contribute less than 10% of the TN load to the estuary, even in the Peconic River corridor. These results highlight the need for targeting best management practices and other land use and pollution control management programs primarily at residential and agricultural land uses to mitigate existing TN loadings.

Surface water model loading assumptions (based on freshwater inflow budget and TN concentration measurements) were verified with this independent analysis. The results agreed

extremely well in the eastern estuary (within 10% of each of three subregions of eastern estuary). In the western estuary, agreement was fair for all four subregions (16% to 32%), except in the Peconic River West (west of USGS gauge), where agreement was markedly poor (460% error). The Suffolk County Dept. of Health Services (SCDHS) will work on refining Peconic River residential and agricultural TN load factors, as discussed below. Fortunately, ample data exist for flow and concentration data at the Peconic River gauge station, and they are used in model calibration and verification, obviating the need for immediate resolution of the discrepancy in loading for that area.

Historic Loading Trends

In terms of historic loading trends, a "probable historic TN load trend" analysis was performed based on readily available information. Based on this preliminary analysis, TN loading to the estuary appears to be at an all time high. It appears that total nitrogen loading to the eastern estuary (east of Flanders Bay) may have risen by over 200% since the 1950's, due to dramatic population growth, coupled with the pervasive use of relatively inexpensive, highly soluble, commercially available, inorganic nitrogen fertilizers. In the western estuary, decreases in duck farm TN loading appear to be roughly offset by increases in nonpoint source TN loading. These estimates may eventually be used in a long-term, historical model run, to test the performance of the water quality and predictive sediment submodel and, possibly, evaluate potential water quality trends in the absence of actual monitoring data. Of course, should a historic run be contemplated, long-term changes in other sources, such as atmospheric deposition and the locally important Riverhead Sewage Treatment Plant, would have to be characterized.

Full Build-Out and Worst-Case Scenarios

Data on "land available for development" was linked with pollution load factors to project full build-out and worst-case load scenarios. Although 40% of the acreage in the watershed is subject to development, as a whole, additional future total nitrogen loading under a "full build-out" scenario is more modest in the western estuary (13% increase), and is more quantitatively significant in the eastern estuary (>20% increase). This is due to potential conversion of agricultural lands to low density residential land uses, which are generally less nitrogen intensive.

Virtually all of the TN load increase would be in the form of residential TN loading, except for the western estuary. In that area, industrial and commercial development potential is also tremendous, mainly due to developable lands in Riverhead Town (2,900 acres at Grumman site, and 1,900 acres at other sites in the Town). Overall, over 90% of the developable industrial acreage in the study area, and almost one-half of the developable commercial acreage, are in Riverhead Town. Thus, management strategies should be targeted and potential pollution from developable commercial and industrial lands, particularly in Riverhead Town, not only for TN, but also for other threats, such as toxics.

Under a scenario in which 100% of farmland is preserved, nitrogen loading could increase fairly substantially in every major region of the estuary at full build-out. Overall, a total nitrogen increase for the estuary study area would be near 40% (about 41% in eastern estuary, and 34% in western estuary). In the eastern estuary, the increase on the South Fork would be most profound (over 60%). Groundwater inputs to the estuary are most significant in the western estuary and South Fork (32% of groundwater inflow to the estuary is in western estuary, and 45% is from the South Fork).

In the western estuary, increases would be substantial in every subregion, but are particularly important for the Peconic River west of the USGS gauge station. At the gauge, TN levels in the river could more than double in a worst-case scenario, although this projection must be better quantified prior to running final model management alternatives.

Open Space Benefits

If open space programs were not implemented, and those lands were developed at low density residential land uses, current TN loads to the western estuary, South Fork, and Shelter Island would more than double, as compared with existing conditions. Open space programs have obviously been tremendously successful, not only for drinking water protection and habitat/living resource concerns, but also for TN load controls and surface water quality preservation. The programs should obviously continue to be aggressively pursued, not only for habitat and living resources benefits, but also as a means to control TN inputs.

Recommended Investigations

Given the magnitude of the estimated loads, coupled with the likely variability of loadings, the area of greatest need of pollution loading characterization is agricultural TN loading. For the Peconic River, another investigation priority should be to refine residential and agricultural TN load factors, perform a more realistic analysis for the actual groundwater-contributing area (rather than the substantially larger land use study area), and review literature on riverine sedimentary denitrification, transient export events and other phenomena. Even more broadly, a Peconic River hydrodynamic surface water quality model should be considered. Finally, a residential fertilizer loading refinement is warranted, given the magnitude of the source, even though it is believed to be far less variable than agricultural TN loading.

Improved groundwater characterizations are an important goal of the PEP, particularly in the westernmost study area. These will be accomplished in the coming year by US Geological Survey via seismic reflection tows (to better refine geology under Flanders Bay). Also, Camp, Dresser, & McKee, under contract to Suffolk County, is performing groundwater modelling which will define groundwater-contributing areas and delineate zones of contribution according to travel time to estuary (e.g., 1-year travel time, 10-year travel time, etc.).

Preliminary "Worst-Case" Model Runs

For preliminary sensitivity analysis, the "worst-case" TN loads discussed above should be used. A factor of safety on the order of 10% should also be used to account for potential intensification of land uses (e.g., rezonings to allow denser development), as well as possible estimation errors. Specifically, the following estimates are recommended:

Western Estuary	*Existing*	*Worst Case*
Peconic River Flow: *(at USGS gauge)*	0.65 mg/l	1.5 mg/l
Peconic River East:	6 mg/l	7 mg/l
North Flanders Bay:	9 mg/l	10.5 mg/l
South Flanders Bay:	3 mg/l	4.8 mg/l

Eastern Estuary		
North Fork:	9 mg/l	10.9 mg/l
South Fork:	3 mg/l	5 mg/l
Shelter Island:	3 mg/l	4.5 mg/l

1) Goals

A) Primary Goal

The overarching goal of this effort was to construct an empirical nitrogen loading budget for major, external, manageable, anthropogenic nitrogen loads. Internal loads, such as sediment nutrient flux, were not included in the analysis. Atmospheric deposition was also excluded, as it is not primarily caused by manageable activities in the estuarine study area. Thus, the only "major" sources considered in this analysis were groundwater (mainly fertilizer and sanitary waste) and duck farms. Other categories of sources, such as sewage treatment plants, may be locally significant, but are at least an order of magnitude lower in quantitative loading, and are not believed to exert a significant influence on a system-wide basis.

B) Time Period of Trends Analysis

This task began with a budget for existing conditions as a baseline, and constructed a retrospective nitrogen loading rate curve for the past century, dating to the time period immediately preceding the advent of significant commercial duck farming activity. For purposes of this analysis, the prospective, "full build-out" analysis was assumed to occur over the next 50 years. Thus, the analysis considered the time period of roughly 1900 to 2050.

C)Objectives

The analysis was performed to:

* provide basic status and trends information to support management initiatives and decisions.
* verify existing surface water model TN nonpoint source load assumptions by developing nonpoint source load estimates using an independent methodology. For the model, groundwater inputs of TN were developed by coupling inflow rates (US Geological Survey budgets) with regional groundwater quality estimates (based on SCDHS monitoring well data). For this report, nonpoint source estimates were developed primarily based on land use data coupled with loading factors which are well established in the literature.
* provide data which can be used to test the long-term performance of the surface water quality model and predictive sediment submodel, possibly providing a means to assess likely long-term trends in water quality in the absence of historic monitoring data.
* estimate likely TN loads avoided through open space programs, to document benefits associated with those programs.
* develop preliminary regional estimates for future nitrogen loadings for surface water "management alternative runs," based on "land available for development" data coupled with nitrogen loading factors.
* characterize areas of greatest uncertainty related to nitrogen inputs to focus future

research and monitoring investigations.

This report serves as a companion to the Suffolk County Dept. of Health Service *Point and Nonpoint Source Nitrogen Loading* report (Rev. October 13, 1998). The *Nitrogen Loading* effort was developed primarily to provide an initial characterization of existing conditions, particularly with respect to sediment nutrient flux and groundwater, with the goal of assisting in the development of inputs necessary for calibration and verification of the surface water model.

2) Methodology

This section provides a summary of the rationale of the overall strategy employed in this task. Specific assumptions are noted on individual data tables presented below.

A) Key Data Sources

Several documents and sources of information were reviewed and used in this exercise. The following documents are worth specifically crediting, as they were particularly critical in supporting this analysis, and were used extensively due to their relevance and site-specificity:

Suffolk County Dept. of Planning (January, 1997), *Peconic Estuary Program, Existing Land Use Inventory.*

Suffolk County Dept. of Planning (March, 1998), *Peconic Estuary Program, Land Use Change Analysis.*

Suffolk County Dept. of Planning (April, 1998), *Peconic Estuary Program, Land Available for Development.*

Suffolk County Dept. of Planning (March, 1997), *Peconic Estuary Program, Population Analysis.*

Suffolk County Dept. of Planning (April, 1998), *Peconic Estuary Program, Saturation Population Analysis.*

Hughes, Henry B.F., Porter, Keith S., Cornell University Center for Environmental Research (November, 1983), *Land Use and Ground Water* Quality *in the Pine Barrens of Southampton.*

Trautman, Nancy M., Hughes, Henry B.F., Porter, Keith S., Cornell University Center for Environmental Research (April 1983), *Preliminary Draft Protection and Restoration of Ground Water in Southold, N.Y.*

LaRoche, J, Nuzzi, R., Waters, R., Wyman, K., Falkowski, P.G., Wallace, W.R. (1977), *Brown Tide Blooms in Long Island's Coastal Waters Linked to Interannual Variability in Groundwater Flow.*

L.I. Regional Planning Board (1978), *Long Island Comprehensive Waste Treatment Management Plan* ("L.I. 208 Study,")

SCDHS (1992), *Brown Tide Comprehensive Assessment and Management Program* ("BTCAMP").

Special thanks are extended to the Suffolk County Planning Department, which conducted an exhaustive and rigorous analysis of land use and related issues. While the literature is replete with information on nitrogen loading, without the Planning Department's analysis of existing and potential land uses and population trends, this report would not be possible. The Planning Department's data sets and meticulous comprehensive analyses establish a critical foundation of accurate and usable data in a precise digital format. The information will undoubtedly continue to serve as an invaluable resource for planning and management initiatives for generations to come.

B) *Baseline Loading Methodology*

i) Residential Land Use

For each of the residential land use density categories, a triad of loading factors was used: one for human sanitary waste, a second for fertilizer, and a third for all other TN loads (animal waste and natural precipitation/soil mineralization). This complicated the exercise, as compared with the simpler alternative of using an aggregated TN load factor for each specific land use density, which could have easily been extracted from the literature. The adopted approach was used to enhance the accuracy of the estimates, and to facilitate development and manipulation of various management alternatives.

By segregating the sanitary and fertilizer loading components, various management alternatives can be evaluated individually and collectively. For example, the impact of fertilizer management measures can be tested in the surface water model, and compared with the effectiveness of sanitary system controls, since nitrogen load changes to both can be easily calculated.

The analysis results in a high level of confidence in the sanitary waste loading patterns. The population data for study area subwatersheds provided by the Suffolk County Planning Dept. is superb. When coupled with the well-established literature values for nitrogen loading from human wastes, human sanitary waste loading estimates should be considered to be quite reliable, on a study area-wide basis as well as for subwatersheds.

For non-sanitary waste, the Cornell Southold study was the primary source, since that report had a greater abundance of relevant nitrogen loading data. Also, the Southold soil types are more representative of most of the developed study area, particularly the agricultural areas. Use of the Cornell Southampton report, which is based largely on extremely sandy Pine Barrens soils, would probably result in misleadingly high TN loading estimates.

To verify the relative accuracy of the Cornell-based non-sanitary waste load assumptions, the resulting TN load budget estimates were compared with previous PEP estimates used for the surface water model. These previous estimates were based on USGS groundwater inflow estimates, coupled with SCDHS groundwater quality estimates. The regions compared were the Peconic River/Flanders Bay area, the North Fork (east of Flanders Bay), South Fork (east of Flanders Bay), and Shelter Island.

As discussed below, the two methodologies provide very close TN load estimates for most areas. Thus, on a regional basis, this exercise has provided an invaluable validation of model assumptions, as well as a detailed budget which can be manipulated to project changes of various management actions.

In general, four major subregions are considered in the analysis: the western estuary, north Fork, South Fork, and Shelter Island. The western estuary is further broken down as follows:

* North Flanders Bay, east of CR 105 and west of Miamogue point;
* South Flanders Bay, east of CR 105 and west of Red Cedar Point
* Peconic River East, east of USGS gauge, which is located just west of downtown Riverhead, immediately east of intersection of Mill Road and West Main Street; and
* Peconic River West, west of USGS gauge.

In the eastern estuary, the North Fork comprises Riverhead Land Use Study Area Zone 80 and all of Southold Town. The South Fork consists of all Southampton Town Land Use Study Area Zones east of Zone 30, and all of East Hampton. Shelter Island is simply the entire Town.

While the TN budget estimates appear to be fairly accurate on a regional basis (with the exception of Peconic River West, as discussed below), they must be used with caution when contemplating very specific management actions on a subregional basis. For example, the Cornell fertilizing loading estimates are typically based on one representative type of land use in a given land use class, while actual land use densities in a given area can vary substantially. This could lead to error when evaluating an extremely discretized subregion. For example, Cornell's low, medium, and high density residential loading estimates are based on 1.0, 2.9, and 8.0 units per acre, respectively. The range of PEP land use densities for the same "categories" are less than 1, 1 to 5, and greater than five units per acres, so that actual land uses in a discretized area may vary from the Cornell density assumptions.

The reader should also note that, on a regional basis, virtually all of the nonpoint source total nitrogen loading is ascribed to groundwater, rather then stormwater runoff, which contributed very minor to TN loads. This is due to nitrogen's solubility and rapid transport through Long Island's relatively permeable soils. Again, this is not necessarily true for every small subwatershed at all times.

For most subwatersheds, the error with respect to residential fertilizer estimates is not believed to be problematic for management purposes. This is because the "human sanitary waste" load component for all land use densities has been made fairly accurate based on population projections, and the overall "land use load factor" and "groundwater TN concentrations multiplied by inflow rates" match up fairly well. As discussed in the Cornell reports, human sanitary waste loading becomes the predominant component of nitrogen loading in the medium and high density land uses, comprising the majority of nitrogen loading from medium density residential development.

Given the accuracy of the Cornell nitrogen loading estimates, coupled with likely variability in local fertilizer use patterns based on factors such as economics and environmental sensitivity, additional fine-tuning of residential fertilizer rates is not warranted in this study. However, the Cornell estimates are over a decade old, and are worth revisiting. As discussed in the conclusions, refinement of the Cornell estimates would be a worthwhile endeavor, via additional literature searches and, possibly, local surveys.

ii) Agricultural Land Use

Specific agricultural fertilizer TN loadings assumptions are noted in the appropriate tables below. Because the two nitrogen loading methods yielded comparable results (see discussion above), the overall regional TN agricultural loading budget is believed to be reasonably accurate. However, on a subwatershed basis, the confidence in localized TN loading from agricultural activities is much lower than for residential land uses.

As indicated in the Cornell reports, agricultural TN loading is extremely variable, based on crop type and fertilizer application practices. For typical east end crops, such as sod (nitrogen intensive) and grapes (less intensive), nitrogen load rates can vary by 70% more, as compared with the baseline assumed for this exercise.

Crop type data and fertilizer application practice information was not available to SCDHS at the time of preparation of this report, and may not exist in sufficient detail to adequately characterize subregional TN loading. Because the agricultural TN loading is so large, refinement of agricultural nitrogen loading estimates and management practices is recommended as a priority action to support optimizing subwatershed management plans.

iii) Other Non-Residential Land Use

Nitrogen loading-intensive non-residential land uses consisted primarily of commercial, industrial, and transportation land uses. Specific loading assumptions are noted in the relevant tables.

In the absence of more specific load factors, for most commercial, industrial, and institutional activities, medium-density residential load factors were assumed for non-sanitary waste TN loading. For the sanitary component, the load factor was based on sanitary waste loadings of 300 gpd per acre (20% coverage, 8000 sf/acre, 0.04 gpd/sf), from Suffolk County Sanitary Code values. While commercial, industrial, and "other" (e.g. institutional) loadings can vary significantly, and may be important locally, on a regional basis, these loadings are only about 11% of the total nitrogen loading budget. Thus, the estimates used are believed to be adequate for this exercise.

For vacant and open space land uses, precipitation is assumed to be the primary load. While this may not be true in individual parcels (e.g., golf courses), on a regional basis, the overall loading is estimated to be small (less than 7%) in relation to the large acreage (48%), so that additional refinement of the loading estimate is not imminently critical on a regional basis. Special estimates were developed for the Brookhaven National Lab property (90% vacant, 10% medium density residential for non-sanitary waste) and the former Grumman property (vacant/open space).

iv) Duck Farms

No duck farms in the Peconic estuary currently discharge to surface water. However, for purposes of this analysis, 110 pounds per day currently discharged from Meetinghouse Creek are attributed to the Corwin Duck Farm.

v) Sewage Treatment Plants

Because of their relatively insignificant loads on a regional basis, point sources are not directly presented in the tables and graphs in this report. The BNL sewage treatment plant (STP) discharge is very small, and is assumed to be subsumed into Peconic River baseline flow and loading. Sag Harbor and Shelter Island Heights STP discharge are ignored in this exercise, as they comprise an insignificant quantity (much less than 1%) of eastern study area loadings.

The Riverhead STP is dealt with, insofar as it changes groundwater TN loadings in the budget. For the Riverhead STP, 43 pounds per day of residential TN loading is assumed to be "avoided" (i.e., groundwater TN load would have occurred, but for the STP collecting and treating the sanitary waste that would have been generated in the absence of a sewage treatment plant). This is reflected in the lowered population (by 3,100 persons) in the western estuary "human sanitary waste" loading section of the tables below. The remainder of the STP loading (roughly 100 pounds per day) is assumed to be "imported" sanitary waste TN loads to surface waters, mainly from commercial and institutional activity served by the facility.

Clearly, refined subwatershed budgets are desirable for the Peconic River area, as well as for Sag Harbor, both of which have been preliminarily identified as nitrogen management priorities in the SCDHS report *Peconic Estuary Surface Water Quality* (draft, 1998). Subwatershed characterization capability for the Peconic River and Flanders Bay areas will be refined in 1999 by the USGS seismic reflection study to define sub-sediment geology for Flanders Bay, facilitating enhancement of groundwater inflow estimates. Also, the Camp, Dresser, and McKee (CDM) Suffolk County groundwater model will provide additional information on groundwater flow paths and travel time, further improving characterization and management capability in the sensitive Peconic River/Flanders Bay area.

C) Historic Loading Estimation

The duck farm portion of historic loading patterns was fairly straightforward. In a prior SCDHS report (September 25, 1996 memorandum/report to Technical Advisory Committee entitled *Duck Farm Waste Loading*), various historic records were used to reconstruct annual duck production and TN discharge. These include permitted numbers of ducks, discharge flow reports, discharge TN concentration estimates, and literature values of daily TN excreted per duck. Older newspaper and magazine articles were also used for duck population estimates. The application of multiple methodologies to yield reasonably close estimates resulted in a fairly reliable estimates which probably err on the side of caution in slightly overestimating TN waste loads.

Groundwater TN loading estimation was a far more difficult task. The historic TN load trends presented in this report should be considered to be extremely preliminary estimates, based in part on best professional judgement, and subject to substantial refinement. The numbers should not be considered as absolute values; rather, the overall trends (shapes of the curves) and relative magnitudes of various loadings are the valuable outcomes. For reasons discussed below, the relative magnitude of the curves and overall trends are believed to be the most probable historic TN load trend.

For purposes of this regional analysis, the baseline loading was established for 1998, and historic sanitary and fertilizer loads were calculated based on application of scale factor to the existing loads. Delivery of TN to surface waters was adjusted based on an estimated 10 year lag (see *Laroche et al.).*

For population and sanitary waste loading, the analysis was fairly simple. The PEP population analysis was used to estimate population levels as far back as 1960, providing excellent estimates of human inhabitants of the study area. From about 1945 to just before 1960, population estimates were extrapolated based on regional population growth pattern data published in *LaRoche et al.* Prior to 1945, population was assumed to be fairly constant, at about 30% of 1998 levels. The author discovered no documentation regarding major population variations in that time period, and modest fluctuation at those low levels would not greatly affect the overall TN load estimates. Thus, population estimates prior to 1960 could be refined, particularly for the period prior to1945. However, the estimates contained herein are appropriate for purposes of this preliminary analysis.

In terms of fertilizer loading, less rigorous data exists, and groundwater TN monitoring data is not readily available on a widespread basis prior to the mid 1970's. Thus, LaRoche's reported inorganic TN loading trends from fertilizer sales data was used as a surrogate for actual, local, fertilizer use data. Prior to 1945, a time period not considered by LaRoche due to lack of data, fertilizer use data is assumed to be about 30% of 1998 levels.

The earlier years of the 20th century are difficult to characterize. Some reports (see L.I. 208 Study) indicate the existence of localized areas of groundwater contamination due to TN loading for that time range. However, the weight of anecdotal and informal evaluations and interviews suggest that, due to farming methods and available fertilizers, earlier use of organic fertilizers, as a whole, may have delivered substantially less TN to the land and to groundwater than the current, highly soluble, nitrogen-rich inorganic fertilizers. Also, the TN that was delivered in the older organic forms may have been more likely to be bound up in soils and taken by crops, and more likely to decay and release nitrogen in gaseous form. Thus, the assumption that fertilizer use prior to 1945 was at about 30% of 1998 levels appears to be reasonable, and seems to be supported by the observed tremendous population growth and land use development since the 1940's, coupled with the great regional increase in commercial fertilizer usage.

D) Potential Loading Estimation

Land available for development analyses from the Suffolk County Planning Department were used to estimate potential nitrogen loading at various build-out scenarios. Prior to preparation of this report, this was initially performed in a gross manner by evaluating developable acreage, assigning development factors to that acreage, and calculating potential loading. However, on closer evaluation of the agricultural statistics and loading rates, it became apparent the initial method produced gross overestimates of potential incremental nitrogen loading. This is due to the fact that conversion of agricultural land to predominantly low density residential uses would result in a projected decrease in TN loading.

This report considers three simple build-out scenarios for purposes of developing initial model management alternative runs. Note that various other management build-out loading scenarios, particularly for subwatersheds such as Flanders Bay and Sag Harbor Cove, will be developed for final PEP modelling management alternative runs.

* "Full Build-Out" (developable agricultural lands converted)

* "Worst-Case Scenario" (under existing zoning; no agricultural conversion)

* "No Open Space Scenario" (worst case scenario coupled with conversion of open space to low density residential uses, to assess water quality impacts that open space programs have provided)

The tables and figures presented for these scenarios use basic mass conservation principles. Thus, nitrogen inputs from prior uses (such as agriculture and vacant) are removed, and the new land use nitrogen inputs are added.

For presentation purposes of this report, a window of 50 years is contemplated for full build-out, based on developable acreage as of 1995 and the development rate over the last two decades provided by the Planning Department. In reality, local reports are that development rates have accelerated considerably in recent years, so that final assumptions for model and management purposes are certainly subject to refinement.

Finally, to make the TN loading estimates more comprehensible and usable, they are converted to a resulting groundwater TN concentration, expressed in "mg/l." This calculation was simply made by dividing the mass of nitrogen input per unit time (generated in this report) by groundwater inflow rate per unit time (from USGS budget reports).

3) Discussion of Results

A) Baseline Loading

For simplicity of presentation, analysis of baseline nonpoint source nitrogen loading is generally presented in terms of Western Estuary (Peconic River and Flanders Bay groundwater-contributing areas, approximately those areas west of Miamogue Point on North Fork and Red Cedar Point on South Fork) and Eastern Estuary (North and South Forks east of Flanders Bay, and Shelter Island), although the analysis was also performed separately for various subregions. These are the two most easily demarcated geographic regions, with very different management concerns for these areas: nitrogen control and abatement in the western estuary, and water quality preservation in the eastern estuary. Where appropriate, particularly in subsequent sections dealing with development potential, subregions are further broken down and discussed.

The results of the baseline loading methodology are contained in Table 1 and Figure 1. Table 1 shows that overall groundwater nitrogen loading is approximately 6,500 pounds per day, about 32% of which occurs in the western estuary. The western estuary "Land Use Study Area" (larger than actual groundwater-contributing area, as discussed below) is approximately 32% of the total "Land Use Study Area" (40,500 of 128,000 acres).

Of the individual components of TN loading shown on Table 1 and Figure 1, agricultural TN loading is estimated to be, by far, the most significant, almost three times greater than human sanitary waste and almost double the residential TN fertilizer load. The quantitative significance of agricultural TN loading, coupled with the great variability in loads for given crops and the dated TN load estimates (discussed above), underscore the need for additional characterization efforts to better quantify local agricultural TN load patterns.

In terms of land uses, agriculture contributed the greatest load of TN at almost 2,700 lb/day, slightly more than all residential land uses combined. The significance of this observation is magnified by the fact that agricultural acreage is only about one-half of the total study area residential acreage. Other land uses (commercial, industrial, etc.) contributed a relatively small combined load of 740 pounds per day.

Table 2 and Figure 2 compare the above estimates, derived from land use load factors, with previous estimates developed for the surface water model using primarily freshwater budget (inflow rates) and groundwater for most of the study area; for the Peconic River west of the USGS gauge, actual gauged flow and measured TN concentrations in the river were used. The results agreed extremely well in the eastern estuary, and fairly well in the western estuary. The overall difference was only 3% in the eastern estuary, and 29% in the western estuary, well within reason for this type and level of regional analysis. Estimates in each of the eastern estuary subregions (North and South Forks east of Flanders Bay and Shelter Island) were within 10% for each subregion (see Figure 3).

The nitrogen loading budget was examined in further detail in the western estuary to attempt to examine whether the 29% discrepancy was more pronounced in any given area. Results are shown in Table 3 and Figure 4. Four subregions were used for the western estuary (North Flanders Bay, east of CR 105 and west of Miamogue point; South Flanders Bay, east of CR 105 and west of Red Cedar Point; Peconic River East, east of USGS gauge, which is located just west of downtown Riverhead, immediately east of intersection of Mill Road and West Main Street;

TABLE 1

PECONIC ESTUARY - NONPOINT SOURCE NITROGEN LOADING BUDGET

HUMAN SANITARY WASTE

	OVERALL STUDY AREA			WESTERN/EASTERN AREAS			
	Population (persons)	Load Factor (lb/day/person)	Load (lb/day)	West (persons)	East (persons)	West (lb/day)	East (lb/day)
Year-Round	56072	0.0137	768	18415	37657	252	516
Seasonal	50000	0.0046	228	3412	46588	16	213
Total			**996**			**268**	**729**

RESIDENTIAL FERTILIZER

	OVERALL STUDY AREA			WESTERN/EASTERN AREAS			
	Acres	Load Factor (lb/day)	Load (lb/day)	West Acres	East Acres	West (lb/day)	East (lb/day)
Low-Density	15711	0.0342	538	1981	13730	68	470
Med Density	11944	0.0616	736	1996	9948	123	613
High Density	1180	0.0545	64	552	628	30	34
TOTAL			**1339**			**221**	**1118**

RESIDENTIAL - ANIMAL WASTE & NATURAL PRECIPITATION/SOIL MINERALIZATION

	OVERALL STUDY AREA			WESTERN/EASTERN AREAS			
	Acres	Load Factor (lb/day)	Load (lb/day)	West Acres	East Acres	West (lb/day)	East (lb/day)
Low-Density	15711	0.0079	125	1981	13730	16	109
Med Density	11944	0.0115	137	1996	9948	23	114
High Density	1180	0.0173	20	552	628	10	11
TOTAL			**283**			**48**	**234**

AGRICULTURAL FERTILIZER

	OVERALL STUDY AREA			WESTERN/EASTERN AREAS			
	Acres	Load Factor	Load (lb/day)	West (ac)	East (ac)	West (lb/d)	East (lb/d)
Farmland	14539	0.1836	**2669**	5923	8616	**1087**	**1582**

VACANT & OPEN SPACE

	OVERALL STUDY AREA			WESTERN/EASTERN AREAS			
	Acres	Load Factor	Load	West (ac)	East (ac)	West (lb/d)	East (lb/d)
Vac/Open Sp	61560	0.0070	**430**	17868	43692	**125**	**305**

OTHER LAND USES (mainly commercial, industrial, transportation)

	OVERALL STUDY AREA			WESTERN/EASTERN AREAS			
	Acres	Load Factor	Load (lb/day)	West (ac)	East (ac)	West (lb/d)	East (lb/d)
Commercial	2415	0.1142	276	894	1521	102	174
Indust.(non-Rhd)	370	0.1142	42	118	252	13	29
Inst. (non-BNL)	1898	0.1142	217	349	1549	40	177
Other	9494	0.0070	66	2263	7231	16	51
Riv Ind Grumman	2913	0.0070	20	2913	0	20	0
Riv Ind Other	426	0.1142	49	426	0	49	0
Brkhvn Inst-BNL	5205	0.0136	71	5205	0	71	0
TOTAL	**22721**		**741**			311	430

	OVERALL STUDY AREA		WESTERN/EASTERN AREAS			
	Acres	Load (lb/day)	West (ac)	East (ac)	West (lb/d)*	East (lb/d)
OVERALL TOTAL	**127655**	**6458**	**40488**	**87167**	**2061**	**4399**

TABLE 1 (cont.)
PECONIC ESTUARY - NONPOINT SOURCE NITROGEN LOADING BUDGET

NOTES

Primary Sources:
Protection and Restoration of Ground Water in Southold, N.Y. (Cornell Center for Environmental Research, 1983) for most load factors.
Land Use and Ground-Water Quality in the Pine Barrens of Southampton (Cornell Center for Environmental Research, 1983) as a secondary source.
Long Island Areawide Waste Treatment Management Plant (LI 208 Study, LIRPB, 1978) for human sanitary waste.

Human sanitary load factor: 10 lb/person/year load; 5 lb/person/year to groundwater (LI 208 Study); seasonal = 1/3 of annual year-round load.

Agriculture load factor: 175 lb/acre/year applied to 90% R-Handy loam & 10% C-P soil (potatoes, as per Southold study);
61 lb/acre/year leached for R-H, 123 for C-P, for weighted avg of 67 (equates to 10 mg/l recharge). Application rates range from 30-55 lb/ac/yr for vineyards, 120 for mixed vegetables, 250 for nurseries, and 214-289 for sod.

Resid. fertilizer assumptions (see Southold report): 2.4 lb/N per 1,000 sf application; 12.5, 22.5, & 19.9 lb N/ac/yr for low, med, & high density residential dev.

For vacant/open space, precipitation is assumed to be the primary load.
0.5 mg/l, 22.5 in/year recharge (USGS; recharge = 50% of long-term avg of 45 in) assumed.

Assumptions for other land uses:

Industrial	Uses residential medium-density fertilizer, animal waste, & natural precip/soil mineralization; industrial sanitary factor
Commercial	"
Institutional	"
Other-mainly transportation	"
Riv ind (former Grumman sit	Uses vacant/open space factors.
Riv industrial (other)	Uses industrial factor.
Brkhvn. Inst. (mainly BNL)	Uses 90% vacant load; 10% residential medium-density fertilizer, animal waste, & natural precip/soil mineralization

BNL and Riverhead STP commercial/industrial loads are considered (see below).
"Industrial sanitary waste" factor assumed to be 300 gpd/acre (20% coverage, 8000 sf/acre, 0.04 gpd/acre) resulting in population density equivalent of about 3 persons per acre, or 15 lb/day (0.041 lb TN/day).
Actual rates for industrial and commercial nitrogen discharge vary significantly, but are typically quite low.

Other assumptions
In general, subregional judgemental fine-tuning resulting in less than 1% of subregional loading is avoided.
Day trippers/visitors are ignored, and could result in slightly higher loads.
BNL STP discharge is reflected in Peconic River loading.
Sag Harbor/Sl Heights STP adjustments are ignored (<0.5% of eastern estuary nonpoint source loading).
Riverhead STP service area has been adjusted for residential sanitary waste: 500 ac, mostly med dens resid, 3,100 persons, 43 lb TN/day avoided.
Adjustment is reflected in lowered western estuary population in nonpoint source table.
Remainder of Riverhead STP flow assumed to be "imported" sanitary flow from commercial activities.

Figure 1: Total Nitrogen (TN) Load by Land Use

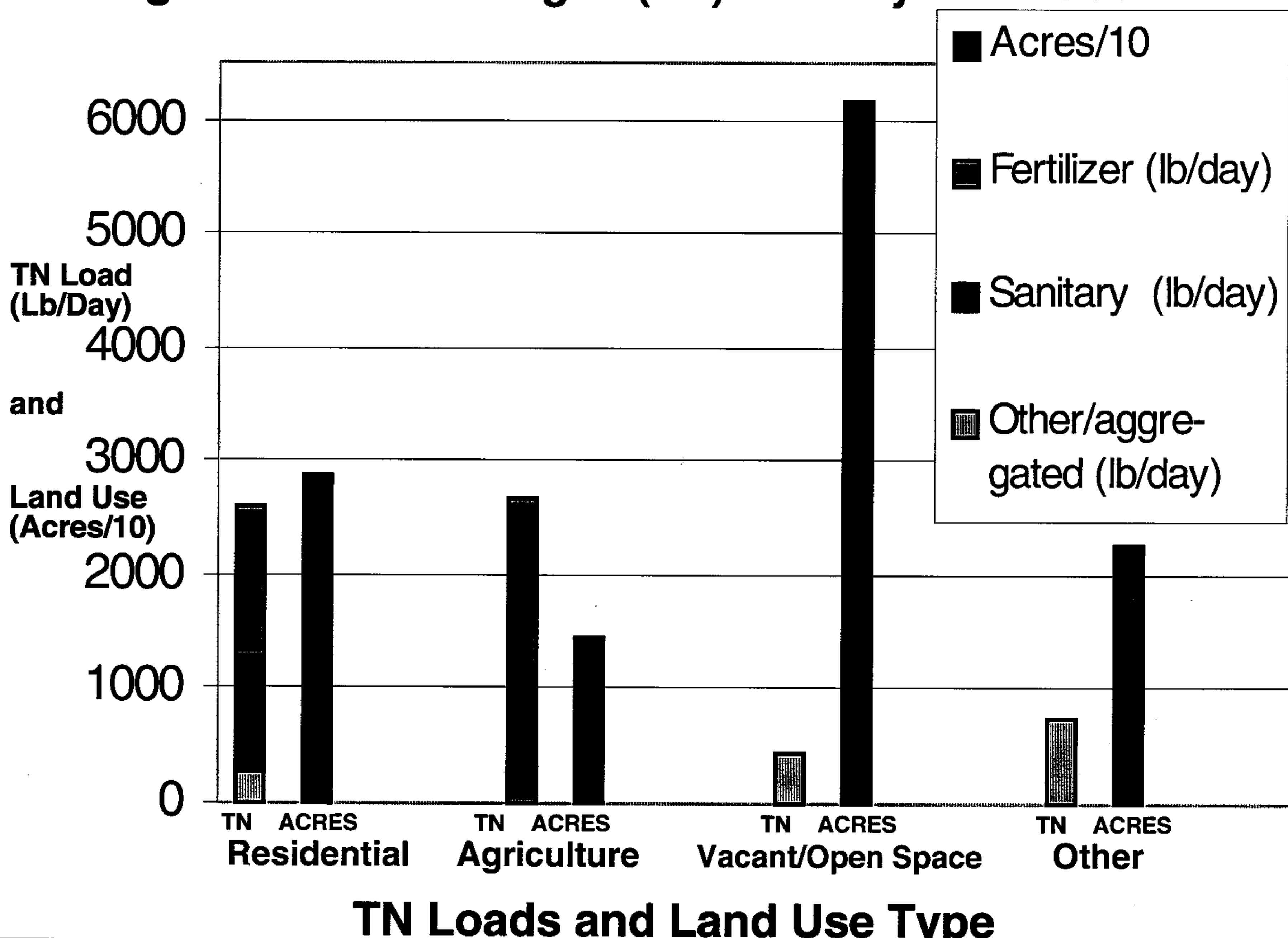


Table 2

COMPARISON OF NONPOINT SOURCE NITROGEN LOADING ESTIMATES:

FLOW/CONCENTRATION vs. LAND USE/BUDGET

Region	Flow/Concention (lb/day)	Literature/Budget (lb/day)	Difference (%)
West	1460	2061	29%
East	4510	4399	-3%
Total	5970	6460	8%

Notes:

Western estuary includes Peconic River & Flanders Bay.

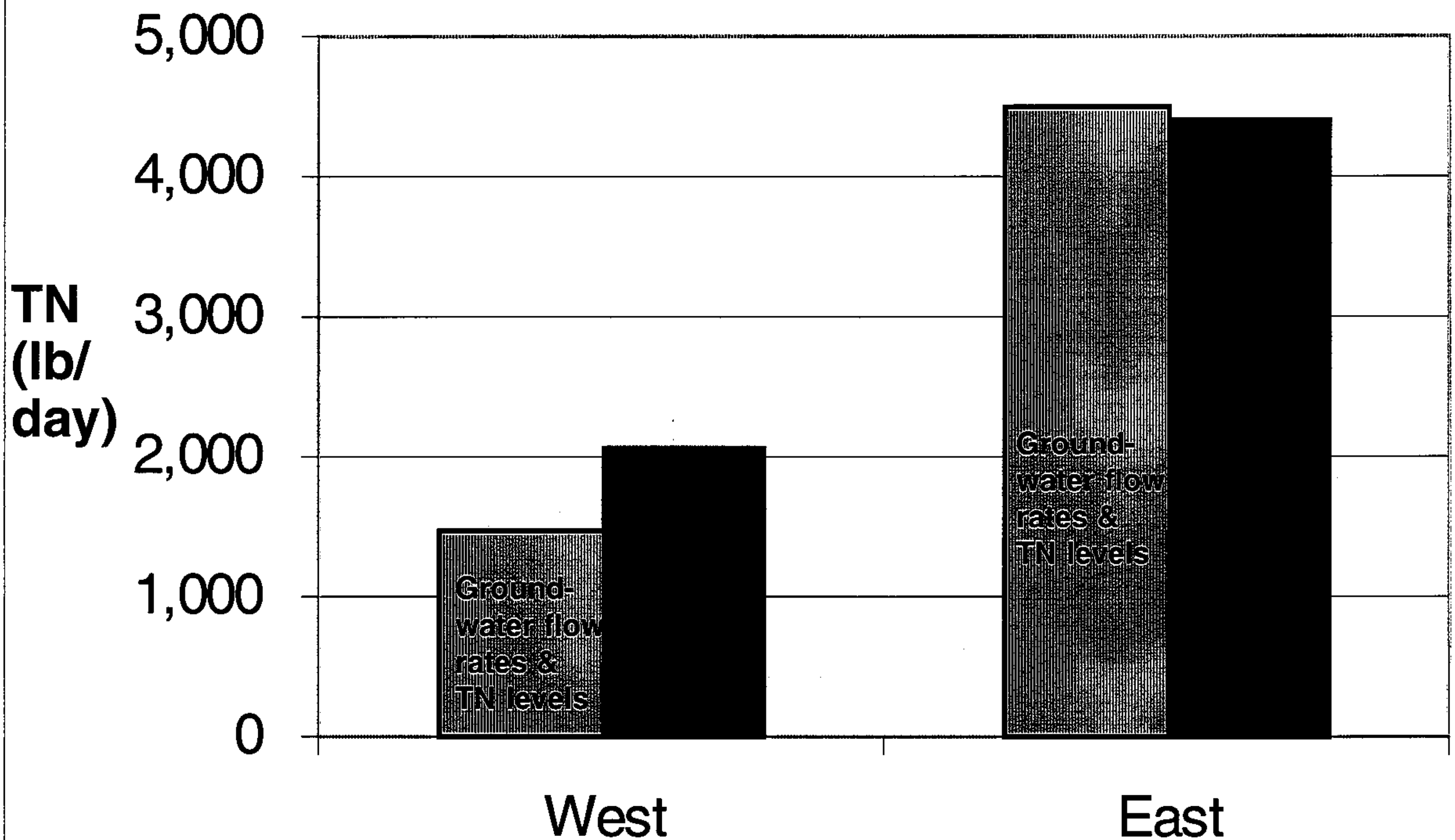
Peconic River flow included as a "flow/concentration" input of 140 lb/day (37 cfs, 0.7 mg/l).

Groundwater underflow flow/concentration estimates:

Area	cfs (USGS)	mg/l (SCDHS)	lb/day
North Fork	44	9	2130
South Fork	127	3	2060
Shelter Island	20	3	320

Peconic River e/o gauge: 20.8 cfs, 6 mg/l N, 670 lb/day N
North Flanders: 8.8 cfs, 9 mg/l N, 430 lb/day N
South Flanders: 13.8 cfs, 3 mg/l N, 220 lb/day N

Figure 2
Comparison of Total Nitrogen (TN) Loading Estimation Methods



"West" estuary is Peconic River & Flanders Bay. "East" includes all areas east of Flanders Bay.

Figure 3
Eastern Estuary TN Loading Estimation Methods

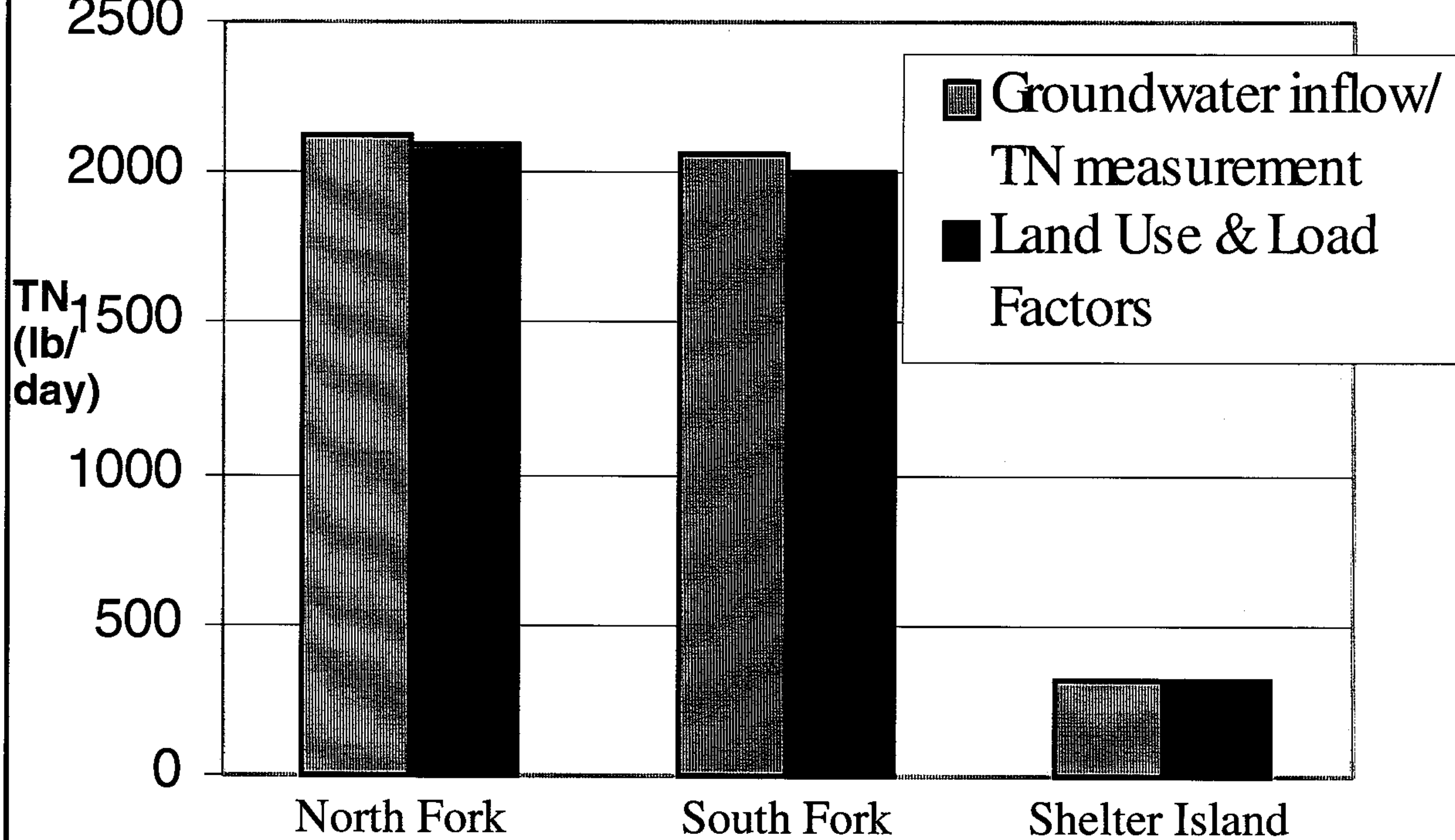


Table 3 - PECONIC ESTUARY - NITROGEN LOADING BUDGET
Western Estuary - Existing Conditions

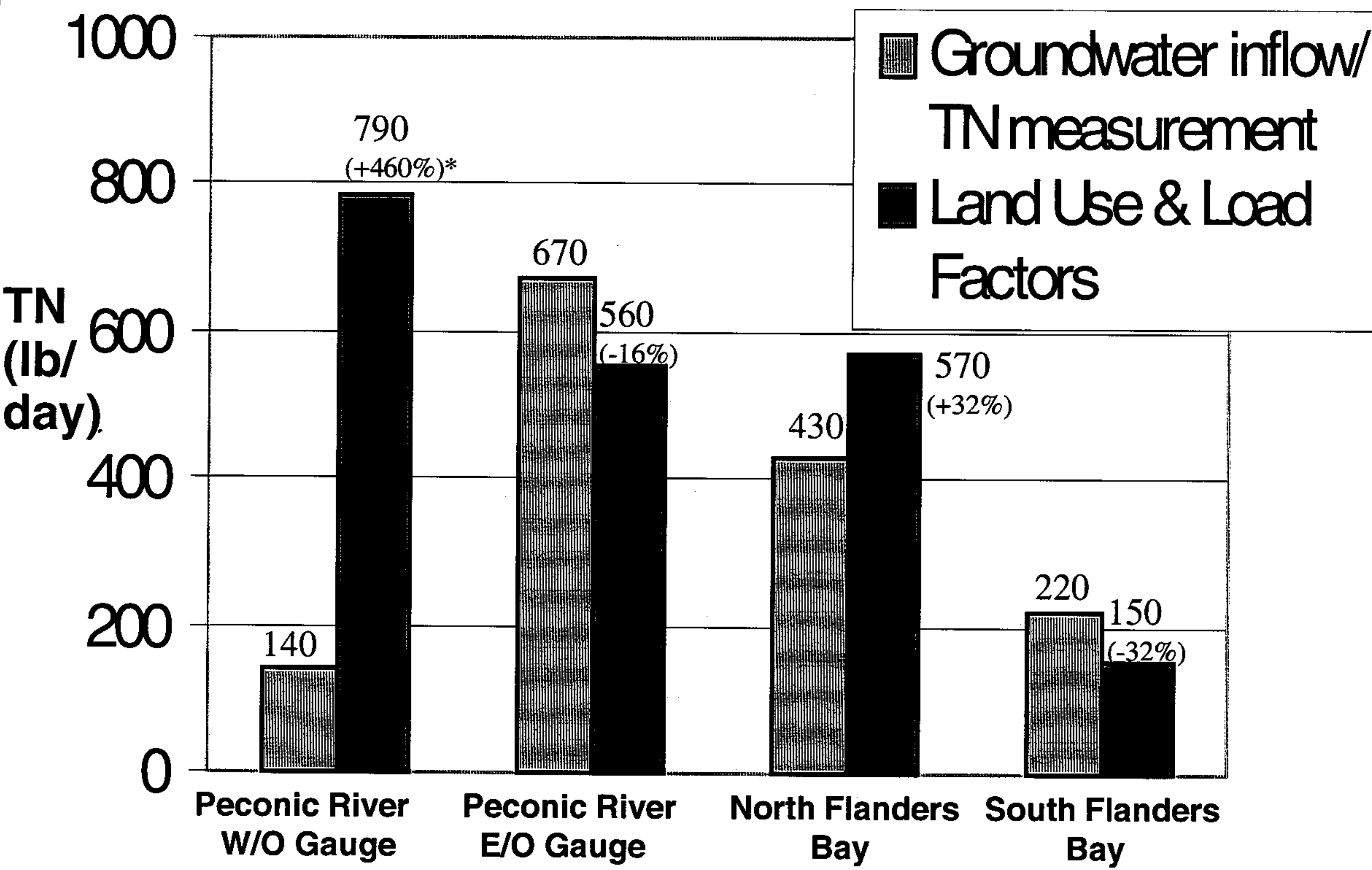
LAND USE AND POPULATION

	Peconic River West of Gauge	Peconic River East of Gauge	North Flanders Bay	South Flanders Bay	TOTAL
POPULATION (persons)					
Year-Round	4683	7458	3024	3250	**18415**
Seasonal	236	554	1667	935	**3392**
RESIDENTIAL LAND USE (ac)					
Low-Density	750	340	495	396	**1981**
Med Density	295	762	577	362	**1996**
High Density	189	240	55	68	**552**
AGRICULTURE (acres)	2312	1237	2368	6	**5923**
VACANT/OPEN SPACE (ac)	8489	2541	560	6579	**18169**
OTHER LAND USES (acres)					
Commercial	285	498	65	30	**878**
Industrial	116	1	0	1	**118**
Institutional	19	311	3	12	**345**
Other (mainly transp)	1029	678	222	413	**2342**
Riv ind - non-Grumman	217	172	37	0	**426**
Riv ind - Grumman	2913	0	0	0	**2913**
Brookhaven inst (mainly BNL)	5205	0	0	0	**5205**
TOTAL ACRES	**21819**	**6780**	**4382**	**7867**	**40848**

POLLUTION LOADING (lb/day TN)

	Peconic River West of Gauge	Peconic River East of Gauge	North Flanders Bay	South Flanders Bay	TOTAL
POPULATION					
Year-Round	64	102	41	45	**252**
Seasonal	1	3	8	4	**16**
RESIDENTIAL LAND USE					
Low-Density	32	14	21	17	**84**
Med Density	22	56	42	26	**146**
High Density	14	17	4	5	**40**
AGRICULTURE	424	227	435	1	**1087**
VACANT/OPEN SPACE	58	17	4	45	**125**
OTHER LAND USES					
Commercial	33	58	8	3	**102**
Industrial	13	0	0	0	**13**
Institutional	2	36	0	1	**40**
Other (mainly transp)	7	5	1	3	**16**
Riv ind - non-Grumman	25	20	4	0	**49**
Riv ind - Grumman	20	0	0	0	**20**
Brookhaven inst (mainly BNL)	71	0	0	0	**71**
TOTAL (Lb/Day TN)	**786**	**555**	**568**	**151**	**2060**

Figure 4
Western Estuary TN Loading Estimation Methods



* *Peconic River estimate is extremely preliminary, and will be substantially refined, as discussed in the report.*

and Peconic River West, west of USGS gauge).

Agreement was fairly good for all subregions, except the Peconic River West, where agreement was markedly poor. In the Peconic River East, North Flanders Bay, and South Flanders Bay, random variation (sometimes higher, sometimes lower) of 16% to 32% was identified. This is within reason, and to be expected, since smaller subregions will tend to have slightly greater errors than regional averages due to variations in local land use practices (for land use/loading analysis), coupled with less site-specific data for groundwater quality (for groundwater inflow/quality analysis).

In the Peconic River West, the land use/loading method yielded expected loading estimates which were 460% higher than loadings measured in the river at the USGS gauge. Because the measured flow and river TN concentrations are quite accurate, the discrepancy is probably due to the following factors:

- * TN load factors not accurate for Peconic River West area.
- * Land use study area is too large (much larger than groundwater-contributing area).
- * Riverine sedimentary denitrification, plant uptake, possible organic carbon/TN "burial, and transient export events are not accounted for.

The TN load factors may not be appropriate for the discreet Peconic River West study area. For example, residentially developed areas may have substantially less clearing (and associated fertilizer use) in this area. Even more importantly, agricultural areas may be fallow, or be less nitrogen-intensive, in this area.

With respect to the "land use study area" issue, the "land use study area" was intentionally made larger than the "actual groundwater-contributing area," to avoid splitting parcels and better facilitate potential planning efforts. Thus, even when a small portion of a parcel was in the groundwater-contributing area, the entire parcel was deemed to be in the land use study area.

Finally, there is a fair amount of denitrification which typically occurs in Suffolk County streams, which was not accounted for in these estimates. Based on a formidable stream monitoring program, Suffolk stream TN concentrations are typically observed to be on the order of about one-half of the levels observed in groundwater. Plant uptake, denitrification, and, possibly, sedimentary loss (via burial) are believed to be responsible for the TN loss. While plants do die and release TN, streams may export this TN in transient events, so that the TN is not reflected in annual or seasonal mean TN concentrations.

In the coming months, SCDHS will collect additional data and input to try and better resolve the above factors. Aerial photo review and discussions with agencies such as the Soil and Water Conservation District/Natural Resources Conservation Service will better refine load factors based on improved estimates of residential clearing and agricultural uses and fertilizer practices in the Peconic River area. Also, SCDHS GIS manipulations will produce land uses for the actual groundwater-contributing area, producing a smaller area of nitrogen-generating land. Literature review (including prior modelling of the Peconic River) may shed light on the nitrogen loss in the river. It is conceivable that TN reductions due to these three factors may bring the "land use/pollution input" budget in line with the measured concentrations in the Peconic River.

The lack of a well-calibrated TN load budget for the western estuary is not a problem for calibration and verification of the existing model, since the PEP has the luxury of ample actual flow and concentration data for the river at the USGS gauge station, integrating upstream groundwater influences on the estuary. For preliminary sensitivity exercises, scaled increases (with a factor of safety) can also be used to approximate increases in river TN concentrations as a result of worst case land use changes (see discussion below). For final management alternatives and decisions, however, a refined TN load budget will obviously be necessary. Given the importance of potential Peconic River land use changes (see discussion below), a predictive model for the Peconic River should also be considered.

B) Historic Loading Estimation

Duck farm waste loading estimates discussed above are included in Table 4, and historic nonpoint source TN load estimates are contained in Table 5. Both data sets are compiled in Table 6, and are presented graphically in Figure 5.

As shown in Table 4, duck farm waste loading raised dramatically between 1915 (about 480 lb/day) and the late 1930's (about 1,400 pounds per day). This waste loading was concentrated in the Peconic River and Flanders Bay. The loading remained substantial through the 1960's, and began to fall dramatically in the 1970's. By the mid to late 1970's, only about 500 lb/day of duck farm waste loading was discharged, mostly from the Corwin Duck Farm. With the disappearance of the few remaining small duck farms, and the removal of the direct surface water discharge of the huge Corwin Duck Farm in the 1980's, duck farm-related waste loading dropped to only about 110 pounds per day (as measured by Meetinghouse Creek discharge).

As estimated by the methodology and assumptions discussed above, with the growth in population and in availability of cheap, commercial, inorganic fertilizers, groundwater TN loading to surface waters increased dramatically between approximately the mid to late 1950's through the early to mid 1980's (see Table 5). Prior to the 1950's, groundwater TN loads are estimated to be about 1,900 lb/day. By 1990, groundwater TN loading had risen to over 6,400 lb/day, more than a threefold increase.

Table 6 and Figure 5 illustrate the trends in duck farm TN loading, as well as nonpoint source TN loading in the western and eastern estuaries, over the 20th century. On an estuary-wide basis, TN loading rose to about 3,300 lb/day in 1930, and probably remained fairly stable through about 1950. In 1960, TN loading in groundwater began to rise substantially, and duck farm loading began to decrease a few years later. Due to the rise in groundwater TN, every decade saw an overall increase in TN loading for the estuary as a whole.

For the eastern estuary, the TN load increase is most dramatic, with a net increase of about 3,100

TABLE 4

DUCK FARM WASTE LOADING *

Year	Annual # of Ducks**	Estimated Daily TN Loading, Pounds/Day (During Duck-Raising Season) ***
1915	350,000	480
1938	1,000,000	1,400
1940	1,000,000	1,400
1950	1,000,000	1,400
1960	1,000,000	1,400
1970	1,000,000	1,400
1972	1,000,000	1,400
1976	---	500
1980	---	500
1983	---	400
1988	---	110
1996	---	110

** These estimates are based on best judgment and readily available data. Improved estimates may be made if the modelling effort warrants. For purposes of spacial waste allocation, 400 pounds per day can be attributed to Meetinghouse Creek from 1976 through 1987, and the entire duck loading of 110 pounds per day thereafter. Data is scarce on distribution of duck loading prior to the 1970's. Based on duck farm permit limits in 1980, the possible duck allocation in recent history was as follows: Meetinghouse Creek, 49%; Peconic River, 24%; Saw Mill Creek, 10%; Terry's Creek, 17%.*

*** 1915-1972 estimates are based on estimates of duck population and loading factors reported by SCDHS in 1996. 1976-1996 estimates are based on flow reports and Meetinghouse Creek monitoring data. The 1972 data is computed both based on number of ducks (1,000,000/year, 1,375 pounds/day TN) and flow reports (yielding reasonable close estimate of 1,500 pounds/day TN). The 1980 estimate is based on permitted number of ducks (475 pounds/day TN) and the 1976 flow estimate (yielding 500 pounds/day TN).*

**** According to historical accounts, duck raising is a nine-week cycle (National Geographic, 1951). This analysis assumes a 36 to 40 week duck season, and that daily duck population is about one-fourth the annual production. This correlates reasonably well with historic accounts that show daily duck maximums of over one-fourth the annual production.*

Table 5

Historic Groundwater Nonpoint Source Total Nitrogen (TN) Loading Estimates

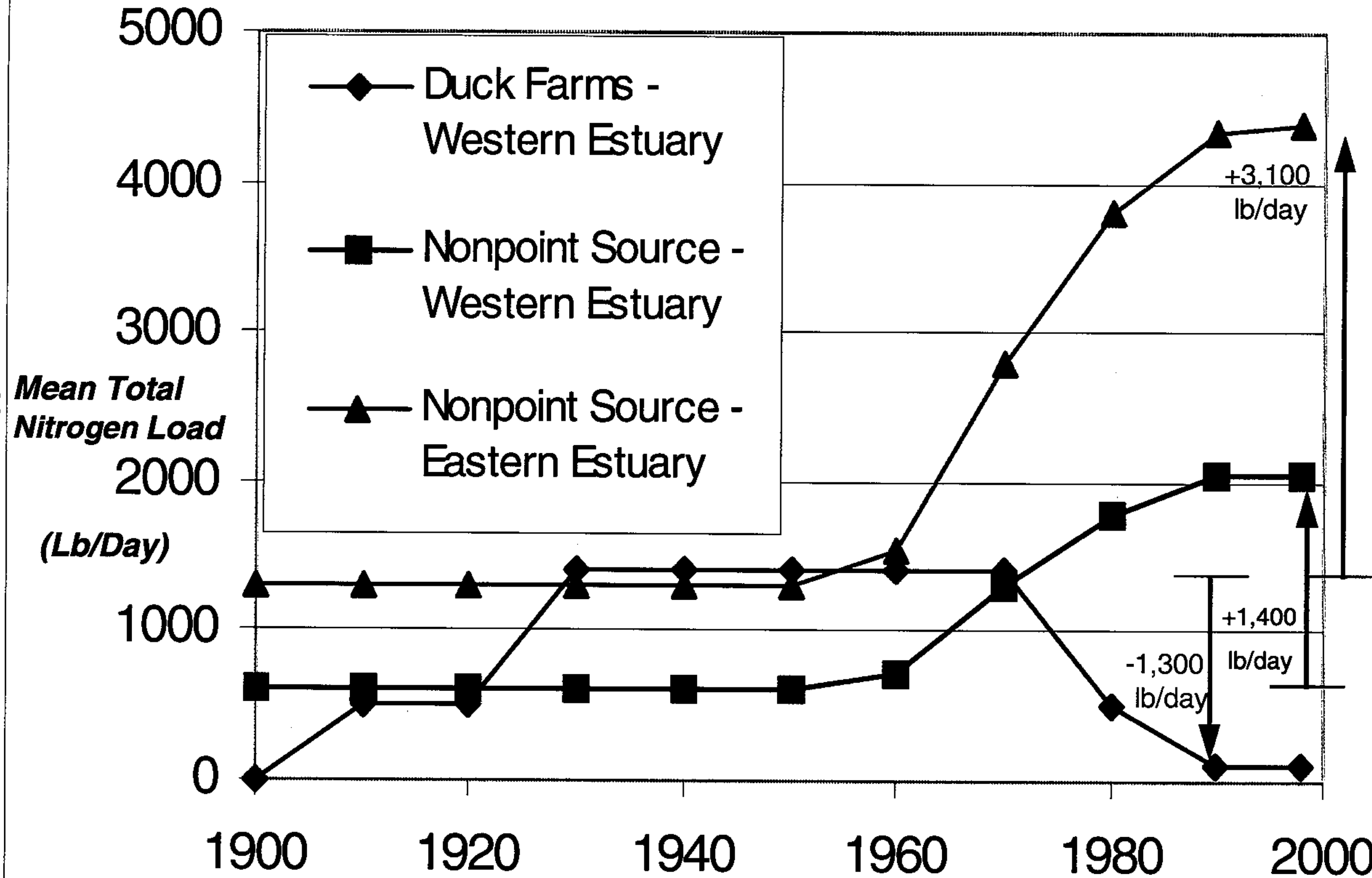
Groundwater Discharge Year	*Sanitary Load* *(% of current load to groundwater)*	*Fertilizer Load*	TN Load to Groundwater (lb/day) West	East	Total
1998	*98*	*100*	2060	4390	6450
1990	*91*	*100*	2040	4330	6370
1980	*78*	*88*	1790	3800	5590
1970	*60*	*64*	1310	2790	4100
1960	*40*	*34.4*	720	1550	2270
1950	*30*	*29.6*	610	1300	1910
1940	*30*	*29.6*	610	1300	1910
1930	*30*	*29.6*	610	1300	1910
1920	*30*	*29.6*	610	1300	1910
1910	*30*	*29.6*	610	1300	1910
1900	*30*	*29.6*	610	1300	1910

"% of current load" is based on a mean 10 year groundwater travel time lag.
E.g., 1970 population of 78% of the 1998 level is reflected in a 1980 groundwater sanitary waste TN loading factor of 78% of 1998 level.
1995 nonpoint source load estimates (land use + load factors) are used as baseline levels of loadings, except for Peconic River w/o gauge, which uses 140 lb/day measured TN (40 lb/d sanitary, 100 lb/d other).
Sources:
PEP Population Analysis (SCPD, 1997); Brown Tide Blooms in L.I.'s Coastal Waters Linked to Interannual Variability in Groundwater Flow (LaRoche et al., 1997).
Population and fertilizer estimates prior to 1945 are gross estimates, assumed to be 30% of 1995 levels.
The period reported as showing dramatic growth of fertilizer use and population is 1950 through the mid 1970s.

Table 6
Historic Nitrogen Loading Trends
Nonpoint Sources and Duck Farms

Year	Duck Farms Western Estuary TN (lb/day)	Nonpoint Source Western Estuary TN (lb/day) *% 1998 loading*	Nonpoint Source Eastern Estuary TN (lb/day) *% 1998 loading*	Total Duck Farm & Nonpoint Source Load TN (lb/day)
1998	110	2060 *100*	4390 *100*	6560 *100*
1990	110	2040 *99*	4330 *99*	6480 *99*
1980	500	1790 *87*	3800 *87*	6090 *93*
1970	1400	1310 *64*	2790 *64*	5500 *84*
1960	1400	720 *35*	1550 *35*	3670 *56*
1950	1400	610 *30*	1300 *30*	3310 *50*
1940	1400	610 *30*	1300 *30*	3310 *50*
1930	1400	610 *30*	1300 *30*	3310 *50*
1920	500	610 *30*	1300 *30*	2410 *37*
1910	500	610 *30*	1300 *30*	2410 *37*
1900	0	610 *30*	1300 *30*	1910 *29*

Figure 5: Peconic Estuary - Nitrogen Loading Trends*



Estimates are for major regional sources only. "Western Estuary" is Peconic River & Flanders Bay. Assumes 10 year lag for groundwater transport of nonpoint sources. All estimates are preliminary, and loading estimates prior to 1960 are gross.

lb/day between about 1950 and 1998. The western estuary saw very little net change, as the increase in groundwater TN (+1,400 lb/day) was offset by the ensuing decrease in duck farm TN loading (-1,300 lb/day).

Given the inherent variability in crop type, fertilizer application rates, and resulting groundwater quality (see above), any localized subwatershed long-term historic modelling should certainly consider refining TN load estimates via literature searches and other techniques (e.g., groundwater modelling coupled with historic land use data to "track" old TN pollution). However, the reader should consider the gross levels of loadings estimated, coupled with probable error ranges. For example, even if the 1940 estimate of fertilizer loading is in error by 50%, it would result in a change of less than 1,000 lb/day of TN, fairly small compared to the current fertilizer load of over 6,400 lb/day.

The fertilizer data, showing explosive growth in inorganic fertilizer use beginning in the 1950's, was successfully used by LaRoche et al., and is believed to be reasonably accurate for purposes of generalized regional assessments, particularly in light of the relative magnitude of historic data sources. Significant population growth and land use development since the 1940's, coupled with the increase in commercial fertilizer use, seem to validate the approach.

As discussed above, the numbers should not be considered as absolute values. Rather, the overall trends (shapes of the curves) and relative magnitudes of various loadings are the valuable outcomes of the analysis. The relative magnitude of the curves and overall trends are believed to represent the most probable historic TN load trends based on readily available information, given the cautionary note that the analysis is preliminary, and subject to substantial refinement.

Should these estimates be used in a long-term, historical model run, which predicts sediment recovery rates of only a few years, it would hopefully result in only marginal errors in surface water TN levels and in sediment equilibration rates to current conditions, which are believed to be well-calibrated, and which equilibrate relatively quickly. Of course, should a historic run be contemplated, long-term changes in other sources, such as atmospheric deposition and the locally important Riverhead Sewage Treatment Plant, would have to be characterized.

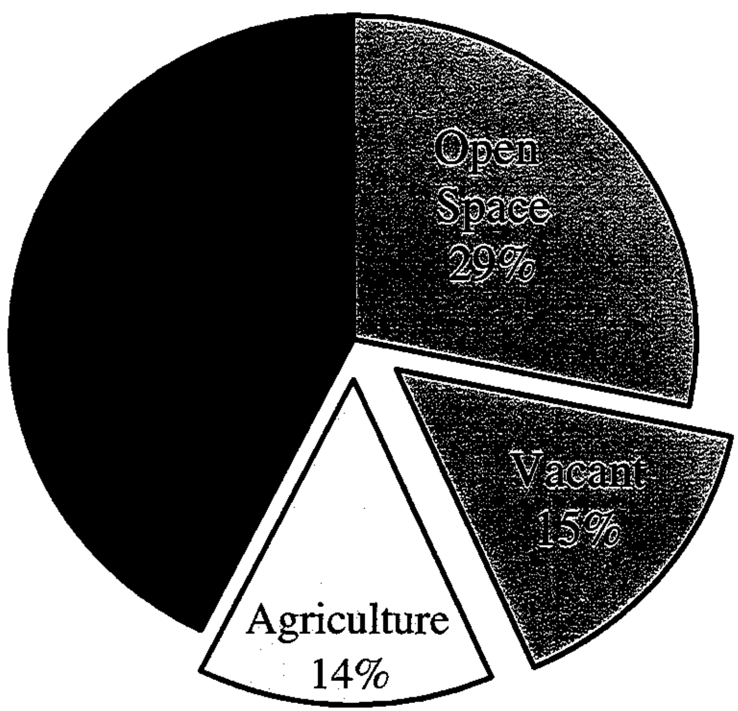
C) *Potential Loading Estimation*

Figure 6 shows the 1995 land use breakdown in the study area. The large percentage of vacant land and open space (44% in the western study area, 51% in the east) is responsible for the relatively low TN in most of the study area. However, a large portion of the study area is still developable, posing a substantial potential threat to water quality in the main bays as well as in the embayments.

If only the agricultural and vacant land were considered as developable, a substantial error would occur in the analysis. First, a portion of the agricultural land has been dedicated to perpetual agricultural use via farmland preservation program and "purchase of development rights." More profoundly, a large portion of the acreage which is partially "developed" can be further

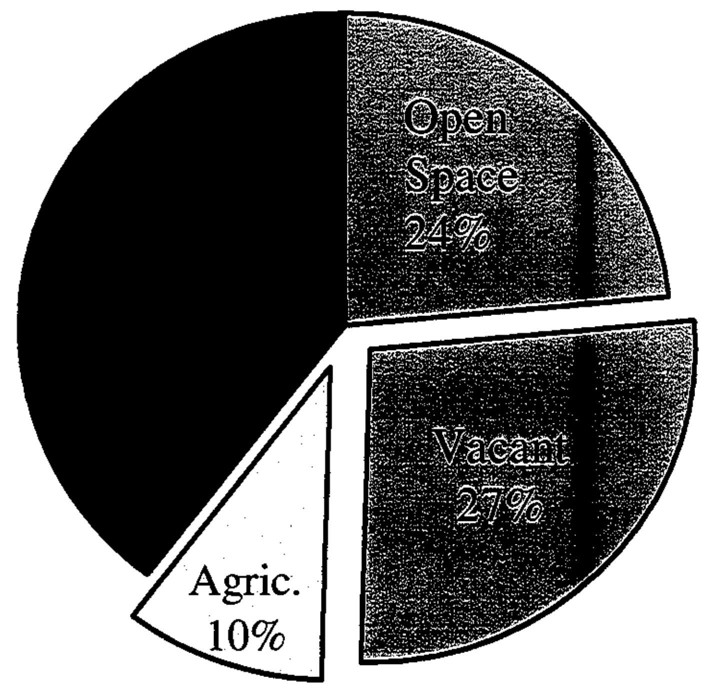
Fig. 6: 1995 Land Uses in Peconic Estuary Study Area

Western Area



41,000 Acres

Eastern Area



87,000 Acres

40% Of Study Area Acreage is Subject to Development

subdivided and developed. Overall, fully 40% of the study area (51,900 acres) is upland acreage available for development, as of 1995.

i) "Full Build-Out"

Table 7 shows the results of the analysis for the full build-out scenario, where developable agricultural lands are converted to mostly low-density residential use. In the western estuary area, approximately 8,700 upland acres could be developed residentially, and almost 5,400 could be used for other land uses, mainly commercial and industrial. Surprisingly, the net increase in loading in the western estuary would only be approximately 270 pounds per day, only about 13% higher than the existing regional load. In that area, reductions in TN load due to the conversion of approximately 4,500 acres of agriculture would almost offset development of vacant and partially developed lands.

As indicated in the tables, agricultural TN load rates, on a per acre basis, are modestly more than medium density development, and substantially more than the low density development rates. The overall development which will occur throughout the study area will be predominantly low density, and this is the assumption in Table 5. Human sanitary waste estimates, as extrapolated from Planning Department population projections, result in higher TN loads, per acre, in the western estuary, where development density will be higher.

Note that the "agricultural conversion" acreage in Table 7 is lower than the existing agricultural acreage in Table 1. The substantial difference is presumed to be attributable to farmland preservation programs.

Although TN loading from overall residential development, on a western estuary regional basis, is not tremendous, localized threats may occur in subwatersheds of creeks and embayments. Also, the rate of development of vacant land may surpass the rate of agricultural conversion, resulting in greater nitrogen enrichment (see "worst case analysis").

Overall, the results of the analysis for the western estuary are encouraging, in that nitrogen load controls to effectuate "no net increase" in nitrogen loading appear to be realistic. Moreover, meaningful TN load reductions through aggressive agricultural and residential BMP's are a possibility.

Although western estuary long-term TN regional load threats do not appear to be great in terms of subregional magnitude, the industrial development potential is tremendous, particularly in Riverhead Town (2,900 acres at Grumman site, and 1,900 acres at other sites). Fairly modest industrial TN load rate assumptions were used in the analysis, typical of most industrial activities in the study area. They are still fairly conservative in probably overestimating loads from fairly "dry" industries and commercial establishments, but, as with agriculture, loads from these establishments can vary greatly. Additional analysis and planning for the industrial TN discharges, as well as potential toxics threats, are warranted, particularly in the Peconic River area.

TABLE 7

PECONIC ESTUARY - POTENTIAL ADDITIONAL NITROGEN LOADING AT FULL BUILD-OUT

HUMAN SANITARY WASTE

	OVERALL STUDY AREA			WESTERN/EASTERN AREAS			
	Population (persons)	Load Factor (lb/day)	Load (lb/day)	West (persons)	East (persons)	West (lb/day)	East (lb/day)
Year-Round	44518	0.0137	610	15901	28617	218	392
Seasonal	35526	0.0046	162	3170	32356	14	148
Total			**772**			**232**	**540**

RESIDENTIAL FERTILIZER

	OVERALL STUDY AREA			WESTERN/EASTERN AREAS			
	Acres	Load Factor (lb/day)	Load (lb/day)	West Acres	East Acres	West (lb/day)	East (lb/day)
Low-Density	46079	0.0342	1578	8707	37372	298	1280
Med Density	0	0	0	0	0	0	0
High Density	0	0	0	0	0	0	0
TOTAL			**1578**			**298**	**1280**

RESIDENTIAL - ANIMAL WASTE & NATURAL PRECIPITATION/SOIL MINERALIZATION

	OVERALL STUDY AREA			WESTERN/EASTERN AREAS			
	Acres	Load Factor (lb/day)	Load (lb/day)	West Acres	East Acres	West (lb/day)	East (lb/day)
Low-Density	46079	0.0079	366	8707	37372	69	297
Med Density	0	0	0	0	0	0	0
High Density	0	0	0	0	0	0	0
TOTAL			**366**			**69**	**297**

AGRICULTURAL FERTILIZER

	OVERALL STUDY AREA			WESTERN/EASTERN AREAS			
	Acres	Load Factor	Load (lb/day)	West (ac)	East (ac)	West (lb/d)	East (lb/d)
Farmland	-11500	0.1836	**-2111**	-4500	-7100	**-826**	**-1285**

VACANT & OPEN SPACE

	OVERALL STUDY AREA			WESTERN/EASTERN AREAS			
	Acres	Load Factor	Load	West (ac)	East (ac)	West (lb/d)	East (lb/d)
Vac/Open Sp	0	0.0000	**0**	0	0	**0**	**0**

OTHER LAND USES (mainly commercial, industrial, transportation)

	OVERALL STUDY AREA			WESTERN/EASTERN AREAS			
	Acres	Load Factor	Load (lb/day)	West (ac)	East (ac)	West (lb/d)	East (lb/d)
Commercial	649	0.1142	74	404	245	46	28
Industrial	320	0.1142	37	167	153	19	17
Institutional	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0
Riv Ind Grummar	2913	0.0732	213	2913	0	213	0
Riv Ind Other	1882	0.1142	217	1882	0	217	0
Brkhvn. Inst.	0	0	0	0	0	0	0
TOTAL	**5783**		**541**	5366	398	**496**	**45**

	OVERALL STUDY AREA	WESTERN/EASTERN AREAS	
	Load (lb/day)	West (lb/d)*	East (lb/d)
OVERALL TOTAL	**1146**	**269**	**877**

Information sources and loading assumptions the same as in Table 1.
Former Grumman site assumed to have STP discharging out of study area; other factors for site are med. density res.

Table 7
PECONIC ESTUARY - POTENTIAL ADDITIONAL NITROGEN LOADING AT FULL BUILD-OUT
NOTES

Sources and assumptions are the same as in Table 1, except as otherwise noted.

Resid. fertilizer assumptions (see Southold report): 2.4 lb/N per 1,000 sf application; 5.6, 10.1, & 9 lb N/ac/yr for low, med, & high density reidential dev.

For vacant/open space, precipitation is assumed to be the primary load.
0.5 mg/l, 22.5 in/year recharge (USGS; recharge = 50% of long-term avg of 45 in) assumed.

Assumptions for other land uses:

Industrial/Commercial	Uses residential medium-density fertilizer, animal waste, & natural precip/soil mineralization
Institutional	"
Other-mainly transportation	"
Brkhvn. Inst. (mainly BNL)	Uses 90% vacant load; 10% residential low-density fertilizer, animal waste, & natural precip/soil mineralization

BNL and Riverhead STP commercial/industrial loads are considerd (see below).
In the absence of better data, other commercial/industrial activity is assumed to be primarily "dry."
The other "wet" commercial/industrial sanitary loading is believed to be on the order of 1% or less of regional loading;
the bulk of commercial/industrial nonpoint source loading is captured in the load factors above.

Other assumptions
In general, judgmental fine-tuning resulting in less than 1% of subregional loading is avoided.
Day trippers/visitors are ignored, and could result in slightly higher loads.
BNL STP discharge is reflected in Peconic River loading.
Sag Harbor/SI Heights STP adjustments are ignored (<0.5% of eastern estuary nonpoint source loading).
Riverhead STP service area has been adjusted for residential sanitary waste: 500 ac, mostly med dens resid, 3,100 persons, 43 lb TN/day avoided.
(adjustment reflected in lowered western estuary population in nonpoint source table)
Remainder of Riverhead STP flow assumed to be "imported" sanitary flow from commercial activities.

In the eastern study area, more substantial development potential exists, with the possibility of over 37,000 acres being developed residentially. Only about 400 acres of new commercial and industrial development is possible under existing zoning. The overall residential development density potential for new development is lower in the east end, reflected in the smaller per-acre human density for new development.

In terms of TN loading in the eastern estuary, a more substantial increase of about 900 lb/day would be possible. This represents an increase of over 20% in nonpoint source loading for that region.

Figure 7 illustrates the reasons for the above trends. In the western estuary, at full build-out, the agricultural TN loss of 830 lb/day substantially outweighs the residential increase of about 600 lb/day. The commercial and industrial development growth potential is the determining factor in the overall increase in TN loading. In the eastern estuary, while 1,300 lb/day of TN will be averted due to agricultural conversion, 2,100 lb/day will be added from residential development, raising concerns for main bays, as well as embayment, water quality.

Figure 8 translates the TN loads into resulting, typical groundwater quality concentrations on a regional basis for the eastern estuary. That figure shows that, for the North Fork, TN concentrations would actually drop. The South Fork would see an increase from about 3 mg/l to about 5 mg/l. On Shelter Island, TN concentrations would rise from about 3 mg/l to just above 4 mg/l. In the western estuary, the increase would be about 13% overall; potential west estuary increases for specific subregions are further broken down below in the "worst case" scenario.

As a final exercise in this task, likely nonpoint source TN trends from the years 1950 to 2040 are represented graphically in Figure 5. Note the dramatic historic rise in TN loading rates in the eastern estuary, which is projected to continue well into the 21st century. In contrast, the TN loading curve to the western estuary began to flatten out somewhere around 1980, and will continue to rise more modestly.

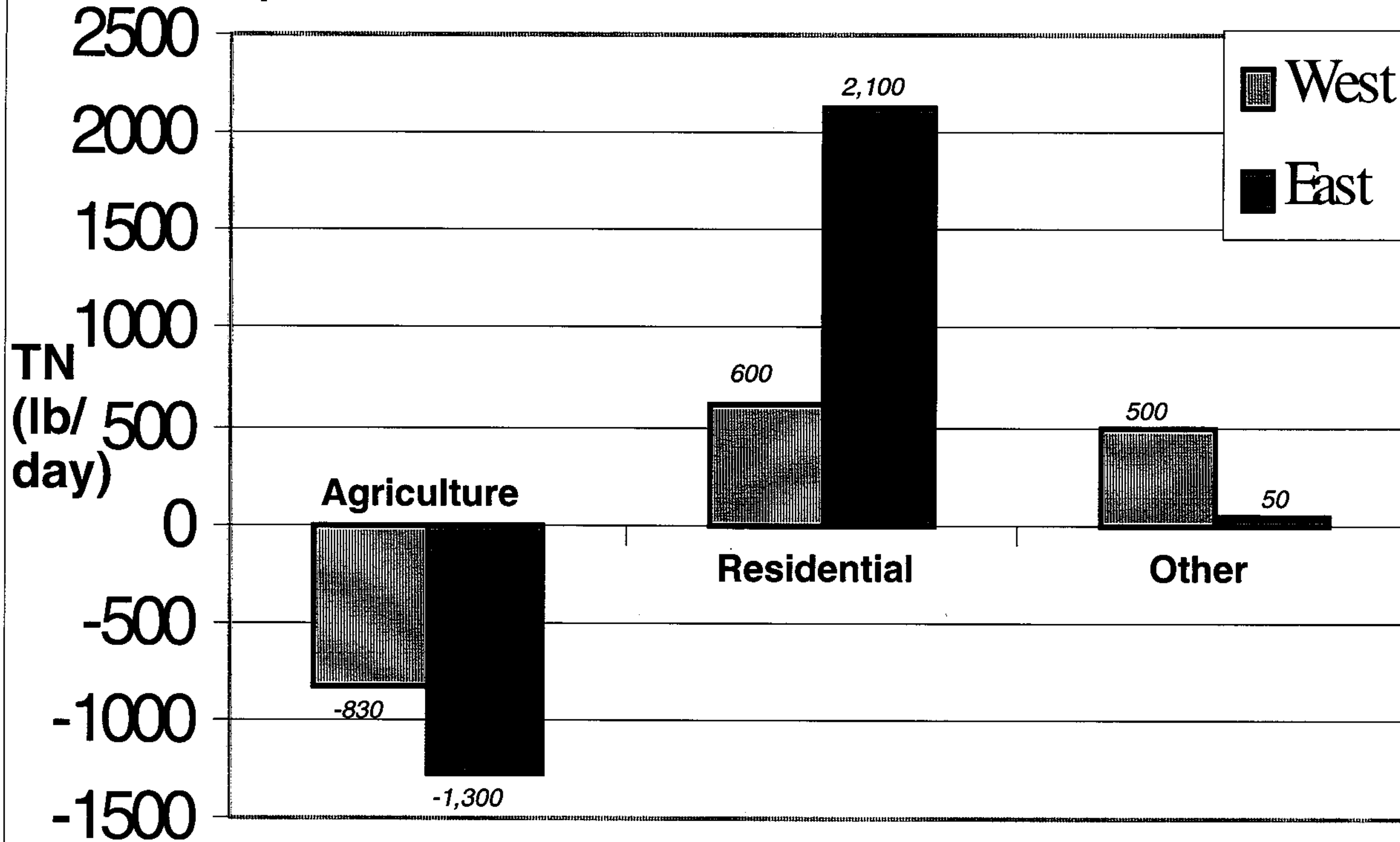
ii) "Worst-Case Scenario"

This scenario considered the possibility that there would be no agricultural conversion, and that all other developable lands were developed under existing zoning, which is predominantly low density residential. The results are included in Tables 8 and 9 and Figures 9 and 10.

Table 8 shows that, under the scenario of "no agricultural conversion," nitrogen loading could increase fairly substantially in the western and eastern regions of the estuary. Overall, a total nitrogen increase for the estuary study area of almost 40% (about 2,500 pounds per day) is possible.

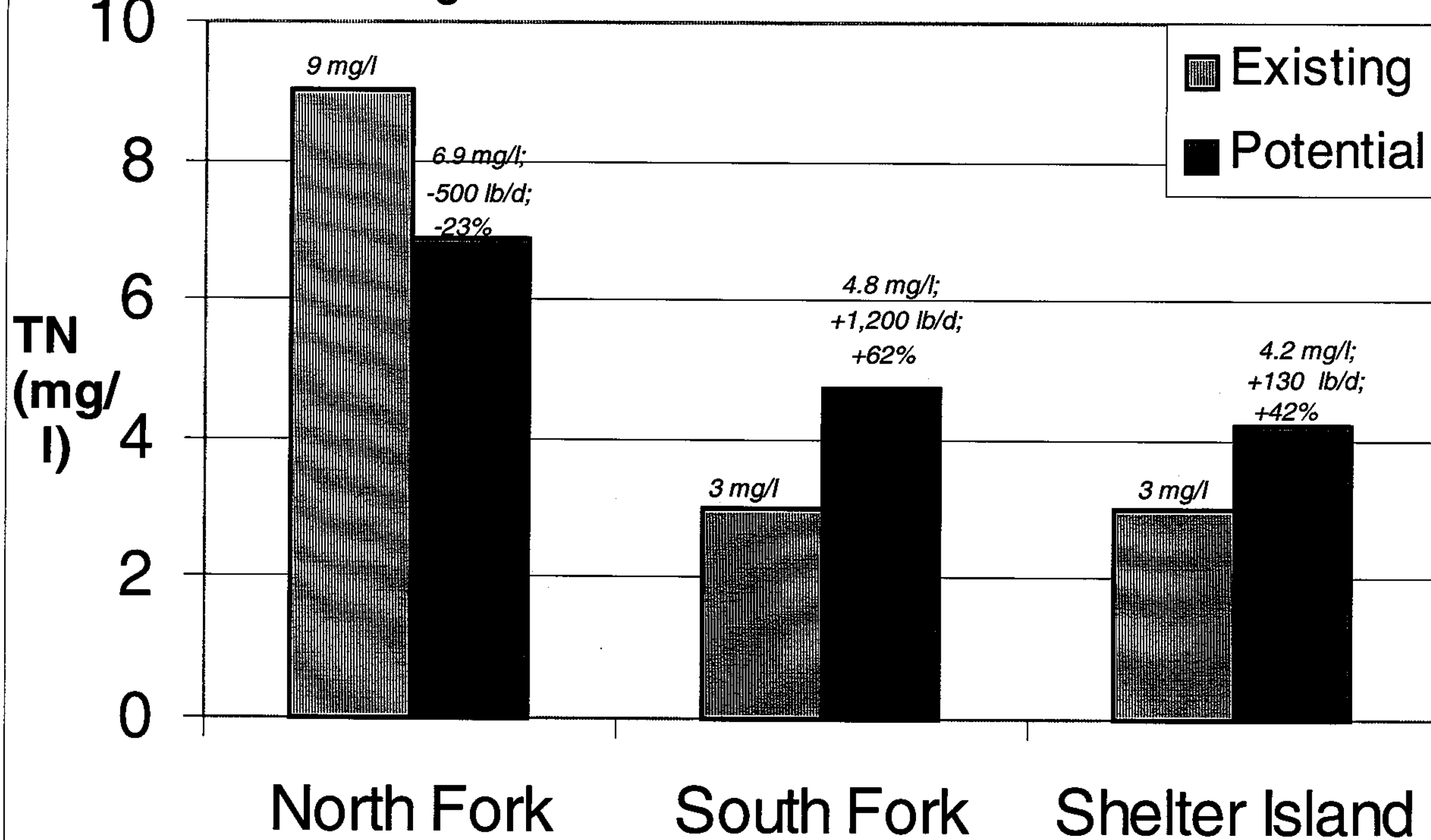
In the western estuary areas of the Peconic River and Flanders Bay, almost 50% in TN loading increase (about 700 lb/day) could be realized. Note that a large portion of this is due to potential

FIG. 7: ESTIMATED TOTAL NITROGEN (TN) LOADING CHANGES
Nonpoint Sources to Groundwater at Full Build-Out



"West" estuary is Peconic River & Flanders Bay. "East" includes all areas east of Flanders Bay.

FIGURE 8
ESTIMATED GROUNDWATER TOTAL NITROGEN (TN) CONCENTRATIONS
Existing Conditions and Full Build-Out



Regions are all east of Flanders Bay.

For Peconic River/Flanders Bay subregion, a 13% increase is calculated.

TABLE 8

PECONIC ESTUARY - POTENTIAL WORST-CASE ADDITIONAL NITROGEN LOADING

Existing Zoning; No Agriculture Conversion

HUMAN SANITARY WASTE

	OVERALL STUDY AREA			WESTERN/EASTERN AREAS			
	Population (persons)	Load Factor (lb/day)	Load (lb/day)	West (persons)	East (persons)	West (lb/day)	East (lb/day)
Year-Round	33126	0.0137	454	8802	24324	121	333
Seasonal	29257	0.0046	134	1755	27502	8	126
Total			**587**			**129**	**459**

RESIDENTIAL FERTILIZER

	OVERALL STUDY AREA			WESTERN/EASTERN AREAS			
	Acres	Load Factor (lb/day)	Load (lb/day)	West Acres	East Acres	West (lb/day)	East (lb/day)
Low-Density	35900	0.0342	1229	5500	30400	188	1041
Med Density	0	0	0	0	0	0	0
High Density	0	0	0	0	0	0	0
TOTAL			**1229**			**188**	**1041**

RESIDENTIAL - ANIMAL WASTE & NATURAL PRECIPITATION/SOIL MINERALIZATION

	OVERALL STUDY AREA			WESTERN/EASTERN AREAS			
	Acres	Load Factor (lb/day)	Load (lb/day)	West Acres	East Acres	West (lb/day)	East (lb/day)
Low-Density	35900	0.0079	286	5500	30400	46	240
Med Density	0	0	0	0	0	0	0
High Density	0	0	0	0	0	0	0
TOTAL			**286**			**46**	**240**

AGRICULTURAL FERTILIZER

	OVERALL STUDY AREA			WESTERN/EASTERN AREAS			
	Acres	Load Factor	Load (lb/day)	West (ac)	East (ac)	West (lb/d)	East (lb/d)
Farmland	0	0	**0**	0	0	**0**	**0**

VACANT & OPEN SPACE

	OVERALL STUDY AREA			WESTERN/EASTERN AREAS			
	Acres	Load Factor	Load	West (ac)	East (ac)	West (lb/d)	East (lb/d)
Vac/Open Sp	0	0	**0**	0	0	**0**	**0**

OTHER LAND USES (mainly commercial, industrial, transportation)

	OVERALL STUDY AREA			WESTERN/EASTERN AREAS			
	Acres	Load Factor	Load (lb/day)	West (ac)	East (ac)	West (lb/d)	East (lb/d)
Commercial	537	0.1142	61	331	207	38	24
Industrial	291	0.1142	33	186	105	21	12
Institutional				0	0	0	0
Other				0	0	0	0
Riv Ind Grumman	2913	0.0732	213	2913	0	213	0
Riv Ind Other	580	0.1142	66	580	0	66	0
Brkhvn. Inst.				0	0	0	0
TOTAL	**4321**		**374**	4010	312	**338**	**36**

	OVERALL STUDY AREA	WESTERN/EASTERN AREAS	
	Load (lb/day)	West (lb/d)*	East (lb/d)
OVERALL TOTAL	**2500**	**700**	**1800**

Information sources and loading assumptions the same as in Table 6.

Former Grumman site assumed to have STP discharging out of study area; other factors for site are med. density res.

TABLE 9

Western Estuary (Peconic River & Flanders Bay Areas)

Potential Worst-Case Additional Nitrogen Loading

Existing Zoning; No Agriculture Conversion

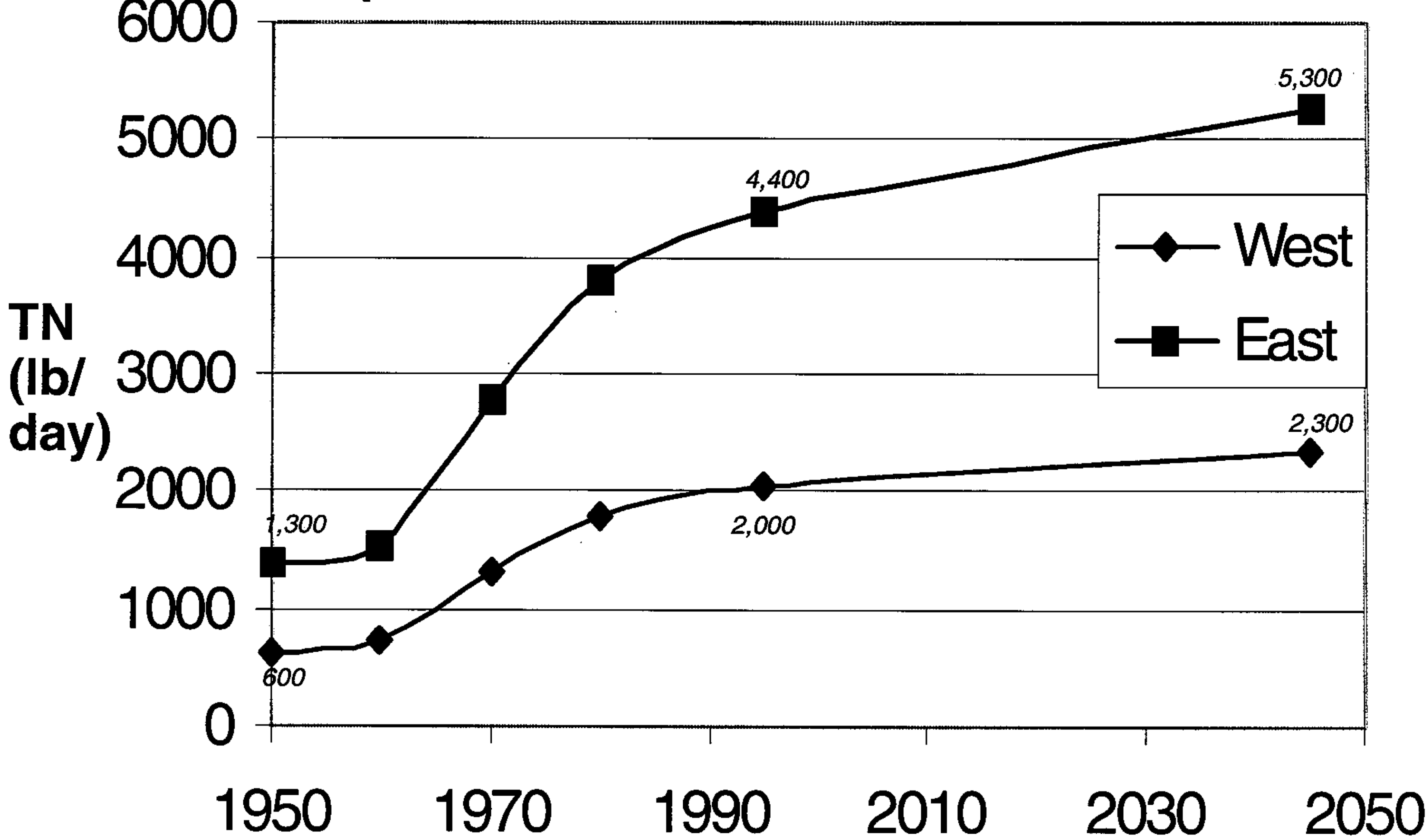
ACREAGE SUBJECT TO DEVELOPMENT

Town	***Peconic River West***	***Peconic River East***	***North Flanders Bay***	***South Flanders Bay***
RESIDENTIAL				
Riverhead	323	798	619	0
Brookhaven	1848	0	0	0
Southampton	0	62	0	1833
TOTAL RESIDENTIAL	2171	860	619	1833
COMMERCIAL & INDUSTRIAL				
Riverhead-Grumman	580	250	113	0
Riverhead - Other	2913	0	0	0
Brk	187	61	0	0
SH	0	0	0	5
TOTAL COMM./IND.	3680	311	113	5
OVERALL TOTAL	**5851**	**1171**	**732**	**1838**
Total west estuary developable (non-ag acres):		*9,600*		

INCREASE IN TN LOADING (lb/day)

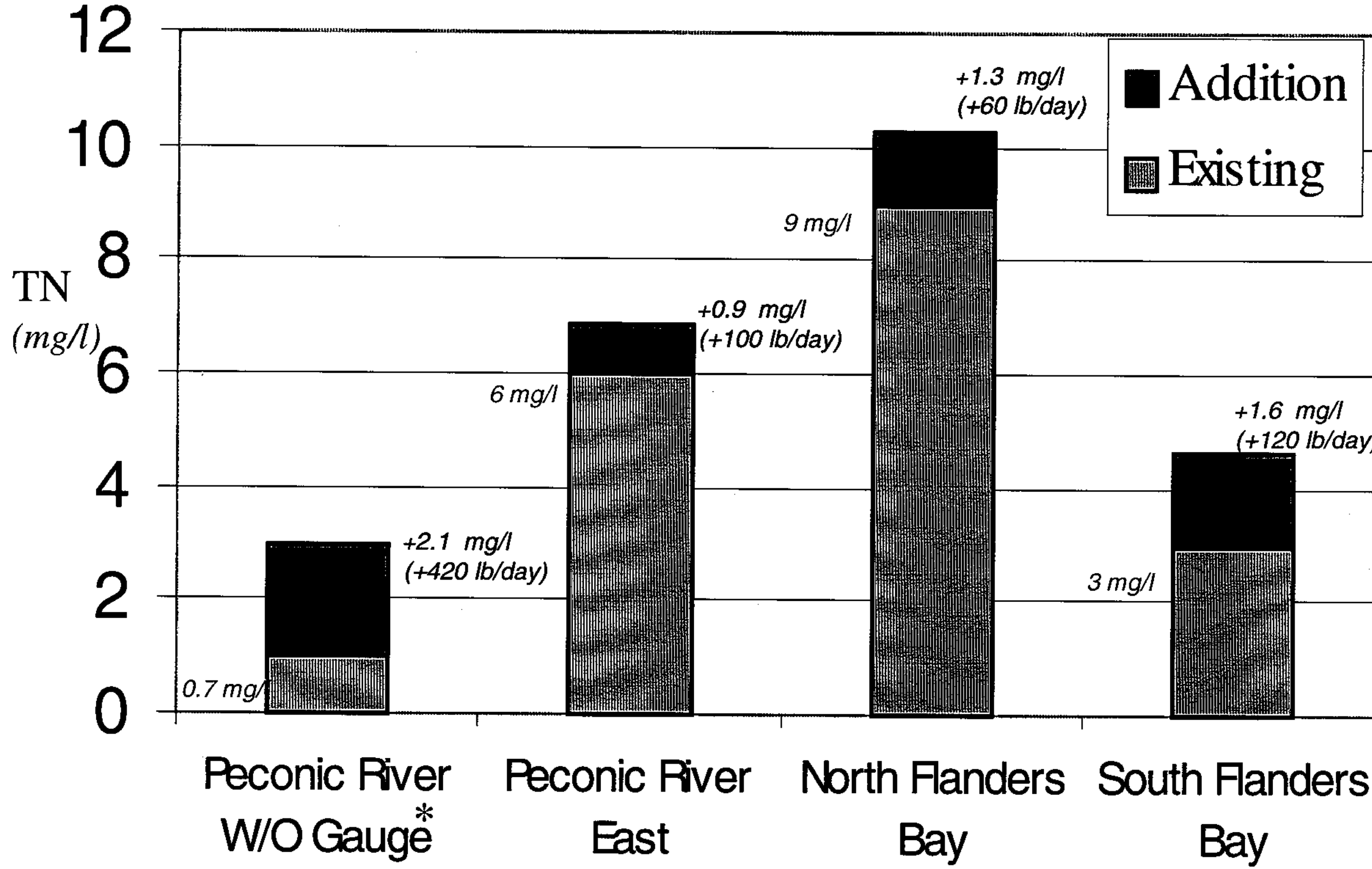
Town	***Peconic River West***	***Peconic River East***	***North Flanders Bay***	***South Flanders Bay***
RESIDENTIAL				
Riverhead	27	66	50	0
Brookhaven	98	0	0	0
Southampton	0	4	0	115
TOTAL RESIDENTIAL	***124***	***69***	***50***	***115***
COMMERCIAL & INDUSTRIAL				
Riverhead-Grumman	61	26	12	0
Riverhead - Other	213	0	0	0
Brk	20	6	0	0
SH	0	0	0	1
TOTAL COMM./IND.	***293***	***33***	***12***	***1***
OVERALL TOTAL	**420**	**100**	**60**	**120**
Total west estuary study area load (lb/day):	*700*			

FIG. 9: ESTIMATED TOTAL NITROGEN (TN) LOADING TRENDS
Nonpoint Sources to Groundwater



"West" estuary is Peconic River & Flanders Bay. "East" includes all areas east of Flanders Bay.

Figure 10: Western Estuary - Potential Worst-Case Groundwater Degradation
(Full build-Out, No Agricultural Conversion)



* *Assumes 420 lb/day is in water column at the Peconic River at the USGS gauge station. Actual increase would be smaller.*

development in industrial and commercial lands, particularly in Riverhead Town. Table 9 further breaks down the increases by land uses in four subregions of the western estuary. The Peconic River West, the largest of the four subregions, also had, by far, the largest potential increase in TN loading, at over 400 lb/day.

Figure 10 shows graphically the increases in western estuary TN levels in the Peconic River and in groundwater east of the USGS gauge. East of the USGS gauge, groundwater increases of about 15% are possible in the Peconic River East and North Flanders Bay, and an increase of about 50% is possible in South Flanders Bay. The Peconic River stands to gain 2.1 mg/l if the entire potential TN increase is reflected in the flow. However, due to the factors discussed above, the actual increase would be much smaller. Using linear extrapolation, an increase of 420 lb/day would be about 50% higher than the budgeted 790 lb/day for existing conditions, resulting in a Peconic River TN concentration of about 1 mg/l TN. However, riverine reaction to increasing loads cannot be assumed to be linear, so that a conservative factor of safety, such as a TN of 1.5 mg/l, should be used in estimating possible worst-case conditions.

In the eastern estuary, an overall increase of about 40% is possible. Figure 11 illustrates the breakdown of the TN load impacts on groundwater TN concentrations for the North Fork, South Fork, and Shelter Island. The North Fork would increase from about 9 mg/l to about 11 mg/l, an increase of approximately 20%. The increase on the South Fork would be even more profound, from approximately 3 mg/l to about 5 mg/l, over 60%. Shelter Island would increase from 3 mg/l to the range of 4 to 5 mg/l, about a 50% increase.

Particularly significant in quantitative terms are the potential western estuary and South Fork loadings, due to the relatively high volume of groundwater delivered from those areas. As shown in Figure 12, about one-third (32%) of the groundwater inflow to the estuary is delivered from the Peconic River (which is fed by groundwater) and Flanders Bay groundwater systems. Approximately 45% of the total groundwater is delivered from the South Fork, east of the Shinnecock Canal.

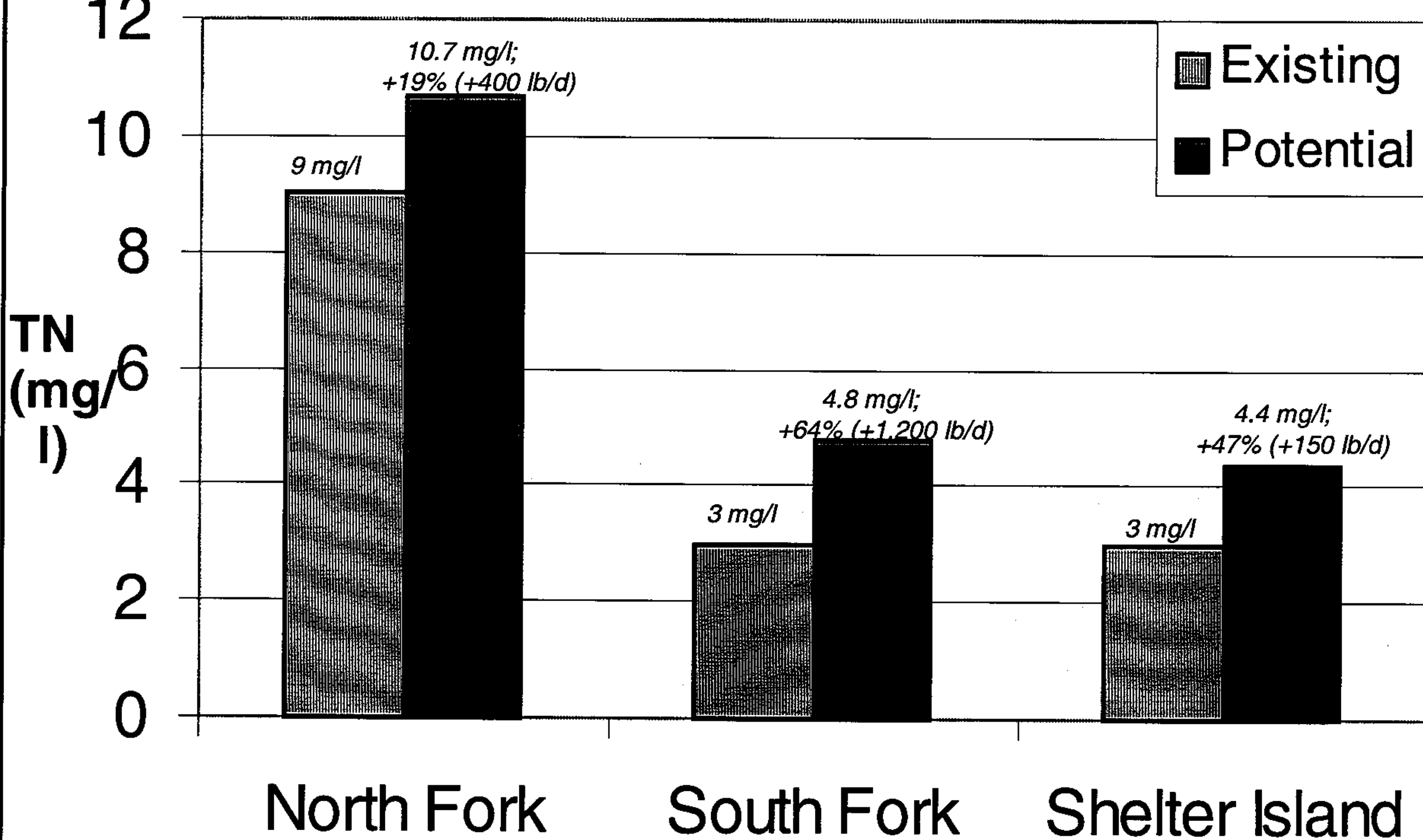
These groundwater inflow rates translate into the potential additional loading of about 700 pounds per day from the poorly flushed western estuary, and approximately 1,200 pounds per day from the South Fork east of Flanders Bay. These estimates are far higher than the potential additions of 400 pounds per day from the North Fork and 150 pounds per day from Shelter Island.

iii) "No Open Space Scenario"

The impacts of a hypothetical scenario were evaluated, wherein "open space" land uses are converted to low density residential uses. This illustrated water quality benefits that have accrued as a result of open space programs, by assessing likely impacts that would have occurred has open space programs not been implemented.

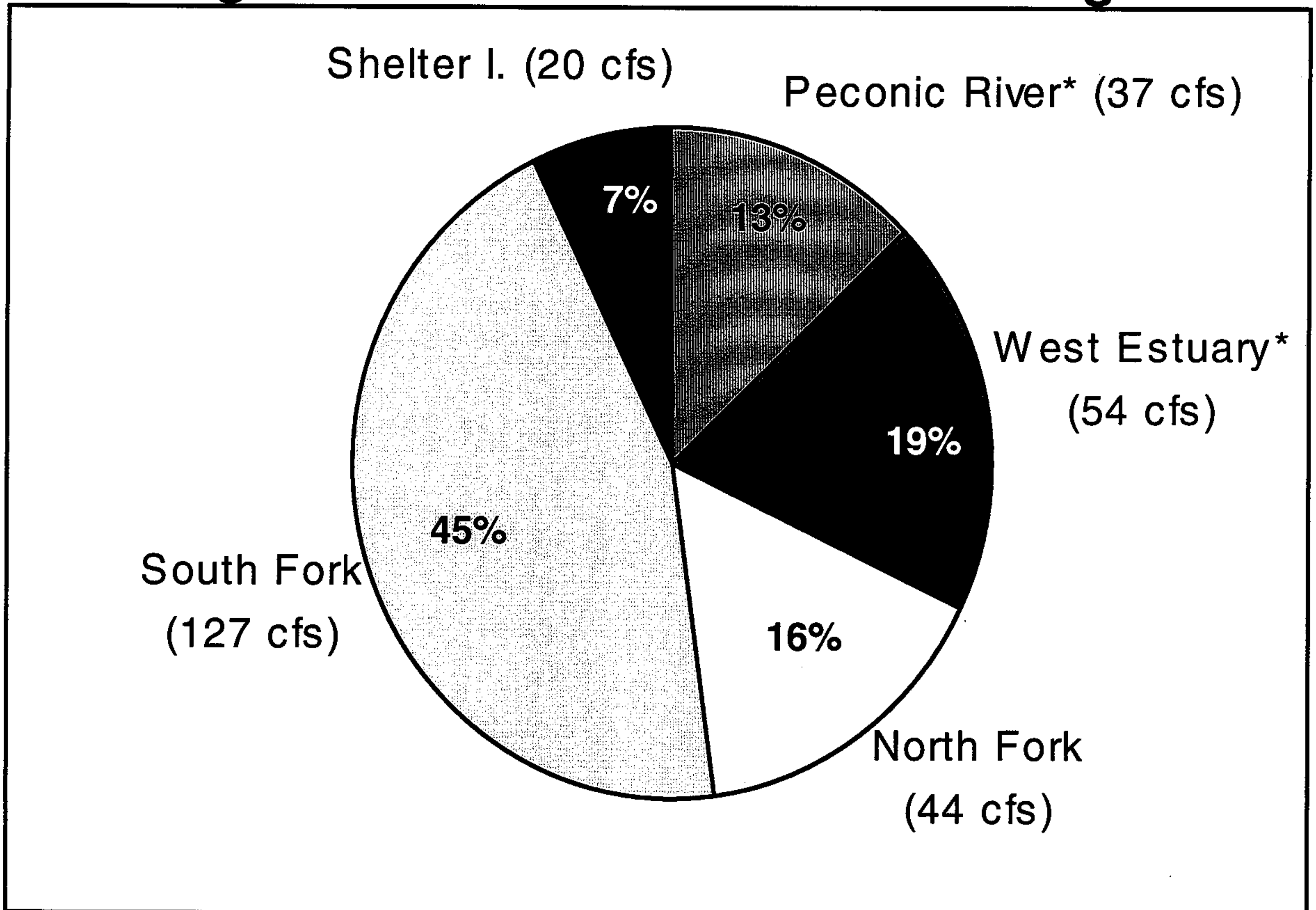
The assumption of conversion to low density land uses is made to ensure a conservative and

FIGURE 11
ESTIMATED GROUNDWATER TOTAL NITROGEN (TN) CONCENTRATIONS
WORST-CASE CONDITIONS *



* Full build-out, except no agricultural conversion. Regions shown in graph are all east of Flanders Bay.

Figure 12: Groundwater Inflow Budget



* Peconic River long-term mean flow as measured at USGS gauge.

** West Estuary is downstream of Peconic River USGS gauge, including Flanders & western Great Peconic Bays.

defensible impact assessment, which does not overstate the beneficial impact of the open space programs. In reality, various more intensive land uses would likely have occurred, resulting in even higher TN loadings.

Figure 13 shows the cumulative impacts of the "worst case full build-out" and "no open space" scenarios in terms of subregional percent increases, as well as resulting groundwater quality concentrations. This shows that open space programs have been tremendously successful in preventing potential nitrogen loading to the estuary, particularly in the critical western estuary and in the high inflow South Fork areas.

In the western estuary and on the South Fork, current TN loads to the estuary would more than double, as compared with existing conditions, if open space alone were developed at low density residential land uses. This would mean an additional 1,700 lb/day TN in the western estuary, and 2,100 lb/day on the South Fork. As shown in Figure 13, groundwater TN concentrations for the South Fork would be elevated to about 8 mg/l in a full build-out (worst case), no open space scenario.

Shelter Island would also see a tremendous local increase in TN loading, again at over 100%. This would translate into about 370 lb/day in additional TN loading. Increase on the North Fork due to conversion of open space would be more modest, at about 20% (about 400 lb/day) as compared with existing conditions.

4) Conclusions and Recommendations

The status and trends information developed herein is helpful in guiding management strategies, even without the assistance of an interpretive and predictive model. Several key insights which are evident, based on the discussion above, are as follows:

A) Existing Conditions

TN Load Sources

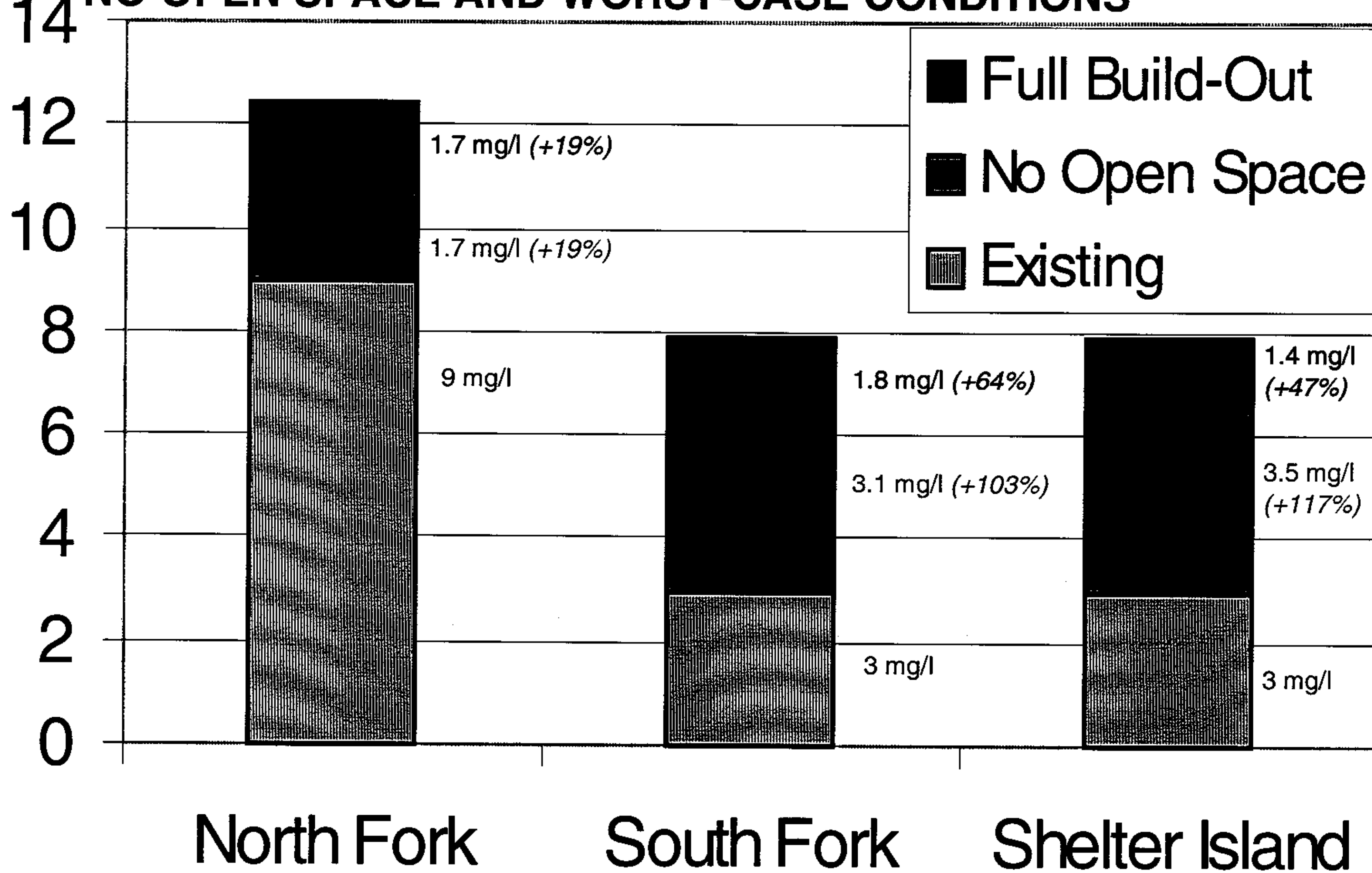
For existing conditions, the dominant sources of total nitrogen to the estuary are agriculture (41% of TN loading) and residential development (40% of TN loading). Agriculture has a per-acre loading rate of about double the residential land in the study area, as agriculture contributes a comparable amount of TN loading with only about half the acreage. Of the individual components of TN loading, agricultural TN loading is estimated to be, by far, the most significant, almost three times greater than human sanitary waste and almost double the residential TN fertilizer load.

Residential/Agricultural Land Use and Pollution Control Management Priorities

Based on substantial nitrogen loadings, on a regional basis, best management practices and other land use and pollution control management programs should be targeted primarily at residential and agricultural land uses to mitigate existing TN loadings. Commercial and industrial lands

FIGURE 13

ESTIMATED GROUNDWATER TOTAL NITROGEN (TN) CONCENTRATIONS NO OPEN SPACE AND WORST-CASE CONDITIONS *



** Full build-out, except no agricultural conversion. Regions shown in graph are all east of Flanders Bay.*
All percentages are calculated in relation to existing groundwater concentrations.
Western estuary TN loading would increase by 82% with no open space.

contribute less than 10% of the TN load to the estuary, even within the Peconic River area. However, commercial and industrial land uses may be significant management priorities on a very discreet local subwatershed basis.

Agricultural TN Load Inventory and Management Plans

Due to highly variable nature of agricultural TN loads, coupled with the magnitude of those loads, an improved inventory of agricultural TN loading should be performed. Agricultural environmental management programs currently underway should be continued and expanded.

Verification of Modelling Load Assumption

Existing surface water model TN nonpoint source load assumptions were verified by developing nonpoint source load estimates using an independent methodology. For the surface water model calibration, groundwater inputs of TN were developed by coupling inflow rates (US Geological Survey budgets) with regional groundwater quality estimates (based on SCDHS groundwater quality data). For this report, nonpoint source estimates were developed primarily based on land use data coupled with loading factors which are well established in the literature.

The results agreed extremely well in the eastern estuary, and fairly well in most of the western estuary. The overall difference was only 3% in the eastern estuary, and the difference was less than 10% on the North Fork, South Fork, and Shelter Island.

The budget deviated by 29% in the western estuary, well within reason for this type and level of regional analysis. Agreement was fairly good for all four subregions of the western estuary, except the Peconic River West, where agreement was markedly poor. In the Peconic River West, the land use/loading method yielded expected loading estimates which were 460% higher than loadings measured in the river at the USGS gauge. SCDHS will attempt to improve the budget by:

* refining residential and agricultural TN load factors for Peconic River West area.
* limiting analysis to the actual groundwater-contributing area, rather than the substantially larger land use study area
* reviewing literature on riverine sedimentary denitrification, plant uptake, possible organic carbon/TN "burial," and transient export events.

The lack of a well-calibrated TN load budget for the western estuary is not a problem for calibration and verification of the existing model, since the PEP is using actual flow and concentration data for the river at the USGS gauge station, integrating upstream groundwater influences on the estuary. For final management alternatives and decisions, however, a refined TN load budget will obviously be necessary. Given the importance of potential Peconic River region land use changes, a predictive model for the Peconic River should be considered.

B) Historic Loading Trends

In terms of historic loading trends, it appears that groundwater total nitrogen loading to the eastern estuary (east of Flanders Bay) may have risen by over 200% since the 1950's. This is due to dramatic population growth, coupled with the pervasive use of relatively inexpensive, highly soluble, commercially available, inorganic nitrogen fertilizers. In the western estuary, decreases in duck farm TN loading appear to be roughly offset by increases in nonpoint source TN loading. In summary, TN loadings to the estuary may be at an all time peak level.

The relative magnitude of the overall trends are believed to represent the most probable historic TN load trends based on readily available information, given the cautionary note that the analysis is preliminary, and subject to substantial refinement. The estimates highlight the importance of nonpoint source management strategies as an especially high priority for the Peconic Estuary Program. The estimates may also eventually be used in a long-term, historical model run, to test the performance of the water quality and predictive sediment submodel and, possibly, evaluate potential water quality trends in the absence of actual monitoring data. Of course, should a historic run be contemplated, long-term changes in other sources, such as atmospheric deposition and the locally important Riverhead Sewage Treatment Plant, would have to be characterized.

C) Full Build-Out

Although 40% of the acreage in the watershed is subject to development, as a whole, additional future total nitrogen loading under a "full build-out" scenario is more modest in the western estuary (13% increase), and is more quantitatively significant in the eastern estuary (>20% increase). This is due to potential conversion of agricultural lands to low density residential land uses, which are generally less nitrogen intensive.

The PEP dual approach of "water quality preservation" in the eastern estuary, and "no net increase, with the goal of ultimate load reductions in the western estuary" are validated by this analysis as being realistic. In the western estuary, where only 270 lb/day additional TN loading is projected, nitrogen load controls to effectuate "no net increase" in nitrogen loading are very feasible. Moreover, meaningful TN load reductions through aggressive agricultural and residential BMP's are a possibility. In the eastern estuary, where about 880 lb/day additional TN loading is possible, largely on the South Fork, water quality preservation is a paramount goal, particularly for peripheral creeks and embayments. Best management practices and nitrogen abatement strategies should be aggressively pursued in all areas.

Virtually all of the TN load increase would be in the form of residential TN loading, except for the western estuary. In that area, industrial and commercial development potential is also tremendous, mainly due to developable lands in Riverhead Town (2,900 acres at Grumman site, and 1,900 acres at other sites in the Town). Overall, over 90% of the developable industrial acreage in the study area, and almost on-half of the developable commercial acreage, are in Riverhead Town. Thus, management strategies should be targeted and potential pollution from developable commercial and industrial lands, particularly in Riverhead Town, not only for TN, but also for other threats, such as toxics.

D) Worst-Case Scenario

Under a scenario in which 100% of farmland is preserved, nitrogen loading could increase fairly substantially in every major region of the estuary. Overall, a total nitrogen increase for the estuary study area would be almost 40% (41% in eastern estuary, 34% in eastern estuary). In the eastern estuary, the increase on the South Fork would be most profound (over 60%). Groundwater inputs to the estuary are most significant from the western estuary and South Fork (32% of groundwater inflow to the estuary is from western estuary, and 45% is from the South Fork).

In the western estuary, increases would be substantial in every subregion, but are particularly important for the Peconic River west of the USGS gauge station. At the gauge, TN levels could more than double in a worst-case scenario.

In the eastern estuary, substantial increases would be possible in every area, but would be most pronounced on the South Fork. In that area, a 60% increase is possible.

This information highlights that, for regional management purposes, potential worst-case TN loads are extremely significant, particularly from the western estuary and South Fork. These should be considered as regional management priorities.

E) Open Space Benefits

If open space programs were not implemented, and those lands were developed at low density residential land uses, current TN loads to the western estuary, South Fork, and Shelter Island would more than double, as compared with existing conditions. Increases on the North Fork due to conversion of open space would be more modest, at about 20% as compared with existing conditions.

Open space programs have obviously been tremendously successful, not only for drinking water protection and habitat/living resource concerns, but also for TN load controls and surface water quality preservation. The programs should continue to be aggressively pursued, not only for habitat and living resources benefits, but also as a means to control TN inputs.

F) Model Sensitivity Runs

For each of the residential land use density categories, a triad of loading factors was used: one for human sanitary waste, a second for fertilizer, and a third for all other TN loads (animal waste and natural precipitation/soil mineralization). The adopted approach was used to enhance the accuracy of the estimates, and to facilitate development and manipulation of various management alternatives. Thus, future population growth projections and land use development patterns can readily be translated to incremental TN loadings (and groundwater TN concentrations).

For preliminary sensitivity analysis, the "worst-case" TN loads discussed above should be used for model runs. A factor of safety on the order of 10% should also be used to account for potential intensification of land uses (e.g., rezonings to allow denser development), as well as possible estimation errors. Given the results of the analysis discussed above (coupled with an additional 10% "factor of safety" potential increase), the following inputs for regional modelling "worst-case" conditions are recommended:

Western Estuary	*Existing*	*Worst Case*
Peconic River Flow: (At USGS gauge)	0.65 mg/l	1.5 mg/l
Peconic River East:	6 mg/l	7 mg/l
North Flanders Bay:	9 mg/l	10.5 mg/l
South Flanders Bay:	3 mg/l	4.8 mg/l
Eastern Estuary		
North Fork:	9 mg/l	10.9 mg/l
South Fork:	3 mg/l	5 mg/l
Shelter Island:	3 mg/l	4.5 mg/l

The "worst-case" runs can be used to bound the degradation potential to the estuary. The "best case" assumption of about 20% TN load reductions can bound maximum potential improvements. The range of potential results can then be compared against the TN guideline. Economic estimates of various management measures will be developed by the consultant, and costs of various management strategies can be weighed against benefits to improve regional and subwatershed management strategies.

G) Investigation Priorities

The estimates contained in this report are adequate for initial model calibration and verification, sensitivity analysis, and preliminary management alternatives. However, prior to running of final management alternatives, the PEP should consider the following refinements, particularly with respect to agricultural TN loading. Peconic River characterization and improved residential characterizations may be additional priorities.

Agricultural Investigations

Part of this study was aimed at characterizing areas of greatest uncertainty related to nitrogen inputs to focus future research and monitoring investigations. Given the magnitude of the estimated loads, coupled with the likely variability of loadings, the area of greatest need of pollution loading characterization is agricultural TN loading. In terms of land uses, agriculture contributed the greatest load of TN at almost 2,700 lb/day, slightly more that all residential land uses combined. The significance of this observation is magnified by the fact that agricultural acreage is only about one-half of the total residential study area acreage.

Some of the agricultural information may be obtained through existing Agricultural Environmental Management Initiatives, and through discussions with agencies such as Cornell Cooperative Extension, the Soil and Water Conservation District, and the Natural Resources Conservation Service. However, based on preliminary discussions with these agencies, a substantial expansion of pre-existing programs will be necessary to accomplish characterization goals.

Residential Investigations

A residential fertilizer loading refinement is warranted, given the magnitude of the source, even though it is believed to be far less variable than agricultural TN loading. Improved characterization could be accomplished by surveys of residents regarding planting practices and fertilizer use. One goal could be to better establish updated nitrogen loading rates as a function of lot size in various areas of the study area.

Another avenue of investigation would be procuring and analyzing data from Towns on land use practices for new development (clearing restrictions, clustering, etc). While clustering, buffers, and clearing restrictions are being used more aggressively, the Citizens Advisory Committee (CAC) has reported a growing trend towards highly manicured "mini-estates," as well. Other interesting land use issues have been raised by CAC observers, including the increasing rate of conversion of seasonal homes to year-round residences.

Peconic River Investigations

As discussed above, another investigation priority should be to refine Peconic River residential and agricultural TN load factors, perform a more realistic analysis for the actual groundwater-contributing area (rather than the substantially larger land use study area), and review literature on riverine sedimentary denitrification, plant uptake, possible organic carbon/TN "burial," and transient export events. A Peconic River surface water quality model should be considered.

Other Issues

The variability within the "open space" category is worth examining. For example, golf courses are "open space," but are not necessarily benign in terms of TN loading.

Continuing updates of land uses is a critical issue. This will be addressed as part of the PEP long-term monitoring plans.

Finally, improved groundwater characterizations are an important goal of the PEP, particularly in the westernmost study area. These will be accomplished in the coming year by US Geological Survey seismic reflection tows (to better refine geology under Flanders Bay). Also, Camp, Dresser, & McKee, under contract to Suffolk County, is performing groundwater modelling which will define groundwater-contributing areas and delineate zones of contribution according to travel time to estuary (e.g., 1-year travel time, 10-year travel time, etc.).

H) Priority Land Use Management Categories

The Comprehensive Conservation and Management Plan should consider placing particular emphasis on managing existing residential and agricultural uses. These uses contribute greater than 80% of the nonpoint source TN load to the estuary. Industrial and commercial uses contribute less than 10% of the TN load to the estuary, even in the Peconic River corridor.

For new development, focus should clearly be on residential uses everywhere, especially in the western estuary and South Fork. Management of industrial and commercial development in the

Peconic River area, particularly in Riverhead Town, will be critical. In the western estuary areas of the Peconic River and Flanders Bay, almost 50% in TN loading increase (about 700 lb/day) above existing conditions could be realized. The majority of this increase could be attributable to industrial and commercial uses. The South Fork could see a TN loading increase of over 60% above existing conditions, due almost entirely to residential development.